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Appendix C-1
Surface Water Quantity Effects Assessment

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Bathurst Inlet Port and Road Project Surface Water Quantity Effects Assessment

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GLOSSARY, ACRONYMS AND ABBREVIATIONS

Glossary, Acronyms and Abbreviations

Glossary

ablation	The removal of snow through vaporization, melting or other erosive force.
baseflow	The portion of stream flow that comes from groundwater rather than surface runoff.
bed load transport	The movement of sediment particles along the bed of a channel. Distinct from suspended sediment transport where sediment is held within the water column.
bed movement	Changes in the form of a river channel in response to sediment transport.
catchment	Area of land drained by a river. Another term for river basin or watershed.
freshet	The relatively high annual stream discharge period resulting from spring/summer melt of the snowpack accumulated over the winter.
hydrograph	A graphical plot of stream discharge versus time.
ponding	Surface accumulation of water.
snowpack ripening	Process of early melt within a snowpack in early spring, where the density of the snow increases. Snowmelt runoff begins to be produced and contributes to the streamflow hydrograph.
valued ecosystem component (VEC)	The environmental attributes or components identified as a result of a social scoping exercise as having scientific, social, cultural, economic, or aesthetic value.
wetland	A swamp, marsh or other land that is usually water-saturated.

Acronyms and Abbreviations

BIPR	Bathurst Inlet Port and Road
DEIS	Draft Environmental Impact Statement
DIAND	Department of Indian Affairs and Northern Development
GN DOE	Government of Nunavut Department of the Environment
the Project	the Bathurst Inlet Port and Road Project
VEC	valued ecosystem component
WSC	Water Survey of Canada

1. INTRODUCTION

1. Introduction

This section details the effects assessment for surface water quantity and fluvial erosion. The construction and operation of the port and road infrastructure have the potential to affect surface water flows in a number of watersheds, including the Mara River, Burnside River and Western River, as well as the downstream aquatic environments of Bathurst Inlet.

There is limited human use of surface water as a resource or for navigation in the study area. Surface water quantity and fluvial erosion are considered valued ecosystem components (VEC) because it is important to maintain present conditions for aquatic and terrestrial life. In this assessment, the impact of the Project on surface water quantity and fluvial erosion are considered for five issues of hydrological significance:

- **Flow paths and drainage areas:** Flow paths define the hydrological network in any watershed and describe the linkages between different streams and river systems. Changes to flow paths or drainage areas can impact downstream flow rates and sediment transport.
- **Annual flow volumes**: The annual flow volume is a measure of the total volume of water flowing through a site of interest. An impact assessment of development on the annual flow volume will indicate the large-scale Project effects on the water available for aquatic and terrestrial life.
- **Seasonal distribution of flow:** Within the study area, stream flows vary throughout the year, with high flows during spring freshet (*e.g.*, May and June) and low flows during late summer and fall (*e.g.*, August and September). The monthly flow distribution reflects the annual cycle of temperature and precipitation within the study area and is integrated with the natural life cycle of many aquatic organisms. The assessment will consider the impact of the development on the natural monthly distribution of flows.
- **High flow conditions:** Peak (*i.e.*, flood) flows have impacts on human and natural environments. Floods can result in damage and loss of life, but also provide a natural source of sediment and water to sustain wetland and floodplain areas along river channels. The assessment will consider the impact of the Project on high flow conditions.
- **Low flows:** A minimum flow is required to maintain the health of aquatic ecosystems. A decrease in low flow conditions can impact aquatic life and water quality. The assessment will consider the impact of the Project on low flow conditions.

2. ENVIRONMENTAL SETTING

2. Environmental Setting

This section provides some general statements about the hydrological regime within the Bathurst Inlet Port and Road (BIPR) Project (the Project) study area, discusses the main flow-generating processes, summarizes current water use, and reviews available data sources.

2.1 Study Area Watersheds

The road will be constructed in two major watersheds (the Burnside and Western River catchments) as well as a number of smaller drainages that flow directly into Bathurst Inlet (Figure 2.1-1). The headwaters of the Burnside River basin are Contwoyto Lake; its primary tributary from the east and south is the Mara River.

The lands along the southernmost 15 km of the road drain west into Contwoyto Lake. Further east, the road passes through the Mara watershed, a major tributary of the Burnside River. The road alignment then passes close to the boundary of the Hackett River catchment a tributary to the Mara. The mouth of the Burnside River is on the western shore of Bathurst Inlet, near the community of Bathurst Inlet.

Approximately 50 km of the middle section of the road crosses the headwaters of the Western and Siorak rivers. This area drains primarily to the southeast into the Western River, which drains north into the southern tip of Bathurst Inlet. The northernmost 40 km of the road traverses the Amagok Creek basin, which drains directly into Bathurst Inlet near the port.

2.2 Streams and Stream Bed Characteristics

The road crosses rivers, creeks, bogs, and wetlands. Field surveys in 2001 and 2002, showed the route to cross 104 perennial and ephemeral streams. Approximately 67% of the streams drain relatively small watersheds (areas of less than 10 km^2). Only three stream crossings have upstream watershed areas exceeding 100 km^2 (Table 2.2-1).

Streams in the Project area have channel characteristics typical of the low-relief, glacially denuded Arctic. In general, small streams have poorly defined channels; these are relatively straight with low relief, and flow through ground moraines and boulder fields. Larger streams are characteristically meandering and less steep, passing through more defined channels with finer-grained substrates.

Bed load transport and bed movement in these streams is likely to be low for the majority of streams, as they are generally dominated by low stream gradients and low flow velocities, which do not promote substantial sediment movement. The potential for transport is greater in the larger streams, which have finer-grained bed sediments.

Table 2.2-1
Number of Stream Crossings and Characteristics of Watersheds

Watershed Area Range (km^2)	Number of Streams Crossed	Mean Bankfull Width (m)	Mean Bankfull Depth (m)	Mean Stream Slope (%)
Undefined	9	n/a	n/a	n/a
<0.5	14	1.7	0.3	0.9
0.6 to 1.0	13	4.1	0.4	1.3
1.1 to 5.0	34	13.5	0.4	1.6
5.1 to 10.0	9	5	0.4	0.6
10.1 to 100.0	22	20.6	0.6	1.1
>100.1	3	73.3	0.8	1.4
Total	**104**	**16.4**	**0.5**	**1.2**

2.3 Streamflow Generating Processes

The Project area is in the zone of continuous permafrost in the continental Canadian Arctic. This region is composed of vegetated tundra slopes dotted with lakes and wetland fens. Hydrologic processes are dominated by snow accumulation and melt, surface runoff, stream flow, and lake hydrology. The annual flow profile is controlled by long cold winters and short summers. Most of the annual runoff occurs during freshet and is derived from the melting snow pack. Late August and September precipitation events can also produce substantial runoff, especially in smaller basins. Flows are often lowest during summer months, in late July or early August. Due to the presence of permafrost, there is no deep groundwater flow. Baseflow in streams is low and supported only by flow through the shallow upper active layer of the soil profile, the only part of the soil profile that melts in the summer months. During summer the evaporation rate generally exceeds rainfall and a soil moisture deficit can build up within the upper active layer of the soil profile and lake levels can decline.

The hydrological year for northern watersheds is typically defined by the freeze-up time, which occurs in October for the Project region. In small watersheds, like many of those along the road, streams typically freeze to their bottom with zero flow during winter. Snow builds up during winter and is released in the spring freshet. The hydrological year is considered to run from the beginning of October to the end of September.

The shapes of hydrographs and the responses of streams to both spring snowmelt and precipitation are strongly correlated to basin size. Smaller watersheds with little or no lake storage respond more rapidly to inputs than larger watersheds. Extrapolating data from streams of larger basins may not produce representative hydrographs for smaller watersheds. A conceptual model of theoretical typical annual discharge patterns for small watersheds is shown in Figure 2.3-1. This figure shows a steep peak during freshet and a second peak in late August through September. These peaks vary with watershed size and precipitation. In very small basins, the freshet can be as short as a few days.

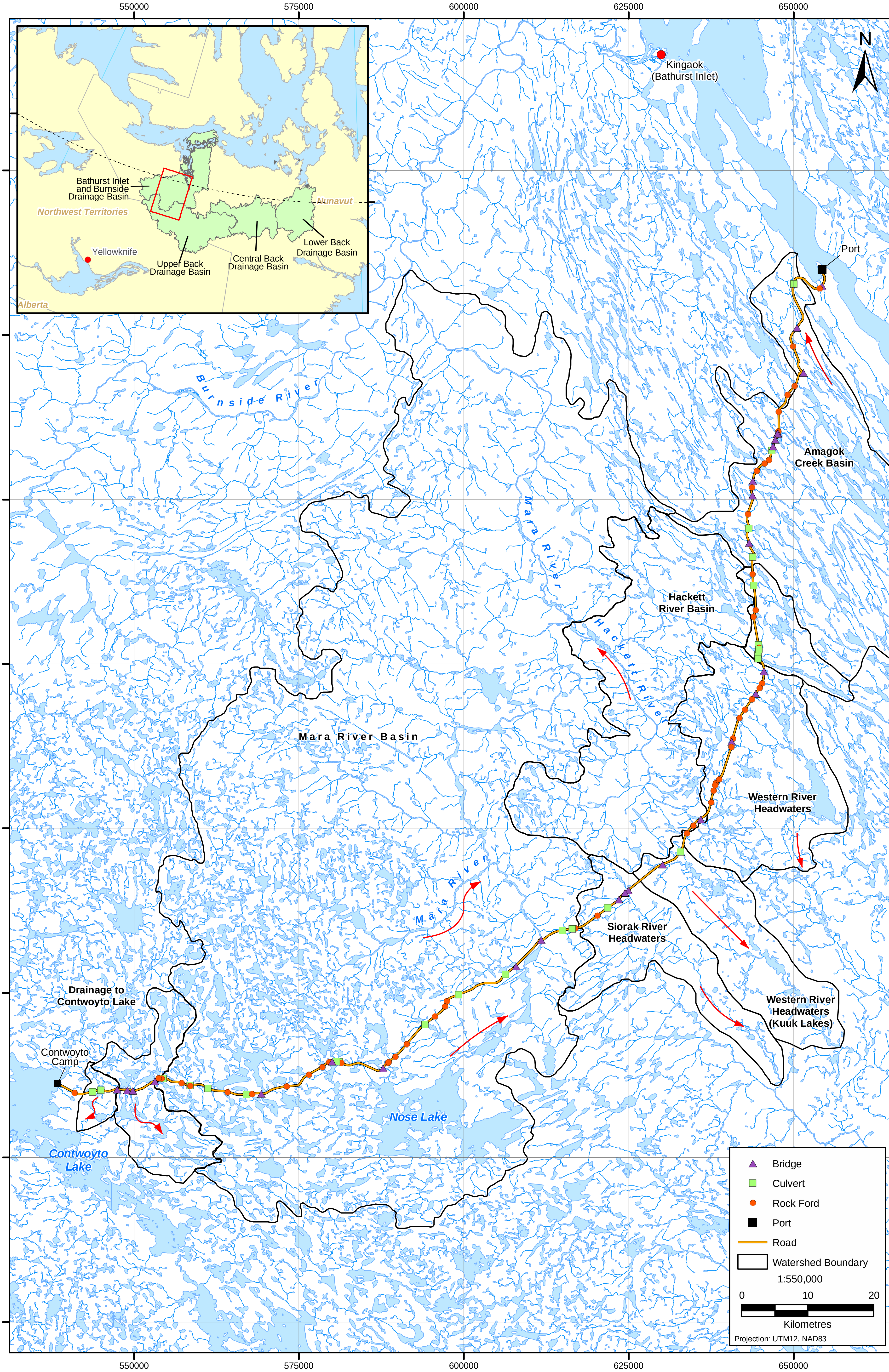

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FIGURE 16.1-1

Large Watersheds of the Bathurst Inlet Road

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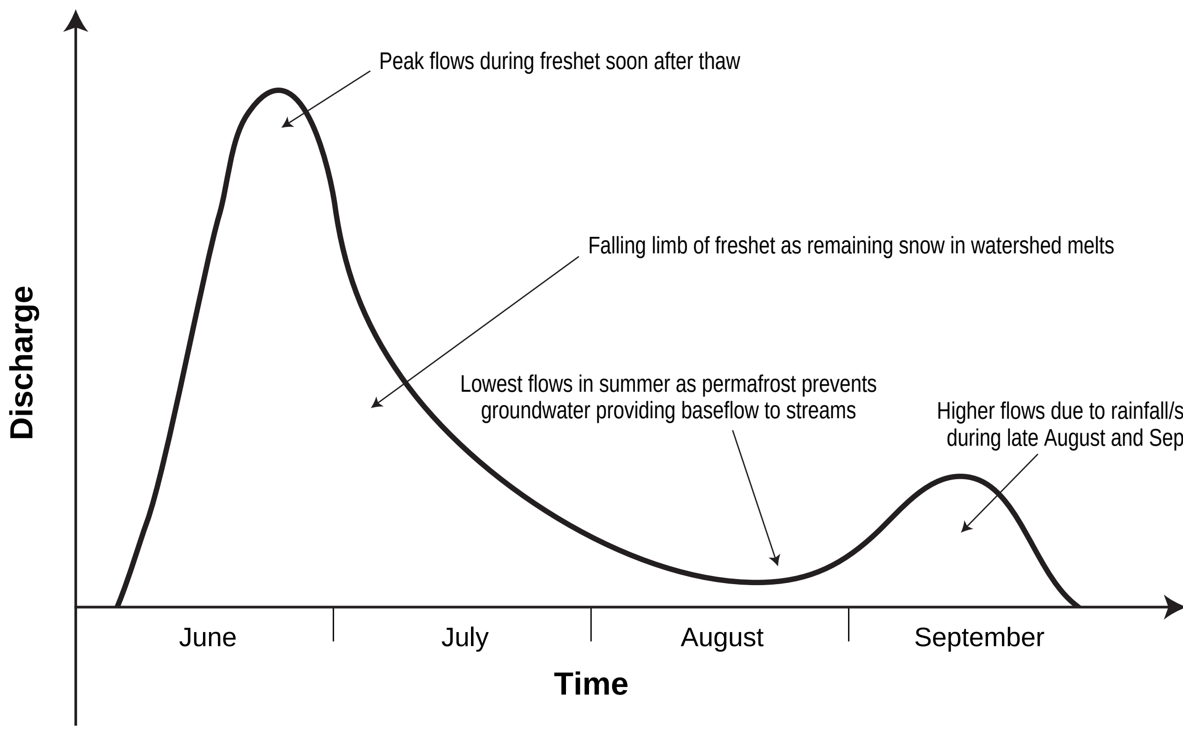

Note: Approximate scale only

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Theoretical Typical Annual Flow Hydrograph for a Small Northern Watershed

FIGURE 2.3-1

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They can also have more dramatic responses to precipitation. In larger watersheds, the overall regional hydrology of lakes creates significant attenuation of water and diminishes the magnitude of flows. The attenuation of water in lakes also creates reduced risks of flooding in the area because water is stored in lakes and released downstream more slowly

The overall shape of the annual flow hydrograph for northern watersheds is relatively easy to predict. Rivers draining larger basins will break up earlier, but will not reach peak flows quickly, while smaller streams will break up and reach peak shortly afterwards. However, predicting the volume of freshet or the size of the peak flow during freshet is much more difficult. This is due to a number of factors that influence freshet runoff, including:

- **Amount of snowpack available to be melted in spring:** Snowpack is dependent on the amount of snowfall during the previous winter and the amount of snow remaining in each watershed in May / June. Snow can be lost or redistributed due to ablation, melting, or wind.
- **Rate of temperature rise in spring:** This can greatly affect peak flow rates as a rapid increase in temperature after the snowpack has saturated can produce high melt rates.
- **Timing of opening of stream channels linking lakes:** In the Project area, snowmelt from hillslopes surrounding lakes can occur before the stream channel draining the lake becomes ice free. In this case, meltwater can be stored in the lake and then released once the channel is open to flow.
- **Soil moisture conditions and lake levels at the end of the previous summer:** If there was dry summer during the previous year, lake levels could have been lowered and a soil moisture deficit could have developed within the hillslopes surrounding the lakes. As a result, a portion of the annual runoff will recharge the lakes and soil moisture and not be transmitted from the watershed as stream flow.

The amount of runoff during summer and fall is controlled by the relative impact of rainfall and evaporation. Evaporation rates in summer often exceed total rainfall such that soil moisture deficits build up in the shallow active layer of the soil. Studies of hillslope processes in northern watersheds (Quinton and Marsh, 1998) have shown that summer rainfall may produce little or no runoff from hillslopes in the permafrost zone. It is likely that stream flow increases only when there is high intensity rainfall, or rain falling directly onto lake surfaces.

2.4 Available Hydrological Data

There has been much research into the hydrology of permafrost regions in recent decades (Woo *et al.*, 2000). However, our understanding of runoff generating processes in northern permafrost-affected watersheds still lags far behind our knowledge of processes in southern permafrost-free watersheds. Much of this uncertainty is due to a lack of hydrological datasets, especially for small watersheds (GN DOE and DIAND, 1983; Wedel, 1990). Analysis of all available Water Survey of Canada (WSC) data for the Northwest Territories and Nunavut illustrated that there are very few hydrological monitoring stations in the Canadian Shield on small watersheds (<500 km^2). Only three WSC stations are near the road, and none of these have upstream watershed areas of less than 1,500 km^2. The majority of the other hydrology stations in Nunavut or the Northwest Territories lie either in the Mackenzie Valley, where runoff is influenced by mountainous terrain, or close to Great Slave Lake, well south of the road area. Due to the size of the watersheds in the area of the road, two additional watersheds with areas of less than 1,000 km^2 were chosen for purposes of comparison; one from the Baker Lake area and another from Great Bear Lake. The watersheds monitored by stations in these basins are more similar in size to basins near the road, and show a similar hydrological response.

The WSC formerly operated one hydrometric station on the Gordon River and two stations on the Burnside River. These rivers flow into Bathurst Inlet from the southeast and southwest, respectively (Table 2.4-1). Qinguq Creek, in the Baker Lake area of Nunavut, drains into Hudson Bay and is approximately 550 km southeast of Bathurst Inlet, while Atitok Creek is 450 km west of Bathurst Inlet and drains into the Arctic Ocean (Figure 2.4-1).

Table 2.4-1
WSC Hydrometric Stations in the Road Area

River Name	I.D.	Latitude	Longitude	Period of Record	Drainage Area (km^2)	Annual Runoff (mm)
Gordon at Mouth	10QC002	66˚ 48' 36"	107˚ 06' 04"	1977-1994	1,530	219
Burnside at Mouth	10QC001	66˚ 44' 00"	108˚ 48' 08"	1976-present	16,800	241
Burnside at Contwoyto Lake	10QC004	66˚ 00' 45"	111˚ 17' 34"	1993-present	n/a	n/a
Atitok Creek near Dismal Lakes	10PC002	67˚ 12' 52"	116˚ 36' 32"	1980-1990	217	201
Qinguq Creek near Baker Lake	06MA002	64˚ 15' 42"	96˚ 18' 53"	1976-1994	432	224

n/a = not available.
Bathurst Inlet Normal Annual Precipitation 279.2 mm.
Lupin Airport Normal Annual Precipitation 299.2 mm.
Baker Lake Environment Canada Climate Station Annual Precipitation 270.4 mm.

These stations are further away from the road, but have watershed areas more representative of the watersheds along the road. The "at mouth" monitoring stations at both the Gordon and Burnside rivers are more than 100 km north of a large proportion of the road. The Burnside River monitoring station at Contwoyto Lake is more representative of the southern reaches of the road in regards to latitude but is also farther west than the road. The drainage for this basin is complicated since Contwoyto Lake serves as the headwater for both the Burnside and Back River drainages and therefore the drainage basin size of this station has not been defined. A major shortcoming of the available data is the size of the respective drainages. On average, the gauged catchments are at least two orders of magnitude greater than the streams that are crossed by the road.

2.5 Estimation of Key Hydrologic Parameters

2.5.1 Average Annual Runoff

Runoff is a measure of the hydrological response of a watershed. It is a parameter that is normalized by watershed area, so that watersheds of different sizes can be compared directly. Another attractive feature of runoff as a hydrological parameter, is that it is presented as a water depth in millimeters (mm) over an entire watershed, allowing direct comparison with precipitation totals. Runoff is calculated by dividing the total flow volume (m^3) observed at a monitoring station with the basin area (m^2) draining into the site.

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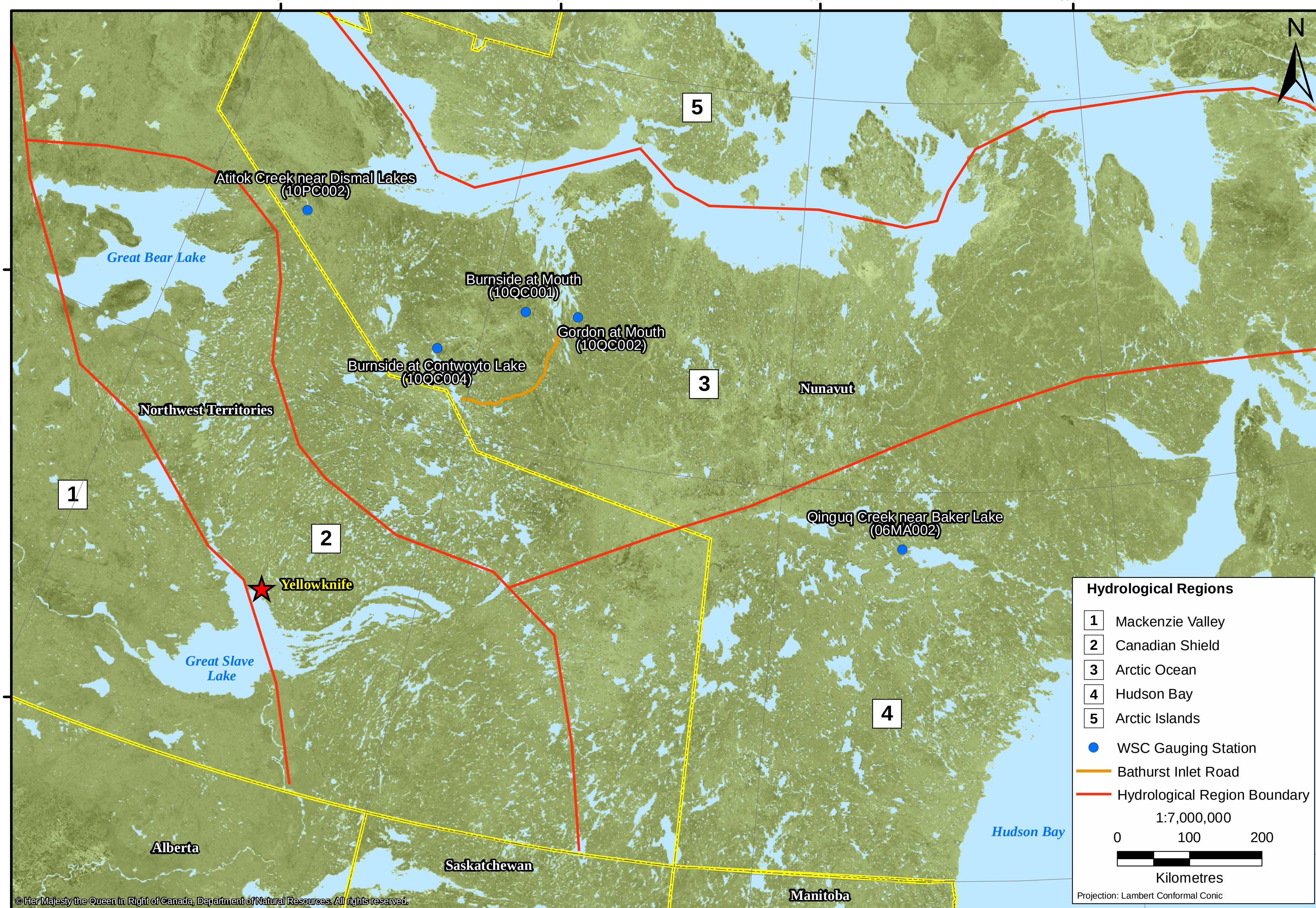

FIGURE 2.4-1

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Large WSC Gauging Station in the Bathurst Inlet Road and Port Area

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Average annual runoff from the Gordon and Burnside River basins for the period of record was 219 and 241 mm, respectively. This suggests that, on average, 73 to 86% of the annual precipitation measured at Bathurst Inlet (279.2 mm) and Lupin Airport (299.2 mm) will produce runoff. Annual average runoff was 224 mm at Qinguq. Precipitation normals at the Baker Lake climate station, operated by Environment Canada, was 270.4 mm. This suggests that runoff from the Qinguq basin is in the same range as the Burnside and Gordon rivers. Kane and Yang (2004) presented a range of runoff coefficients from 0.35 to 0.85 for basins in similar latitudes. Therefore, the runoff coefficient derived for this area appears to be in the high range and presents a conservative estimate for runoff calculations from precipitation. Annual runoff increases from the south to the north and appears to reflect the regional distribution of permafrost. Lower basin yields are observed in the zone of discontinuous permafrost, and higher yields are observed in the continuous permafrost zone (HBT AGRA Limited, 1993). Since runoff is normalized by watershed area, results from these larger watersheds can be reasonably extrapolated to the smaller basins. The annual runoff from the smaller watersheds in the study area is estimated to be between 200 to 250 mm.

2.5.2 Monthly Flow Distribution

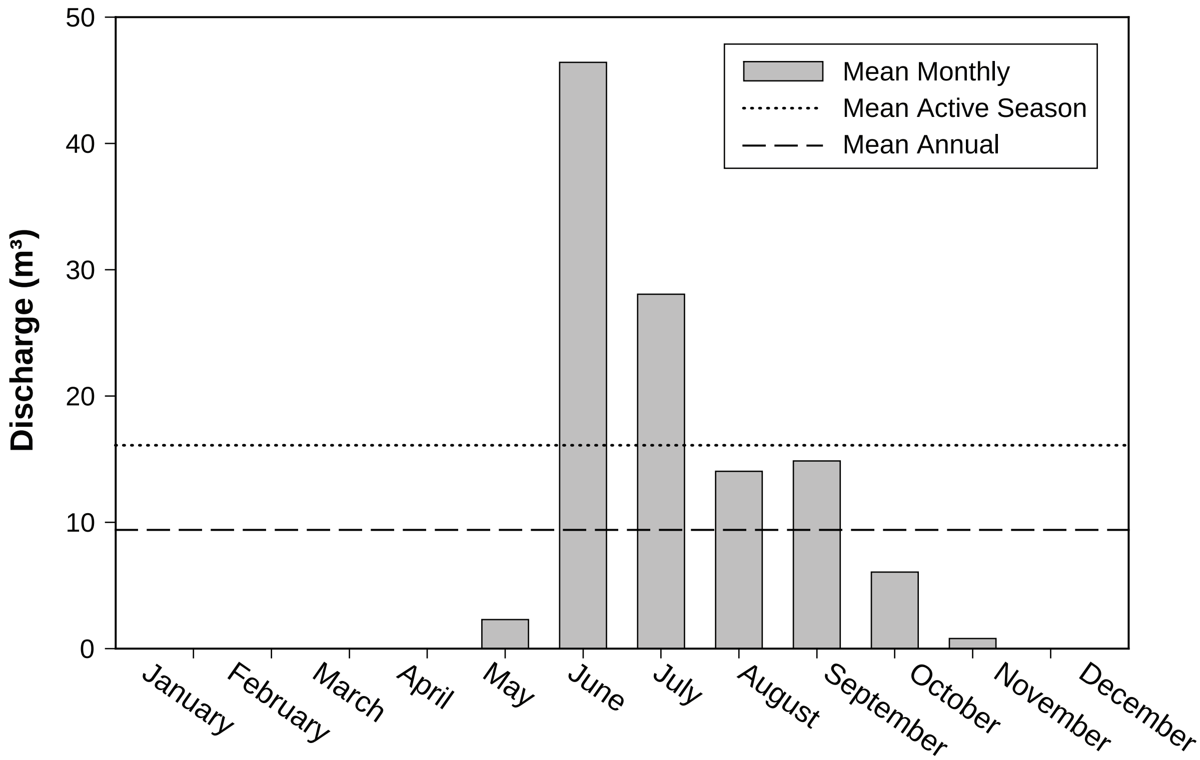
Based on 16 years of data for the Gordon River, maximum discharge occurs in June, with flows decreasing through the summer months into fall and winter (Figure 2.5-1). September shows a slight increase in flow due to increased precipitation in late August and September. Mean annual flows are deceptively low, with a five-month period of no discharge from December to April; therefore, the active season discharge was calculated which excludes these months.

2.5.3 Flood Flows

Floods in the Arctic are typically produced by rapid snowmelt during freshet conditions in late May or early June. Flood frequency analysis is used to predict the magnitude of flood flows for different return periods. The return period refers to the probability of occurrence of the flood event. A 1-in-100 year return period (Q_{100}) event is the magnitude of flow that has a 1% chance of being met or exceeded in a given year; similarly, a Q_{50} has a 2% chance of being exceeded in a year. The average annual flood is generally defined as the Q_2.

Based on data from regional analyses of Arctic watersheds, a generalized graph of peak flows has been created to show approximate estimates of peak flows based on watershed size that may be expected along the road.

Flood frequency analyses were conducted using five Arctic streams to produce a regional analysis of watersheds ranging in size from 1 to 500 km^2. Figure 2.5-2 illustrates the relationship between watershed area and discharge for four flood frequency return periods. This figure can be used to illustrate approximate flood flows that could be expected for watersheds of a known size. This regional analysis was created for general information on the watersheds and should not be used for design purposes.



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PORT AND ROAD PROJECT

Mean Monthly Discharge for Gordon River Showing Mean Annual and Mean Active Season Discharges

FIGURE 2.5-1

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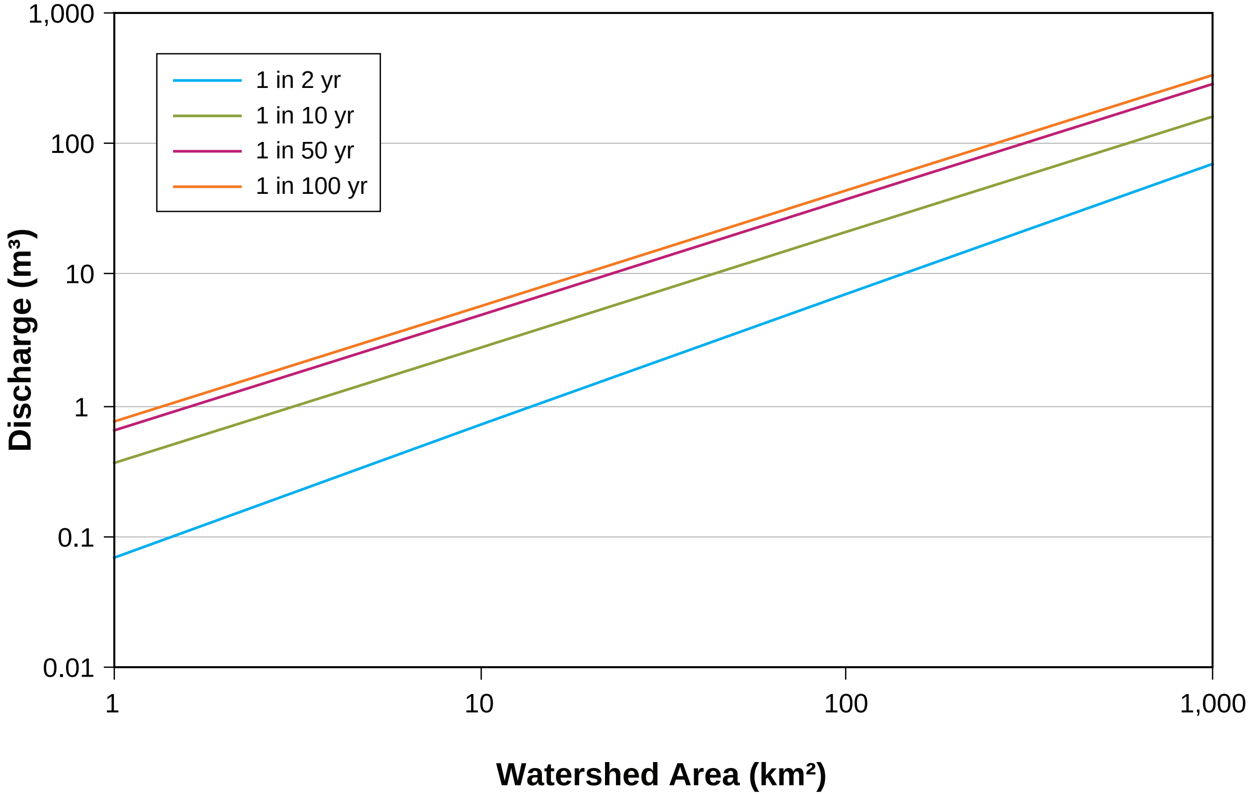

Note: Not for design purposes.

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Regional Flood Frequency Analysis for Low Arctic Tundra Watersheds

FIGURE 2.5-2

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3. METHODOLOGY

3. Methodology

This assessment is designed to predict the effects of the Bathurst Inlet Road on the surface water quantity and fluvial erosion before the road is constructed. It follows a detailed methodology outlined in Appendix A-5 of the DEIS.

3.1 Valued Ecosystem Component Selection

Surface water quantity is considered a VEC because streams in the Project area provide habitat for important fish populations. Maintenance of sufficient water quantity is important for the continued ecosystem health of aquatic species. Analysis of surface water quantity will consider potential impacts to the total available water volume and the timing and magnitude of flow events.

Fluvial erosion and sediment transport is considered a VEC because streams in the Project area are habitat for important fish populations. While sediment transport is a natural process, road infrastructures in or near streams may change the hydraulic characteristics of the channel and induce either erosion or deposition of sediments. Erosion and deposition may have the potential to degrade aquatic habitat as well as compromise road infrastructure. Analysis of potential areas for fluvial erosion will consider potential impacts of infrastructure on fluvial environments.

3.2 Boundaries

Boundaries are defined to give both a spatial and temporal extent of the impacts that are potentially expected from the Project.

3.2.1 Spatial Boundaries

The main Project infrastructure will be the port and related facilities at Bathurst Inlet and the road to Contwoyto Lake. The road will cross streams in the Burnside and Western river basins as well as smaller basins draining directly into Bathurst Inlet and Contwoyto Lake. Based on consideration of the locations of the Project components, the largest watersheds draining the lands around the port facilities and crossing the road have been identified for assessing surface water quantity and sediment transport impacts. Therefore, all watersheds crossed by the road and streams downstream of the road make up the spatial boundary for this environmental effects assessment.

3.2.2 Temporal Boundaries

Temporal boundaries are established by the time period of the three respective phases of the road. Construction and closure phases of the road are expected to last for 2.5 and 1 years, respectively and the operational life of the road will last a period of 19 years and decommissioning for approximately a year, for a temporal boundary of 22.5 years for the Project.

3.3 Approach and Methods

This assessment for surface water quantity and fluvial erosion is structured to address the three types of stream crossings and their likely effects on the stream and river environments. Each crossing type will be addressed as to the proposed construction method during the likely range of flow conditions expected.

The data collected for this effects assessment is not extensive for the purposes of surface water quantity or fluvial erosion assessment. No hydrometric stations were installed at any road crossing locations to monitor flows. Manual flow measurements were conducted at one time during the 2001 and 2002 summer season, which does not allow an extrapolation of data for seasonal or annual patterns to individual crossings. Data from WSC hydrometric stations is very limited in the area and virtually none is available for small basins. The tundra has the advantage of predictable annual patterns of hydrology. Freshet is generally the largest flood event each year, and the remainder of the season exhibits low flow which tends to zero in the long winter months. These predictable patterns allows for adequate confidence in the assessment of effects on surface water quantity and fluvial erosion.

4. EFFECTS ASSESSMENT

4. Effects Assessment

4.1 Identification and Description of Potential Project Effects

In this section, potential impacts from the Project on surface water quantity and sediment transport are identified based on consideration of activities associated with the major Project components (port facilities and all-weather road) and the Project phases (construction to post-closure). Potential effects on surface water quantity associated with each of the Project components and phases are outlined in Table 4.1-1. Potential effects on sediment transport associated with each of the Project components and phases are outlined in Table 4.1-2.

Table 4.1-1
Identification of Potential Effects to Surface Water Quantity

Project Component	Project Activity and/or Sub-Component(s) Causing Effect	Potential Effect	Description of Potential Effect
Construction			
Road	construction of cross drainage and stream crossings	Change in surface water quantity	Flow may temporarily be changed during installation of stream crossings during open water season. The compact road surface and reduced vegetation cover may increase runoff.
Operation and Maintenance			
Road	Use of road	Change in surface water quantity	Decreased vegetation cover, and the compact road surface may increase runoff. Stream crossings may cause ice and snow to obstruct stream flow.
Closure			
Road	Standard decommissioning: grading and restoring natural drainage at crossings.	Change in surface water quantity	Decommissioning the road would restore natural drainage patterns to baseline conditions.

Table 4.1-2
Identification of Potential Effects to Fluvial Geomorphology

Project Component	Project Activity and/or Sub-Component(s) Causing Effect	Potential Effect	Description of Potential Effect
Construction			
Road	Construction of stream crossings	Change in sediment load and erosion	Sediment load may be increased during installation of stream crossings. Specific concerns for larger stream crossings where construction may take place during the open water season.
Operation and Maintenance			
Road	Use of road	Change in sediment load and erosion	Stream crossing infrastructure may change flow velocities and potentially increase erosion and sediment transport rates in these areas.
Closure			
Road	Standard decommissioning: grading, restoring natural drainage at crossings.	Change in sediment load and erosion	Decommissioning the road would restore natural fluvial patterns to baseline conditions.

4.1.1 Port Facilities

The port facilities are on a peninsula in Bathurst Inlet with little loose soil or fine-grained material and large sections of exposed bedrock. Since there are no streams near any port structures, no effects on surface hydrology, sediment transport, or sediment erosion in the area of the port are anticipated. A diversion of water from upslope areas of the infrastructure is expected; however, the quantity of surface runoff is not expected to change. Therefore, the port facilities are not discussed any further in this assessment.

4.1.2 Road

The road will extend 211 km from the port facilities at Bathurst Inlet to Contwoyto Lake. The road traverses south from Bathurst Inlet for approximately 90 km, and then gradually swings westward toward Contwoyto Lake. Road construction will be conducted for approximately two and a half years, and will require excavation of quarries for fill material to be used on the road surface. The road alignment crosses 104 ephemeral and perennial watercourses which will need to be constructed in dry conditions. Watercourse crossings include the installation of 19 bridges, 38 bottomless arch culverts, and 47 fords for small and ephemeral streams. Table 4.1-3 outlines the location of crossings along the alignment with the proposed crossing type and general watercourse characteristics.

Water Quantity

Flow in the streams may be temporarily affected during construction if the crossing construction occurs during open water period. The road is unlikely to affect flows. Runoff from the road surface will simply drain into the tundra and will not report to streams directly through drainage ditches.

Fluvial Geomorphology

Sediment transport may be temporarily affected during construction and decommissioning of the stream crossings if it occurs during the open water period. During road operations and maintenance, no substantial effects to sediment transport and erosion in the stream environments are expected, given that design criteria, fluvial erosion control measures, and sediment management plans are followed.

Description of the Nature and Extent of Potential Effects

In this section, the nature and extent of potential effects are assessed for each of the Project components and phases. The definitions used to assess the nature and extent of the potential surface water quantity effects are provided in Table 4.1-4.

4.1.3 Construction

Water Quantity

Impacts to surface water quantity due to construction of the road will be limited to the areas near stream crossings. Construction will be required to be conducted in dry conditions within the stream. The majority of work will be conducted when no effects are expected on water quantity. A total of 104 water course crossings have been identified along the road.

Table 4.1-3
Stream Crossing Structure Type, Location, and Stream Characteristics

Road Distance km	Latitude	Longitude	Slope %	Bankfull Depth (m)	Bankfull Width (m)	Watershed Area (km2)	Proposed Crossing
2.2	66° 31' 22.74"	107° 31' 35.93"	0.5	0.8	6.2	66.4	Bridge
2.8	66° 31' 11.39"	107° 32' 10.01"	0.5	0.4	3.8	1.1	Ford
7.8	66° 31' 41.34"	107° 37' 23.01"	0.5	0.6	1.7	6.8	Culvert
14.1	66° 28' 5.56"	107° 37' 14.87"	0.4	1.0	9.3	75.3	Culvert
18.3	66° 26' 34.24"	107° 38' 14.94"	N/A	N/A	N/A	1.7	Ford
22.9	66° 24' 21.87"	107° 36' 23.73"	1.0	0.8	46.7	1143.1	Bridge
25.7			N/A	N/A	N/A	0.7	Ford
27.4			N/A	N/A	N/A	0.5	Ford
30.4			N/A	N/A	N/A	3.4	Ford
33.4			N/A	N/A	N/A	0.3	Ford
33.7	66° 19' 34.08"	107° 42' 19.03"	0.8	0.5	36.5	N/A	Bridge
33.8	66° 19' 29.79"	107° 42' 24.11"	0.5	0.5	9.9	42.7	Bridge
34.8	66° 19' 1.31"	107° 42' 51.90"	1.2	0.3	14.1	60.5	Bridge
35.9	66° 18' 29.58"	107° 43' 24.83"	0.5	0.3	34.0	43.0	Bridge
36.6	66° 18' 9.18"	107° 43' 40.47"	0.6	0.6	18.0	2.7	Bridge
38.1			N/A	N/A	N/A	0.2	Ford
39.0	66° 17' 6.94"	107° 45' 17.13"	N/A	N/A	N/A	0.4	Culvert
40.6			N/A	N/A	N/A	2.6	Ford
42.3	66° 15' 43.68"	107° 47' 50.23"	0.7	0.3	6.2	9.5	Culvert
43.3	66° 15' 12.62"	107° 48' 6.56"	0.1	0.4	13.0	6.1	Ford
44.5	66° 14' 34.37"	107° 48' 5.24"	0.4	0.4	28.8	2.0	Culvert
47.5			N/A	N/A	N/A	2.5	Ford
49.7	66° 11' 53.35"	107° 49' 8.14"	0.9	0.4	2.3	9.9	Culvert
52.0	66° 10' 42.28"	107° 49' 15.83"	0.5	0.3	50.0	46.3	Bridge
54.3			N/A	N/A	N/A	3.6	Ford
56.9			N/A	N/A	N/A	0.7	Ford
58.7	66° 7' 12.19"	107° 48' 43.06"	0.8	0.3	6.7	5.2	Culvert
62.3			N/A	N/A	N/A	0.5	Ford
63.5			N/A	N/A	N/A	0.2	Ford
66.5	66° 2' 19.20"	107° 48' 24.41"	0.9	0.4	2.2	0.5	Ford
67.9							Culvert
68.3	66° 2' 5.65"	107° 48' 20.21"	0.8	0.4	4.0	N/A	Culvert
68.6	66° 1' 57.10"	107° 48' 22.55"	0.7	0.6	4.8	6.2	Culvert
69.4	66° 1' 34.53"	107° 48' 34.05"	0.5	0.4	0.7	N/A	Culvert
70.1	66° 1' 12.53"	107° 48' 37.41"	4.8	0.3	2.7	2.3	Culvert
72.2	66° 0' 10.94"	107° 47' 36.73"	0.7	2.0	10.8	39.8	Culvert
74.1	65° 59' 11.64"	107° 48' 4.34"	N/A	N/A	N/A	3.9	Ford
74.9	65° 58' 49.35"	107° 48' 39.06"	N/A	N/A	N/A	1.6	Ford
76.0	65° 58' 21.86"	107° 49' 29.08"	0.5	0.5	2.7	16.0	Culvert
77.0	65° 57' 55.93"	107° 50' 16.25"	0.8	0.4	1.2	6.3	Ford
78.9			N/A	N/A	N/A	0.5	Ford
80.4			N/A	N/A	N/A	2.4	Ford
83.7			N/A	N/A	N/A	1.6	Ford
84.2	65° 54' 33.05"	107° 54' 42.92"	0.7	0.6	6.1	81.0	Culvert
85.0	65° 54' 6.39"	107° 54' 52.93"	1.7	0.4	2.3	5.0	Ford
90.3	65° 51' 31.66"	107° 57' 35.65"	1.9	0.3	4.0	2.6	Ford
91.1			N/A	N/A	N/A	0.5	Ford
91.4	65° 51' 4.54"	107° 58' 28.16"	N/A	N/A	N/A	1.0	Ford
92.3	65° 50' 37.61"	107° 58' 48.37"	N/A	N/A	N/A	2.2	Ford
94.1	65° 49' 40.88"	107° 59' 26.74"	N/A	N/A	N/A	4.2	Ford

Note: N/A indicated not available data.

(continued)

Table 4.1-3
Stream Crossing Structure Type, Location, and Stream Characteristics (completed)

Road Distance km	Latitude	Longitude	Slope %	Bankfull Depth (m)	Bankfull Width (m)	Watershed Area (km2)	Proposed Crossing
97.2	65° 48' 20.74"	108° 1' 41.35"	0.5	0.7	79.8	4.4	Bridge
98.8			N/A	N/A	N/A	0.4	Ford
100.3			N/A	N/A	N/A	1.2	Ford
103.3	65° 45' 44.44"	108° 5' 57.87"	3.0	0.5	50.0	3.9	Bridge
103.3a	65° 45' 43.49"	108° 5' 59.66"	1.3	0.6	1.7	2.6	Culvert
106.7	65° 44' 46.12"	108° 9' 36.99"	1.0	0.7	44.0	13.4	Bridge
113.2	65° 42' 48.26"	108° 16' 35.91"	0.3	0.7	2.2	23.8	Culvert
113.8	65° 42' 35.89"	108° 17' 16.73"	2.2	0.8	1.1	1.4	Culvert
115.2	65° 42' 5.47"	108° 18' 35.34"	1.2	0.4	3.2	18.1	Culvert
117.4	65° 41' 25.35"	108° 20' 50.01"	N/A	N/A	N/A	5.0	Culvert
119.4			N/A	N/A	N/A	1.3	Ford
123.3			N/A	N/A	N/A	0.8	Ford
123.8	65° 39' 50.00"	108° 28' 5.04"	N/A	N/A	N/A	1.2	Culvert
125.3			N/A	N/A	N/A	23.8	Ford
128.8	65° 39' 2.07"	108° 34' 15.07"	1.1	0.9	125.8	1825.6	Bridge
134.6	65° 36' 57.57"	108° 39' 27.52"	6.8	0.3	57.6	71.0	Bridge
136.6			N/A	N/A	N/A	0.7	Ford
144.6			N/A	N/A	N/A	1.9	Ford
146.6			N/A	N/A	N/A	2.3	Ford
147.5			N/A	N/A	N/A	1.0	Ford
149.7			N/A	N/A	N/A	2.7	Ford
151.6			N/A	N/A	N/A	28.8	Ford
155.7			N/A	N/A	N/A	0.6	Ford
158.2	65° 29' 54.52"	109° 3' 48.32"	N/A	N/A	N/A	0.3	Ford
159.5	65° 29' 28.78"	109° 5' 10.33"	0.5	0.3	0.7	0.7	Culvert
159.7			N/A	N/A	N/A	0.8	Ford
160.7	65° 28' 59.72"	109° 6' 16.64"	0.7	0.4	2.1	15.8	Culvert
167.6	65° 29' 31.52"	109° 14' 29.86"	N/A	N/A	N/A	N/A	Ford
168.0	65° 29' 36.48"	109° 14' 53.86"	5.0	0.3	2.0	4.2	Culvert
168.3	65° 29' 38.24"	109° 15' 25.12"	N/A	N/A	N/A	N/A	Culvert
169.1	65° 29' 38.99"	109° 16' 16.95"	N/A	N/A	N/A	66.9	Bridge
169.4			N/A	N/A	N/A	0.1	Ford
169.6	65° 29' 36.35"	109° 16' 54.53"	1.3	0.3	1.0	0.7	Culvert
170.8	65° 29' 13.82"	109° 18' 13.73"	0.5	0.5	38.4	13.5	Culvert
173.1	65° 28' 37.71"	109° 20' 53.91"	0.6	0.4	4.0	9.8	Culvert
177.2			N/A	N/A	N/A	8.7	Ford
181.4	65° 27' 10.17"	109° 30' 22.25"	1.9	0.6	47.4	352.5	Bridge
182.8	65° 27' 10.13"	109° 32' 9.67"	N/A	N/A	N/A	N/A	Ford
183.6	65° 27' 8.16"	109° 33' 14.69"	0.7	0.2	3.1	4.1	Culvert
186.5	65° 27' 21.95"	109° 36' 54.73"	3.0	0.1	0.2	0.6	Culvert
189.6	65° 27' 43.50"	109° 40' 47.29"	0.8	0.4	1.8	4.4	Culvert
192.4	65° 27' 57.69"	109° 44' 13.48"	0.9	0.4	4.6	11.3	Culvert
192.4a	65° 27' 57.57"	109° 44' 16.58"	1.0	0.3	1.9	N/A	Culvert
193.8			N/A	N/A	N/A	0.8	Ford
196.7	65° 28' 35.03"	109° 49' 30.25"	0.6	0.3	1.3	1.8	Culvert
197.0	65° 28' 35.90"	109° 49' 50.78"	1.0	0.2	1.1	0.3	Culvert
197.4	65° 28' 37.36"	109° 50' 27.43"	0.5	0.2	1.9	N/A	Culvert
198.2			N/A	N/A	N/A	0.3	Bridge
201.9	65° 27' 38.33"	109° 55' 33.73"	0.7	0.8	60.2	65.6	Bridge
202.8	65° 27' 41.57"	109° 56' 36.86"	3.0	0.5	26.6	34.4	Bridge
204.3	65° 27' 45.18"	109° 58' 36.55"	0.5	0.8	14.4	1.0	Bridge
206.9	65° 27' 43.12"	110° 1' 48.72"	0.5	0.5	8.7	12.4	Culvert
208.2	65° 27' 35.22"	110° 3' 27.82"	0.5	0.2	1.7	1.5	Culvert
211.0			N/A	N/A	N/A	2.1	Ford

Note: N/A indicated not available data.

Table 4.1-4
Ratings Used to Assess Potential Effects on Surface Water Quantity and Fluvial Geomorphology

Effect	Description
Major	A major shift away from the baseline conditions, or a fundamental change to surface water quantity and or sediment transport and erosion, either by a relatively high amount for a long period, or such that watershed hydrology or geomorphology is greatly changed from the baseline conditions.
Medium	A significant shift from the baseline conditions that may be long-term or a high amount for a temporary period, resulting in a change in the hydrologic and or fluvial geomorphic conditions of the watershed.
Low	Minor shift away from the baseline conditions. Changes in water quantity are likely to be relatively small, or be of a minor temporary nature such that watershed hydrology and or fluvial geomorphology is slightly affected.
Negligible	A slight change from the baseline conditions, with no discernible effect upon the watershed hydrology or fluvial geomorphology results.

Depending on the crossing structure different methods can be used to keep the work area dry during construction. Smaller streams which will receive arch culverts or fords can have temporary dams constructed and water pumped downstream or water be diverted around the construction area. The largest bridge which will need 2 piers will require that precast bridge footings be installed during low flow periods and be protected by berms. Any diverted water will be re-introduced to the stream further downstream, so the total water volume will not be impacted. Generally no stream crossing construction will be conducted during the freshet period due to high water levels. Any impacts to surface water quantity during construction will be local and short-term, and are considered negligible.

Fluvial Geomorphology

Improper water management and routing can lead to concentration of flows, ponding, increased erosion, sediment delivery to streams, and the potential for road and infrastructure instability. Impacts on sediment transport during the road construction will vary at each individual stream crossing. Construction is planned for the winter months, reducing a large proportion of activity that may cause increased sediment loads. Only construction conducted during the open water season will have effects on sediment load of the streams.

Fords and small stream crossing construction will be conducted during the winter months, when there is no flow, to limit the amount of sediment entrainment during the construction period. This will result in negligible effects.

Some construction of the bridges and arch culverts will take place during the open water period. The placement of riprap to stabilize stream banks may cause disturbance of the banks and increases in sediment load. However, these effects are short in duration and local in extent and considered as negligible residual effects.

Bridge construction will be conduced using prefabricated components that are assembled in the field outside the wetted perimeter of the channel. Girders will be hoisted in place or launched as to not disturb the stream channel. Two centre piers are proposed for the bridge crossing the Mara River, which will involve work in the river during the open water season including the construction of berms to protect the piers. Best construction practices will help minimize the amount of sediment transport and erosion that is caused during construction operations. These effects are expected to be short in duration and low magnitude and lead to negligible residual effects on the stream environment.

4.1.4 Operation and Maintenance

Water Quantity

Potential impacts to the hydrological response of a watershed associated with roads include:

- increased runoff depths, due to decreased vegetated cover, and the compact road surface; and
- obstructed flow paths at stream crossings, especially during high flow events.

The change in land cover from vegetated to road surface may increase annual runoff depths. The baseline annual runoff coefficient for the Project area is approximately 0.75 to 0.85. The new road surface could increase the runoff coefficient to approximately 0.90; this represents an increase in runoff of approximately 5 to 15%. However, the total area of the road corridor (~170 ha) represents less than 1% of the watershed area in each of the ten main watersheds intersecting the road. The road will not have ditches, which convey water quickly to stream networks. Therefore, water may report to the tundra more rapidly from the road surface, however, this is not expected to result in any significant increases of total runoff depth or peak flows during storm events.

One hundred and four stream crossings have been identified along the road from Bathurst Inlet to Contwoyto Lake. Bridges, arch culverts, and fords will be designed and installed at these crossings following engineering guidelines. The bridges, fords, and culverts will all be designed to pass the 1-in-25 year (Q_{25}) storm flow with additional 300 mm of freeboard. Riprap will be appropriately sized and used where necessary to prevent erosion and to protect the crossing structures.

Under most flow conditions, the culverts and bridges will be able to convey discharge with no impact on natural stream flows. The risk of at least one event being larger than the design flood in the 20-year operational life of the road is 50% (Chow *et al.*, 1998). However, there is additional 300 mm of freeboard in the design of the bridges that reduces this value.

If design flows are exceeded, culvert or bridge structures may partially obstruct flows, which could result in elevated upstream water levels (backwatering), local flooding, and overtopping of the structure. This may delay the timing of the peak flow; however, the total flow volume would not be impacted. The rip-rap at the inlet of culverts and bridges will protect against structure failure of crossing structures during peak flows.

Fluvial Geomorphology

Effects on fluvial geomorphology are largely related to flow velocity and pathways as well as bed and bank morphology and composition. The road will cross 104 streams and rivers along which bridges, arch culverts, and fords will be built to allow flow to cross the road, depending on stream size. These structures may cause changes in flow patterns and potentially increased flow velocities due to confinement and constriction.

Regardless of the type of structure used, armouring the stream bank is required. Fords will be designed to resist erosion, while bridges and arch culverts will need riprap to protect the anchors and abutments from being eroded. Armouring the streambed may also be required in situations where bed substrate is of small particle sizes and flow velocities are affected by infrastructure that is placed in the stream. The Mara River crossing is of consideration since piers will increase velocity and turbulence and may cause erosion of the bed material.

Any change or confinement in flow has the potential to increase flow velocities and increase the potential for erosion and sediment transport given the bed and bank composition. This is of specific concern for the Mara River Bridge where 2 centre piers in the river are proposed for the crossing construction, which will constrict flow and increase velocities, potentially increasing scour. However, using appropriate riprap will ensure that effects on sediment transport will remain unchanged and have negligible effect on the stability of the structure and sediment loads of the stream.

4.1.5 Closure

Water Quantity

The closure plan requires deactivation of the road and removal of stream crossing structures along the road corridor. Work associated with closure will return drainage patterns to baseline conditions. Impacts to surface water quantity are expected to be no more than effects expected during construction (Section 4.1.3).

Fluvial Geomorphology

Decommissioning the road and removing bridges and culverts will have short-term effects on the sediment transport of the streams along the road corridor. Work to decommission the road and stream crossings will be conducted during low flow periods, when erosion and sediment load can be minimized. If any effects result from this activity, they are expected to be short in duration and low in magnitude.

4.2 Summary

Table 4.2-1 summarizes the effects assessment for surface water quantity.

Table 4.2-1
Summary of Effects Assessment for Surface Water Quantity

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
Description	Project Phase (Timing)	Project Component	Direction	Nature	(Design Changes, Management, Monitoring, Compensation, Enhancement)	Description of Residual Effect (after mitigation)	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context (Resilience)	Influence on Resource Capacity	Probability of Occurrence	**Significance**	Confidence Limit
Change in Surface Water Quantity	Construction	Road	Neutral	n/a	Best management practices will be followed when working in or around stream environments	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	n/a
	Operation and Maintenance	Road	Adverse	Direct	Monitoring program will ensure that cross drainages are clear of debris and sediment	Reduction in peak flow, attenuation on upstream side of road	Low	Local	Short-term	Regular	Short-term	Neutral	Nil	Low	**Negligible**	Intermediate
	Decommissioning	Road	Neutral	n/a	Best management practices will be followed when working in or around stream environments	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	n/a
	Post-closure	Road	Neutral	n/a	n/a	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	n/a
Change in Fluvial Geomorphology and Erosion	Construction	Road	Adverse	Direct	Best management practices will be followed when working in or around stream environments	Work in and around streams may contribute to fluvial erosion	Low	Local	Short-term	One Time	Short-term	Neutral	Nil	Moderate	**Negligible**	Intermediate
	Operation and Maintenance	Road	Neutral	n/a	n/a	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	n/a
	Decommissioning	Road	Adverse	Direct	Best management practices will be followed when working in or around stream environments	Work in and around streams may contribute to fluvial erosion	Low	Local	Short-term	One Time	Short-term	Neutral	Nil	Moderate	**Negligible**	Intermediate
	Post-closure	Road	Neutral	n/a	n/a	No	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**n/a**	n/a

5. MITIGATION AND MANAGEMENT PLANS

5. Mitigation and Management Plans

Environmental management and mitigation measures are a means of reducing the effects of the Project on the affected environment. Mitigation measures for hydrological parameters affected by the different Project activities and phases are described below. These management plans are offered as recommendations to serve as mitigation measures.

5.1 Road

The Bathurst Inlet Road alignment crosses 211 km of the continental tundra between Contwoyto Lake and Bathurst Inlet. The alignment was chosen to optimize stability, avoid water bodies and watercourses, proximity to available quarry locations, and best service potential mining project along its route. Along the road alignment 104 rivers, streams, and non classified drainages have been identified with additional bogs, and wetlands. Construction of the road is conducted by placing a thick layer of quarried rock over the tundra and constructing bridges, arch culverts, and fords for watercourse crossings. All fish bearing streams will receive either bottomless arch culverts or bridges as crossings. Construction of the road is scheduled to last 2.5 years and will continue year round for this period.

5.1.1 Construction

Water Quantity

Best management practices will be followed when working in and around stream environments to install water crossings. Construction during the winter months will help minimize impacts on both water quantity and sediment transport and erosion. An environmental monitor will be overseeing the construction of water crossings to determine appropriate methods to help minimize impacts during the open water season.

All fish bearing crossings that will be constructed during the open water season will need to be kept dry or require fish salvage prior to any instream work. This will require that water is diverted or pumped beyond the construction zone and reintroduced downstream or the area would be blocked off and fish removed. These procedures will be overseen by an environmental monitor to assess best methods to minimize impacts on the stream environment. While pumping or diverting flow will temporarily displace the natural flow path in the immediate vicinity of construction, no change in surface water quantity is expected downstream.

Fluvial Geomorphology

Environmental monitors will ensure that construction of stream crossings will use best management practices for both sediment transport and erosion control during the construction phase. Any increased sediment transport caused by construction during the open water season will be short in duration and have negligible effects (see Appendix D-2 of the DEIS for erosion management plan details).

5.1.2 Operation and Maintenance

Water Quantity

Crossings along the road will be designed to accommodate a Q_{25} flow event with additional free board clearance. This will inherently mitigate effects to flows at greater than Q_{25} magnitudes. However, over time sediment and/or debris (*e.g.*, snow and ice) may accumulate in or around the structure, decreasing the ability of the structure to pass the flow during the spring freshet. A regular monitoring program will be established to ensure crossing structures, as well as drainages are free to convey flow through the system. This will be especially important at the beginning of spring melt and the beginning of the fall.

Spring clearing of ice build up, which may develop in culverts over the winter, will be important in handling snowmelt runoff. The road will be part of the permafrost environment thus the ice in culverts may remain frozen during the freshet period and will not convey water as designed if completely filled with ice. The extents of ice build-up will be monitored and appropriate maintenance undertaken before the beginning of freshet in critical culverts to reduce water buildup on the upstream side of the road. Monitoring in the low flow period may also be necessary for the removal of sediment and other debris that may have accumulated in the culverts and above fords. Clearing sediment and debris in the low flow period is recommended and should be more efficient to do.

Fluvial Geomorphology

The monitoring program will help ensure that stream crossing structures are able to facilitate flows and also reduce the risk of erosion, sediment transport, and structure failure. Spring snow melt and early autumn storms are of the greatest concern for fluvial processes. Therefore, maintenance and clearing of stream crossing structures to facilitate these higher magnitude flows is essential to minimize impacts on the stream ecosystem and infrastructure (see Appendix D-2 of the DEIS for erosion management plan details).

5.1.3 Closure

Water Quantity

Best management practices will be followed when working in and around stream environments to remove culverts, fords, and bridges. An environmental monitor will be overseeing the work to determine appropriate methods for diverting or pumping water around the reach where decommissioning activities will take place during the open water season. While pumping or diverting flow will temporarily displace the natural flow path in the immediate vicinity of construction, no change in surface water quantity is expected downstream.

Fluvial Geomorphology

Management and mitigation of sediment transport and erosion during decommissioning will be conducted in the same fashion as during construction. If decommissioning of watercourse crossings will be required during the open water period best management practices will be followed and overseen by environmental monitors to ensure that sediment loads and erosion is minimized during these activates.

5.2 Assessment of the Significance of Residual Adverse Effects

Based on the description of potential Project effects, the road was identified as having the potential for adverse residual effects, with specific reference to stream and river crossings. The significance of these potential effects is assessed in this section. The assessment considers the magnitude, spatial extent, duration, frequency, reversibility, and resilience of the potential effects.

A regular management program will be established to ensure crossing structures are free of debris to convey flow through the system. The structures will be riprapped to protect them from failure under extreme flows, and minimize erosion and sediment transport loads. If the design flow is exceeded, water would back up behind the structure. This would affect the timing of flow (attenuating peak flows), but would not affect the total volume of water. Should such an extreme event occur, effects would be highly localized and short-term. Once flows subside, natural flow patterns would be restored. The level of significance of this effect is considered negligible. Effects on the fluvial environment are expected to be short in duration and localized negligible effects from extreme flow conditions.

5.2.1 Probability of Occurrence and Scientific Uncertainty

Based on a 20-year road life, there is a less than 50% probability that the design flow (Q_{25}) will be exceeded at each of the road stream crossings over the operational life of the road. The confidence limits are intermediate. There is considerable uncertainty associated with the estimation of extreme flow events; however, an appropriate factor of safety will be included in the design of all stream crossings.

6. MONITORING AND EVALUATION

6. Monitoring and Evaluation

No monitoring plan for water quantity will be established for the watercourse crossings throughout the operational life of the road. Variability due to climate change may be monitored through the climatic long-term monitoring program. Fluvial geomorphology and erosion in stream environments also will not have a specific monitoring program but will be assessed in conjunction with watercourse crossing infrastructure and soil erosion monitoring program (Appendix D-2 of the DEIS).

REFERENCES

References

An explanation of the acronyms used throughout this reference list can be found in the *Glossary, Acronyms and Abbreviations* section.

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Appendix C-2
Surface Water and Sediment Quality Effects Assessment

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

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Bathurst Inlet Port and Road Project Surface Water and Sediment Quality Effects Assessment

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

ARD	acid rock drainage
BIPR	Bathurst Inlet Port and Road
BMP	best management practices
CCME	Canadian Council of Ministers of the Environment
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EVS	EVS Environment Consultants
GSC	Geological Survey of Canada
LSA	local study area
ML	metal leaching
NIRB	Nunavut Impact Review Board
NTKP	Naonaiyaotit Traditional Knowledge Project
NWB	Nunavut Water Board
Rescan	Rescan Environmental Services Ltd.
RISC	Resources Inventory Standards Committee
RSA	regional study area
STP	sewage treatment plant
the Project	the Bathurst Inlet Port and Road Project
the proponent	Bathurst Inlet Port and Road Joint Venture Ltd.
TOC	total organic carbon
TSS	total suspended solids
VEC	valued ecosystem component

1. INTRODUCTION

1. Introduction

The Bathurst Inlet Port and Road (BIPR) Project (the Project) is located in the Kitikmeot Region of Nunavut. The proposed marine port is located on the west side of Bathurst Inlet, about 40 km south of the community of Bathurst Inlet. This effects assessment for the proposed all-weather road considers the construction and use of the 211 km road from the proposed port site at Bathurst Inlet south-west to its end at Contwoyto Lake.

Baseline studies of the road route were conducted by SNC-Lavalin and Rescan Environmental Services Ltd. (Rescan). The road will be used while the ground is frozen from January to April. Road maintenance activities will occur late in the summer and in early fall. Truck traffic from January to April will primarily carry fuel and cargo to operating mines in the area. Prospective users of the road include the EKATI, Diavik, Jericho and Snap Lake diamond mines. The 20 person camp at Contwoyto Lake will serve as the connecting and staging point between the proposed road from Bathurst Inlet and the existing ice road to Yellowknife (Appendix A-3 of the Draft Environmental Impact Statement (DEIS)) (SNC Lavalin, 2007b).

1.1 Objectives

Detailed baseline data on surface water and sediment quality were collected in 2001 and 2007 to determine environmental conditions prior to development (Appendices C-6 and C-8 of the DEIS, respectively). The objective of these baseline studies was to characterize the aquatic environment within the local Project area in order to meet the criteria of an Environmental Impact Statement (EIS) as required by the Nunavut Impact Review Board (NIRB). These studies included biological and physical assessments. This effects assessment for surface water and sediment quality will focus on the following components of the freshwater environment:

- stream water quality;
- stream sediment quality;
- physical limnology (Contwoyto Lake);
- lake water quality; and
- lake sediment quality.

2. ENVIRONMENTAL SETTING

2. Environmental Setting

2.1 Regional Setting

The regional study area (RSA) for surface water and sediment quality includes all watersheds that the road passes through. The RSA is southwest of Bathurst Inlet and runs through the Amagok Creek, Western River, Siorak River, and the Mara River watersheds before reaching drainages for Contwoyto Lake. (Figure 2.1-1). The local study area (LSA) includes all crossings and the bay located in the southeastern portion of Contwoyto Lake where the road terminates. The LSA encompasses 200 m on either side of the road at each crossing and along the shoreline of Contwoyto Lake adjacent to the camp.

The area receives anywhere from 250 to 350 mm of annual precipitation, about 50% of which occurs in the form of snow. Environment Canada historical temperature for the community of Bathurst Inlet ranged from a maximum temperature of 17.9ºC to a minimum of -43.7ºC. Temperatures are coldest from December to March with the least amount of precipitation occurring in this period. Glaciation events have significantly contributed to the current terrain and the numerous small and large waterbodies covering the landscape. The streams in the area range in size from large, continually running rivers (*i.e.* Mara River) to small, ephemeral streams with undefined channels.

The chemical composition of freshwater environments directly influences the resident aquatic communities (Longmuir *et al.*, 2007). Nutrient concentrations are correlated with the productivity of these ecosystems and either elevated or insufficient levels can affect ecological functions such as growth and reproduction of organisms. Recent studies of Arctic freshwater systems in the context of climate change conclude that ice-free seasons will be longer resulting in increased evaporation and water temperatures and reduced permafrost; all of which will alter water chemistry by generally increasing productivity (Prowse *et al.*, 2006). However, based on data compiled by the Geological Survey of Canada (GSC, 2000), the general area of the Project is one expected to show a high thermal response to warming, but with only low to minimal predicted impact from permafrost thaw.

High quality freshwater is considered very important to the Inuit in the area. This is the case not only in the context of providing good quality habitat for fish and wildlife but also to fulfil the need for potable water. As summarized in the Naonaiyaotit Traditional Knowledge Project (NTKP), potable water is not always readily available and may require travel to obtain (Appendix F-5 of the DEIS). The NTKP is an important source of knowledge for this effects assessment. High water clarity is one of the key characteristics used by the Inuit to determine water quality. Locations where water is obtained while travelling include lakes and flowing rivers, pools under cliffs, underground streams and springs and pools from rain or melting snow in rock crevasses and wetlands. Over time the Inuit have noticed changes to inland waters which have generally degraded water quality. These changes include reduced flows in small and large (Mara River) river systems, reduced fish spawning runs and changes in the position of water channels and shallower lakes.

2.2 Streams

Based on field surveys conducted by SNC-Lavalin and Rescan, the proposed road will cross a total of 104 streams of various sizes between Bathurst Inlet and Contwoyto Lake (Appendix C-7 and A-3 of the DEIS) (Figure 2.2-1). Many of the small drainages have shallow, poorly defined channels that flow through moraines and boulder fields or tussock grasses. Larger streams are characteristically meandering, passing through more defined channels with finer-grained substrates (Plate 2.2-1). Peak streamflows typically occur in June, but could occur in late May and end in early July, depending on ice break-up.

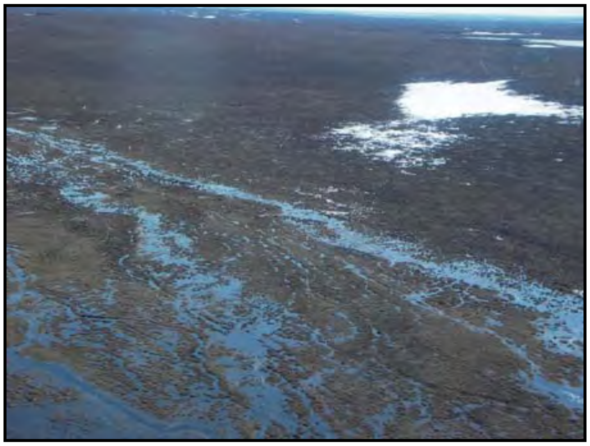


Plate 2.2-1. Example of small (site B2) (left) and larger (site B6) (right) stream sites along the proposed road route.

In 2001, a number of streams that had distinct channels and flowing water were surveyed. Of these streams, six were chosen that represented a wide range of stream size and were distributed along the entire road route between Contwoyto Lake and Bathurst Inlet (Figure 2.2-2). Although stream size varied, all six streams were shallow with similar riffle and glide depths (Appendix C-6 of the DEIS). Stream locations were selected based on three criteria initially obtained from the fish and fish habitat assessments: presence of Arctic grayling or larger migratory fish, stream size, and geographical location. These six streams were sampled for water and sediment in 2001 and 2007, although sediment samples could only be collected at three sites in 2001. Sampling locations were similar in both years but some differed slightly based on stream flow and sampling feasibility. Table 2.2-1 provides the coordinates of these six sites and the samples that were collected in 2001 and 2007.

Water sampling during each sample year was completed using standard methods (RISC, 1997). The six stream sites were generally characterized as clear with relatively low conductivity and total suspended solid (TSS). The pH in 2007 was relatively lower than 2001 values, with all sites except B6 falling below the lower Canadian Council of Ministers of the Environment (CCME) guideline (6.5) for pH (CCME, 1999b). For most variables, the site closest to Bathurst Inlet (B6) was distinct from other stream sites. B6 was turbid, had much higher conductivity and TSS. The exceedingly high TSS value is probably the reason relatively high values of several water nutrients and metals are found at this site. The differences seen at B6 may reflect tidal

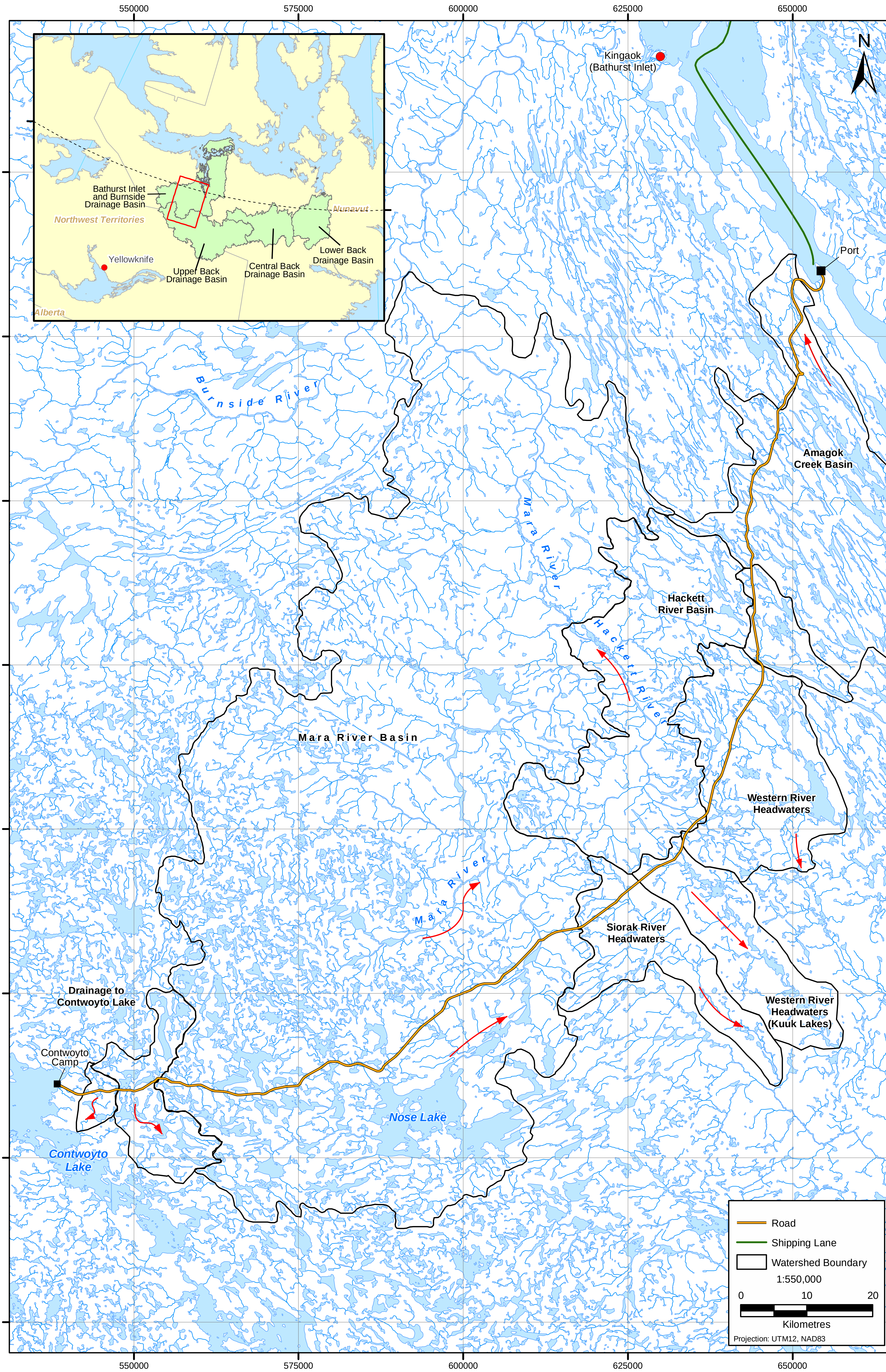

FIGURE 2.1-1

the BATHURST INLET PORT AND ROAD PROJECT

Large Watersheds of the Bathurst Inlet Road

Rescan

gis no. 623-7-121 Job No. 623-7 November 15, 2007

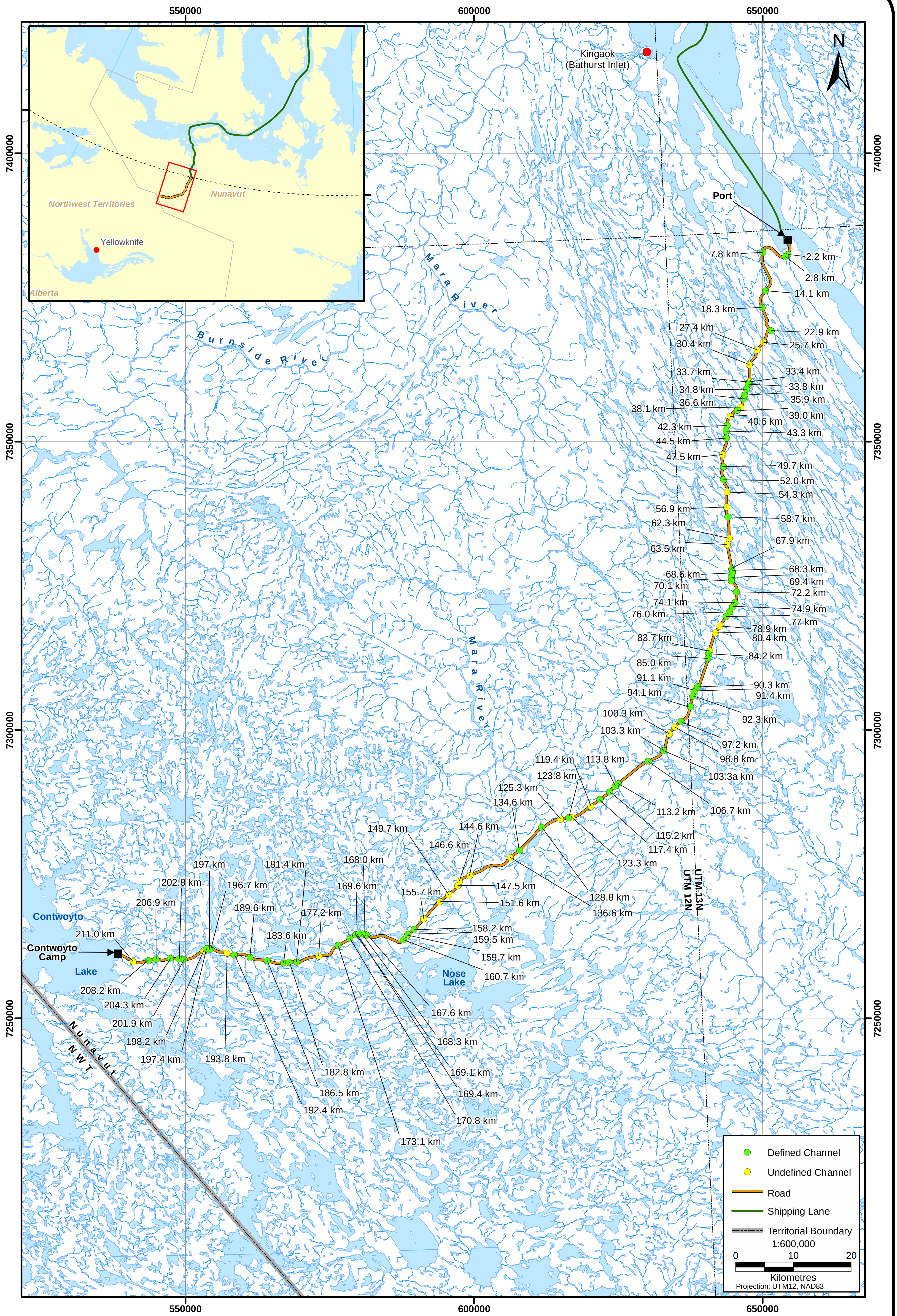

FIGURE 2.2-1

the BATHURST INLET PORT AND ROAD PROJECT

Stream Crossings of the Bathurst Inlet Port and Road Project

Rescan™

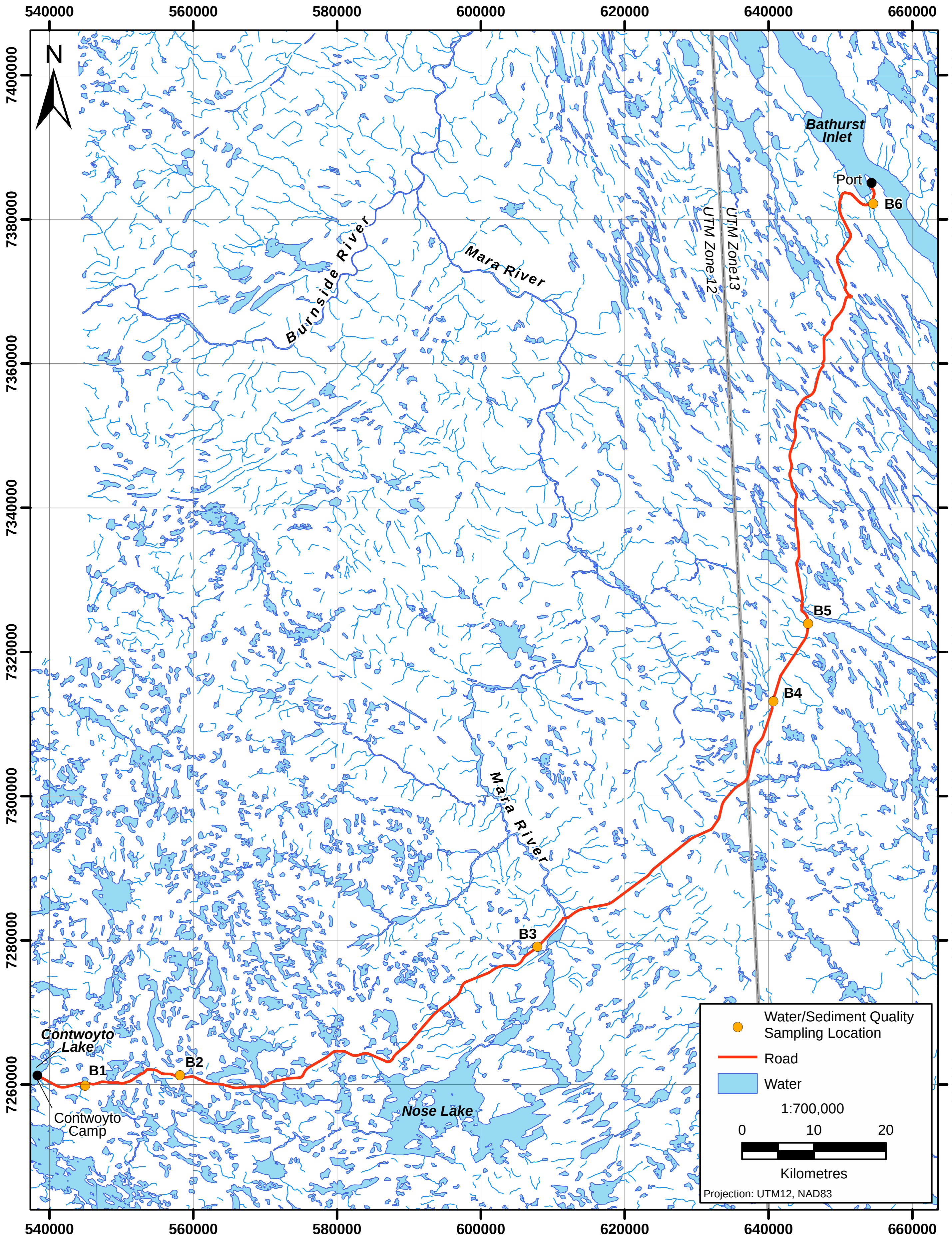

FIGURE 2.2-2

Water and Sediment Quality Sampling Locations along the Road of the Bathurst Inlet Port and Road Project

The Bathurst Inlet Port and Road Project

Rescan

influence from Bathurst Inlet or the different bedrock in that area of the drainage basin. More sedimentary rock is present in this drainage compared to igneous material in other drainage basins and runoff from sedimentary rock is richer in ions due to lower resistance to weathering.

Table 2.2-1
Co-ordinates and Variables Measured at Stream Sampling Stations, 2001 and 2007

2001 Station ID	2007 Station ID	GPS Co-ordinates (UTM)			Variables Measured
		Easting	Northing	Zone	
Bathurst km 203.6	B1	544966	7259896	12	Water and sediment quality
Bathurst km 189.8	B2	558085	7261386	12	Water and sediment quality (2007 only)
Bathurst km 132.0	B3	607859	7279197	12	Water and sediment quality (2007 only)
Bathurst km 82.1	B4	367594	7312496	13	Water and sediment quality (2007 only)
Bathurst km 70.4	B5	373143	7323064	13	Water and sediment quality
Bathurst km 2.5	B6	387880	7380208	13	Water and sediment quality

Nutrient and metal concentrations were also generally higher at B6 than the typical low values found at the other stream crossings. Nitrate concentrations were all below the CCME guideline of 2.93 mg/L. The highest nitrate value was at B6 in 2001 (0.028 mg/L), in 2007 though the highest value was found at B3 (0.035 mg/L). Total phosphate, which is considered to be the limiting nutrient in freshwater ecosystems, was also relatively high at B6 (0.106 mg/L). Total metal guidelines for the protection of aquatic life were exceeded at B6 and in some cases at B5 (copper). In one or more samples for total aluminum, cadmium and chromium (2007 only), copper and iron the guidelines were exceeded.

Stream sediments were measured at only three stream crossings in 2001 (Table 2.2-1) since several streambeds were composed primarily of boulders, cobble and gravel, making it difficult to find a sampling location. Sediment sampling was completed using standard methods (RISC, 1998). In general, the samples collected were primarily composed of sand and the distribution of particle size in sediments did not differ considerably between 2001 and 2007.

Nutrients as measured by total organic carbon (TOC), available phosphate, and total nitrogen were generally low, except for one sample in 2007 (B1, near Contwoyto Lake) that had high phosphate and TOC values. This single replicate at B1 resulted in the average available phosphate and TOC to be considerably higher in 2007 than in 2001. Several metals were not detected at any sites, including cadmium and lead. B6 had relatively low average metal concentrations for several variables. All average metal concentrations in stream sediments were below CCME guidelines except for arsenic (B1) and chromium (B4 and B5) in 2007 (CCME, 1999a; Appendix C-8 of the DEIS).

2.3 Contwoyto Lake

Contwoyto Lake is the major waterbody in the headwaters of the Burnside River drainage basin, with a surface area of approximately 950 km^2. The baseline study in 2001 surveyed several locations on Contwoyto Lake. Since the road will end at Contwoyto Lake, only the lake shoreline near Contwoyto camp has the potential to be impacted and will be considered in the effects assessment.

Some information is available regarding historical conditions at Contwoyto Lake (Moore, 1978; EVS, 1996). The lake has been the receiving environment for effluent from mining activities since the early1980s. The Lupin gold mine is located on the northwestern shore of Contwoyto Lake and most of the previous studies have focused on this area of the lake. Prior to mining activity, baseline work showed that the lake was comparable to other Arctic lakes with respect to water quality and biological communities (Moore, 1978). Although changes in water quality have been measured in association with discharge events, conditions quickly returned to background levels within a few weeks of discharges (EVS, 1996). Sediment was found to have elevated levels of arsenic and nickel in the area of Lupin mine. Changes in the benthic community were described as difficult to measure because of differences in sampling methods and taxonomic conventions (EVS, 1996).

In 2001, samples were collected in Contwoyto Lake site at the terminal end of the proposed road for physical limnology, water and sediment quality. Possible effects on Contwoyto Lake include shoreline degradation, drainage changes and water quality degradation due to the footprint and waste discharge from the proposed service camp at this location.

Contwoyto Lake is characterized by a moderately sloping shoreline (averaging 1 m depth per 18 m distance) near Contwoyto Camp. Water temperature in August averaged 12.7 °C and dissolved oxygen averaged 10.3 mg/L, with a saturation of 97%. The lake was not thermally stratified during the sampling period, as the temperature difference from surface to bottom was only 0.2°C. Light penetration through the clear surface waters was very good, with the lake bottom at 8.5 m visible from the surface.

The lake water was soft (3.3 mg $CaCO_3$/L) and had low ion content (total dissolved solids <10 mg/L; conductivity = 10 µmhos/cm), with low nutrient (nitrate nitrogen = 0.009 mg/L; total phosphorus = 0.004 mg/L) and metal (iron < 0.030 mg/L; aluminum = 0.011 mg/L) concentrations, typical of undisturbed northern lakes. The low nutrient concentrations indicate poor nutrient availability for primary production. All metal concentrations were below CCME guidelines for the protection of aquatic life.

Sediments along the shoreline near the terminal end of the road consisted primarily of boulders and bedrock at many sites but the sediment sampling site was composed of >85% sand. Sediments at the site contained low nutrient concentrations, represented by total organic carbon (0.44%), available phosphorus (6 mg/kg) and total nitrogen (0.04 %). Metal concentrations also were low (total aluminum = 5,967 mg/kg; total iron = 9,427 mg/kg), with average values 92% below CCME guidelines for the protection of aquatic life.

3. METHODOLOGY

3. Methodology

3.1 Valued Ecosystem Component Selection

Surface water quality is considered a valued ecosystem component (VEC) because the streams and lakes in the Project area provide habitat for many aquatic organisms, including important fish species. In addition to its importance to aquatic organisms, surface water quality was chosen as a VEC because it is a key component of healthy environments for humans. As a critical factor in biological and physical environments, surface water is protected under the *Canada Water Act*. For the purposes of this assessment, two primary variables of surface water were selected as VECs: surface water quantity and surface water quality. Effects to surface water quantity are addressed in a separate effects assessment (Appendix C-1 of the DEIS). Project issues with the potential to degrade water quality include surface runoff, siltation and dust particulates from the road, nitrogen residues for blasting, metal leaching (ML) and acid rock drainage (ARD) from road quarry sites, and the direct discharge of potential contaminants into waterbodies (primarily as treated effluent) including accidental spills.

Sediment quality is a chosen VEC because of its relationship with water quality and its importance to various groups of aquatic life that have regular or continuous contact with stream and lake sediments (*i.e.* periphyton, macrophytes, benthic invertebrates and fish). Sediment particles and pore water within the sediment can act as sinks for various contaminants, releasing them back into the aquatic environment under changing environmental conditions. Analyses of possible sources of contaminants will consider potential impacts on sediment quality. The Canadian Council of Ministers of the Environment (CCME) outlines guidelines that would inhibit the degradation of sediment quality. Project activities that could affect sediment quality include surface runoff, siltation and dust particulates from the road, ML/ARD from road quarry sites, fuel spills and the direct discharge of potential contaminants into waterbodies (primarily as treated effluent). Deposition of soil particles into the aquatic environment may result in altered chemical loadings (metals, nutrients) or physical changes to benthic habitats.

3.2 Boundaries

Spatial and temporal boundaries, detailed below, are based on the proposed development plans and consider the expected duration of the Project.

3.2.1 Spatial Boundaries

Spatial boundaries reflect the Project components, which in the case of water and sediment quality are the road including Contwoyto Camp (approximately 1.45 ha). The footprint of the road from the port to Contwoyto Camp will be approximately 211 km long. The road width will be 13.2 m with pullouts (4 m wide and 50 m in length) located every 1 km and at bridge approaches. Quarry sites are also located along the road and there will be thirty-nine quarry sites in total (Figure 3.2-1). The potential effects on water and sediment quality are generally considered to be localized at the point of impact, therefore, the spatial boundary for this effects assessment include all streams crossed by the road and adjacent to quarries and the bay where Contwoyto Camp is located.

3.2.2 Temporal Boundaries

The Project has an approximate planned life of 22.5 years. The temporal boundaries used for the surface water and sediment quality section of the Project effects assessment follow the time period of the four respective phases of the Project:

- construction (2.5 years);
- operation and maintenance (estimated 19 years);
- decommissioning and closure (approximately 1 year); and
- post-closure (>5 years).

The time period considered for the post-closure phase takes into account that some effects (*e.g.*, acid rock drainage) have the potential to extend well into the post-closure phase and may require monitoring far into the future.

3.3 Approach and Methods

Data collection for this effects assessment included surveying the 104 stream crossings, then choosing six representative streams for the collection of quantitative data. Baseline data and historical data on Contwoyto Lake were also considered.

The issues related to various Project activities involving the road and Contwoyto Camp were assessed for effects to surface water and sediment quality not using models but consist of logical discussion of physical and chemical processes in relation to biological receptors, based on professional judgment. It inherently assumes throughout the assessment that activities of road building, transport, storage, and sewage treatment/disposal will use appropriate technology and best management practices to properly mitigate and/or minimize effects. Procedures associated with these Project activities are well developed and understood from decades of previous experience. However, all potential effects are examined; including spills and road failures. Sufficient baseline information is available to monitor for potential future impacts, and there are no critical data gaps identified for this assessment.

The effects on each VEC were then summarized on standardized VEC assessment tables. The criteria used for the effects assessment can be found in Appendix A-5 of the DEIS. The potential effects on surface water and sediment quality were assessed in order to recognize mitigation and monitoring needs.

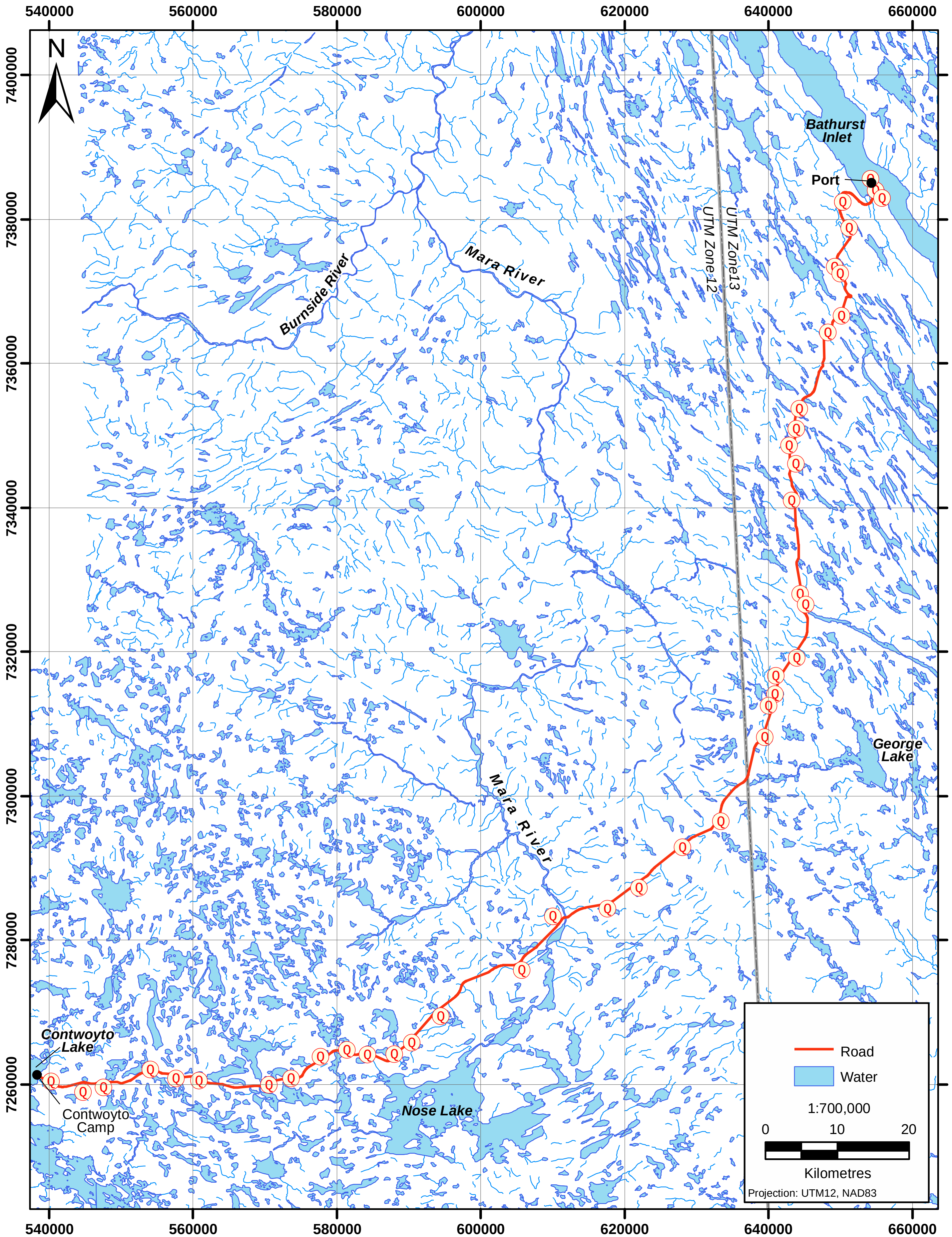

FIGURE 3.2-1

THE BATHURST INLET PORT AND ROAD PROJECT

Prospective Quarry Sites along the Road

Rescan

4. EFFECTS ASSESSMENT

4. Effects Assessment

4.1 Description of Potential Project Effects on Water Quality

Potential effects to surface water quality originating from Project activities are discussed in this section. Potential effects to sediment quality are discussed in Section 4.3. The Project component associated with these effects is the 211 km road including the camp at Contwoyto Lake and the 39 quarry sites along the road between the port site and Contwoyto Camp. Access to the quarries will be on spur roads. All quarries will be greater than 30m from any lakes or streams. Contwoyto Camp will occupy approximately 1.45 ha. It will include a 20-person camp plus services and a truck-parking area. It is predicted that the camp at Contwoyto Lake will draw 6,000 L of water per day from the lake for potable and emergency fire fighting needs. The use of water from the lake will be regulated in the water licence from the Nunavut Water Board (NWB). The removal of this volume of water from the lake is not expected to affect surface water quality and is therefore not discussed further.

4.1.1 Siltation and Surface Runoff Contaminant Loading

Activities associated with each phase of the Project have the potential to create adverse effects on water quality by shifting away from baseline conditions. There are two seasonal periods when siltation and surface runoff may degrade water quality; during the summer months and during the annual freshet.

4.1.2 Airborne Contaminant Loading

During several Project phases, airborne contaminants in the form of dust particles from blasting and road traffic. Also, particulates from vehicle/generator emissions and incinerating garbage and sewage sludge, may degrade water quality.

4.1.3 Discharge Contaminant Loading

Various direct discharges or potential seepage associated with the Project have the potential to alter water quality including;

- treated sewage effluent from mobile construction camps and Contwoyto Camp; and
- spills of various substances (*i.e.*, fuel, sewage sludge).

A water license with specific requirements from the NWB will regulate treated effluent discharge.

4.1.4 Nitrogen Residues from Blasting

Blasting activities at the quarries along the road will produce residues containing nitrogen compounds. Generally, these residues remain on the rock surfaces and are available to travel by surface flow into surrounding waters and alter water quality.

4.1.5 Metal Leaching and Acid Rock Drainage

Crushing, hauling and placing large quantities of rock can accelerate the natural process of weathering and leaching. The oxidation of sulphide minerals can create ARD if sufficient quantities of neutralizing minerals are not available. Sulphides were noted in the bedrock along the road at kms 102 and 104 (Appendix D-5 of the DEIS). The area around the south western end of the proposed road, between Quarry 23 and 39, also indicated ARD potential (Appendix D-6 of the DEIS).

4.2 Detailed Effects

Most of the potential Project effects would occur during the construction, operations and decommissioning phases, although the post-closure phase was considered for some effects. A summary of all considered effects on water quality is available in Table 4.2-1.

4.2.1 Construction Phase

Project activities that may affect surface water quality include: the extraction of materials from quarries; leaching of explosives residues from construction rock; the "end dumping" and leveling of quarried materials to construct the road base and Contwoyto Camp; installing stream crossings; potential spills and the discharge of treated effluent into Contwoyto Lake or into nearby streams and lakes along the road.

Disturbance of the terrain will increase surface runoff and could accelerate local erosion rates, which if not managed properly, may result in siltation that could deteriorate water quality. Slope failure and debris along the edge of the road may also generate siltation in the watercourses. Best management construction practices, as outlined in Section 5 of this report, will be followed to ensure that proper management plans are implemented throughout all Project activities. Environmental monitors will also be on site during construction to ensure watercourses are not affected. Surface runoff and siltation could potentially affect stream crossings along the road during construction but will likely occur sporadically on a local level. Effects may be variable during the summer and freshet periods where a pulse of contaminants may alter the water quality. The probability of such an event is high during the construction phase but is considered to have local, short term effects, and therefore have a negligible significance on water quality.

Disturbing soil and rock material through blasting and truck transport, contouring quarries, and vehicle emissions have the potential to affect air quality such that atmospheric deposition could subsequently affect surface water quality. Detailed air quality effects are discussed in Appendix B-2 of the DEIS. Dust particle sizes generated from the use of explosives are expected to be relatively large such that particles will be local to the blast site. Particles from truck traffic and construction are also considered to occur on a local level. Dust clouds during dry conditions may be larger but generally the dust will occur sporadically and be suspended for a relatively short time prior to deposition. Although it is quite likely that deposition of some kind will occur during construction, the effects of dust on water quality are projected to be negligible when considering residual effects after mitigation (as discussed in Section 5).

Table 4.2-1
Summary of Effects Assessment Table for Water Quality

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
Description	**Project Phase (Timing)**	**Project Component**	**Direction**	**Nature**	**(Design Changes, Management, Monitoring, Compensation, Enhancement)**	**Description of Residual Effect (after mitigation)**	**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological Context (Resilience)**	**Influence on Resource Capacity**	**Probability of Occurrence**	**Significance**	**Confidence Limit**
Summer surface runoff, siltation and associated water chemistry effects (A21, A22, A23, A24, A25, A26)[1]	Construction	Road	Adverse	Direct	Silt fences; best management practices; environmental monitoring; erosion management plan	Increase in total suspended solids resulting in degraded water quality	Moderate	Local	Short term	Sporadic	Reversible short term	High	Nil	High	Negligible	High
Freshet surface runoff, siltation and associated water chemistry effects (A21, A22, A23, A24, A25, A26, B17, B19, C5, C7)[1]	Construction, Operations and Decommissioning	Road	Adverse	Direct	Silt fences; best management practices; environmental monitoring; erosion management plan	Increase in total suspended solids resulting in degraded water quality	Low - Moderate	Local	Short term	Regular	Reversible short term	High	Nil	Moderate - High	Low	High
Airborne contaminant loading (A21, A22, A23, A24, A25, A26)[1]	Construction	Road	Adverse	Direct	Best management practices, environmental monitoring	Increase in dust particles resulting in degraded water quality	Moderate	Local	Short term	Sporadic	Reversible short term	High	Nil	High	Negligible	High
Contaminant discharge and associated water chemistry effects (A28)[1]	Construction	Road	Adverse	Direct	Best management practices, environmental monitoring, spill contingency plan, tertiary treatment	Increase in nutrients and potential toxins resulting in degraded water quality	Low	Local	Short term	Regular	Reversible short term	High	Nil	Moderate	Negligible	Intermediate
Leaching of nitrogen residues from Blasting (A21, B23)[1]	Construction	Road	Adverse	Direct	Best management practices, environmental monitoring	Increase in nitrogen loadings (blasting residues) resulting in degraded water quality	Moderate	Local	Short term	Sporadic	Reversible short term	Neutral	Low	Low	Negligible	Intermediate
Metal leaching and Acid Rock Generation (ML/ARD) contamination (A21, A22)[1]	Construction and Operations	Road	Adverse	Direct	Best management practices, environmental monitoring	ML/ARD resulting in degraded water quality	Moderate	Local	Medium term	Regular	Reversible short term	Neutral	Low	Low	Low	Low
Summer surface runoff, siltation and associated water chemistry effects (B17, B19, C5, C7)[1]	Operations and Decommissioning	Road	Adverse	Direct	Silt fences; best management practices; erosion management plan; spill contingency plan	Increase in total suspended solids resulting in degraded water quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Moderate	Negligible	High
Airborne contaminant loading (B17,B19,B20, B21, B22, B24, B27,B29, C5, C7)[1]	Operations and Decommissioning	Road	Adverse	Direct	Best management practices	Increase in dust particles resulting in degraded water quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Moderate	Low	High
Contaminant discharge and associated water chemistry effects (B24, B25,B27, B28)[1]	Operations	Road	Adverse	Direct	Best management practices, environmental monitoring, spill contingency plan, tertiary treatment	Increase in total suspended solids resulting in degraded water quality	Low	Local	Short term	Regular	Reversible short term	High	Nil	Moderate	Low	Intermediate
Summer surface runoff, siltation and associated water chemistry effects (D3, D4)[1]	Post-Closure	Road	Adverse	Direct	Monitoring; remediation activities	Increase in total suspended solids resulting in degraded water quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Low	Negligible	High
Freshet surface runoff, siltation and associated water chemistry effects (D3, D4)[1]	Post-Closure	Road	Adverse	Direct	Environmental monitoring; remediation activities	Increase in total suspended solids resulting in degraded water quality	Low	Local	Short term	Regular	Reversible short term	High	Nil	Low	Negligible	High
Metal leaching and Acid Rock Generation (ML/ARD) contamination (D3, D4)[1]	Post-Closure	Road	Adverse	Direct	Environmental monitoring; remediation activities	ML/ARD resulting in degraded water quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Low	Negligible	Low

Note:
1: Numbers in brackets correspond to a specific project activity outlined in Table 5.1-2 in the Effects Assessment Methodology (Appendix A-5 of the DEIS).

Various discharges associated with the Project have the potential to alter water quality, including treated sewage from mobile construction camps and spills of various substances (*i.e.* fuel, *lubricant)* used during construction. After the removal of solid waste from sewage of the mobile camps (solids will be incinerated at the port site), the remaining treated effluent will be discharged onto the open tundra at least 100 m from any open water. This would occur regularly at various locations.

Accidental spills of other substances would likely be more sporadic. During construction the spills will most likely be low volume spills at the storage and re-fuelling sites, although with proper management (Spill Contingency and Emergency Response Plan; Appendix G-4 of the DEIS) they will not affect water quality. Regardless of frequency all discharges are considered to have local and short term effects making their significance negligible.

Explosives use at quarries along the road could increase nitrogen loading in streams as a result of nitrogen blasting residue on rock construction materials. The accumulation of these residues (NO_3, NO_2, NH_4^+) on disturbed rock material and the nitrogen load to the aquatic environment depends on the volume of explosives used. Most nitrogen loading will occur from runoff, although a more minor source may be from dust. Nitrogen loading would primarily occur when water is flowing (spring and summer flows). Increases in nitrogen concentration may be moderate during construction but lower during operations and would be local and short term resulting in a negligible significance. Downstream waterbodies would be monitored at freshet for nitrogen levels

When exposed to oxygen and water, fresh rock will naturally weather and leach water soluble compounds in the rock. These processes can be accelerated by crushing and redistributing large quantities of rock. The oxidation of sulphide minerals can create ARD if sufficient quantities of neutralizing minerals are not available. In the event that acidic drainage is formed, the lower pH can create higher rates of ML. However, metal leaching can also occur at sites of neutral and alkaline drainage. The study of environmental geochemistry of surficial samples (Appendix D-6 of the DEIS) indicates areas along the road that have greater potential for ARD and those areas with elevated carbonate and neutralizing capacity. However, this report clearly states that because of the uncertainties in the analytical data, deeper rock and granular materials should be sampled before excavation and analyzed for a more complete assessment of ARD potential for each quarry. Also, the potential for ML is present but cannot be quantitatively defined with existing information and requires long term leaching tests, which are currently underway. The ML/ARD characterization will therefore be conducted during the construction phase and adaptive management will be implemented to ensure that excavated rock is properly managed and disposed so that surface water quality is preserved. This will include a water management plan in areas that develop ML/ARD concerns.

4.2.2 Operations and Decommissioning Phase

Project activities during operations that may affect surface water quality include trucks hauling fuel and cargo from January to April (approximately 7,050 loads per year), snow removal and the application of sand and gravel during the winter, some rock crushing, summer road maintenance, potential spills, treated sewage discharge, power generation, and incinerations at

Contwoyto Camp. During decommissioning structure removal and surface contouring may affect surface water quality.

During operations and decommissioning, siltation and surface runoff from the road and facilities at Contwoyto Camp will be minimal. It is expected that a pulse of material will enter the water during freshet. Because of the high volume of flowing water, the effect will only be short-term. Although there is a moderate possibility for an effect to occur, these facilities will be engineered with appropriate structures to mitigate erosion and siltation, as discussed in Section 5 of this report.

Airborne contaminants from the deposition of dust particles will have a negligible effect on water quality during operations and decommissioning. If water quality is degraded by particles from dust, incineration of garbage and sewage sludge, or diesel emissions, it will likely be on a sporadic basis with short term and local effect. See Air Quality Effects Assessment for details (Appendix B-2 of the DEIS).

Discharge of treated sewage into Contwoyto Lake will occur during the operations phase. The quality of the effluent from the tertiary sewage treatment plant (STP) will be similar to that produced by the port STP. The effluent will be monitored prior to discharge into the lake. Some potential exists for fuel spills to occur, for which a spill contingency plan will be in place. During operations and decommissioning, the significance of discharged contaminants to alter water quality is low.

During operations the areas that have been characterized as potential ML/ARD will be monitored as described in Section 5. This characterization will result from standard analyses of deep rock and gravel samples. Monitoring during operations and decommissioning will occur during annual freshet and late in the summer since water flow is required to generate ML/ARD. The significance of this effect is considered low, but confidence in this evaluation is also low until reliable analytical results are produced from deeper and more representative samples from prospective quarries. This significance rating is due to the current uncertainty regarding quarries and would be "negligible" if quarries can be confirmed to be non ML/ARD rock.

4.2.3 Post-Closure Phase

After mitigation plans have been executed during decommissioning, the effect from surface runoff and siltation will be negligible. Where concern exists regarding a potential effect, freshet monitoring could occur for two or three seasons after closure.

Upon closure of the Project, previous water sampling will have indicated the potential for areas requiring future monitoring for ML/ARD. After necessary remediation involving the application of neutralizing material, monitoring will continue as far into the future as required until it is determined that remediation measures are successful. No significant effects are expected.

4.3 Description of Potential Project Effects on Sediment Quality

Potential effects to sediment quality from Project activities associated with the road, including the camp at Contwoyto Lake and the quarry sites along the road as described in Section 4.1, are discussed in this section.

The potential effects to sediment quality are a subset of the water quality effects. The description of each is similar to the description listed in Section 4.1. The effects specific to sediment quality are:

- siltation and surface runoff contaminant loading;
- discharge contaminant loading; and
- ML/ARD.

4.4 Detailed Effects

Project activities that could degrade sediment quality are more likely to occur during the construction phase than any other Project phase. A summary of all considered effects to sediment quality is available in Table 4.4-1.

4.4.1 Construction Phase

Project activities during the construction phase that could affect sediment quality include: the extraction of materials from quarries; the "end dumping" and leveling of quarried materials to construct road base and Contwoyto Camp; installing stream crossings; potential spills and the discharge of sewage effluent into Contwoyto Lake or directly onto the tundra. This discharge will occur according to the specific requirements of the water license obtained from the Nunavut Water Board regarding sewage effluent.

Siltation during the summer or during a freshet pulse in the spring could result in physical or chemical effects to sediment quality, depending on the nature of introduced particles. During construction, there is the potential of increased TSS loading to local streams due to terrain disturbance and erosion. The volume of this loading is partially dependent on precipitation which increases erosion and transport of soil into aquatic environments. The actual construction of the road and associated infrastructure, with activities such as blasting and the moving of large quantities of soil and rock, are the primary sources of siltation. The minimal truck traffic on the road during construction may raise some dust and increase the risk of erosion but the effect from this activity is expected to be minimal. The probability of siltation occurring is high, but since the effect is expected to occur locally over the short term the significance of such an event is considered low. Environmental Monitors will be on site during construction to ensure that erosion management plans and best management practices are in place during construction.

Discharges into the aquatic environment have the potential to reduce sediment quality through the introduction of contaminated materials. This includes deposition of liquids or particulates containing potential toxins from the Project area. The primary concern with respect to discharges during construction is the sewage from mobile construction camps and the Contwoyto Camp. There will be a tertiary treatment plant in operation at Contwoyto Lake during the construction stage. Sewage solids from mobile camps will be trucked off site while the remaining effluent will be discharged onto the tundra. The effect is expected to be negligible since the volumes of sewage will be relatively small and the placement of the discharged material will be at least 100 m from waterbodies. Environmental Monitors will monitor the quality of effluent prior to discharge.

Fuel spills are also a potential effect at this stage but are considered to be of low probability and sporadic if they do occur. A Spill Contingency and Emergency Response Plan will be in place and enforced by Environmental Monitors during the construction phase.

As described in Section 4.2.1, the study of environmental geochemistry of surficial samples (Appendix D-6 of the DEIS) indicates areas along the road that may have potential for ML/ARD and those areas with elevated neutralizing capacity. The significance of ML/ARD on sediment quality is low but further sampling will be required prior to excavating material for construction. Monitoring will also be required during construction to determine if ML/ARD is affecting sediment quality. This significance rating is due to the current uncertainty regarding quarries and would be "negligible" if quarries can be confirmed to be non ML/ARD rock.

4.4.2 Operations and Decommissioning Phases

Project activities during operations and decommissioning that could affect sediment quality are similar to those described in Section 4.2.2.

Siltation affecting sediment quality, during the summer and freshet, from the road and facilities at Contwoyto camp will be minimal. There is a low probability for an effect to occur, and the significance of the effect will be negligible. These facilities will be engineered with appropriate structures to mitigate erosion and siltation; as discussed in Chapter 5. Environmental Monitors will also oversee decommissioning activities; such as bridge removals, to ensure best management practices.

During operations, a tertiary STP will treat all sewage from Contwoyto Camp prior to discharge. Low quality effluent discharged into a nutrient poor environment such as this could have significant effects to the physical and chemical structure of the sediment. The quality of the sewage effluent will be monitored prior to discharge to meet regulations set for discharge into this freshwater environment. For this reason the effect of this discharge is considered negligible.

The likelihood of accidental spills having an effect on sediment quality is low. If they do occur, a Spill Contingency and Emergency Response Plan will be in place and contaminated soil will undergo bioremediation (Appendix G-7 of the DEIS) making any effect on sediment quality of negligible significance.

If ML/ARD becomes an issue for water quality (as described above) it then has the potential to affect sediment quality. As with water quality, the probability of this effect is considered low but the confidence in this evaluation is also low until reliable analytical results are produced from additional representative sampling.

4.4.3 Post-Closure Phase

The probability of siltation or ML/ARD having an effect on sediment quality during the post-closure phase is low and the mitigation measures taken during decommissioning make the significance of an effect negligible.

Table 4.4-1
Summary of Effects Assessment Table for Sediment Quality

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
Description	Project Phase (Timing)	Project Component	Direction	Nature	(Design Changes, Management, Monitoring, Compensation, Enhancement)	Description of Residual Effect (after mitigation)	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context (Resilience)	Influence on Resource Capacity	Probability of Occurrence	Significance	Confidence Limit
Summer siltation and associated physical and chemical effects (A21, A22, A23, A24, A25, A26)[1]	Construction	Road	Adverse	Direct	Silt fences; best management practices; environmental monitoring; erosion management plan	Introduced materials changing the substrate and resulting in degraded sediment quality	Moderate	Local	Short term	Sporadic	Reversible short term	Neutral	Low	High	Negligible	High
Freshet siltation and associated physical and chemical effects (A21, A22, A23, A24, A25, A26)[1]	Construction	Road	Adverse	Direct	Silt fences; best management practices; environmental monitoring; erosion management plan	Introduced materials changing the substrate and resulting in degraded sediment quality	Moderate	Local	Short term	Regular	Reversible short term	Neutral	Low	High	Low	High
Contaminant discharge and associated physical and chemical effects (A28, B23, B24, B25,B27, B28)[1]	Construction and Operations	Road	Adverse	Direct	Best management practices, environmental monitoring, tertiary treatment, spill contingency plan	Increase in nutrients and potential toxins resulting in degraded sediment quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Low	Negligible	High
Metal leaching and Acid Rock Generation (ML/ARD) contamination (A21, A22)[1]	Construction and Operations	Road	Adverse	Direct	Best management practices, environmental monitoring	ML/ARD resulting in degraded sediment quality	Moderate	Local	Medium term	Regular	Reversible short term	Neutral	Low	Low	Low	Low
Summer siltation and associated physical and chemical effects (B17, B19, C5, C7, D3, D4)[1]	Operations, Decommissioning and Post-closure	Road	Adverse	Direct	Silt fences; best management practices; erosion management plan; spill contingency plan, remediation activities	Introduced materials changing the substrate and resulting in degraded sediment quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Low	Negligible	High
Freshet siltation and associated physical and chemical effects (B17, B19, C5, C7)[1]	Operations and Decommissioning	Road	Adverse	Direct	Silt fences; best management practices; erosion management plan; spill contingency plan	Introduced materials changing the substrate and resulting in degraded sediment quality	Low	Local	Short term	Regular	Reversible short term	High	Nil	Moderate	Negligible	High
Freshet siltation and associated physical and chemical effects (D3, D4)[1]	Post-closure	Road	Adverse	Direct	Environmental monitoring; remediation activities	Introduced materials changing the substrate and resulting in degraded sediment quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Low	Negligible	High
Metal leaching and Acid Rock Generation (ML/ARD) contamination (D3, D4)[1]	Post-closure	Road	Adverse	Direct	Environmental monitoring; remediation activities	ML/ARD resulting in degraded sediment quality	Low	Local	Short term	Sporadic	Reversible short term	High	Nil	Low	Negligible	Low

Note:
1: Numbers in brackets correspond to a specific project activity outlined in Table 5.1-2 in the Effects Assessment Methodology (Appendix A-5 of the DEIS).

4.5 Summary of Residual Effects to Water and Sediment Quality

Following the assessment of potential effects to the surface water and sediment quality VECs in light of planned Project design and mitigation, some significant residual effects were identified. Tables 4.2-1 and 4.4-1 present a summary of effects with a greater than negligible significance.

All of these effects could act alone or together to degrade water and sediment quality. This could result in effects to other VECs including freshwater aquatic resources and fish species (*e.g.*, Arctic grayling in streams), and birds and mammals that feed on fish or drink the water.

5. MITIGATION AND MANAGEMENT PLAN

5. Mitigation and Management Plan

Mitigation and management plans are offered as recommendations and will be refined during the environmental assessment process leading to the Final Environmental Impact Statement (FEIS) and Project Certificate.

5.1 Introduction

This plan details the management of surface water and sediment quality, and techniques to mitigate effects to freshwater habitat. In particular, this plan focuses on the management of effects to surface water quality and sediment arising from disturbed areas during the construction, operation, decommissioning and post-closure phases of the Project. The objective of this plan is to address potential water quality and sediment quality problems through best management practices. As identified in the effects assessment, the primary potential effects relating to surface water and sediment quality requiring mitigation and management include:

- siltation and surface runoff contaminant loading;
- airborne contaminant loading;
- discharge contaminant loading; and
- ML/ARD.

Maintaining high-quality freshwater and stream sediment is important for the wellbeing of human communities, as well as aquatic plant and animal life in the region. This is especially the case in Nunavut where freshwater environments play important ecological, economic and cultural roles. Mitigation measures, best management practices and engineering of the road will be used wherever possible to protect the freshwater environment. During the construction and operation of the road, active erosion of terrain on or adjacent to the road will be prevented to avoid alteration of natural drainage patterns.

The proposed Project involves construction and operation of a 211 km road which includes spur roads to quarry sites, camps and port facilities. All roads will require routine summer maintenance to prevent or correct stream bank failures, sinkholes or blockage of culverts at crossings.

5.2 Water Quality and Sediment Management Plan

A number of considerations will be evaluated for environmental protection at sites along the road, especially during construction. Best management practices (BMPs) will be implemented as the basis for all work undertaken, particularly when working in or around water. Examples of BMPs to preserve freshwater quality and sediment quality include:

- selecting appropriate clean equipment;
- endeavoring to keep existing vegetation intact wherever possible, as it will provide significant benefits for sediment management;

- in all sloped areas being disturbed, minimizing the steepness of slopes to limit erosion potential;
- installing silt fencing during construction;
- use sediment control ponds at quarries and at the camp; and
- using water as a dust suppressant on in areas of high traffic (*i.e.*, the camp) during dry periods, if required.

The selected measures will be installed based on a site-specific basis and as prescribed by the site supervising professional or Environmental Monitor during construction and the Environmental Coordinator during operations.

5.2.1 General Mitigation Measures

Where possible, Bathurst Inlet Port and Road Joint Venture Ltd. (the proponent) will continue to identify areas of higher risk for water quality and sediment quality during the various phases of the Project. Mitigation measures to prevent the contamination of water and sediment quality will begin with the detailed road design and include the construction, operation, decommissioning and post-closure phases. These measures will largely focus on the reduction of downstream sediment loadings to minimize effects on water and sediment quality. A number of examples of effective best management practices for the preservation of water and sediment quality are summarized below:

- maximizing the diversion of clean waters around areas of potential disturbance during construction;
- establishing buffer zones around disturbed areas for natural filtering of surface runoff waters en route to watercourses;
- intercepting sources of potential sediment-laden waters as close to the disturbed area as possible and using runoff control and conveyance measures to move these waters to a receiving waterbody;
- revegetating of disturbed areas near water;
- using appropriate sediment traps and barriers such as silt fences around disturbed areas to minimize erosion;
- using sediment catchment basins if needed;
- properly storing and handling fuels and other chemicals at camps and on road (earth berms surrounding storage tanks, maintenance of tanks and hoses); and
- monitor freshwater quality and sediment quality.

5.2.2 Construction Phase

The construction phase will have a specific set of issues, as it involves the disruption of existing habitat and terrain. Disturbances caused by construction tend to release fine sediments (*e.g.*, silt) into surface waters, resulting in the decline of water quality and stream sediment quality.

Therefore, along with the above general mitigation measures the following measures should also be followed:

- Surface drainage patterns will be managed to minimize erosion and associated sedimentation during construction;
- Measures such as armouring and silt fencing will be utilized along the road to prevent sediment access to streams and waterbodies;
- Disturbed areas will be revegetated where possible;
- Receiving waterbodies from quarries that have been identified as potential ML/ARD will be monitored;
- A qualified Environmental Monitor will ensure necessary measures are implemented to protect the environment during the construction phase; and
- The Environmental Monitors will conduct water quality monitoring (*e.g.* measuring turbidity) at all streams during installation of stream crossings structures to ensure water and sediment quality is not impacted by sedimentation or other potential accidental spills.

5.2.3 Operation Phase

The operations phase will present a different set of issues in the management of water and sediment quality. Measures to mitigate effects to water and sediment quality include:

- routine erosion control and sediment management along the road, especially following periods of precipitation or snow melt;
- inspections of disturbed areas (*e.g.*, bridge and culvert installations) for signs of erosion and sediment discharge into watercourses;
- developing procedures for the collection and analysis of water samples (*e.g.* for STP effluent, and receiving waterbodies from quarries with a risk of MC/ARD);
- development of a notification and emergency response procedure; and
- treated sewage effluent piped from the camp to Contwoyto Lake will undergo tertiary treatment to remove solids, nutrients and organics, and to condition the discharge water such that it does not alter the physical, chemical or biological properties of the lake.

5.2.4 Decommissioning and Post-Closure

Upon decommissioning of the road, the camp will be closed and dismantled. Some areas will be recontoured, stabilized and allowed to regenerate and return to the natural terrestrial habitat.

The specific mitigation measures to ensure water and sediment quality in the Project area include:

- Sediment control works will be very similar to those used during camp construction and operations.

- The camp will be re-graded and stabilized and allowed to naturally regenerate to prevent erosion for the long-term.
- Water quality monitoring will continue if there are any problems with ML/ARD.

6. MONITORING AND EVALUATION

6. Monitoring and Evaluation

Monitoring and evaluation for the Project will include the use of Environmental Monitors during the construction phase to ensure best management practices are followed. During operations the monitoring of the road conditions will be conducted every summer to determine if any repairs are required regarding culverts, slopes, eroded areas, and depressions.

During construction, and as far into the future as required, water quality would be monitored in the receiving environment of quarries that were identified as potentially acid generating. Water quality samples would be collected at freshet. Sampling will continue after required remediation activities until the risk of ML/ARD is considered negligible.

During construction and operations, the treated sewage effluent discharge piped from the lake camp to Contwoyto Lake will be permitted, and several variables will be monitored based on regulatory requirements in the water license. These will likely include:

- discharge flow volume;
- pH;
- TSS/turbidity;
- fecal coliforms; and
- biological oxygen demand.

Effluent monitoring will ensure that Contwoyto Lake is not affected by low-level nutrient or organic loading from the treated waste discharge. The frequency, duration and geographic extent of monitoring will be determined during the Water License Application.

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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 C-3
Freshwater Aquatic Resources Effects Assessment

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

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Bathurst Inlet Port and Road Project Freshwater Aquatic Resources Effects Assessment

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

ARD	acid rock drainage
BIPR	Bathurst Inlet Port and Road
BMP	best management practices
CCME	Canadian Council of Ministers of the Environment
DEIS	Draft Environmental Impact Statement
EIS	Environmental Impact Statement
EVS	EVS Environment Consultants
LSA	local study area
ML	metal leaching
NIRB	Nunavut Impact Review Board
NTKP	Naonaiyaotit Traditional Knowledge Project
PAH	polycyclic aromatic hydrocarbon
PAG	potentially acid-generating
STP	sewage treatment plant
RSA	regional study area
TOC	total organic carbon
TSS	total suspended solids
the Project	the Bathurst Inlet Port and Road Project
the proponent	Bathurst Inlet Port and Road Joint Venture Ltd.
Rescan	Rescan Environmental Services Ltd.
VEC	valued ecosystem component

1. INTRODUCTION

1. Introduction

The freshwater environment is critical to the ecological, economic and cultural health of Nunavut. Primary and secondary aquatic producers can be useful indicators of water quality and the health of the environment. Water quality is important to every human community, as well as for aquatic plant and animal life in the region.

The Bathurst Inlet Port and Road (BIPR) Project (the Project) is located in the Kitikmeot region of Nunavut. An ocean port in Bathurst Inlet and a camp at Contwoyto Lake will be developed. The proposed marine port is located on the west side of Bathurst Inlet approximately 40 km south of the community of Bathurst Inlet. This effects assessment for the proposed all-weather road considers the construction and use of a 211 km road from the port site to its end at the southern shore of Contwoyto Lake. The road will connect to the existing winter road accessing mines in the region.

Historical information is available for the aquatic biology (*i.e.*, physical limnology, sediment, periphyton, phytoplankton, zooplankton, benthos) (Moore, 1978; EVS, 1996) of Contwoyto Lake. Located at the southwest end of the road route, this lake is the major waterbody of the area, with a surface area of approximately 950 km^2 (95,600 ha.) and a drainage area of 8,000 km^2. In addition, 104 crossings (of which 70 had defined channels) are located along the road route between Bathurst Inlet and Contwoyto Lake (Figure 1.1-1) Detailed baseline freshwater information on the biology and chemistry of the habitat along the proposed road route was collected during baseline studies in 2001 (Appendix C-6 and C-7 of the Draft Environmental Impact Statement (DEIS)) to determine environmental conditions prior to development.

The objective of the baseline studies conducted in 2001 was to characterize the aquatic environment within the BIPR Project area in order to meet the criteria of an Environmental Impact Statement (EIS) as required by the Nunavut Impact Review Board (NIRB). These studies included biological assessment of following components of the aquatic ecosystem:

- physical limnology;
- water quality;
- sediment quality;
- primary producers: periphyton and phytoplankton;
- secondary producers: zooplankton and benthic invertebrates (or benthos); and
- fish and fish habitat.

This report will focus on primary and secondary producers in freshwater streams and lakes.

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November 15, 2007

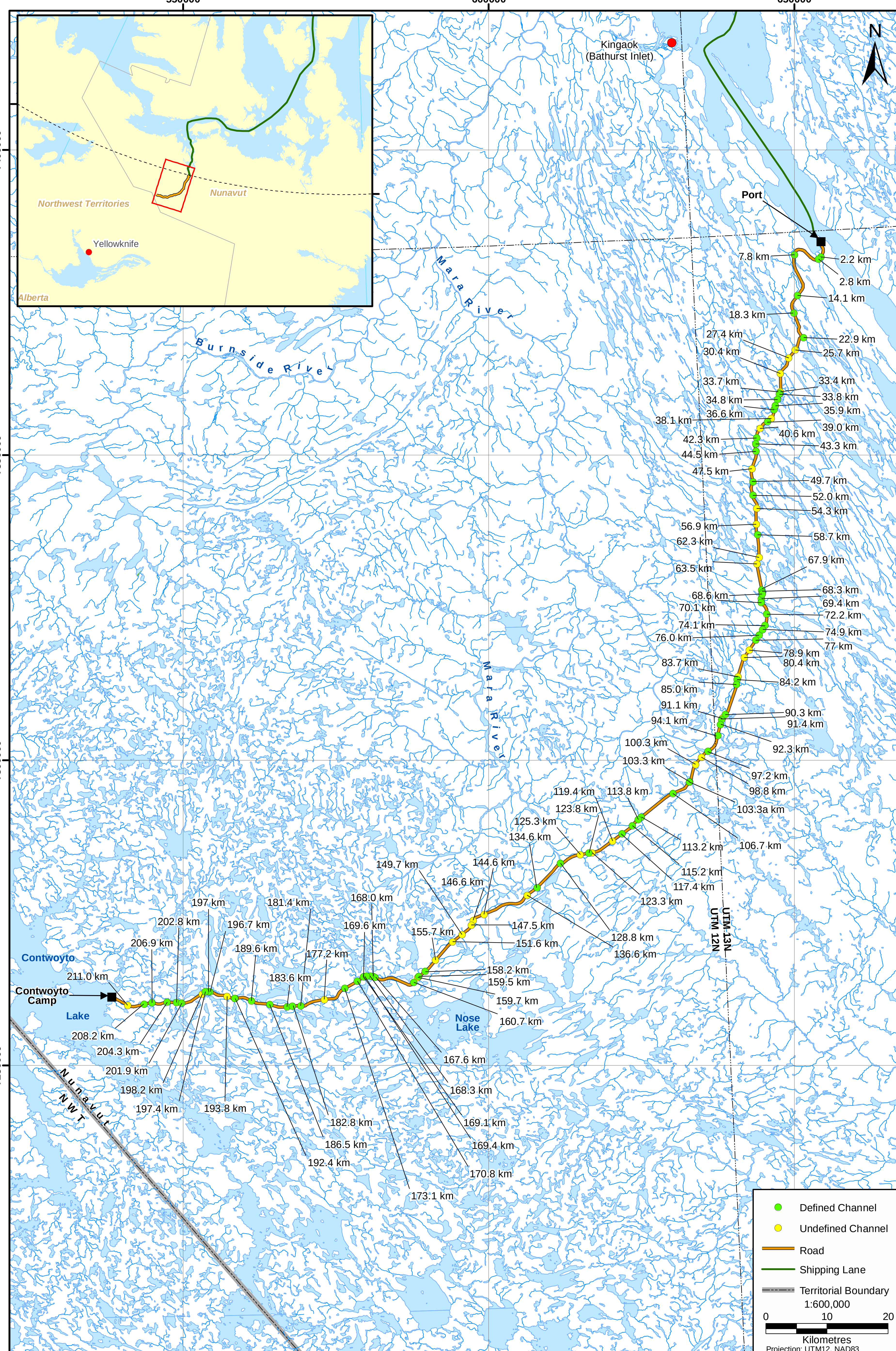

FIGURE 1.1-1

the BATHURST INLET PORT AND ROAD PROJECT

Stream Crossings of the Bathurst Inlet Port and Road Project

Rescan

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2. ENVIRONMENTAL SETTING

2. Environmental Setting

2.1 Regional Setting

The regional study area (RSA) for freshwater aquatic resources includes all watersheds that the road passes through. The RSA is southwest of Bathurst Inlet and runs through the Amagok Creek, Western River, Siorak River, and the Mara River watersheds before reaching drainages for Contwoyto Lake. The local study area (LSA) includes all crossings and the bay located in the southeastern portion of Contwoyto Lake (which will receive treated sewage effluent) where the road terminates. The LSA encompasses 200 m on either side of the road at each crossing and along the shoreline of Contwoyto Lake adjacent to the camp.

Preserving the quality of freshwater systems is considered very important to the Inuit in the area. This is the case not only in the context of providing good quality habitat for fish but also to fulfill the need for potable water. As summarized in the Naonaiyaotit Traditional Knowledge Project (NTKP), potable water is not always readily available and may require travel to obtain (Appendix F-5 of the DEIS). The NTKP is an important source of knowledge for this environmental impact assessment of the Project.

2.2 Streams

Primary and secondary producer communities were sampled in streams along the road route from Bathurst Inlet to Contwoyto Lake. In 2001, a total of six stream crossings were surveyed for primary and secondary producers (kms 2.2, 72.2, 84.2, 134.6, 192.4 and 206.9) (Figure 2.1-1; Appendix C-6).

Periphyton chlorophyll *a* biomass was generally <100 $\mu g/cm^2$ with the exception of site B3 (km 134.6; 273 $\mu g/cm^2$). For the streams of the Jericho Project, periphyton biomass was also low, related to the oligotrophic conditions of the region (0.6 to 16.8 ug/cm^2) (RL&L, 2000). In general, periphyton densities were similar to those observed in other undisturbed tundra streams (Rescan, 1995). All the sites had average periphyton densities below 4 x 10^5 $cells/cm^2$ except at site B6 (km 2.2) where densities reached an average above 12 x 10^5 $cells/cm^2$. However, biomass was very low at this site which was dominated by numerous small diatoms. Periphyton diversity varied considerably among streams. Richness ranged from 17 to 39 genera, and Simpson Diversity Indices ranged from 0.57 (moderate) to 0.91 (high). Cyanophytes were the most abundant primary producers (63%), followed by diatoms (29%) and green algae (8%), similar to periphyton communities reported for the High Lake Project (Wolfden, 2007) and the Doris Hinge Project (RL&L, 2002).

Benthic invertebrate populations were generally <3,500 $organisms/m^2$ with the exception of the site B3 (7,181 $organisms/m^2$). Richness ranged from 16 to 48 taxa. Dipteran larvae (mainly chironomids) dominated the stream benthic communities of three streams, while nematodes dominated another site (B1), and dipterans and stoneflies shared dominance with mayflies and oligochaetes at the two remaining sites.

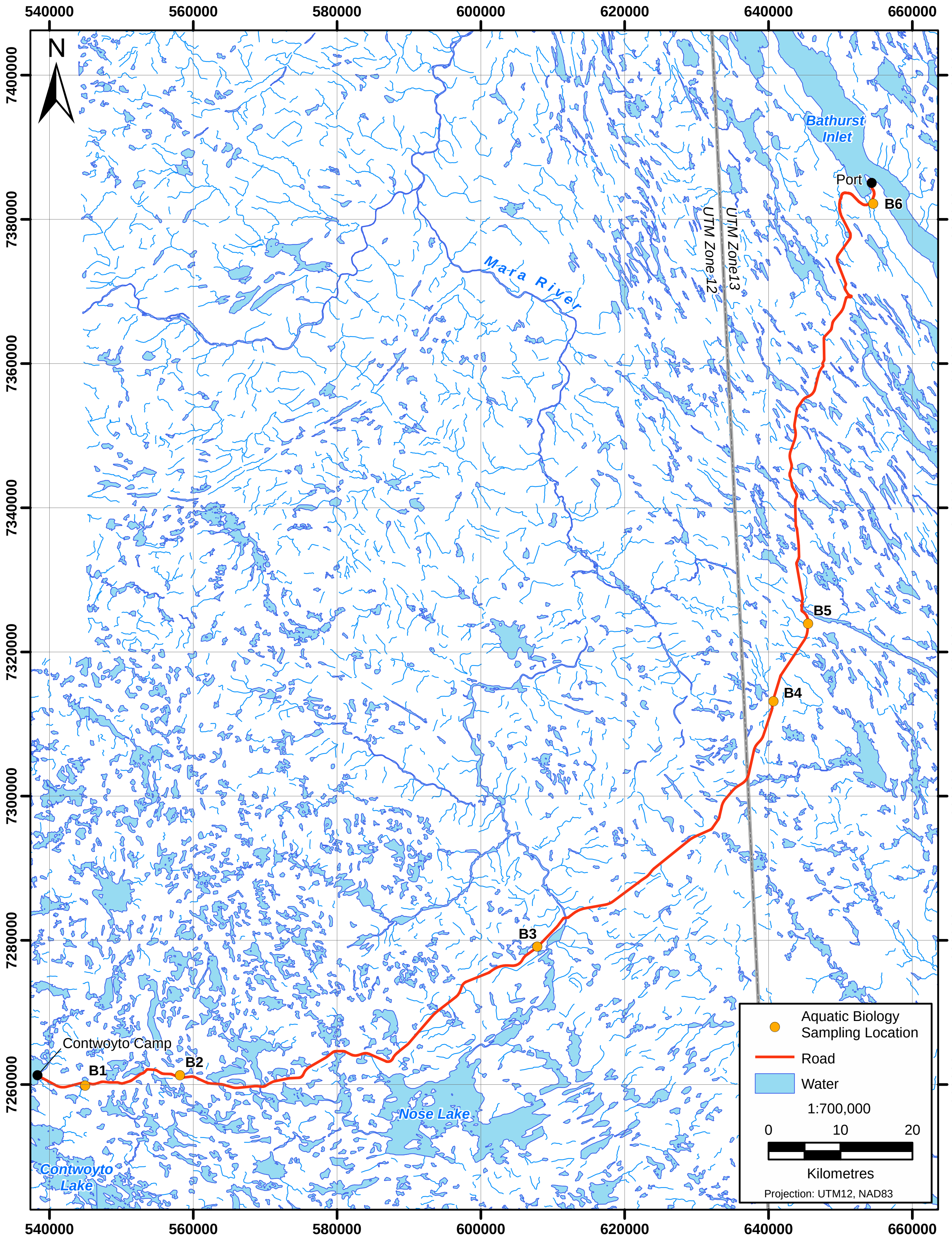

FIGURE 2.1-1

Aquatic Biology Stream Sites along the Road of the Bathurst Inlet Port and Road Project

The Bathurst Inlet Port and Road Project

Rescan

Caddisfly larvae were also present in modest numbers at all sites. Chironomids, stoneflies and mayflies were dominant in study streams of the High Lake Project (Wolfden, 2007).

2.3 Contwoyto Lake

Aquatic ecosystems were sampled in Contwoyto Lake at the terminal end of the road for physical limnology, primary producers, and secondary producers. Three sites spanning the length of the lake were surveyed.

Surface water temperature in August averaged 12.7°C, dissolved oxygen averaged 10.3 mg/L, with a saturation of 97% (Appendix C-6 of the DEIS). Bathymetry indicated that depth ranged from 1.8 to 30 m. The lake was not thermally stratified during the sampling period, as the temperature difference from surface to bottom was only 0.2°C. Light penetration through the clear surface waters was very good, with a Secchi disk depth of 12.3 m.

Phytoplankton communities in August showed relatively high diversity (32 genera), but were low in total abundance (<150 cells/mL) and chlorophyll *a* biomass (ranged from 0.20 to 0.63 μg/L (Appendix C-6 of the DEIS). The community was dominated by chlorophytes (45%) and dinoflagellates (31%), followed by chrysophytes (12%) and diatoms (10%). Similar phytoplankton assemblages were observed for the Jericho Project (RL&L, 2000) and the High Lake Project (Wolfden, 2007). Phytoplankton density ranged from 134 to 44,336 cells/mL in lakes of the Doris Hinge Project, showing the high variability among sites where cyanophytes dominated (RL&L/Golder, 2002).

Zooplankton communities showed a similar trend to phytoplankton, with an average diversity of 14 species and a density of <31,000 organisms/m^3. The dominant group were rotifers (53%), with the rest of the community made up mostly of cladocerans (21%), cyclopoids (15%) and calanoids (9%). For the High Lake Project, zooplankton density ranged from 22 to 14,342 organisms/m^3, and both cyclopoid and calanoid copepods dominated with smaller proportions of daphnid cladocerans present (Wolfden, 2007). Rotifers (very small-bodied zooplankton) were also dominant in lakes of the Doris Hinge Project, with larger-bodied cladocerans also present in moderate densities (RL&L, 2002). Densities were highly variable (1,683 to 44,796 organisms/m^3) among lakes of the Doris Hinge Project. Zooplankton density ranged from 3,040 to 6,017 organisms/m^3 for the Jericho Project, and calanoids and cladocerans dominated with lesser numbers of rotifers (RL&L, 2000).

The average density of benthic invertebrates in Contwoyto Lake was less than 1,750 organisms/m^2, with the community comprised of 21 genera. Kick net sampling done for the High Lake Project revealed low densities (2 to 78 individuals per sample), with chironomids dominant and smaller numbers of oligochaetes and other taxa present (Wolfden, 2007). These low densities are likely related in part to the naturally high background metal concentrations in the vicinity of the proposed mine site. For the Jericho Project, nematodes and chironomids were dominant in littoral zones, and chironomids were dominant at deeper zones (RL&L, 2000). Dipterans (chironomids) also dominated the community (52%) in Contwoyto Lake, followed by molluscs (21%) and nematodes (11%) and seven other taxa comprised the remaining 16%.

3. METHODOLOGY

3. Methodology

3.1 Valued Ecosystem Component Selection

The Project has the potential to negatively affect freshwater aquatic resources both directly and indirectly throughout the lifetime of the road. As a result, freshwater aquatic resources were identified as a potential valued ecosystem component (VEC) based on their ecological importance as food sources to fish which have a cultural importance. The VEC considered in this document included all physical and biological components of the freshwater environment in the Project area (except for fish and fish habitat, which were treated as separate VECs). For this assessment, the freshwater aquatic resources VEC included all primary producers (periphyton and phytoplankton) and secondary producers (zooplankton and benthic invertebrates, or benthos) and their freshwater habitat.

VEC selection is based on the results of two activities. First, baseline studies were performed involving the sampling of six streams along the road alignment, up to and including Contwoyto Lake. Also, public scoping was performed by NIRB. This process involved holding public meetings involving local interest groups including regional and local government officials, community representatives, commercial harvesters, outfitters, and the general public. At these meetings representatives from Rescan Environmental Services Inc. (Rescan) provided information regarding environmental baseline information acquired in the Project area.

Following the completion of baseline studies and public scoping, freshwater aquatic resources was selected as a VEC. The scientific rationale for its selection includes its importance as a fundamental component of aquatic ecosystem diversity, its ability to produce and transfer energy through the ecosystem (source of food to fish), and its involvement in oxygen production, and nutrient and organic cycling (contributing to fish habitat).

Potential impacts to freshwater aquatic resources include: sublethal effects and mortality associated with increased ions, metals and total suspended solids in waters; loss or alteration of aquatic habitat due to construction (*i.e.*, sedimentation); and altered productive capacity at a community level (resulting from nutrient loading or degradation, or related to either of the first two effects listed above).

3.2 Boundaries

Boundaries are defined to give both a spatial and temporal extent of the impacts that are potentially expected from the Project.

3.2.1 Spatial Boundaries

The main Project infrastructure will be the port and related facilities at Bathurst Inlet and the road to Contwoyto Lake. The proposed marine dock is situated on a rocky peninsula over 2 km from the nearest freshwater stream or lake; therefore, this Project component was included only in marine aquatic VECs assessments.

The road will cross streams in the Burnside and Western river basins as well as smaller basins draining directly into Bathurst Inlet, and will terminate on the east side of Contwoyto Lake. Therefore, the lake and all watersheds crossed by the road and streams downstream of the road make up the spatial boundary for the regional study area, and a 200 m buffer zone on either side of the road demarcates the local study area for this effects assessment.

Any resulting lethal or sublethal effects are considered in light of the residing primary and secondary producer communities existing in the study area. This therefore implies that effects are assessed at the scale of an entire length of a stream, or an entire lake, as appropriate for that local biological community, and to what extent these potential effects could affect the entire community (and not single individuals). Effects on a sub-local scale are noted and considered in this assessment (and in the Cumulative Environmental Effects Assessment (Appendix G-5 of the DEIS), where applicable), but do not constitute significant residual effects by themselves.

3.2.2 Temporal Boundaries

Temporal boundaries incorporate the Project's proposed lifetime (21.5 years including construction and operation), and extend into closure (1 year) and post-closure.

3.3 Approach and Methods

The environmental assessment approach used in this assessment is similar to that described for the Project as a whole (Appendix A-5 of the DEIS). The assessment uses all currently available information on Project design and existing environmental conditions (from baseline data) to provide realistic and plausible characterization of potential effects to freshwater aquatic resources. It does not rely on models, but consists of logical discussion of physical and chemical processes in relation to biological receptors, based on professional judgment. It inherently assumes throughout the assessment that activities of road building, transport, storage, and sewage treatment/disposal will use appropriate technology and best management practices to properly mitigate or minimize effects. Procedures associated with these Project activities are well developed and understood from decades of previous experience. However, all potential effects are examined, including spills and road failures.

4. EFFECTS ASSESSMENT

4. Effects Assessment

Freshwater aquatic resources may experience adverse effects from various Project activities including: 1) mortality or sublethal effects (*e.g.*, reduced growth rates of algal species, chemicals entering habitat and causing increased benthic drift in streams); or 2) habitat loss and physical alteration. These effects could translate into reduced productive capacity at the community level. Therefore altered productive capacity is included in discussions of mortality, sublethal effects, or habitat loss/alteration (including eutrophication), but not on its own. Water quality, sediment quality, and fish and fish habitat in freshwater systems are each treated as separate VECs assessed in individual reports.

All Project activities were screened for their potential to cause effects to freshwater aquatic resources. Following this screening, a detailed evaluation of each activity's potential effects to aquatic resources was conducted, in consideration of planned Project design and mitigation strategies (Table 4.1-1). Potential effects to biological receptors (*i.e.*, aquatic resources) are discussed by physical or chemical stressors (*e.g.*, sedimentation) arising from Project activities (*e.g.*, road construction).

4.1 Mortality and Sublethal Effects

Aquatic biota may experience mortality related to some proposed Project activities. Mortality may occur coincident to the destruction of habitat during construction activities within or near streams, by removal of organisms in excavated substrates (pier construction), or by smothering of organisms with road debris (sand and gravel). Mortality may also be caused by exposure to various contaminants related to accidental discharges into nearby waterways, including possible ML/ARD release from quarries, treated effluent discharge from camps, or chemical/fuel spills during ground transport along the proposed all-weather road.

Project activities may also cause adverse sublethal effects that do not result in mortality but which lead to reduced aquatic productive capacity on a community level. These sublethal effects could include reduced growth, altered physiology, reduced reproduction, and behavioural changes (*e.g.*, avoidance of an area).

Both lethal and sublethal effects can be direct or indirect, and are considered together in this assessment. Indirect effects include a change in food availability to benthos, reduced benthic habitat quality from algal die-off, and trophic effects (changes in prey or predator numbers affecting a group of organisms).

Physical or chemical stressors related to Project activities and acting as sources of biological effects are grouped together and discussed below. These include direct removal, sedimentation, aerial deposition, metal leaching, leaching of blasting residue, planned discharges, spills, and blasting vibrations. Resulting lethal or sublethal effects to aquatic resources directly affects their productive capacity.

4.1.1 Direct Removal

During construction, installation of the two bridges will involve destruction of small surface areas of stream habitat (under piers or under rip rap support structure at each bridge), resulting in direct mortality of aquatic biota. However, many benthos will drift downstream of in-stream activity, and will quickly colonize the disturbed areas around culverts and bridge pilings in the same season. This will also occur following removal of bridges in the closure phase. Culverts will be built on dry land and will not affect stream habitat or biota. For these reasons, and the relatively insignificant areas that will be disturbed relative to total stream length, direct removal will have no significant residual effect on aquatic resources (Table 4.1-1).

Water drawdown at Contwoyto Lake (6,000 L/day or 6 m^3/day) represents less than 0.000001% of the lake water volume. Water will be returned as treated effluent to the lake. Therefore, the effect on lake water levels and biota will be negligible. All water use from the lake will be regulated in the water licence from the Nunavut Water Board.

4.1.2 Sedimentation

During construction, sediment loading (sedimentation) to the nearby freshwater environment has a high probability of occurring. Large quantities of rock substrate of various sizes will be used to build the road, and this will be obtained by blasting at several quarry sites along the proposed road. During construction, and to a lesser extent, operations, rock will be crushed at the quarries and transported to the road terminus for 'end-loading', some of which could enter streams. Snow removal during winter will redistribute sand and gravel to the road side which could lead to sedimentation in adjacent waterways. During all Project phases, erosion of road banks at stream crossings from construction to closure could result in sedimentation of local streams. During closure and decommissioning, minor sedimentation could also occur when bridges are removed, but this was rated as a negligible effect.

Spring thaw will result in a low (operations) to moderate (construction) pulse of total suspended sediment (TSS) into local waterways based on quantities of substrate being used on the road at these phases. Most larger grain TSS will settle out in the immediate stream area near the point of sedimentation, and finer TSS will likely travel through the system over a period of days to weeks depending on flow rates. This pulse will be for a short period and local, lethal, and sublethal effects including burial of periphyton and benthos would be considerable only at the immediate perimeter of the road. Effects will be limited to smaller quantities of fines extending further along the length of most streams due to dilution with clean waters from surrounding areas, reducing the TSS pulse as it progresses from the road. On a regional scale, impacts were judged to be of low significance during all Project phases since the local habitat affected is not unique to the region. Effects will be mitigated through use of best management practices, silt fences, water quality monitoring during construction, and proper culvert and bridge design, installation, and removal as required.

4.1.3 Aerial Deposition

During construction, truck transport of road substrate as well as sand and gravel stockpiles will be a source of wind-blown finer particulates, and depending on particle size, some aerial deposition of dust to surrounding waterways could occur.

Table 4.1-1
Summary of Effects Assessment for Freshwater Aquatic Resources

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
Description	Project Phase (Timing)	Project Component	Direction	Nature	Design Changes, Management, Monitoring, Compensation, Enhancement	Description of Residual Effect (after mitigation)	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Ecological Context (Resilience)	Influence on Resource Capacity	Probability of Occurrence	Significance	Confidence Limit
Sedimentation into waterways from movement of road construction materials, bank erosion/failure causing mortality, sublethal effects, and habitat loss/alteration	Construction	Road	Adverse	Direct and Indirect	Silt fences, best management practices in constructing road and camp, water quality monitoring, Erosion and Sediment Control Plan	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Moderate	Local	Short-term	Sporadic	Reversible Short-term	High	Nil	High	**Low**	High
Sedimentation into waterways from movement of road construction materials, bank erosion/failure mortality, sublethal effects, and habitat loss/alteration	Operation	Road	Adverse	Direct and Indirect	Silt fences, best management practices in constructing road and camp, Erosion and Sediment Control Plan	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Low	Local	Short-term	Sporadic	Reversible Short-term	High	Nil	Moderate	**Negligible**	High
Sedimentation into waterways from removal of bridges and structures and recontouring landscape mortality, sublethal effects, and habitat loss/alteration	Decommissioning and Closure	Road	Adverse	Direct and Indirect	Silt fences, best management practices, Erosion and Sediment Control Plan	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Low	Local	Short-term	One-time	Reversible Short-term	High	Nil	Low-Moderate	**Negligible**	High
Freshet sedimentation into waterways from winter buildup of road and diesel exhaust particulates, snow removal to banks transferring sand/gravel - physical effects of TSS causing mortality, sublethal effects, and habitat loss/alteration	Construction	Road	Adverse	Direct and Indirect	Best management practices in winter road construction and snow management (sand/gravel), water quality monitoring.	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Moderate	Local	Short-term	Regular	Reversible Short-term	High	Nil	High	**Low**	High
Freshet sedimentation into waterways from winter buildup of road and diesel exhaust particulates, snow removal to banks transferring sand/gravel - physical effects of TSS causing mortality, sublethal effects, and habitat loss/alteration	Operation	Road	Adverse	Direct and Indirect	Best management practices in winter road management (sand/gravel).	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Low	Local	Short-term	Regular	Reversible Short-term	High	Nil	High	**Low**	High
Aerial deposition of dust/particulates from blasting, rock crushing, incinerating garbage causing mortality, sublethal effects, and habitat loss/alteration	Construction	Road	Adverse	Direct and Indirect	Dust suppression, silt fences, best management practices in constructing road and camp, water quality monitoring, Erosion and Sediment Control Plan	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Moderate	Local	Short-term	Sporadic	Reversible Short-term	High	Nil	Low	**Negligible**	Moderate
Aerial deposition of dust/particulates from blasting, rock crushing, incinerating garbage causing mortality, sublethal effects, and habitat loss/alteration	Operation	Road	Adverse	Direct and Indirect	Dust suppression, silt fences, best management practices in constructing road and camp, Erosion and Sediment Control Plan	Minor pulses of TSS causing some mortality, reduced growth through respiratory inhibition, reduced photosynthesis due to covering/increased turbidity, benthic drift increased, reduced egg survival	Low	Local	Short-term	Sporadic	Reversible Short-term	High	Nil	Low	**Negligible**	Moderate
Cement spill during transport enters waterway causing mortality, sublethal effects, and habitat loss/alteration	Operation	Road	Adverse	Direct	Proper driver training, handling of cement at camps and on trucks, Spill Contingency and Emergency Response Plan.	Potential for cement materials to enter waterways causing localized physical effects to biota	Low	Local	Short-term	One-time	Reversible Short-term	High	Nil	Low	**Negligible**	High
PAHs and hydrocarbons from camp power generation and truck diesel exhaust causing mortality, sublethal effects	Construction	Road	Adverse	Direct and Indirect	Use of well-maintained trucks and generators to reduce emissions.	Potential for particulates, PAHs and hydrocarbons from trucks and generators to cause localized toxic effects to biota	Low	Local	Short-term	Continuous	Reversible Short-term	High	Nil	Moderate	**Negligible**	High
PAHs and hydrocarbons from camp power generation and truck diesel exhaust causing mortality, sublethal effects	Operation	Road	Adverse	Direct and Indirect	Use of well-maintained trucks and generators to reduce emissions.	Potential for particulates, PAHs and hydrocarbons from trucks and generators to cause localized toxic effects to biota	Moderate	Local	Short-term	Continuous	Reversible Short-term	High	Nil	Moderate	**Negligible**	High
Fuel spill at camp or during transport enters waterway causing mortality, sublethal effects to biota, altered habitat	Operation	Road	Adverse	Direct and Indirect	Proper storage and handling of fuels at camps and on trucks, use of berms, Spill Contingency and Emergency Response Plan, water quality monitoring (construction phase only)	Potential for PAHs and hydrocarbons from fuel spill/leak to cause localized toxic effects to biota, altered habitat	High	Local	Short-term	One-time	Reversible Short-term to Medium-term	Neutral to low	Nil	Very low	**Low**	Moderate
MLARD from quarry walls causing metal loading to waterways, mortality, sublethal effects to biota	All	Road	Adverse	Direct and Indirect	MLARD assessment of quarry rock cutwalls and substrates for road, appropriate use of rock for road, avoiding acid-generating sources, water quality monitoring.	Potential for metal loadings from quarry areas into waterways leading to toxic effects to biota	Low	Local	Short-term	Regular	Reversible Short-term	High	Nil	Unknown	**Negligible**	Moderate
Eutrofication from sewage from lake and road camps leading to increased algal growth, possible shift in ecosystem structure and function (mortality, sublethal effects, and habitat loss/alteration)	Construction	Road	Adverse	Direct and Indirect	Tertiary treatment of camp sewage will remove/reduce solids, nutrients, metals and oxygen demand.	Potential for minor increases in N loading, increasing algal production, ecosystem shift	Low	Local	Short-term	Regular	Reversible Short-term	High	Nil	Low-Moderate	**Negligible**	High
Eutrofication from sewage from lake camp leading to increased algal growth, possible shift in ecosystem structure and function (mortality, sublethal effects, and habitat loss/alteration)	Operation	Road	Adverse	Direct and Indirect	Tertiary treatment of camp sewage will remove/reduce solids, nutrients, metals and oxygen demand.	Potential for minor increases in N loading, increasing algal production, ecosystem shift	Low	Local	Short-term	Regular	Reversible Short-term	High	Nil	Low-Moderate	**Negligible**	High
Nitrogen input from blasting residues eutrofying waterways, possible shift in ecosystem structure and function (mortality, sublethal effects, and habitat loss/alteration)	Construction	Road	Adverse	Direct and Indirect	Proper storage and handling of blasting materials away from waterways, regular maintenance of facility, berms, and local water quality monitoring	Potential for minor increases in N loading, increasing algal production, ecosystem shift	Low-Moderate	Local	Short-term	Sporadic	Reversible Short-term	High	Nil	Low	**Negligible**	Moderate
Treating contaminated soils and removing sludge could lead to water quality degradation affecting aquatic biota (mortality, sublethal effects, and habitat loss/alteration)	Decommissioning and Closure	Road	Adverse	Direct and Indirect	Proper storage and handling of sludge and soils, storage away from waterways, regular maintenance of facility, berms.	Potential for minor increases in contaminants and N loading, adverse effects to biota	Low-Moderate	Local	Short-term	One-time	Reversible Short-term	High	Nil	Low	**Negligible**	Moderate
Habitat Loss under footprints of bridge pilings, crossings materials on banks(mortality and sublethal effects during construction only)	Construction, Operation	Road	Adverse	Direct	Silt fences, best management practices in constructing road and camp, water quality monitoring (constr. only), Erosion and Sediment Control Plan, Habitat Compensation.	Loss of habitat under footprints for life of project until reclaimed.	Low	Local	Medium-term	Regular	Reversible Short-term	High	Nil	High	**Negligible**	High
Loss of Habitat due to lake water drawdown	Construction	Road	Adverse	Direct	Regulate water usage relative to lake water stage if required beyond 6,000 L/d	none	-	-	-	-	-	-	-	-	-	-
Loss of Habitat due to lake water drawdown	Operation	Road	Adverse	Direct	Regulate water usage relative to lake water stage if required beyond 6,000 L/d	none	-	-	-	-	-	-	-	-	-	-
Sedimentation from Blasting Tremors at quarries, causing lethal and sublethal effects, and habitat alteration	Construction	Road	Adverse	Direct	Allow time between blast for aquatic biota and habitat to recover/ restabilize.	Localized burial of periphyton and benthos in adjacent streams and lakes, leading to lethal/sublethal effects, habitat alteration.	Low	Sub-local	Short-term	Sporadic	Reversible Short-term	High	Nil	Moderate-High	**Negligible**	Moderate

Summer road maintenance by pickup truck and graders (during operations) could also contribute to aerial dispersion of wind-blown particulates from the road to surrounding waterways.

However, exhaust from burning diesel from to truck engines, power generators, rock crushing, garbage and sewage incineration all release particulates and polycyclic aromatic hydrocarbons (PAHs) and other organics into the air. Many of these compounds are highly toxic to aquatic life. The magnitude of effects is low (construction) to moderate (during heavier traffic of operations), but the extent of effects is limited. Proper engine maintenance and technologies to minimize emissions will mitigate PAH release to the environment. Therefore, no significant lethal or sublethal effects are related to diesel exhaust. Air quality monitoring through dustfall collectors in winter and vegetation surveys in summer will be used to assess exposure and effects to aquatic environments. Through this, effects to aquatic resources will be mitigated.

Blasting residue can also travel airborne to surrounding waterways. The localized portions of waterways in the downwind zone of quarries may be subject to dust deposition leading to sublethal effects, but effects would not extend through the full area of watersheds. Therefore, no significant residual effects are expected at the local or regional level from aerial distribution of dust due to blasting (Appendix B-2 of the DEIS).

During spring thaw, airborne particulates from these sources combined will all be flushed as a pulse into adjacent waterways. The TSS loadings from these activities results in negligible to low magnitude residual effects to freshwater aquatic resources, limited to the sub-local area proximal to the road only. Aerial deposition of TSS will contribute to the low significant residual effects linked to sedimentation (as discussed in the preceding paragraphs).

4.1.4 Planned Discharges

The mobile camps along the road will treat sewage and all treated effluent discharge will be released to designated lands a minimum of 100 m from waterways or be trucked to the sewage treatment plant. No residual effects are expected based on proper handling and treatment procedures.

The camp at Contwoyto Lake will conduct tertiary treatment of its sewage, and effluent discharge will be piped into the lake, following regulated flow rates and permitted concentrations of regulated parameters (dependent on permit requirements from the Nunavut Water Board). Eutrophication of the lake could occur if nutrient levels are not strictly regulated. This could lead to increased phytoplankton growth, a shift in taxa and reductions in algal diversity due to changes in nutrient availability and physical habitat characteristics. Trophic effects are also possible (*e.g.*, nitrification leading to increased algal production resulting in increased oxygen demand (following die-off of algae) affecting fish populations). These effects are unlikely for three reasons: 1) due to the very large volume of the lake; 2) the use of tertiary treatment of sewage effluent; and 3) the early warning of potential future effects provided by routine effluent monitoring. This monitoring would indicate if sewage effluent quality was below permitted standards, whereby corrective action could be taken to reduce discharge or possibly alter the treatment process. Therefore, negligible biotic effects are predicted in relation to planned discharge of treated sewage effluent to Contwoyto Lake.

4.1.5 Leaching, Residues and Spills

4.1.5.1 Leaching

Metal leaching from rock used to build the road and from cutwalls of the quarry site may result in metal loading to aquatic environments that could lead to lethal and sublethal effects to aquatic biota. The characterization of quarry rock will permit appropriate selection and use of available rock substrates. However, some quarries have been identified as potentially acid-generating (PAG) rock, which could lead to metal toxicity to stream biota if not properly managed. There is a fair degree of uncertainty relating to the assessment of ML/ARD effects from quarried rock. However, there will be a ML/ARD Management Plan in place that will determine the potential for acid generation and metal leaching prior to any quarrying (Appendix D-2). Quarries that are PAG will not be used. Some water quality monitoring at quarry sites may be warranted. Based on this information, negligible residual lethal/sublethal effects to biota were assigned due to potential ML/ARD occurrence along the road.

4.1.5.2 Residues

Blasting residues are composed of nitrogenous compounds; if these compounds reach waterways, it could lead to nutrient loading, which can alter productive capacity, particularly in oligotrophic systems such as those of the Arctic region of Canada. The use of ammonium nitrate for blasting will provide nutrient loading to some degree, although this (like ML/ARD) depends on the specific details of each of the quarries, which are not fully designed at this time. A short pulse of nitrogen may reach adjacent waterways at some quarry areas during precipitation or freshet, but recontouring of surfaces would minimize runoff to streams, localizing any residuals at the quarries. Effects to aquatic resources would be minor, dependent on water chemistry (affecting speciation of the nitrogen compounds), but loadings would be low if they occurred. This will mitigate eutrophication of local streams and reduce the risk of lethal or sublethal effects of these compounds to aquatic life.

4.1.5.3 Spills

Sewage sludge will be incinerated at the Contwoyto Camp or port incinerator. As long as proper handling and disposal practices are followed, no effects to aquatic resources are predicted.

Transport and storage of blasting materials (ammonium nitrate) will follow standard protocols to safeguard against any releases to the aquatic environment, since both ammonia and nitrate are toxic to aquatic life, and could alter the trophic status of waterbodies through nutrient loading. Materials will be stored away from waterways, and staff will be trained in proper handling of materials. A spill contingency plan will be implemented (as with all chemicals used on this Project) and staff will be trained in proper containment and clean-up protocols. No significant effects to aquatic resources are related to the transport and storage of nitrogenous blasting compounds.

Truck transport of fuel and cargo (*e.g.*, cement) from the marine port westwards to Contwoyto Lake will be a potential source of spills to the aquatic environment. Cement components (sand, gravel, silicates, and lime) would not be of major concern as these are dry, fairly stable and non-toxic, and containment and clean-up would be fairly straightforward. However, diesel fuel spills

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from truck accidents could cause lethal and sublethal effects to aquatic biota depending on volumes released. The likelihood of a truck accident is fairly low given the relatively flat terrain of the region. Using data from the Diavik project (Diavik, 1998), a spill rate of 1/ (90,000,000) per truck per kilometre was calculated for travel on northern roads. Using an estimate of 5,262 truckloads of fuel per year, using the road length of 211 km, and a 20-year period, a spill rate of:

$$1/(90{,}000{,}000) \times 5{,}262 \text{ loads/year} \times 211 \text{ km} \times 20 \text{ years} = 1/4.05 = 25\%$$

was calculated. This indicates the probable incidence of fuel spills from truck transport is extremely low (25% chance that one truck will spill over the 20 years of operations, or approximately 1% chance that a truck will spill each year). The assumptions above are based on assuming drivers are well-trained and adhere to a strict policy of no alcohol or drug consumption while at work. The calculation is for a spill to occur along the road and the probability for the spill to occur over a waterbody is much lower.

This assessment considers the effects of a major fuel spill during winter transport, which may not be fully contained. The magnitude of lethal and sublethal effects would be high on a local level (portions of or entire length of a stream), since water quality in the Arctic region is quite pristine. Arctic biota are not generally adapted to chemical (*i.e.*, hydrocarbon) exposure, and diesel fuel is toxic to many forms of aquatic life. However, it does not persist nearly as long as crude oil compounds. It would be a short term pulse exposure. It was rated with very low likelihood but moderate certainty (based on currently available data), and would have a low residual effect.

4.1.6 Blasting Tremors

A total of 39 rock quarries are planned along the proposed road. All quarries will be greater than 30 m from any lakes and streams. Blasting at these quarries will cause compression and depression waves in the local area, which can alter physical habitat by destabilizing and disturbing bottom substrates, leading to redistribution of sediment, causing sublethal effects including reduced growth and reproduction. Algae density could be more seriously reduced (since benthos are mobile and can burrow out of sediment), however a reduction of algae could reduce benthic production through shortage of available food. Depending on frequency of blasting, distance to a waterbody, and substrate composition at each waterbody, increased turbidity during blasting could reduce algal production through reduced light penetration. As the majority of substrates observed in streams in 2001 were gravel and sand (Appendix C-6 of the DEIS), effects would likely be limited to lakes extremely close to one of the quarries. The blasting activity would pose a low magnitude of effect to biota, but limited on a spatial scale to within a relatively close radius of blast zone, and limited temporally to that period when that quarry was actively mined for rock. Effects to algae and benthos could translate to potential effects to fish species which feed on benthos (*e.g.*, Arctic grayling), coupled with direct effects to fish swim bladders (Appendix C-4 of DEIS). Residual effects are therefore expected to be spread out over time such that no stream-wide mortality or sublethal effects would occur. Recovery through recolonization would promptly follow termination of local blasting. Therefore, blasting is not expected to cause significant mortality or sublethal effects.

4.2 Habitat Loss and Alteration

Several Project components will result in potential loss or alteration of aquatic habitat. This could result in indirect loss of productive capacity of aquatic resources. Related activities include culvert and bridge installation and removal, cargo/fuel spills, and blasting tremors disrupting habitat through loss of substrate stability.

4.2.1 Direct Loss

As discussed in Section 4.1.1, the proposed development of an all-weather road and camp at Contwoyto Lake is associated with very minor potential loss of habitat. The 70 wetted stream crossings built with culverts or bridges that would be designed and be outside the bankful width of each stream to avoid any destruction of habitat. However, only two major crossings required under the current design will have effects on the substrate. Habitat loss would be limited to footprint surface areas of bridge pilings and protection of abutments with riprap (Appendix C-4), but these surface areas represent insignificant proportions (<0.1%) of the total stream habitats involved with the road. This means that productive capacity is not reduced to a measurable degree on a stream level of scale. Only sub-localized effects would occur from the construction of pilings and placement of riprap. Upon closure and decommissioning, however, pilings would be removed, altering habitat in the short-term. But recolonization by algae and benthos would be rapid as there would not be any residual stressors remaining. Therefore, no significant residual effects are related to direct loss of habitat under the road footprint.

Water drawdown at Contwoyto Lake (6,000 L/day or 6 m^3/day) represents less than 0.000001% of the lake water volume. Water will be returned as treated sewage effluent to the lake. Therefore the effect on lake water levels and aquatic habitat will be negligible. All water use from the lake will be regulated in the water licence from the Nunavut Water Board.

4.2.2 Sedimentation

Physical habitat alteration may occur due to sedimentation of waterways during construction and operation activities (*e.g.*, road failure, bank erosion, bulldozer spilling road materials into streams, aerial deposition of particulates from blasting and exhaust). However, by following proper engineering and best management practices, these occurrences should be minimized. While adverse biological effects were associated with sedimentation, habitat quality itself would not be significantly altered. Note that chemical habitat alteration is considered above (Section 4.1).

4.2.3 Planned Discharges

The mobile camps along the road will treat sewage and all treated effluent will be released to designated lands a minimum of 100 m from waterways or will be trucked to the treatment plants at Contwoyto Camp and at the port. No residual effects to habitat are expected based on proper handling and treatment procedures.

The camp at Contwoyto Lake will conduct tertiary treatment of its sewage, and treated effluent will be released to the lake following regulated flow rates and permitted concentrations of regulated parameters (dependent on permit requirements from the Nunavut Water Board).

Therefore, treatment and camp design/waste management will mitigate effect to the freshwater habitat.

4.2.4 Leaching, Residues and Spills

Aquatic habitat could be altered or lost due to metal leaching, residues, or fuel spills, which could release physical or chemical stressors. Metal inputs to aquatic environments from ML/ARD rock from quarries could alter the aquatic habitat of resident biota, but proper testing, classification and selection of appropriate building substrate (non-PAG) will act to mitigate significant effects. While biological effects could occur, habitat quality itself should not be altered, unless significant metal binding to sediment occurs. This is unlikely in streams due to the scarcity of metal-absorbing organic matter and clays, but could potentially occur in lakes. However, this metal transfer process would depend on several environmental factors, and there is therefore a high degree of uncertainty related to this assessment.

Blasting residues in quarry areas will be spatially isolated from nearby streams. Minor TSS and nutrient inputs to the nearest streams may occur as a pulse of low concentration over a small area only. Therefore, no significant effect of blasting residue loading to habitat quality is foreseen.

Transport of fuel during construction and operation of the Project presents a potential source of habitat alteration and chemical degradation. To avoid serious effects to waterways, proper driver training and education will be provided, and speed limits and laws regarding alcohol and drug use will be enforced. In the case of a major accidental spill of fuel, localized significant changes in the aquatic habitat would occur, related to lethal and sublethal impacts discussed in detail in Section 4.1, but extending to hydrocarbon pollution of aquatic sediment and shoreline substrate. To reduce the risk of a major spill, emergency spill procedures will be developed to deal with any fuel spill. These include the use of absorbent pads through to the digging of containment berms to minimize the spread of the fuel. It is expected that any rare truck accident resulting in fuel spills would result in only sub-local effects of moderate to high magnitude and medium duration. Fuel spills are therefore expected to have a low significant residual effect to habitat quality.

4.2.5 Blasting Tremors

As discussed in Section 4.1.4, blasting within any of the 39 proposed quarry zones may alter physical habitat by destabilizing and disturbing bottom substrates, leading to redistribution of sediment, which then buries invertebrates and algae. The blasting activity would pose a moderate level of adverse effect to aquatic habitat, but limited on a spatial scale to a relatively close radius of blast zone, and limited temporally to that period when that quarry was actively mined for rock. Altered aquatic habitat could compound potential effects to fish themselves, based on potential damage to fish swim bladders (Appendix C-4 of the DEIS). Residual effects are therefore expected to be spread out over time such that no stream-wide adverse effects to aquatic habitat would occur, and recovery through recolonization would promptly follow termination of local blasting. Therefore, blasting is not expected to cause significant effects to habitat.

4.3 Summary of Residual Effects to Aquatic Resources

Following the assessment of potential effects to aquatic resources in light of planned Project design and mitigation, some significant residual effects linked to lethal and sublethal effects to biota and altered habitat quality were identified. These include the:

- potential for fuel spills resulting in lethal and sublethal effects to aquatic biota, and degraded habitat quality;
- potential for sedimentation causing lethal and sublethal effects to biota, identified separately for construction, operation, and decommissiong/closure phases.

All of these effects could act separately or combine to reduce the productive capacity of freshwater aquatic resources. This could result in effects to other VECs, including freshwater fish species (*e.g.*, Arctic grayling in streams), and birds and mammals that feed on fish.

5. MITIGATION AND MANAGEMENT PLANS

5. Mitigation and Management Plans

Mitigation and management plans are offered as recommendations and will be refined during the environmental assessment process leading to the Final Environmental Impact Statement (FEIS) and Project Certificate.

The proposed Project involves the construction and operation of the all-weather winter road (211 km long), and will also include spur roads to quarry sites, temporary construction camps and port facilities. Some of these roads would require routine summer maintenance to prevent or correct stream bank failures, sinkholes, or blockage of culverts at crossings (during freshet).

ML/ARD potential will be assessed for all quarry rock to be used as road substrates, and will be based on lab tests conducted during construction.

Sewage will undergo tertiary treatment to remove solids, nutrients and organics, and to condition the discharge water in order to control pH, conductivity, turbidity, and bacteria such that it does not alter the physical, chemical, or biological properties of the receiving environment.

Mitigation of potential Project impacts to freshwater aquatic VECs will be achieved through careful engineering and design; however, some effects may occur. Mitigation includes:

- use of rip-rap during construction of stream crossings to help stabilize stream banks and minimize particulates washing into streams;
- use of silt curtains during construction at open water to capture bulk sediment loadings that could potentially spill into adjacent waterways during construction;
- proper storage and handling of fuels and other chemicals at camps and on road (earth berms surrounding storage tanks, maintenance of tanks and hoses);
- proper selection and use of culverts;
- Environmental Monitors deployed during construction phase;
- Spill Contingency and Emergency Response Plan;
- Waste Management Plan;
- Sediment and Erosion Control Plan;
- proper bridge design and installation (construction phase); and
- proper decommissioning of road, contouring landscapes, removing culverts and bridges, and monitoring adjacent waterways to ensure aquatic environment is not affected.

Where mitigation is not possible (*i.e.*, habitat loss), a fish habitat compensation plan will be developed to ensure no net loss of fish habitat (Appendix C-4 of the DEIS).

6. MONITORING AND EVALUATION

6. Monitoring and Evaluation

Monitoring and evaluation includes construction monitoring, surveying the road for structural issues, monitoring of quarries for ML/ARD issues if present, and monitoring treated effluent discharge to Contwoyto Lake. Road monitoring will be conducted every summer, to determine if any repairs are required regarding culverts, slopes, eroded areas, and depressions. Repair work would also occur in summer months. Treated effluent discharge piped from the lake camp into Contwoyto Lake will be monitored based on conditions in the licence from the Nunavut Water Board.

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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 C-4
Freshwater Fish and Fish Habitat Effects Assessment

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

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Bathurst Inlet Port and Road Freshwater Fish and Fish Habitat Effects Assessment

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

AEMP	Aquatics Effects Monitoring Program
ARD	acid rock drainage
BC MOF	British Columbia Ministry of Forests
BC MWLAP	British Columbia Ministry of Water, Lands and Air Protection
BIPR	Bathurst Inlet Port and Road
CCME	Canadian Council of Ministers of the Environment
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	catch-per-unit-effort
DEIS	Draft Environmental Impact Statement
DFO	Department of Fisheries and Oceans
FSZ	fisheries sensitive zone
EIS	Environmental Impact Statement
HADD	harmful alteration, disruption or destruction
HSI	habitat suitability index
ML	metal leaching
NIRB	Nunavut Impact Review Board
NTKP	Naonaiyaotit Traditional Knowledge Project
PCB	polychlorinated biphenyls
the Project	the Bathurst Inlet Port and Road Project
Rescan	Rescan Environmental Services Inc.
RL&L	RL&L Environmental Services Ltd.
SARA	*Species at Risk Act*
TK	Traditional Knowledge
TSS	total suspended solids
VEC	valued ecosystem component

1. INTRODUCTION

1. Introduction

The Bathurst Inlet Port and Road (BIPR) Project (the Project) is located in the Kitikmeot region of Nunavut. An ocean port in Bathurst Inlet and a camp at Contwoyto Lake will be developed. The proposed marine port is located on the west side of Bathurst Inlet approximately 40 km south of the community of Bathurst Inlet. This effects assessment for the proposed all-weather road considers the construction and use of a 211 km road from the port site to its end at the southern shore of Contwoyto Lake. The road will connect to the existing winter road accessing mines in the region.

The freshwater environment is critical to the ecological, economic, and cultural health of Nunavut. Many fish species, especially salmonids, are captured for subsistence or sport while others can be useful indicators of water quality and the health of the environment. Good water quality is important for every human community, as well as for aquatic plant and animal life in the region.

Historical information is available on the fish communities (Roberge *et al.*, 1986; RL&L, 1996a, 1996b) of Contwoyto Lake. Located at the southwest end of the proposed road, this lake is the major waterbody of the area, with a surface area of approximately 950 km^2 (95,900 ha) and a drainage area of 8,000 km^2. The 211 km road will end at Contwoyto Lake, so only the lake shoreline at the end of the road may be affected. In addition, 104 crossings, of which 70 had defined channels, are located along the proposed road between Bathurst Inlet and Contwoyto Lake. Detailed baseline freshwater information on fish habitat and communities along the road route were collected during baseline studies in 2001 and 2002 (Appendices C-6 and C-7 Draft Environmental Impact Statement (DEIS)) to determine environmental conditions prior to development.

The objective of the baseline studies conducted in 2001 and 2002 was to characterize the aquatic environment within the Bathurst Inlet Port and Road (BIPR) Project (the Project) area in order to meet the criteria of an Environmental Impact Statement (EIS) as required by the Nunavut Impact Review Board (NIRB). These studies included biological assessment of fish habitat and fish community in order to satisfy conditions of the 'No Net Loss' principle of the Department of Fisheries and Oceans Canada (DFO, 1996) during the construction, operation and decommissioning of the road.

2. ENVIRONMENTAL SETTING

2. Environmental Setting

2.1 Regional Setting

The two major freshwater geographical features associated with the proposed road are Contwoyto Lake and the Mara River. Contwoyto Lake is located approximately 400 km northeast of Yellowknife, NWT, in the heart of the Canadian Shield. The lake drains both to the north and south, through the Burnside and Back rivers respectively. The Burnside River flows from the northern end of Contwoyto Lake into Kathawachaga Lake and then into Bathurst Inlet. The Mara River is a 260 km long tributary of the Burnside River that originates at Nose Lake. The Back River drains from the southern end of Contwoyto Lake into Pellatt Lake, and then flows over 1,000 km into the Arctic Ocean at Chantrey Inlet.

Terrain in the area surrounding Contwoyto Lake is generally low and undulating, with numerous lakes and streams occurring in depressions. The proposed road is within the tundra zone, an area of continuous permafrost that limits the depth of streams and rivers, with many watercourses characterized by wide, shallow channels. The area receives anywhere between 250 to 350 mm of annual precipitation, about 50% of which occurs in the form of snow. Temperatures are coldest from December to March, with historical temperatures for the community of Bathurst Inlet ranging from a maximum temperature of 17.9ºC to -43.7ºC. Freshet generally occurs during late May to late June with ice reformation commencing towards the end of September.

The Naonaiyaotit Traditional Knowledge Project (NTKP) (Appendix F-5 of the DEIS) identified the following fish species that live either permanently or temporarily in the region's freshwater lakes and rivers:

- Arctic grayling (*Thymallus arcticus*);
- lake trout (*Salvelinus namaycush*);
- cisco whitefish (Arctic cisco, *Coregonus autumnalis*);
- lake whitefish (*Coregonus clupeaformis*);
- rainbow smelt (*Osmerus mordax*);
- slimy sculpin (*Cottus cognatus*);
- Arctic char (*Salvelinus alpinus*);
- broad whitefish (*Coregonus nasus*);
- northern pike (*Esox lucius*);
- longnose sucker (*Catostomus catostomus*); and
- eels (American eelpout, *Lycodes reticulates*).

However, not all of these species were captured during fish community surveys carried out during baseline studies along the road. In addition, three species not mentioned in the NTKP were captured during electrofishing surveys: round whitefish (*Prosopium cylindraceum*), burbot

(*Lota lota*) and ninespine stickleback (*Pungitius pungitius*). Distribution maps presented in Scott and Crossman (1973) also suggest that two more species of cisco are found in the region: cisco (*Coregonus artedii*) and least cisco (*Coregonus sardinella*).

The discrepancy between the NTKP and electrofishing surveys can be explained by a number of factors. Firstly, information provided by Inuit consultants was on a regional basis, rather than specific to the proposed road route. It is therefore possible that the distribution of the species noted in the interviews does not cover the proposed road route. Secondly, Inuit terms for fish species were cross-referenced to English and scientific names during report compilation, rather than interviews. For example, when Inuit consultants referred to whitefish, a distinction was not made between lake whitefish, broad whitefish and round whitefish. Species identified in the NTKP interviews, but not during electrofishing surveys, may live in proximity to the proposed road but not utilise the stream habitat in which the majority of electrofishing studies were conducted, or only use such habitat at a different time of year. For example, landlocked Arctic char are predominantly found in lakes, as are anadromous Arctic char, except during their migratory phase. Finally, fish that are naturally present in low numbers have a low probability of capture in surveys conducted over a short section of stream.

In addition to the NTKP studies, a number of fish habitat and community surveys have been conducted on Contwoyto Lake, primarily near the northern end of the lake in association with the Lupin gold mine (Moore, 1978; RL&L, 1985; Roberge *et al.*, 1986; Ash *et al.*, 1991; RL&L, 1995, 1996a, 1996b). These studies revealed a similar fish community to that recorded at the terminal end of the proposed road (Appendix C-6 of the DEIS). However, the relative abundance of fish differed between survey sites, which may be due to variability in fish habitat, fishing methods, and/or previous fishing pressure.

2.2 Streams

Baseline studies conducted for the Project consisted of fish habitat assessments and fish community surveys at stream crossings along the proposed road from Bathurst Inlet to Contwoyto Lake (Figure 2.2-1; Appendices C-6 and C-7 of the DEIS). In 2001, a total of 55 streams were surveyed that had distinct channels and flowing water. Habitat and community assessments at these crossings were conducted over a length of 200 m. Stream reconnaissance surveys were repeated in 2002 because of a change in the road alignment, changes in annual water flow, and to resample streams where no fish were captured in 2001. A total of 35 stream crossings were surveyed in 2002.

2.2.1 Fish Habitat

The majority of streams to be crossed by the road are narrow (median 4.3 m bankfull width) and shallow (median 0.4 m bankfull depth), with low gradient (median 0.7% slope), low water velocity and discharge (median 0.044 m^3/s) in the late summer (Appendices C-6 and C-7 of the DEIS). The water of these streams typically is characterized as clear with near-neutral pH and low conductivity. As expected from the low gradients, the majority of habitat units were glides (68%). Riffles (18%) and pools (8%) were also present, while cascades were rare (2%). There were equal proportions of sand (27%), cobble (29%), and boulders (28%), while gravel was less abundant (14%) and bedrock was rare (2%).

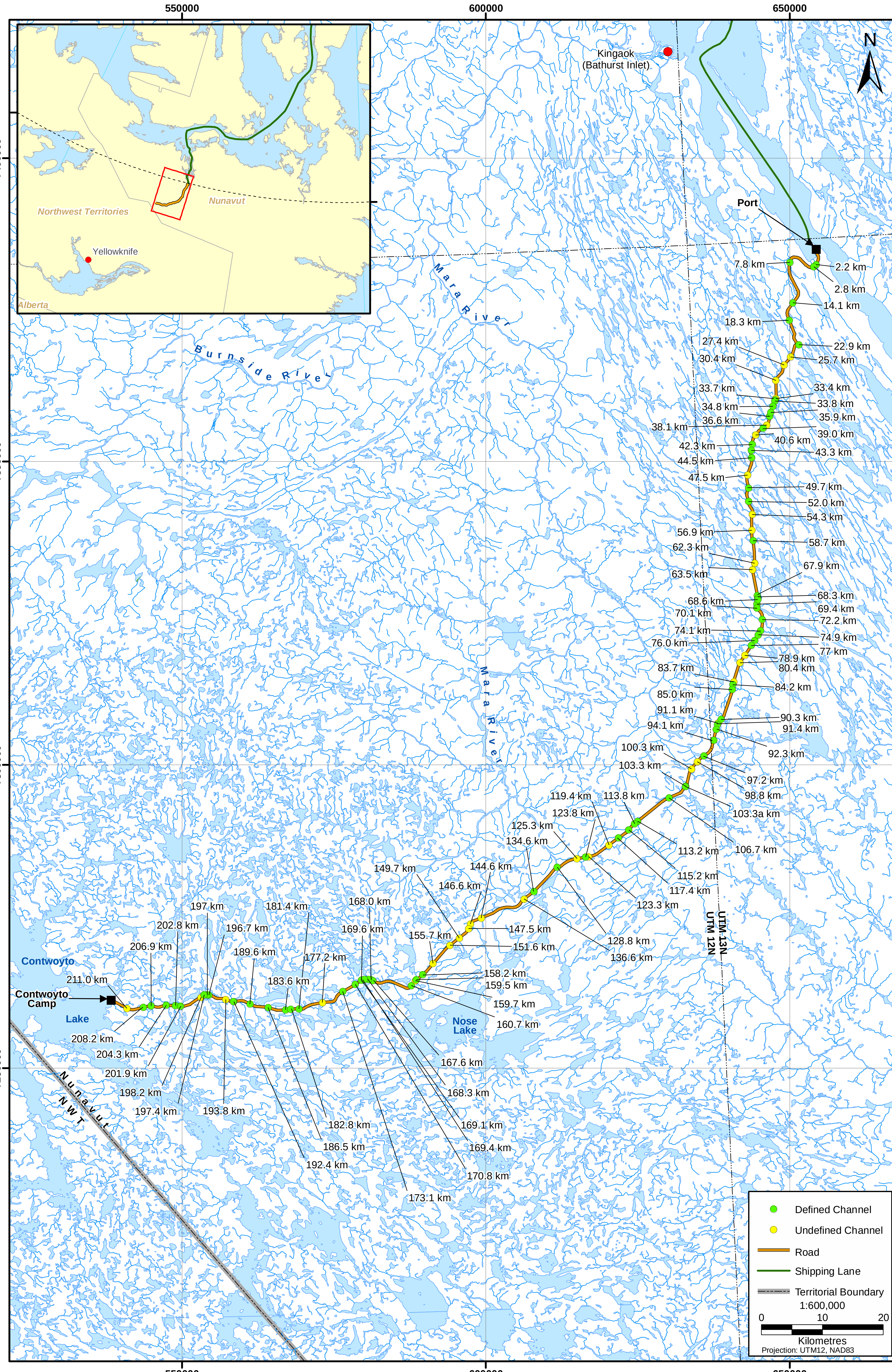

FIGURE 2.2-1

the BATHURST INLET PORT AND ROAD PROJECT

Stream Crossings of the Bathurst Inlet Port and Road Project

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Boulders (29%) and instream vegetation (13%) provided the majority of cover for fish. One consequence of dominant boulder cover is the presence of mostly small fish that can hide easily within the crevices. Populations of smaller fish in tundra streams generally consist of juveniles of large-bodied species (*e.g*., Arctic grayling and burbot), and all stages of species with small adult body sizes (*e.g*., slimy sculpin and ninespine stickleback).

Very few pools were present, due to the shallowness of streams. This shallowness is typical of the region because the impenetrable permafrost layer causes water to flow sideways instead of cutting deep into the ground. Therefore most tundra streams are shallow across a wide range of discharges, as evidenced by the large variation in mean (16.2 m) and median (4.3 m) bankfull widths compared to depths (mean 0.5 and median 0.4 respectively).

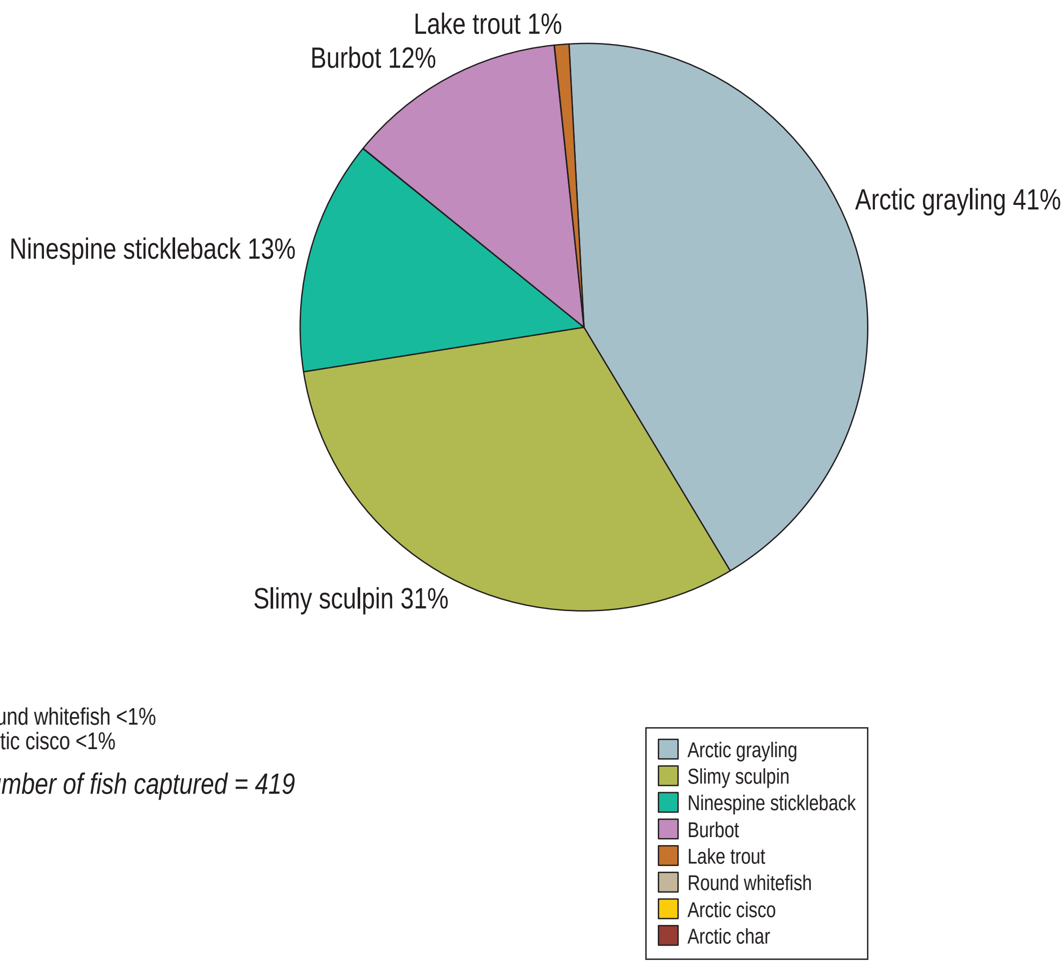
2.2.2 Fish Community

A total of 47% (26 of 55) of the streams sampled in the Project area did not contain fish in 2001, compared with 57% (20 of 35) in 2002 (Appendices C-6 and C-7 of the DEIS). Between one and four fish species were present in the streams that did contain fish. Salmonids (fish from the Family Salmonidae) had the greatest species representation, comprising four of the seven fish species captured. However, Arctic grayling was the only salmonid present in high numbers, and was the most prevalent species of fish. The six other fish species captured during fish community surveys were slimy sculpin, ninespine stickleback, burbot, lake trout, round whitefish and Arctic cisco. Arctic grayling and slimy sculpin comprised the majority (72%) of fish captured along the proposed road (Figure 2.2-2).

Length-frequency distributions of captured fish indicate that streams were used mainly as juvenile rearing habitat by the species found in high numbers. Adult sculpin and sticklebacks also used the streams for spawning habitat. The three species found in low numbers (lake trout, round whitefish, and Arctic cisco) are typically found in lake habitat, and were likely migrants or temporary residents. The majority of streams had low fish densities (mean CPUE = 0.011 fish/sec, median CPUE = 0.002 fish/sec), but seven streams had high densities of juvenile Arctic grayling (CPUE $\geq$ 0.025 fish/sec).

Electrofishing catch data were used to classify the habitat value of the 104 crossings along the road based on species composition (Table 2.2-1). Twenty-five of the fish-bearing streams were found to contain fish of high value, defined as those with cultural importance, or caught for subsistence or sport (*i.e*., Arctic grayling, lake trout, round whitefish, Arctic char, Arctic cisco or burbot). Twenty streams were classified as having medium habitat quality because they were fish-bearing, but only forage fish species were captured (*i.e*., slimy sculpin or ninespine stickleback). Twenty-four streams had low quality fish habitat (distinct channel with water, no fish) and 35 streams contained fish habitat of nil quality (dry or no distinct channel).

In proximity to the proposed road, the NTKP placed particularly high fisheries values on the inflows and outflows of Contwoyto Lake (Tahikyoak) and Nose Lake (Kingalhoak), which are important fishing areas (Figure 2.2-3). Fishing is most commonly carried out at the mouths of the rivers in the spring, shortly after ice melt. However, fishing also occurs in the fall. A consultant for the NTKP remarked that:



Round whitefish <1%
Arctic cisco <1%

Number of fish captured = 419

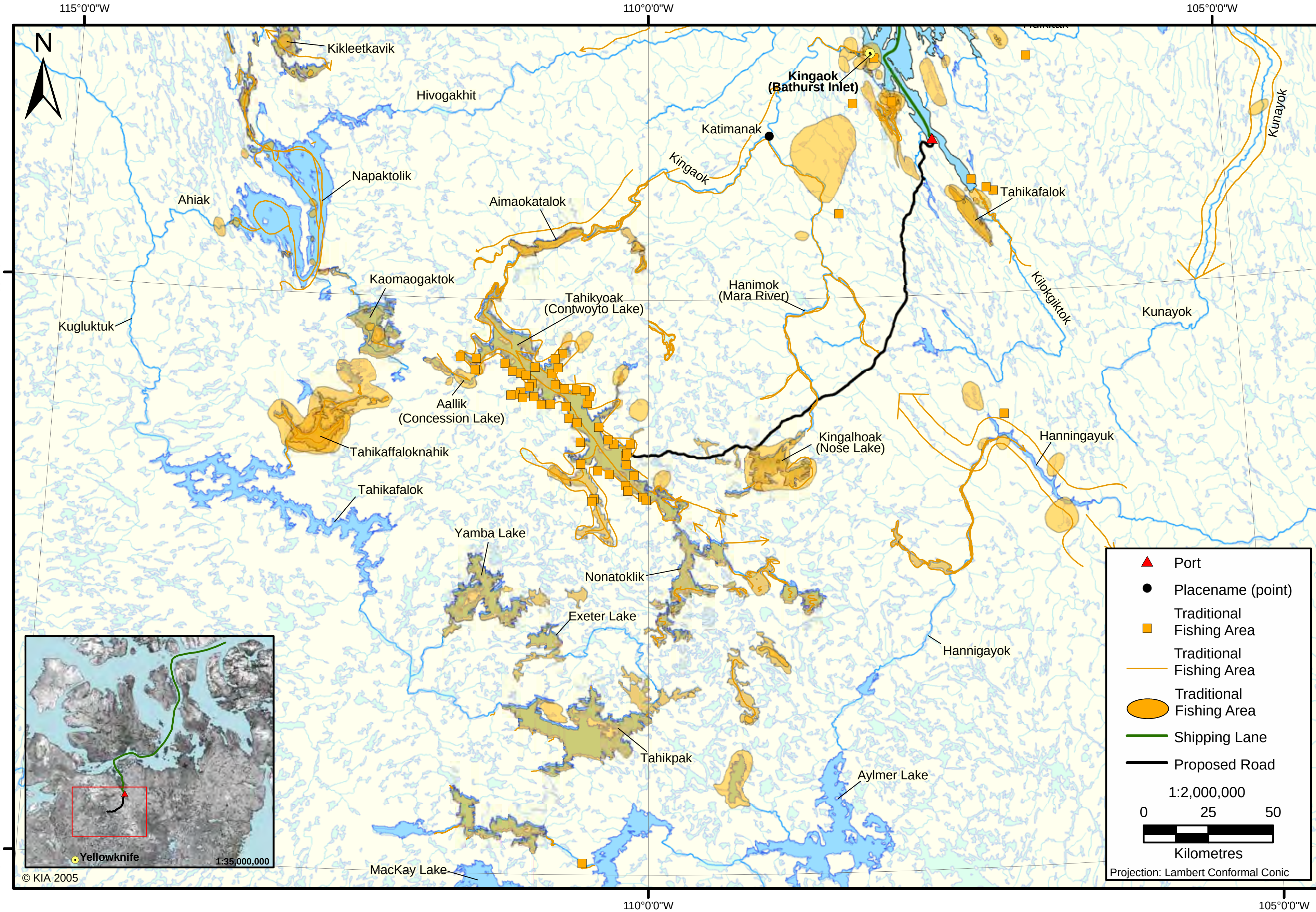
FIGURE 2.2-2

Fish Species Composition at Stream Crossing Sites along the BIPR Road, 2001

Table 2.2-1
Fisheries Classification for all Stream Crossings along the Road

Stream Crossing (km)	Fisheries Value	Stream Crossing (km)	Fisheries Value	Stream Crossing (km)	Fisheries Value
2.2	High	72.2	High	149.7	Nil
2.8	Low	74.1	Low	151.6	Nil
7.8	Low	74.9	Low	155.7	Nil
14.1	Low	76.0	High	158.2	Low
18.3	Low	77.0	Low	159.5	Medium
22.9	High	78.9	Nil	159.7	Nil
25.7	Nil	80.4	Nil	160.7	High
27.4	Nil	83.7	Nil	167.6	Low
30.4	Nil	84.2	High	168.0	Medium
33.4	Nil	85.0	Low	168.3	Medium
33.7	Medium	90.3	Low	169.1	High
33.8	Low	91.1	Nil	169.4	Nil
34.8	Medium	91.4	Low	169.6	Medium
35.9	Medium	92.3	Low	170.8	High
36.6	Low	94.1	Low	173.1	High
38.1	Nil	97.2	High	177.2	Nil
39.0	Medium	98.8	Nil	181.4	High
40.6	Nil	100.3	Nil	182.8	Low
42.3	Medium	103.3	High	183.6	High
43.3	Nil	103.3a	High	186.5	Medium
44.5	Medium	106.7	High	189.6	Low
47.5	Nil	113.2	Low	192.4	Medium
49.7	Medium	113.8	High	192.4a	High
52.0	Nil	115.2	Medium	193.8	Nil
54.3	Nil	117.4	Low	196.7	High
56.9	Nil	119.4	Nil	197.0	Low
58.7	Medium	123.3	Nil	197.4	High
62.3	Low	123.8	Medium	198.2	Nil
63.5	Nil	125.3	Nil	201.9	High
66.5	Nil	128.8	High	202.8	High
67.9	Low	134.6	High	204.3	Medium
68.3	Low	136.6	Nil	206.9	High
68.6	High	144.6	Nil	208.2	Medium
69.4	Medium	146.6	Nil	211.0	Nil
70.1	Medium	147.5	Nil		

Fisheries value: Nil = no flow; Low = flow present but no fish; Medium = fish present but low-value (slimy sculpin or ninespine stickleback); and High = high-value fish present (Arctic grayling, lake trout, round whitefish, Arctic char, Arctic cisco or burbot).



the Bathurst Inlet Port and Road Project

FIGURE 2.2-3

Traditional Inland Fishing Lakes and Rivers

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The rivers at Tahikyoak (Contwoyto) are very important. We don't want anything happening to them, because they are fishing areas. All the rivers north and south of Tahikyoak are important. All the rivers from Tahikyoak are where we continue to hunt and fish in the spring after the river are flowing. The river mouths are the places where we fish the most…Even the small rivers, there are lots of places to fish, there are so many rivers even the small ones have lots of fish, at times they can have a lot of fish. (Appendix F-5 of the DEIS)

In addition to these two large lakes, three smaller lakes were identified as fishing areas to the west of Nose Lake, as well as a region to the southwest of the proposed port. The Mara and Hackett rivers were also identified as important fishing areas, with the Mara reported to contain Arctic char.

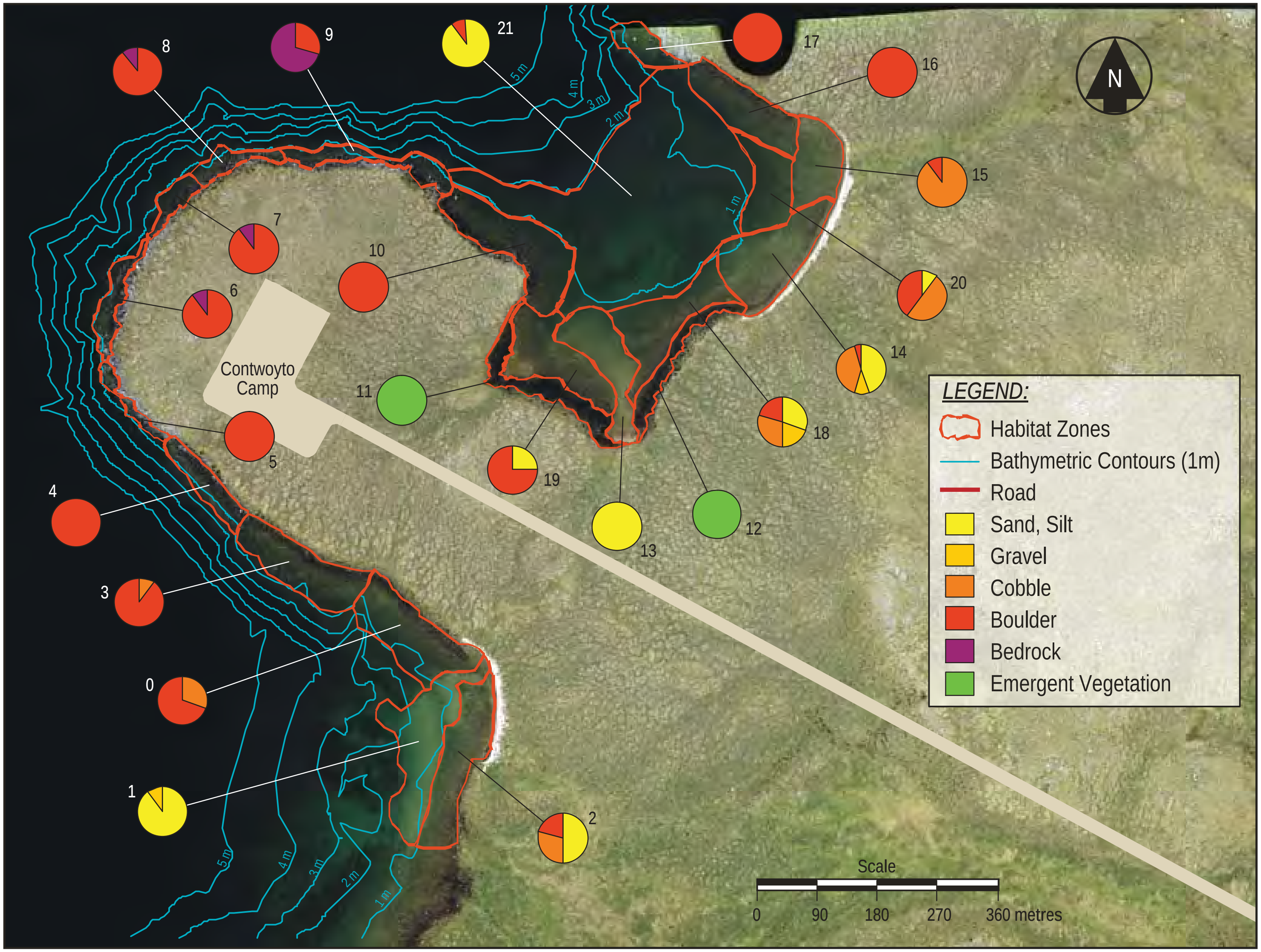
2.3 Contwoyto Lake

Fish and fish habitat were sampled in Contwoyto Lake at the terminal end of the road. Possible impacts on Contwoyto Lake include shoreline degradation at the terminal end of the road, and drainage changes due to the footprint at the proposed service camp.

A habitat assessment of Contwoyto Lake along the shoreline of the peninsula at the terminal end of the road was conducted in 2001. A total of 21 habitat zones were delineated (Figure 2.3-1; Appendix C-6 of the DEIS). The shoreline at the tip of the peninsula was composed predominately of boulder, bedrock and cobble. These areas are preferred habitat for all stages of lake trout and several life stages of Arctic char and burbot. Cobble and boulder is also used as spawning substrate by lake trout and Arctic char. At a distance of 200 m from the shore, the depth of the lake bottom drops to 10 m. Several habitat zones in the bays at the base of the peninsula contained areas of sand and emergent vegetation. These areas are the preferred habitat of lake cisco, ninespine stickleback and burbot.

A total of 77 fish were captured using gillnets at the terminal end of the proposed road. The species composition was primarily lake trout, along with low numbers of round whitefish, Arctic char, Arctic cisco and Arctic grayling (Figure 2.3-2; Appendix C-6 of the DEIS). Lake trout were captured primarily in sinking gillnets, while Arctic char were captured mainly in floating gillnets. The average age of lake trout at this site was 17 years (range: 4 to 42 years), while Arctic char averaged 9 years of age (range: 4 to 12 years). Round whitefish and lake cisco both averaged 7 years of age (range: 4 to 9 years and 5 to 11 years respectively), while Arctic grayling had an average age of 13 years (range: 9 to 18 years).

Minnow traps used along the shoreline captured 66 fish, of which 95% were ninespine sticklebacks and 5% burbot (Appendix C-6 of the DEIS). These fish were not aged. Emergent vegetation was abundant at the minnow trap sites.



the BATHURST INLET PORT AND ROAD PROJECT

Fish Habitat Assessment of the Terminal End of the Bathurst Inlet Port and Road Project, Contwoyto Lake, August 2001

FIGURE 2.3-1

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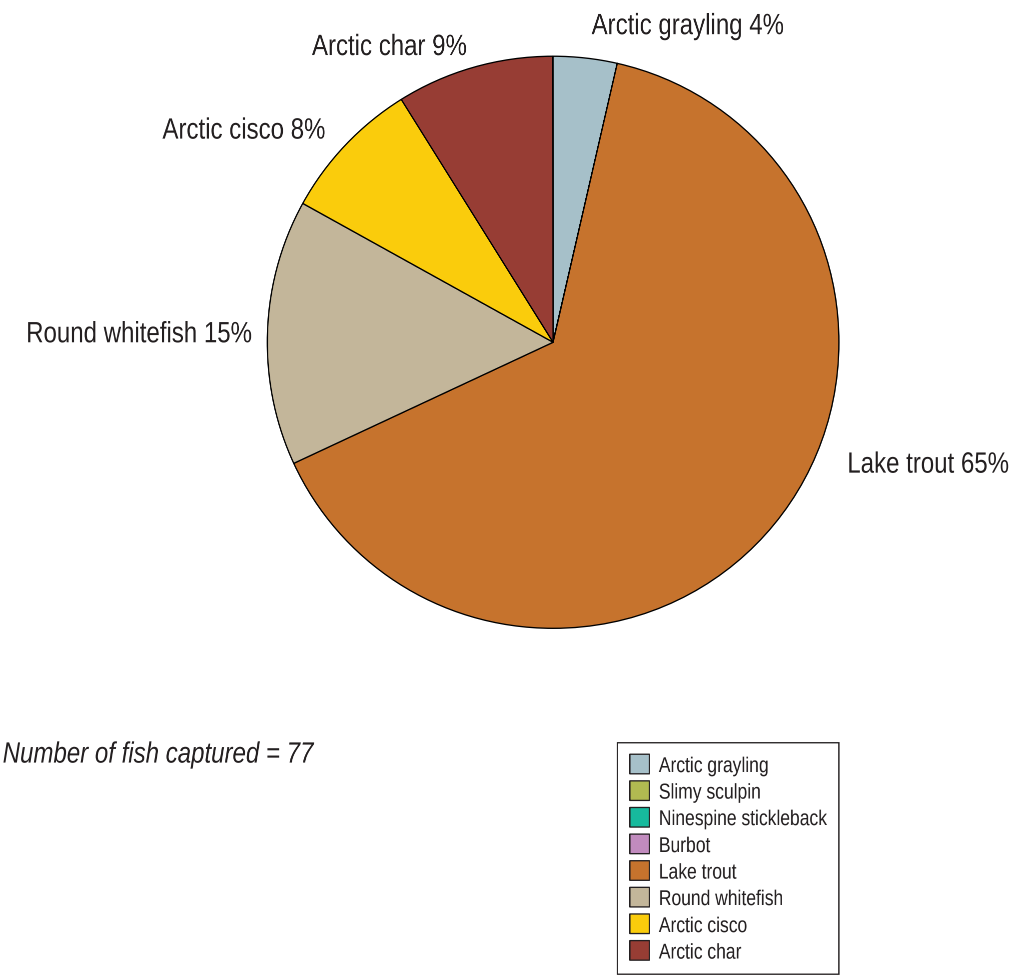

Number of fish captured = 77

FIGURE 2.3-2

Fish Species Composition in Contwoyto Lake at the Terminal End of the BIPR Road, 2001

NTKP interviews also highlighted the presence of Arctic char, a key food species for the Inuit, and Arctic grayling in Contwoyto Lake (Tahikyoak). However, there were discrepancies in the interviews with respect to whether the Arctic char were landlocked or anadromous, although it is possible that the lake contains both resident and anadromous populations. Two consultants commented:

> …*We used nets at the bays on the south side of Tahikyoak (Contwoyto). We caught land-locked charr sometimes, (when we were fishing)…in the fall.*
>
> *The fish move out of the river and back to the lake. The charr from the Bathurst Inlet area go right to Tahikyoak (Contwoyto).*
>
> (Appendix F-5 of the DEIS)

3. METHODOLOGY

3. Methodology

3.1 Valued Ecosystem Component Selection

3.1.1 Rationale

The Project has the potential to negatively affect fish and fish habitat both directly and indirectly throughout the lifetime of the road. As a result, individual fish and fish habitat components were identified as valued ecosystem components (VECs) based on their conservation status, commercial value, cultural importance, and ecological significance. Prior to selecting the VECs two procedures were performed. First, baseline information was acquired by sampling all potential water crossings along the road alignment, up to and including Contwoyto Lake, with fish habitat being sampled at each site. Fish community surveys were conducted wherever a defined channel and water were present. Secondly, public scoping was organized by NIRB. This process involved holding public meetings involving local interest groups including regional and local government officials, community representatives and the general public.

The fact that freshwater fish and fish habitat VECs were selected based on the information gathered from the baseline study, combined with public feedback, reflects a balanced and knowledgeable synthesis of a wide range of information. Understanding the environmental setting where the Project is located and the concerns and issues associated with its responsible development are keys to preserving the environmental and social integrity of the area.

The following sources also were consulted to identify if any species occurring in the area are at risk, or of conservation concern:

- *Species at Risk Act* (SARA); and
- Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Fish and fish habitat VECs in the Project area were identified as:

- **Arctic grayling** (*Thymallus arcticus*) is the most plentiful fish found in streams along the proposed road, and is sought and consumed by sport anglers. Road development may affect Arctic grayling habitat.
- **Arctic char** (*Salvelinus alpinus*)**, lake trout** (*Salvelinus namaycush*) and **whitefish** were also captured in baseline studies (Appendices C-6 and C-7 of the DEIS). The whitefish group contains four species: round whitefish (*Prosopium cylindraceum*), lake whitefish (*Coregonus clupeaformis*), broad whitefish (*Coregonus nasus*), and Arctic cisco (*Coregonus autumnalis*). These fish species have been selected as VECs because they are important to the lake ecosystem as well as being present in streams along the road route. They are also important food resources to the Inuit (Appendix F-5 of the DEIS). These fish species are sensitive to changes in the aquatic environment with respect to their ecological and physiological requirements for long-term sustainability.
- **Fish habitat,** defined as those parts of the environment on which fish depend, directly or indirectly, in order to carry out their life processes (DFO, 1986). This policy applies to

all projects and activities in or near the water that could alter, disrupt or destroy fish habitats, by chemical, physical or biological means.

Table 3.1-1 lists the VECs and their rationale for inclusion in the environmental assessment process. Table 3.1-2 lists the VEC fish species and outlines the life history and habitat requirements of each. A more detailed description of life history and habitat preferences for the VEC species is also given below. Information presented is summarized from McPhail and Lindsey (1970), Scott and Crossman (1973), Richardson *et al*. (2001b), and references therein. Further details on anadromous Arctic char are summarized from McCart (1980) and Johnson (1980).

Table 3.1-1
Fish and Fish Habitat Valued Ecosystem Components

VEC	Rationale for Inclusion
Arctic grayling	Abundance along road route, potential Project effects and potential loss of habitat. Important cultural and sport fish.
Arctic char, lake trout, whitefish	Potential Project effects and potential loss of habitat. Important cultural, sport and commercial fish.
Fish habitat	Important sections of waterbodies that fish depend on for rearing, migration and spawning. Potential habitat degradation.

3.1.2 Species Life History Types and Habitat Preferences

3.1.2.1 Arctic Grayling

The Arctic grayling is commonly found in clear water of large cold rivers, streams and lakes throughout the north. They exhibit lacustrine, adfluvial and fluvial life history types and spawn from April to mid-June, primarily in streams over gravel and rock substrates. However, they have also been observed spawning in shallow water in Alaskan lakes, in association with inlet and outlet streams. Spawning generally occurs at warmer water temperatures near midday, and no nest or redd is prepared. The female may spawn only once, or several times in different areas. Eggs incubate for 13 to 18 days before hatching, with young grayling remaining in the gravel for three to four days before emerging. Juveniles are found in lotic and littoral areas at shallow depths (<0.5 m). Arctic grayling in Great Slave and Great Bear lakes are reported to mature between three and nine years of age. Adults are found associated with sand, silt and gravel substrates in lakes, as well as rocky shorelines, and are typically a shallow water species, inhabiting depths <3.0 m deep. Although no specific information on overwintering habitat was found, grayling are assumed to overwinter in deep pools in rivers and in deep portions of lakes (Richardson *et al.*, 2001b). Adult grayling feed on a variety of aquatic and terrestrial insects including mayflies, caddisflies, midges, bees, wasps, grasshoppers, ants and a variety of beetles. Items occasionally found in the diet include fish, fish eggs, lemmings and planktonic crustaceans.

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Table 3.1-2
Summary of Life History and Habitat Requirements of Selected VEC Fish Species

Variables	Arctic Grayling	Arctic Char	Lake Trout	Whitefish
Life History				
Life-History Strategy	R, F, AD	A, R, AD	R, AD	A, R, AD
Age at Maturity (years)	3 to 9	2 to 9	6 to 13	5 to 8
Spawning Dates	Apr. to Jun.	Sep. to Oct.	Sep. to Oct.	Sep. to Nov.
Egg Incubation	2 to 3 weeks	5 to 6 months	4 to 5 months	4 to 5 months
Hatching Dates	May to Jul.	Mar. to Apr.	Mar. to Apr.	Mar. to May
Emergence Dates	May to Jul.	Jun. to Jul.	Apr. to Jun.	-
Habitat				
Spawning				
Habitat	S, R	L, R	L, R	L, R, S
Substrate Preference	G, C	G, C	B, C	G, C, S
Depth	≥0.2 m	0.5 to 6.0 m	1.0 to 10.0 m	< 5.0 m
Current velocity	Moderate	N/A	N/A	N/A
Temperature	7 to 10 ºC	4 ºC	9 to 14ºC	1 to 8 ºC
Rearing				
Habitat	R, S, L	L, S	L, R, S	L
Substrate Preference	G, C	C, B	C, B	B, C, S
Temperature	4 to 18ºC	-	10 ºC	-
Other				
Diet	FI, TI, F, M	FI, TI, F	FI, TI, F, M	FI, TI, F
Predators	F, O, Bi	F, Bi, S	F	F
Conservation Status				
Federal (Canada)	N/A	N/A	N/A	N/A

Note: Dashes indicate data not available.
Life History Strategy: A = anadromous, R = resident (freshwater), F = fluvial, AD = adfluvial.
Habitat: R = river, S = stream (includes small tributaries), L = lake.
Substrate Preference: S = sand, G = gravel, C = cobble, B = boulder, Be = Bedrock.
Diet: FI = freshwater invertebrates, TI = terrestrial invertebrates, F = fish and fish eggs, M =small mammals, A = amphibians including frogs.
Predators: F = fish, Bi = birds, O = otters, S = seals.
N/A = not applicable.
Sources:(Scott and Crossman, 1973; Richardson *et al.*, 2001a; Quinn, 2005; Working Group on General Status of NWT Species, 2006).

3.1.2.2 Lake Trout

Lake trout are found throughout the Northwest Territories and Nunavut, mostly in deep water lakes, but may also be found in large, clear rivers. Lake trout exhibit both lacustrine and adfluvial life history types. They spawn in late summer and early autumn, from September to October in northern regions. Spawning grounds are almost always associated with cobble, boulder and gravel substrates, where there is no vegetative cover, in depths less than one meter to greater than ten meters. Eggs settle into cracks and crevices amongst the rocks, where they incubate for four to five months, with eggs usually hatching in March or April. Young-of-the-year remain in spawning areas from several weeks to several months, moving into deeper areas as water temperatures rise to greater than 15°C. Young-of-the-year and juveniles both prefer areas of cobble and boulder substrate for cover, and inhabit waters with a depth range of two to greater than ten meters. Adult lake trout disperse into deeper water habitats, greater than ten meters in depth, and are often found in the pelagic zone. Lake trout feed on a wide variety of prey items including fish, molluscs, crustaceans, freshwater sponges, and small mammals.

3.1.2.3 Arctic Char

Arctic char occur in northern coastal regions in rivers, lakes, estuaries and marine environments. They exhibit both anadromous and resident lacustrine life history types.

Anadromous Arctic Char

Anadromous Arctic char begin migrating upstream from July to September and spawn in streams and rivers in the fall, usually in areas of groundwater upwelling (McCart, 1980). In the central Canadian Arctic, lake spawning is more prevalent as rivers tend to freeze up in winter (Johnson, 1980). Spawning generally occurs over cobble and gravel substrates in water between 0.5 and 6 m deep. Females construct a redd into which eggs are deposited before being covered with gravel. Post-spawning fish remain in lakes to overwinter before migrating to sea to feed the following spring. Anadromous Arctic char do not spawn in successive years, but every two to five years, with three likely being the average.

Eggs hatch in the spring from late March to April. Fry emerge from spawning gravels in May and move towards the shore and live and feed among the rocks in the littoral zone of lakes. Juvenile char are found in creek or lacustrine habitats during the summer before moving to deeper lacustrine habitats in the fall to overwinter. Juveniles normally spend four to five years rearing in freshwater before beginning downstream migrations to the sea. However, first-time migrants have been known to be as young as two, and as old as nine.

Seaward migrations are undertaken on an annual basis. The char take advantage of the brief period when the seawater is warm enough for char to survive, to feed in the nutrient rich marine environment. As Arctic char lack the ability to survive sub-zero water temperatures (*i.e.*, they lack a blood antifreeze mechanism), there is a movement back into freshwater systems in the late summer and fall. Unlike salmon (*Oncorhynchus* spp.), Arctic char do not appear to exhibit a strong fidelity to natal streams. Gyselman (1984) indicated that minimum calculated fidelity rate for the Nauyuk Lake system in the Northwest Territories was 34% and the maximum was 55%.

Resident Arctic Char

Lacustrine populations of Arctic char spawn at approximately the same time as anadromous char. Spawning generally occurs at depths of 2 to 10 m over cobble, gravel substrates. However, there have been reports of char spawning in shallow water (0.5 to 2.0 m) over silt, mud and clay substrates, in association with vegetation. Spawning behaviour, incubation and hatching times are similar to anadromous char. Young-of-the-year and juveniles are often found over cobble and boulder substrates, which they use as cover to avoid predation by larger fish. As juveniles mature they shift from benthic to pelagic habitats. Adult resident char usually occupy the pelagic zone of lakes during the summer and then shift to benthic/littoral areas in the fall when food is less abundant. Freshwater Arctic char grow much slower than anadromous forms.

3.1.2.4 Whitefish

Round Whitefish

Round whitefish are most commonly found in shallow areas of lakes, ponds, slow flowing rivers and streams as well as brackish waters. They exhibit lacustrine and adfluvial life history types. Spawning occurs from fall to early winter with preferential spawning grounds occurring in waters less than a meter in depth with a gravel substrate. Eggs are released over the substrate and incubate for four to five months before hatching from March to May. Young-of-the-year are most often found over sand, gravel and cobble substrates in shallow water (<5 m). Adults are found in both shallow and deeper water habitats, commonly over cobble and boulder substrates. Round whitefish are benthic feeders.

Lake Whitefish

Lake whitefish are found throughout the Northwest Territories and Nunavut, predominantly in lakes, although they are also found in large rivers and brackish waters. They exhibit lacustrine, adfluvial and anadromous life history types. Lake whitefish spawn in both lakes and rivers over gravel, cobble and boulders at depths of less than 5 m. Eggs are released over the substrate and fall into interstices between rocks where they incubate for several months, hatching sometime from March to May. Young-of-the-year are commonly found in the spawning area in shallow water (<1 m) near the surface, and prefer substrates of boulder, cobble and sand with abundant emergent vegetation and woody debris. Adults are usually found in the open water at depths > 10 m and do not show a preference for substrate. Adults are predominantly benthic, although they may be found in the pelagic zone. Lake whitefish have been reported to make onshore movements into shallow water at night, possibly to feed.

Broad Whitefish

The broad whitefish is found in northern coastal regions, most commonly in large river systems, delta lakes and brackish estuarine waters. They are primarily anadromous, although there are also lacustrine and fluvial forms. Spawning occurs between mid-October and November with eggs hatching in the spring. Young-of-the-year are swept downstream into estuaries and nearshore areas before returning to coastal streams and lakes when 50 mm in length. Young broad whitefish remain in tundra lakes for several years before returning to coastal waters. Juveniles typically mature between seven and eight years of age, although they have been reported to mature as early as three and four. Adults spend the summer feeding in delta and peninsula lakes or nearshore estuarine environments. Broad whitefish are predominantly benthic feeders.

Arctic Cisco

The Arctic cisco is present in northern coastal regions, inhabiting the lower reaches of large muddy rivers, streams, coastal beaches, lagoons, and brackish water. They exhibit a wide-ranging anadromous life history type. Spawning migrations occur in late summer and early fall, with spawning occurring between late September and early October. Spawning is believed to over gravel in areas of low turbidity and high flow. Post-spawning fish return to nearshore areas to overwinter. Eggs hatch in the spring with young-of-the-year being swept downstream to nearshore areas. Juveniles make extensive migrations along the northern coastline between summer foraging areas and overwintering areas. Unlike lake and broad whitefish, Arctic cisco do not use lakes as feeding and overwintering grounds. First spawning occurs between the ages of six and eight.

3.2 Boundaries

3.2.1 Spatial Boundaries

The spatial boundaries of the fish and fish habitat environmental assessment occur from the port site at Bathurst Inlet to the terminal end of the road at Contwoyto Lake. These boundaries include the road right-of-way (Figure 2.2-1) and the area of freshwater habitat within Contwoyto Lake surrounding the peninsula at the terminal end of the road (Figure 2.3-1). The Regional Study Area includes all watersheds the road passes through, including Amagok Creek, Western River, Siorak River, and Mara River watersheds before reaching Contwoyto Lake. The Mara River and Burnside River watersheds are incorporated within this boundary. A 500 m buffer zone from the road demarcates the local study area for this effects assessment.

All lethal and sublethal effects and habitat losses are considered with respect to fish and fish habitat existing in the local and regional study areas. This implies any effects are assessed at the scale of an entire length of a stream, or an entire lake, as appropriate for that local biological community, and to what extent these potential effects could have on the entire community rather than just individuals. Applicable effects on a sub-local scale are noted and considered in this assessment and in the Cumulative Environmental Effects Assessment (Appendix G-5 of the DEIS).

3.2.2 Temporal Boundaries

Temporal boundaries include the Project’s proposed lifetime of 22.5 years, including construction (2.5 years) and operation phases (19 years), and extend into the closure (1 year) and post-closure phases.

3.3 Approach and Methods

Potential effects (positive and negative) of any interactions between the Project components, sub-components and/or Project activities were identified for the selected VECs. This was done for each temporal stage of the Project (*i.e.*, construction, operation and maintenance, decommissioning and closure). A detailed description of the Effects Assessment Methodology is presented in Appendix A-5 of the DEIS. A definition of each variable assessed is also included in the same appendix.

In order to ensure all potential effects were identified, a matrix table was used to identify interactions between the identified effects and all aspects of the Project. The potential effects were identified by reviewing the Project components and baseline setting, then determining the potential effects that could occur. The matrix was then used to identify all interactions and influence that a Project component may have on any one effect. If a Project component was considered not to have any interaction (and thus no potential effect), then no further consideration was given to the Project component in the assessment.

4. EFFECTS ASSESSMENT

4. Effects Assessment

4.1 Assessment of Potential Impacts

The environmental assessment for fish and fish habitat was designed to address the potential impacts of various components of the Project on freshwater VECs. Project components include road building activities, road use, Contwoyto Camp, and the two mobile camps, that all have the potential to affect fish during the different phases of the Project. The potential effects of each Project component on each VEC were assessed for the four temporal stages of the Project (*i.e.*, construction, operation and maintenance, decommissioning and closure). The VECs potentially affected by these components include Arctic grayling, Arctic char, lake trout, whitefish and fish habitat. The issues addressed within this assessment were:

- all streams along the road route that may experience effects on fish;
- habitat loss or alteration, including aquatic vegetation and sensitive areas such as spawning grounds, nursery areas, winter refuges, and migration corridors;
- mortality (including fishing);
- acoustic effects from blasting at quarries near fish-bearing streams along the road; and
- changes in water chemistry (suspended solids, nutrients, major ions, metals) due to runoff or discharges from the Project.

Potential effects have been grouped into three categories: lethal effects, sublethal effects, and loss of habitat (Tables 4.1-1 and 4.1-2). Lethal effects are those that lead to the morbidity or instant mortality of fish, such as the smothering of embryos by a sedimentation event. Sublethal effects act to reduce the physiological or reproductive fitness of fish, such as high levels of suspended sediments reducing visibility and causing respiratory stress or deleterious chemicals causing behavioural changes. Sublethal effects do not result in mortality, but may translate into population level effects in the long-term. Fish habitat may be lost at stream crossings or at camps due to direct habitat removal, degradation, or altered productivity due to reduced water quality.

Under the *Fisheries Act* (DFO, 1985) chemical alteration of water quality by the introduction of deleterious substances to surface waters is considered a harmful alteration, disruption or destruction (HADD) to fish habitat. Water quality HADDs can affect the health of fish populations and change the productivity of primary producers (phytoplankton and periphyton) or food sources (zooplankton and benthic invertebrates). Protection of this productive capacity of fish habitat, “the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish feed” is mandated by DFO (1996). The effect of deleterious chemicals on fish health is detailed in the section on sublethal effects (Section 4.5) while their effect on the productive capacity of fish habitat through their impact on primary and secondary producers is detailed in the fish habitat section (Section 4.6).

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Table 4.1-1
Identification of Potential Environmental Effects for Arctic Grayling, Arctic Char, Lake Trout, and Whitefish

Project Component	Project Activity	Potential Environmental Effects		
		Lethal	Sublethal	Loss of Habitat
	A. Construction Phase			
Road	Extract road construction material from quarries (42 quarries with a road connector to each quarry)	sediment, spills	noise, particulates, sediment, residue, spills, ML/ARD	particulates, sediment*, residue, ML/ARD
	Quarries not required for on-going maintenance will be contoured and abandoned on completion of road construction		ML/ARD	ML/ARD
	Construct road base: push quarried rock and granular materials over the tundra, after being laid down by "end dump" mine trucks. Work will run continuously all year, with 2 shifts working 24 hrs/day	sediment, spills	noise, particulates, sediment, spills, ML/ARD	particulates, sediment, spills, ML/ARD
	Construct bridges and other stream crossings	sediment, spills	noise, particulates, sediment, spills	particulates, sediment, spills, pilings
	Establish and move two mobile construction camps as work progresses: 2 x 60 person camps	sediment, spills	noise, particulates, sediment, spills	particulates, sediment, spills
	Construct permanent 20-person camp at Contwoyto Lake Camp (coarse and crushed rock as per road)	sediment, spills	noise, particulates, sediment, spills	particulates, sediment, spills
	Treat water and sewage from camps and discharge effluent into lake		waste effluent	sewage effluent
	Draw water from Contwoyto Lake for potable water and fire-fighting	entrainment		loss of water
	B. Operation and Maintenance Phase			
Road	Truck haulage of bulk cargo and fuel from January to April, from the Port Site to operating mines	sediment, spills	noise, particulates, sediment, spills	particulates, sediment, spills
	Snow removal and application of sand and gravel during winter operations	sediment, spills	particulates, sediment, spills	particulates, sediment, spills
	Store registered explosive magazines in quarry sites along the roadway		residue	residue
	Power generation at Contwoyto Lake Camp	spills	noise, particulates, spills	particulates, spills
	Treat water and sewage, and discharge effluent into Contwoyto Lake		waste effluent	sewage effluent
	Collect, store and incinerate garbage at Contwoyto Lake Camp		particulates, spills	particulates, spills
	Backhaul non-combustible waste to Yellowknife		noise, particulates, spills	particulates, spills
	Draw water from Contwoyto Lake for potable water and fire-fighting	entrainment		loss of water
	C. Decommissioning & Closure Phase			
Road	Remove bridges and other structures	sediment	noise, particulates, sediment, spills	particulates, sediment, spills
	Contour surfaces to reduce the possibility of erosion	sediment, spills	noise, particulates, sediment, spills	particulates, sediment, spills
	D. Post-Closure Phase			
	Monitor for soil erosion and slumping: remedial action if necessary		sediment	sediment

ML/ARD - metal leaching and acid rock drainage.

Particulates - includes non-toxic and toxic particles.

Residue - nitrogen from explosives.

*** Several quarry sites located next to waterbodies with low flow unlikely to wash away sediment.**

Table 4.1-2
Identification of Potential Environmental Effects for Fish Habitat

Project Component	Project Activity	Potential Environmental Effects: Loss of Habitat
	A. Construction Phase	
Road	Extract road construction material from quarries (42 quarries with a road connector to each quarry)	particulates, sediment*, residue, ML/ARD
	Quarries not required for on-going maintenance will be contoured and	ML/ARD
	Construct road base: push quarried rock and granular materials over	particulates, sediment, spills, ML/ARD
	Construct bridges and other stream crossings	particulates, sediment, spills, pilings
	Establish and move two mobile construction camps as work	particulates, sediment, spills
	Construct permanent 20-person camp at Contwoyto Lake Camp (coarse and crushed rock as per road)	particulates, sediment, spills
	Treat water and sewage from camps and discharge effluent into lake	sewage effluent
	Draw water from Contwoyto Lake for potable water and fire-fightinc	loss of water
	B. Operation and Maintenance Phase	
Road	Truck haulage of bulk cargo and fuel from January to April, from the Port Site to operating mines	particulates, sediment, spills
	Snow removal and application of sand and gravel during winter	particulates, sediment, spills
	Store registered explosive magazines in quarry sites along the	residue
	Power generation at Contwoyto Lake Camp	particulates, spills
	Treat water and sewage, and discharge effluent into Contwoyto Lake	sewage effluent
	Collect, store and incinerate garbage at Contwoyto Lake Camp	particulates, spills
	Backhaul non-combustible waste to Yellowknife	particulates, spills
	Draw water from Contwoyto Lake for potable water and fire-fighting	loss of water
	C. Decommissioning & Closure Phase	
Road	Remove bridges and other structures	particulates, sediment, spills
	Contour surfaces to reduce the possibility of erosion	particulates, sediment, spills
	D. Post-Closure Phase	
	Monitor for soil erosion and slumping: remedial action if necessary	sediment

ML/ARD - metal leaching and acid rock drainage.

Particulates - includes non-toxic and toxic particles.

Residue - nitrogen from explosives.

Treated sewage effluent - contains nitrogenous waste products.

*** Several quarry sites located next to waterbodies with low flow unlikely to wash away sediment.**

Many of the issues listed above overlap in terms of definition and scope. Each pathway describes one primary effect, however multiple effects may occur. Potential effects are discussed as they pertain to the construction, operations, decommissioning and closure, and post-closure phases of the Project. Also, issues were grouped into three categories for discussion: direct and indirect mortality, sublethal effects, and habitat loss and alteration.

4.2 Methodology and Process

Potential effects (beneficial, adverse, and neutral) of any interactions between the Project components, sub-components and/or Project activities were identified for the selected VECs. This effects identification was performed for each temporal stage of the Project (*i.e.*, construction, operations and maintenance, closure, and post-closure) using a matrix table (Tables 4.1-1 and 4.1-2).

The potential effects were identified for each fish resource VEC by reviewing the Project components and baseline setting, followed by determination of potential effects. The matrix table then was used to identify all interactions and influences that a Project component may have on any one effect. If a Project component was considered not to have any interaction with a particular VEC (and thus no potential effect), then it was not considered no further in the assessment.

4.3 Identification of Potential Project Effects

The predicted potential impacts of each mine component on each VEC are identified and assessed in this section. Results of this screening process are presented for the four phases of the Project: construction, operation, and maintenance, decommissioning and closure, and post-closure (Tables 4.3-1 to 4.3-3). Project components that may affect an identified VEC are discussed in relation to lethal effects, sublethal effects, and habitat loss.

In the construction and operations stages, road activities will include culvert installation, bridge building, blasting at quarries, road maintenance (*i.e.*, grading, snow removal), and general road traffic, all of which may effect aquatic and fisheries resources. Relatively minor alterations or losses of fish habitat, mortality, and sublethal effects are expected to occur at crossings along the road. Alterations include loss of habitat at the footprints of bridge pilings, culvert installation, erosion, and sedimentation during construction at each stream crossing. Road traffic and blasting also may cause minor habitat alteration from aerial deposition of dust and explosive residues to waterways. These alterations will represent minor losses of habitat at each crossing based on the small fraction of affected area compared to total stream lengths, and negligible when observed on a landscape scale. Habitat alteration, however, may occur as a result of siltation during construction or due to water withdrawal from Contwoyto Lake.

Table 4.3-1
Summary of Effects Assessment for Arctic Grayling

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
Description	Project Phase (Timing) Construction Operations Decommissioning Post-Closure	Project Component Port Site Road Shipping Lane Human Resources	Direction Beneficial Adverse Neutral	Nature Direct Indirect	(Design Changes, Management, Monitoring, Compensation, Enhancement`	Description of Residual Effect (after mitigation)	Magnitude Negligible Low Moderate High	Geographic Extent Local Landscape Regional Trans-Boundary	Duration Short Term Medium Term Long Term Far Future	Frequency One Time Sporadic Regular Continuous	Reversibility Short Term Long Term Irreversible	Ecological Context (Resilience) High Neutral Low	Influence on Resource Capacity Nil Low Moderate High Unkown	Probability of Occurrence Low Moderate High	Significance Negligible Low Moderate High	Confidence Level High Intermediate Low
Mortality from contact with construction equipment	Construction	Road	Adverse	Direct	Limit stream crossings by equipment, follow Nunavut Operational Statements for Clear-Span Bridges and In-Water Contruction Timing Windows	Blunt tissue damage causing mortality to all life stages	High	Local	Short Term	Sporadic	Short Term	High	Low	Low	Negligible	High
Sedimentation from construction activities and summer run-off causing lethal smothering	Construction	Road	Adverse	Direct	Silt fences Erosion and Sediment Management Plan	Smothering of eggs and larvae	Moderate	Local	Short Term	Regular	Short Term	High	Low	Moderate	Low	High
Sedimentation from truck hauling, snow removal, bridge removal and contouring causing lethal smothering	Operations, Decomissioning	Road	Adverse	Direct	Silt fences Erosion and Sediment Management Plan	Smothering of eggs and larvae	Low	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from construction activities and summer run off increasing TSS and causing sublethal effects	Construction	Road	Adverse	Indirect	Silt fences Erosion and Sediment Management Plan	Increase in TSS above background levels leading to behavioural changes, eye damage, and respiration stress	Low	Local	Short Term	Regular	Short Term	High	Low	Moderate	Low	High
Sedimentation from truck hauling, snow removal, bridge removal and contouring increasing TSS and causing sublethal effects	Operations, Decomissioning	Road	Adverse	Indirect	Silt fences Erosion and Sediment Management Plan	Increase in TSS above background levels leading to behavioural changes, eye damage, and respiration stress	Low	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from soil erosion and slumping increasing TSS and causing sublethal effects	Post-Closure	Road	Adverse	Indirect	Silt fences Erosion and Sediment Mangement Plan	Increase in TSS above background levels leading to behavioural changes, eye damage, and	Low	Local	Short Term	Sporadic	Short Term	High	Low	Low	Negligible	High
Spills from equipment, hauled fuels and cargos, and waste products causing mortality	Construction	Road	Adverse	Direct	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to mortality	High	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Low	High
Spills from equipment, hauled fuels and cargos, and waste products causing mortality	Operations, Decomissioning	Road	Adverse	Direct	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to mortality	Moderate	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Negligible	High
Spills from equipment, hauled fuels and cargos, and waste products causing sublethal effects	Construction	Road	Adverse	Indirect	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to sub-lethal behavioural changes and physiological stress	Moderate	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Low	High
Spills from equipment, hauled fuels and cargos, and waste productscausing sublethal effects	Operations, Decomissioning	Road	Adverse	Indirect	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to sub-lethal behavioural changes and physiological stress	Low	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Negligible	High
Noise from blasting and driving piles for bridges causing mortality	Construction	Road	Adverse	Direct	Blasting mats, avoid blasting during spring spawning, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Blunt tissue damage causing mortality to all life stages	High	Local	Short Term	Sporadic	Short Term	High	Low	Low	Negligible	High
Noise from equipment and construction activities causing causing sublethal effects	Construction, Operations, Decomissioning	Road	Adverse	Direct	Blasting mats, avoid blasting during spring spawning, thermal atmospheric inversions, low cloud cover, or fog conditions, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Increase in noise leading to sub-lethal behavioural changes and physiological stress	Low	Local	Short Term	Sporadic	Short Term	High	Low	Moderate	Negligible	High
Particulates and residue from trucks, road construction, equipment activity, and blasting increasing TSS and causing sublethal effects	Construction	Road	Adverse	Indirect	Blasting mats, avoid blasting during spring spawning, thermal atmospheric inversions, low cloud cover, or fog conditions, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Elevated dust generation on road because road not wetted during summer. Quarries wetted, but dust and nitrogen residues from blasting not washed away quickly in summer as during spring freshet.	Low	Local	Medium Term	Continuous	Short Term	High	Low	Moderate	Low	High
Particulates and residue from trucks, equipment activity and explosives storage increasing TSS and causing sublethal effects	Operations, Decomissioning	Road	Adverse	Indirect	Operation and decomissioning during winter will reduce dust generation. Blasting will not occur during operation, only rock crushing.	Very low dust generation during winter operation	Negligible	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
ML/ARD from exposed rock causing sublethal behavioural effects	Construction, Operations, Decommissioning, Post-Closure	Road	Adverse	Direct	Implementation of ML/ARD Prediction and Prevention Management Plan, and Environmental Effects Monitoring Program.	ML/ARD resulting in behavioural changes and physiological stress	Low	Local	Far Future	Regular	Long Term	High	Low	Low	Negligible	Low
Sewage effluent nitrates from camps discharged into Contwoyto Lake or onto "tundra field" causing sublethal effects	Construction	Road	Adverse	Direct	Tertiary treatment of all effluent and separation from solids at water treatment plant prior to release into lake, removal of solids and filtrate to tundra field at mobile camps, and implementing Environmental Effects Monitoring Program.	Increase in nitrogenous waste products entering lake and streams causing sub-lethal behavioural and physiological changes	Moderate	Local	Medium Term	Continuous	Short Term	High	Low	Low	Low	High
Sewage effluent nitrates from camp discharged into Contwoyto Lake causing sublethal effects	Operations	Road	Adverse	Direct	Tertiary treatment of all effluent and separation from solids at water treatment plant prior to release into lake, removal of solids and filtrate to tundra field at mobile camps, and implementing Environmental Effects Monitoring Program.	Increase in nitrogenous waste products entering lake and streams causing sub-lethal behavioural and physiological changes	Low	Local	Medium Term	Continuous	Short Term	High	Low	Low	Negligible	High
Lake water drawdown leading to a loss of habitat	Construction, Operations	Road	Adverse	Indirect	Regulate water usage relative to lake water stage if required beyond 6,000 L/d; Place screens over intake; Reduce intake flow to prevent the entrainment of fish	Tissue damage or mortality as a result of entrainment on intake screen	Low	Local	Medium Term	Continuous	Short Term	High	Nil	Low	Negligible	High

Numbers in brackets refer to a specific Project activity outlined in Table 5.1-2 in the Effects Assessment Methodology.

TSS - total suspended solids.

DFO - Fisheries and Oceans Canada.

ML/ARD - metal leaching and acid rock drainage.

Table 4.3-2
Summary of Effects Assessment for Arctic Char, Lake Trout, and Whitefish

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
Description	Project Phase (Timing) Construction Operations Decommissioning Post-Closure	Project Component Port Site All-Weather Road Shipping Lane Human Resources	Direction Beneficial Adverse Neutral	Nature Direct Indirect Cummulative Synergistic	(Design Changes, Management, Monitoring, Compensation, Enhancement)	Description of Residual Effect (after mitigation)	Magnitude Negligible Low Moderate High	Geographic Extent Local Landscape Regional Trans-Boundary	Duration Short Term Medium Term Long Term Far Future	Frequency One Time Sporadic Regular Continuous	Reversibility Short Term Long Term Irreversible	Ecological Context (Resilience) High Neutral Low	Influence on Resource Capacity Nil Low Moderate High Unkown	Probability of Occurrence Low Moderate High	Significance Negligible Low Moderate High	Confidence Level High Intermediate Low
Mortality from contact with construction equipment	Construction	Road	Adverse	Direct	Limit stream crossings by equipment, follow Nunavut Operational Statements for Clear-Span Bridges and In-Water Contruction Timing Windows	Blunt tissue damage causing mortality to all life stages	Low	Local	Short Term	Sporadic	Short Term	High	Low	Low	Negligible	High
Sedimentation from construction activities and summer run-off causing lethal smothering	Construction	Road	Adverse	Direct	Silt fences, riparian vegetation, Erosion and Sediment Management Plan	Smothering of eggs and larvae	High	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from truck hauling, snow removal, bridge removal and contouring causing lethal smothering	Operations, Decomissioning	Road	Adverse	Direct	Silt fences, riparian vegetation, Erosion and Sediment Mangement Plan	Smothering of eggs and larvae	Moderate	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from construction activities and summer run-off increasing TSS and causing sublethal effects	Construction	Road	Adverse	Indirect	Silt fences, riparian vegetation, Erosion and Sediment Mangement Plan	Increase in TSS above background levels leading to behavioural changes, eye damage, and respiration stress	Low	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from truck hauling, snow removal, bridge removal and contouring increasing TSS and causing sublethal effects	Operations, Decomissioning	Road	Adverse	Indirect	Silt fences, riparian vegetation, Erosion and Sediment Mangement Plan	Increase in TSS above background levels leading to behavioural changes, eye damage, and respiration stress	Low	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from soil erosion and slumping increasing TSS and causing sublethal effects	Post-Closure	Road	Adverse	Indirect	Silt fences, riparian vegetation, Erosion and Sediment Mangement Plan	Increase in TSS above background levels leading to behavioural changes, eye damage, and	Negligible	Local	Short Term	Sporadic	Short Term	High	Low	Low	Negligible	High
Spills from equipment, hauled fuels and cargos, and waste products causing mortality	Construction	Road	Adverse	Direct	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to mortality	High	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Negligible	High
Spills from equipment, hauled fuels and cargos, and waste products causing mortality	Operations, Decomissioning	Road	Adverse	Direct	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to mortality	Low	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Negligible	High
Spills from equipment, hauled fuels and cargos, and waste products causing sublethal effects	Construction, Operations, Decommissioning, Post-Closure	Road	Adverse	Indirect	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to sub-lethal behavioural changes and physiological stress	Low	Local	Short Term	Sporadic	Short Term	Low	Low	Low	Negligible	High
Spills from equipment causing sublethal effects	Decomissioning	Road	Adverse	Indirect	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Increase in potential toxins leading to sub-lethal behavioural changes and physiological stress	Negligible	Local	Short Term	Regular	Short Term	Low	Low	Low	Negligible	High
Noise from blasting and driving piles for bridges causing mortality	Construction	Road	Adverse	Direct	Blasting mats, avoid blasting during fall spawning, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Blunt tissue damage causing mortality to all life stages	High	Local	Short Term	Sporadic	Short Term	High	Low	Low	Negligible	High
Noise from equipment and construction activities causing causing sublethal effects	Construction, Operations, Decomissioning	Road	Adverse	Direct	Blasting mats, avoid blasting near Contwoyto Lake during fall spawning, thermal atmospheric inversions, low cloud cover, or fog conditions, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Increase in noise leading to sub-lethal behavioural changes and physiological stress	Negligible	Local	Short Term	Sporadic	Short Term	High	Low	Moderate	Negligible	High
Particulates and residue from trucks, road construction, equipment activity, and blasting increasing TSS and causing sublethal effects	Construction	Road	Adverse	Indirect	Blasting mats, avoid blasting near Contwoyto Lake during fall spawning, thermal atmospheric inversions, low cloud cover, or fog conditions, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Elevated dust generation on road because road not wetted during summer. Quarries wetted, but dust and nitrogen residues from blasting not washed away quickly in summer as during spring freshet.	Negligible	Local	Medium Term	Continuous	Short Term	High	Low	Moderate	Negligible	High
Particulates and residue from trucks, equipment activity and explosives storage increasing TSS and causing sublethal effects	Operations, Decomissioning	Road	Adverse	Indirect	Operation and decomissioning during winter will reduce dust generation. Blasting will not occur during operation, only rock crushing.	Very low dust generation during winter operation	Negligible	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
ML/ARD from exposed rock causing sublethal behavioural effects	Construction, Operations, Decommissioning, Post-Closure	Road	Adverse	Direct	Implementation of ML/ARD Prediction and Prevention Management Plan, and Environmental Effects Monitoring Program.	ML/ARD resulting in behavioural changes and physiological stress	Negligible	Local	Far Future	Regular	Long Term	High	Low	Low	Negligible	Low
Sewage effluent nitrates from camps discharged into Contwoyto Lake or onto "tundra field" causing sublethal effects	Construction, Operations	Road	Adverse	Direct	Tertiary treatment of all effluent and separation from solids at water treatment plant prior to release into lake, removal of solids and filtrate to tundra field at mobile camps, and implementing Environmental Effects Monitoring Program.	Increase in nitrogenous waste products entering lake and streams causing sub-lethal behavioural and physiological changes	Low	Local	Medium Term	Continuous	Short Term	High	Low	Low	Negligible	High
Lake water drawdown leading to a loss of habitat	Construction, Operations	Road	Adverse	Indirect	Regulate water usage relative to lake water stage if required beyond 6,000 L/d; Place screens over intake; Reduce intake flow to prevent the entrainment of fish	Tissue damage or mortality as a result of entrainment on intake screen	Low	Local	Medium Term	Continuous	Short Term	High	Nil	Low	Negligible	High

Numbers in brackets refer to a specific Project activity outlined in Table 5.1-2 in the Effects Assessment Methodology.

TSS - total suspended solids.

DFO - Fisheries and Oceans Canada.

ML/ARD - metal leaching and acid rock drainage.

Table 4.3-3
Summary of Effects Assessment for Fish Habitat

Description of Potential Effect					Mitigation and Enhancement	Evaluation of Residual Effect										
	Project Phase (Timing)	**Project Component**	**Direction**	**Nature**			**Magnitude**	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility**	**Ecological Context (Resilience)**	**Influence on Resource Capacity**	**Probability of Occurrence**	**Significance**	**Confidence Level**
Description	Construction Operations Decommissioning Post-Closure	Port Site All-Weather Road Shipping Lane Human Resources	Beneficial Adverse Neutral	Direct Indirect Cummulative Synergistic	**(Design Changes, Management, Monitoring, Compensation, Enhancement)**	**Description of Residual Effect (after mitigation)**	Negligible Low Moderate High	Local Landscape Regional Trans-Boundary	Short Term Medium Term Long Term Far Future	One Time Sporadic Regular Continuous	Short Term Long Term Irreversible	High Neutral Low	Nil Low Moderate High Unkown	Low Moderate High	Negligible Low Moderate High	High Intermediate Low
Sedimentation from construction activities and summer run-off increasing TSS and reducing sunlight, affecting fish food sources	Construction	Road	Adverse	Indirect	Silt fences, Erosion and Sediment Management Plan	Increased TSS above background, and decreased primary and secondary production	Negligible	Local	Short Term	Regular	Short Term	High	Low	Moderate	Negligible	High
Sedimentation from truck hauling, snow removal, bridge removal, contouring, soil erosion and slumping increasing TSS and reducing sunlight, affecting fish food sources	Operations, Decomissioning, Post-Closure	Road	Adverse	Indirect	Silt fences, Erosion and Sediment Management Plan	Increased TSS above background, and decreased primary and secondary production	Negligible	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Sedimentation from construction activities and summer run-off covering substrate and reducing habitat	Construction	Road	Adverse	Direct	Silt fences, Erosion and Sediment Management Plan, Implementation of Fish Habitat Compensation Plan	Habitat loss	Low	Local	Short Term	Regular	Short Term	High	Low	Moderate	Low	High
Sedimentation from truck hauling, snow removal, bridge removal and contouring covering substrate and reducing habitat	Operations	Road	Adverse	Direct	Silt fences, Erosion and Sediment Management Plan, Implementation of Fish Habitat Compensation Plan	Habitat loss	Negligible	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
Pilings and rip rap for bridge construction reducing habitat	Construction	Road	Adverse	Direct	Implementation of Fish Habitat Compensation Plan	Habitat loss, requiring compensation	Low	Local	Medium Term	Continuous	Short Term	High	Low	High	Low	High
Spills from equipment, hauled fuels and cargos, and waste products affecting fish food sources	Construction	Road	Adverse	Indirect	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Decreased primary and secondary production	Low	Local	Medium Term	Regular	Short Term	Low	Low	Moderate	Low	High
Spills from equipment, hauled fuels and cargos, and waste products affecting fish food sources	Operations, Decommissioning	Road	Adverse	Indirect	Spill kits, equipment maintenance, Implementation of Spill Contingency and Emergency Response Plan	Decreased primary and secondary production	Negligible	Local	Medium Term	Regular	Short Term	Low	Low	Low	Negligible	High
Particulates and residue from trucks, road construction, equipment activity, and blasting increasing TSS and reducing sunlight, affecting fish food sources	Construction	Road	Adverse	Indirect	Blasting mats, avoid blasting during Fall spawning, thermal atmospheric inversions, low cloud cover, or fog conditions, follow DFO Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters	Increased TSS above background and decreased primary and secondary production	Negligible	Local	Medium Term	Continuous	Short Term	High	Low	Moderate	Negligible	High
Particulates and residue from trucks, equipment activity and explosives storage increasing TSS and reducing sunlight, affecting fish food sources	Operations, Decomissioning and Closure	Road	Adverse	Indirect	Operation and decomissioning during winter will reduce dust generation. Blasting will not occur during operation, only rock crushing.	Increased TSS above background and decreased primary and secondary production	Negligible	Local	Short Term	Regular	Short Term	High	Low	Low	Negligible	High
ML/ARD from exposed rock affecting fish food sources	Construction	Road	Adverse	Indirect	Implementation of ML/ARD Prediction and Prevention Management Plan, and Environmental Effects Monitoring Program.	Decreased primary and secondary production	Negligible	Local	Far Future	Regular	Long Term	High	Low	Low	Negligible	Low
Sewage effluent nitrates from camps discharged into Contwoyto Lake or onto "tundra field" affecting fish food resources	Construction, Operations	Road	Neutral	Indirect	Tertiary treatment of all effluent and separation from solids at water treatment plant prior to release into lake, removal of solids and filtrate to tundra field at mobile camps, and implementing Environmental Effects Monitoring Program.	Discharge of nitrates	Negligible	Local	Medium Term	Continuous	Short Term	High	Low	Low	Negligible	High
Lake water drawdown leading to a loss of habitat	Construction, Operations	Road	Adverse	Indirect	Regulate water usage relative to lake water stage if required beyond 6,000 L/d; Place screens over intake; Reduce intake flow to prevent the entrainment of fish	None	-	-	-	-	-	-	-	-	-	-

Numbers in brackets refer to a specific Project activity outlined in Table 5.1-2 in the Effects Assessment Methodology.

TSS - total suspended solids.

DFO - Fisheries and Oceans Canada.

ML/ARD - metal leaching and acid rock drainage.

4.4 Lethal Effects

4.4.1 Introduction

Mortality of fish occurs when an action results in the immediate or near immediate death of fish. Direct mortality typically occurs due to a physiological challenge the fish cannot overcome, such as contact with toxic chemicals, hypoxic conditions (low oxygen levels) in the environment, or blunt trauma causing tissue damage.

4.4.2 Physical Damage

Possible causes of lethal tissue damage to fish in the Project area include construction equipment crossing streams for bridge and culvert construction, driving bridge pilings, rock blasting at quarry sites, and water withdrawal from Contwoyto Lake. Stream crossings of equipment will occur during the winter or be one-time events for each crossing during summer (DFO, 2007b). Each site will be pre-inspected for evidence of possible spawning gravels during summer, while instream work will be avoided during the spring spawning period (May 1 to July 15) for Arctic grayling (DFO, 2007d) to avoid direct mortality of eggs, larvae, and adults. With these mitigation measures, direct fish mortality due to construction equipment should be **negligible** (Tables 4.3-1 and 4.3-2).

The sound waves created by blasting near water and driving in pilings for bridges can cause physical damage to fish eggs, larvae, juveniles, and adults (Wright, 1982; DFO, 2004; Faulkner *et al.*, 2006; Faulkner *et al.*, In press). The most common tissue damage occurs to the swim bladder of juveniles and adults, and to the embryo of eggs. However, the effect of blasting along the road is likely to be **negligible** for adjacent streams (Tables 4.3-1 and 4.3-2), even for abundant Arctic grayling, for three main reasons: the lethal effects of sound waves near water are very localized; all quarry site blasting will be located at least 10 m from fish-bearing streams to avoid damage (<100 db) to possible spawning habitat (Wright and Hopky, 1998); and, only the Mara River stream crossing currently has a bridge plan involving the use of pilings. Also, no quarries are located in the immediate vicinity of Contwoyto Camp, so blasting will not affect Arctic char, lake trout, or whitefish that are prevalent in Contwoyto Lake (Appendix C-6 of the DEIS). Table 4.4-1 lists the location, distance from the nearest waterbody, and the likelihood of fish presence adjacent to each quarry along the proposed road. In addition, Table 4.4-2 summarizes the suggested minimum setback distances for the safe use of explosives in all soil types adjacent to fish-bearing habitat (Wright and Hopky, 1998). However, final setback distances will need to be calculated based on Nunavut guidelines, which use 50 kPa in calculating the setback criteria, rather than the 100 kPa used by Wright and Hopky (1998).

Water withdrawal from Contwoyto Lake also has the potential to cause fish mortality. Mortality by pumping fish through the piping will be avoided by installing and maintaining an adequate screen on the pipe intake, as outlined in guidelines developed by DFO (DFO, 1995). Entrainment of fish on the screen will be avoided by maintaining intake flow at a safe level. The significance of effects resulting from withdrawing water from Contwoyto Lake is therefore predicted to be **negligible** (Tables 4.3-1 and 4.3-2).

Table 4.4-1
Quarries and their Distance from Fish-Bearing Waterbodies

Quarry (km)	Quarry Area (Ha)	Distance (m) to Waterbody[1]	Fish Presence[2]	Comments
0.5	1.5	630	Yes	Bathurst Inlet
7.8	2.4	900	Yes	Amagok Creek
12.1	3.1	970	Potential	
18.0	2.7	260	Potential	
19.1	1.0	310	Potential	
26.1	2.2	1300	Potential	
29.5	2.4	430	Potential	
41.7	2.3	90	Potential	
44.5	1.6	25	Potential	
46.7	1.1	470	Potential	
48.9	0.8	280	Potential	
54.7	2.3	450	Potential	
61.4	2.5	460	None	
66.5	2.4	530	None	
69.2	1.2	425	Potential	
77.0	1.9	1550	Potential	
81.0	1.6	70	None	
83.0	0.6	920	Potential	
85.0	1.8	100	None	
89.4	1.9	575	Potential	
103.0	2.8	500	Potential	
108.8	3.2	920	Potential	
117.6	2.5	420	Potential	
122.0	3.4	490	None	
129.0	1.8	1300	Yes	Mara River
137.7	2.5	165	Potential	
151.5	3.2	245	Potential	
157.4	1.3	730	Potential	
160.0	1.9	450	Potential	
164.0	1.3	360	Potential	
167.0	0.9	440	Potential	
171.0	1.1	300	Potential	
176.0	1.1	180	Potential	
177.0	2.7	530	Potential	
193.0	3.2	900	Potential	
193.0	1.5	750	Potential	
197.2	3.2	430	Potential	
203.7	2.457	80	Potential	
207.2	2.625	310	Potential	
209.0	0.945	360	None	1600 m to Contwoyto Lake

[1] Distance to nearest waterbody with the greatest fish-bearing potential was calculated using ArcGIS.
[2] Fish presence was estimated based on connectivity to known fish-bearing waterbodies.

Table 4.4-2
Minimum Setback Distance for Detonations near Fish-Bearing Habitat for all Substrate Types

Weight of Explosive	Setback Distance[1]
(kg)	(m)
0.5	10.7
1	15.1
5	33.7
10	47.8
25	75.5
50	106.7
100	150.9

[1] Minimum setbacks listed are based on 100 kPa guideline criteria (Wright and Hopky, 1998).
Note: Nunavut guidelines use 50 kPa for safe detonation criteria.

4.4.3 Smothering (Hypoxia/Anoxia)

4.4.3.1 General

Construction activities near streams such as building bridges and culverts, and blasting at quarry sites are likely causes of sedimentation along stream banks. High precipitation in the summer also can lead to sediment run-off into streams. Sedimentation events can be lethal to incubating fish eggs in streambeds and larvae present in the substrate due to deposition of fine sediment within the gravel (Platts and Megahan, 1975; Lisle, 1989). This sediment can block oxygen transport across the membrane to the growing embryo, creating hypoxic (low oxygen) or even anoxic (no oxygen) conditions (Turnpenny and Williams, 1980; Ingendahl, 2001).

Also larvae that have hatched can become buried under the sediment which creates a physical barrier preventing them from emerging (Chapman, 1988; Crisp, 1996). Although lethal sedimentation events will be mitigated using silt fences and following the erosion and sediment control measures, sedimentation is still possible during periods of high precipitation and equipment accidents during construction.

Sedimentation along stream banks is less likely from truck hauling, snow removal (on graveled road), bridge removal and quarry contouring during the operations and decommissioning phases of the Project once mitigation measures are in place. While these activities are possible causes of sedimentation causing lethal effects, their effects are likely **negligible** (Tables 4.3-1 and 4.3-2).

4.4.3.2 Arctic Grayling

Arctic grayling are the fish species most likely to be affected by sedimentation events during construction because they are the most abundant and widespread species along the road. Eighteen stream crossings contain grayling populations, including the four largest crossings at the Mara River, Amagok Creek and two no name creeks (Appendix C-5 of the DEIS). Grayling spawn in large and small streams typical of those to be crossed by the road (Scott and Crossman, 1973), so their early life stages are particularly susceptible to mortality due to sedimentation events. Thus, for the construction phase of the Project the control of sediment is of particular concern during the spring spawning period (May 1 to July 15) for Arctic grayling (DFO, 2007d).

4.4.3.3 Arctic Char, Lake Trout, and Whitefish

The other three fish VECs, Arctic char, lake trout, and whitefish, are not likely to be affected because these species use the streams in the Project area mainly as migratory corridors. Streams may be used by some fish as spawning or rearing habitat, but the presence of these species outside of Contwoyto Lake was uncommon to rare. Spawning for these species occurs in the fall and typically in lakes (Table 3.1-2). Because construction at Contwoyto Lake will consist of the camp and terminal end of the road, sedimentation is expected to be minimal.

4.4.4 Physiological Toxicity

4.4.4.1 General

Most petroleum products from potential spills along the road (*e.g.*, gasoline, diesel, fuel oil) are toxic to fish and can cause mortality (Tagatz, 1961; Hedtke and Puglisi, 1982; Lockhart *et al.*, 1996). The lethality of these products increases when accompanied by low dissolved oxygen levels (<4 ppm). The toxic action of these hydrocarbons occurs through their water soluble constituents and emulsions causing damage to gill epithelia, nerve damage, liver destruction and general organ failure (Fryday *et al.*, 1996; Omoregie and Ufodike, 2000). The possibility of fish exposure to spilled toxins is likely to occur only during the summer months of the construction phase, when streams along the road are flowing.

Explosives to be used for blasting rock at the quarry sites typically contain ammonium nitrate as an oxidizing agent. Residues that contain ammonia, ammonium nitrate, or the oxidative intermediate nitrite, in high enough concentrations can be toxic to all life-history stages of fish (Lewis and Morris, 1986; Servizi and Gordon, 1990; Camargo *et al.*, 2005). These residues may enter the water immediately after blasting from particulates settling out of the air, or during summer precipitation events as run off.

Nitrogenous waste products contained in sewage discharge can reduce water quality depending on the degree of dilution, treatment, and composition relative to the surrounding environment. Oxygen depletion is the most common effect of nitrogenous wastes due to microbial growth on its organic content (Munro and Roberts, 2001). However, toxic effects are possible due to the presence of inorganic nutrients (*e.g.*, phosphates, ammonia and nitrates) that can cause mortality (Smith and Suthers, 1999; Saborido-Rey *et al.*, 2007) and trigger algal blooms as well. One nutrient common in sewage discharge is the highly toxic nitrite ion, although its presence is likely short-lived before oxidizing to nitrate (Munro and Roberts, 2001). While sometimes present in municipal sewage, it is not expected that heavy metals or toxic organic wastes such as polychlorinated biphenyls (PCBs) will be present in the waste products of the camps. Treated sewage outfalls will be located in Contwoyto Lake during the construction and operations phases of the Project, and along the tundra near the mobile camps during summers of the construction phase only. During the winter, sewage from the mobile camps will be collected and transported to a sewage treatment facility. Therefore, the probability that fish in streams along the road route will be exposed to treated sewage effluents is highest during the summers of the construction phase.

4.4.4.2 Arctic Grayling

Because Arctic grayling are abundant along the road route, they are the fish species most likely to be affected by accidental spills occurring during construction and hauling, whether from cargo, trucks, or other equipment. Several quarry sites are located in close proximity to streams along the road as well, making contact with residues from blasting possible. In addition, treated effluent discharged to the tundra during the construction phase is most likely to affect grayling populations. However, due to mitigation measures such as spill kits, equipment maintenance, and others contained in response plans for spills (Appendix G-4 of the DEIS), the probability of fish mortalities due to spilled petroleum products or toxic explosives residues is expected to be **low** for the construction phase and **negligible** for the operations and closure phases, when activities are scheduled during winter months (Table 4.3-1). Also, only treated sewage will be discharged from the camps onto the tundra. Therefore, the possibility of fish mortality observed in other effluent studies (Lemly, 1996; Smith and Suthers, 1999) is predicted to be **low** during the construction phases and **negligible** during the remainder of the Project.

4.4.4.3 Arctic Char, Lake Trout, and Whitefish

Any spills that occur from equipment or hauling during the Project are not expected to affect Contwoyto Lake. The lake will be approached at one isolated location during construction of the road, Contwoyto Camp will be constructed away from the shorelines, no water drainages exist on the peninsula where it is located, and haul trucks will cross the lake only during the winter when spills can be completely cleaned up from the snow and ice. Because Arctic char, lake trout, and whitefish are prevalent only within the lake, any effects from spills are expected to be **negligible** (Table 4.3-2). The same is true for residues from construction blasting, because no quarries are located in the vicinity of the lake.

Also, treated sewage discharged into Contwoyto Lake from the camp at the terminal end of the road is not expected to cause mortality in these fish species. Given the volume of water within the lake compared with streams along the road, lethal effects from this effluent are predicted to be **negligible** during all Project phases.

4.5 Sublethal Effects

4.5.1 Introduction

Sublethal effects generally lead to deterioration in the health of individuals or a population. These effects can become manifest as detrimental changes to an organism with respect to their behaviour (*e.g.*, changes in swimming patterns, decreased feeding) or physiology (*e.g.*, increased osmoregulatory stress, decreased swimming performance). These changes can lead indirectly to mortality by increasing the chance of predation, increasing susceptibility to disease or decreasing the ability to survive winter conditions.

4.5.2 Behavioural Changes

4.5.2.1 General

High levels of total suspended solids (TSS) can occur from sedimentation events during construction (*e.g.*, materials accidently pushed into stream, loosening materials along stream banks) and runoff during spring freshet and summer rains. Other sources of TSS include particulates from haul trucks, construction equipment activity, and blasting. High TSS levels can lead to behavioural changes in fish such as alterations in migration routes and spawning behaviour (Cordone and Kelley, 1961). Although salmon will migrate through most areas of suspended particulates, they only spawn in tributaries with clear water or low turbidity. Although a sedimentation event high enough in magnitude to affect spawning or migration is not likely during the lifetime of the Project, moderate sedimentation events are probable during the construction phase. Part of the construction phase of the road will occur during the summer when stream banks are more susceptible to slumping and high precipitation events are possible.

Noise pollution also has been shown to affect fish behaviour. Behavioural changes can include an acute startle response, change in swimming patterns, change in vertical distribution and feeding, and interruption of spawning activities from noise caused by blasting (DFO, 2004), truck traffic, or construction activities. However, the use of proper blasting techniques (Wright and Hopky, 1998), and avoiding bridge construction and blasting during spawning periods should mitigate noise impacts so that effects on fish behaviour are **negligible**.

Behavioural changes in fish after sublethal exposure to spilled petroleum products, or residues from explosives, typically are responses to the physiological changes caused by the toxins. Acute and chronic stress responses, as indicated by disturbances in blood chemistry (Zbanyszek and Smith, 1984; Alkindi *et al.*, 1996), can lead to behavioural changes such as decreased feeding activity (Camargo *et al*., 2005) and changes in swimming behaviour (Struhsaker, 1977; Little and DeLonay, 1996). The likelihood of exposure to toxic substances is expected to be highest during the summer seasons of the construction phase along the road route.

The constituents of sewage effluent have been shown to cause sublethal behavioural effects such as avoidance behaviour (Richardson *et al.*, 2001b). On a population scale, the continued outfall of nitrogenous wastes can lead to changes in species diversity and abundance relative to control areas (Grigg, 1994). As well, increases in parasite load can occur in areas of sewage effluent exposure (Siddall *et al.*, 1994), which can lead to physiological and behavioural changes (Poulin, 1995). Fish exposure to treated sewage effluents in streams along the road route will occur only during the construction phase in the summer, when treated sewage outfalls will be located along the tundra near the mobile camps. Exposure to the point source outfall of treated sewage in Contwoyto Lake will be continuous during the construction and operations phases.

Metal leaching and acid rock drainage (ML/ARD) may occur at quarries, or along the road route from rock obtained from quarry sites (see Appendix D-6 of the DEIS). The expected duration of any ML/ARD that does occur is for the lifetime of the Project. Leachates from ML/ARD have been shown to cause changes in fish swimming behaviour and feeding behaviour, and can lead to mortality when approaching or exceeding conservative toxicity thresholds (Hansen *et al.*, 1999;

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Todd *et al.*, 2006). These upper toxicity limits are not likely to occur in the Project area, so lethal effects were not considered. Sublethal effects occur due to metals accumulation in the gills of fish causing a stress response that can lead to behavioural changes (Wendelaar Bonga, 1997). Several locations along the road route have been identified as possible low yield ML/ARD sites, although confidence in whether these sites will produce ML/ARD and to what degree is low. Mitigation measures therefore include conducting detailed sampling for potential ML/ARD prior to excavation and use of any potential acid-generating rock (Appendix D-2 of the DEIS). The probability of sub-lethal behavioural changes occurring in the Project area is therefore **negligible** (Tables 4.3-1 and 4.3-2).

4.5.2.2 Arctic Grayling

Possible behavioural impacts on Arctic grayling from suspended sediments, spills, and effluents are predicted only during the construction phase of the Project. This is the only phase during which Project activities will occur during the summer months, when snow and ice will not be present to help solidify stream banks or block spills from entering streams. Also, during summer construction treated sewage from the mobile camps will be pumped directly onto the tundra, where the potential exists for heavy rains to transport the effluent into nearby streams. Any post-mitigation effects from these events may affect the behaviour of Arctic grayling, due to their abundance in streams along the road route.

4.5.2.3 Arctic Char, Lake Trout, and Whitefish

Any post-mitigation effects from suspended sediments, spills, and effluents along the road route where they are not abundant are not likely to affect the behaviour of these fish VECs, because of their scarcity in streams along the road route. Any effects from these events within Contwoyto Lake are predicted to be **negligible** because of the large size of the lake and the terminal end of the road acting as only a single point source (Table 4.3-2). Therefore, these prevalent fish species within the lake are not expected to incur any sublethal behavioural effects.

4.5.3 Physiological Changes

4.5.3.1 General

TSS produced by sedimentation and particulates can cause minor physical damages, such as gill damage, leading to decreased fitness because of reduced ability to feed, spawn, and avoid predators. Increased respiratory and osmoregulatory stress can occur due to abrasion to the gill filaments and matting action reducing the surface area (Cordone and Kelley, 1961; Newcombe and MacDonald, 1991; Sutherland and Meyer, 2007). Moderate gill damage to small riverine fish has been shown to occur at suspended sediment levels ≥ 100 mg/L, with severe damage at 500 mg/L (Sutherland and Meyer, 2007). Eye damage also is possible, but sediment loads would have to be very high in fast moving water because the continuous secretion of mucus washes away most sediment particles and protects the eyes. These types of physical damage are most likely to occur during the summer months of the construction phase when sedimentation events are most likely.

The most common sublethal effect of sudden noise for fish is the triggering of an acute stress response. When fish are startled by explosive blasts or construction activities, catecholamines

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are released that increase oxygen uptake and mobilize energy for swimming (Wendelaar Bonga, 1997). A chronic stressor can reduce growth and increase susceptibility to infection. Sustained noise in a single area is not expected during the construction phase because the road endpoints and mobile camps will be moving as construction progresses. **Sporadic** noise will occur during the operations phase at all stream crossings, but these will be point sources at each stream so any stress effects should be **negligible** (Tables 4.3-1 and 4.3-2).

Physiological changes from sublethal exposure to petroleum products (≤7.2 ppm) include increased haematocrit, haemoglobin concentration, erythrocyte counts, plasma glucose and cortisol, along with variable changes in plasma chloride and potassium (Zbanyszek and Smith, 1984; Alkindi *et al.*, 1996). These disturbances in blood chemistry indicate an acute stress response (Wendelaar Bonga, 1997) to the exposed hydrocarbons that can lead to decreased feeding activity, growth, and swimming performance (Lockhart *et al.*, 1996; Hymel *et al.*, 2002).

Toxic residues from blasting that enter freshwater habitat at a slow rate or at concentrations below toxic levels still can cause physiological changes in fish. Nitrate concentration at the maximum USA federal limit for drinking water (10 mg NO_3-N/L) can affect the physiology of fish leading to decreased growth (Camargo *et al.*, 2005). Other physiological changes include nerve damage during development, along with damage to muscles and liver. Sublethal impacts from either spills or toxic residues are most likely to occur during the summer months of the construction phase when streams are free of ice and direct contamination is possible.

Exposure to nitrogenous wastes has been shown to cause a general stress response (Wendelaar Bonga, 1997) in fish that can lead to sublethal changes in development (Weis and Weis, 1989; Weis *et al.*, 1989), decreased growth (Smith and Suthers, 1999; Saborido-Rey *et al.*, 2007) and decreased swimming performance (Shingles *et al.*, 2001). As well, chronic exposure can increase the susceptibility of fish to infection (Carballo *et al.*, 1995). These sublethal effects are most likely to occur in streams along the road during the summer months of the construction phase when treated sewage outfalls for the mobile camps will be located along the tundra. At this time the treated effluent will be susceptible to being washed into streams during heavy rain events. The treated sewage outfall from the camp at Contwoyto Lake will function continuously during the construction and operational phases of Project.

Physiological effects of ML/ARD leachates on fish include acid-base disturbance, changes in gill Na,K-activated ATPase activity, ionic fluxes and metals toxicity (Evans, 1987; Wood, 1992). Chronic stress due to exposure to ML/ARD constituents at sublethal levels can lead to decreased growth in fish because of higher metabolic demands (Todd *et al.*, 2006). The stress response is due to metal uptake and pH surges that in turn stimulate increased gas exchange (Wood, 1992). The probability of sub-lethal physiological impacts on fish in the Project area is most likely **negligible** because of low-yield ML/ARD rock, but the confidence level is low (Tables 4.3-1 and 4.3-2).

4.5.3.2 Arctic Grayling

Arctic grayling are the most abundant fish in the streams along the road route, and therefore are the species most susceptible to sediments and toxins from spills, explosives, and waste products. The significance of physiological impacts caused by these substances after mitigation is predicted to be

low during the construction phase and negligible during the other Project phases for this VEC (Table 4.3-1). The construction phase will continue during the summer months when snow and ice will not be present to help solidify stream banks or block spills from entering streams. Also, blasting and construction along the road will allow particulates and residues to enter the water directly. During summer construction, treated sewage from the mobile camps will be pumped directly onto the tundra where transport into nearby streams by heavy rains is possible.

4.5.3.3 Arctic Char, Lake Trout, and Whitefish

These species are not abundant in streams along the road so post-mitigation effects from suspended sediments, spills, and effluents are not likely to affect their physiology. Any effects from these events within Contwoyto Lake are predicted to be **negligible** because of the large size of the lake and the fact that most activities will occur along the road route (Table 4.3-2). Treated effluent released from the sewage outfall at Contwoyto Camp into the lake is not expected to negatively affect fish in the area. Besides the fact that this point source of treated effluent will be negligible compared to the volume of the lake, nutrients and food resources from sewage can benefit fish larvae under some conditions (McVicar *et al.*, 1988). Also, significant changes in fish distribution and abundance do not necessarily occur at sewage outfall sites (Gray *et al.*, 1992). Therefore, Arctic char, lake trout and whitefish common to the lake are not expected to incur any sublethal physiological effects during the Project.

4.6 Fish Habitat Loss

4.6.1 Introduction

The productive capacity of fish habitat is defined as "the maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend" (DFO, 1986). Productive capacity may be altered by physical or chemical changes to fish habitat, or by direct loss of fish habitat. A summary of the effects of the road on the productive capacity of fish habitat is presented in Table 4.3-3. Another detailed analysis of primary and secondary production in freshwater along the road route can be found in Appendix C-3 of the DEIS.

4.6.2 Productive Capacity

4.6.2.1 General

Incidental sedimentation events are likely to occur during summer construction at stream crossings because of equipment activities and precipitation run-off. During this time, particulates are also likely to enter the streams due to road activities and blasting at quarries. The effect of these events can be temporarily elevated TSS as well as siltation of the substrate (DFO, 1986). Sediments may accumulate in some of the streams because they are shallow with low discharge rates (Appendices C-6 and C-7 of the DEIS). Although sedimentation events are most likely to occur during the construction phase, the effects on the productive capacity of streams and at Contwoyto Lake will be **negligible** because of sediment and erosion control measures (Table 4.3-3).

Contamination of habitat leading to decreased productive capacity may occur if petroleum products are spilled from equipment or haul loads, or from blasting particulates containing toxic residues. Toxin such as diesel fuel can significantly reduce primary and secondary producer densities and assemblages (Lytle and Peckarsky, 2001). The most likely time for these events to occur is during the summers of the construction phase when the waterways are open. Contamination is less likely at Contwoyto Lake than at the streams along the road because little construction will occur at the edge of the lake, and no quarries are located nearby. Although toxic effects on productive capacity from blasting residues should be negligible during the Project, effects from accidental spills during the construction phase are possible.

Possible ML/ARD sites along the road route have been identified as well as the quarry sites where rock will be exposed from blasting. Acids and metals leaching into aquatic environments can lead to decreased densities and species richness of primary and secondary producers (McKnight and Feder, 1984). ML/ARD generation along the road is predicted as being low-yield, so the likelihood of productive capacity being affected is **negligible**, however this prediction is uncertain. The ML/ARD Management Plan (Appendix D-2 of the DEIS) will reduce the potential for generation of ML/ARD.

While the toxic components of nitrogenous wastes can have deleterious effects on fish, their effects on the productive capacity of fish habitat can be variable. In fact, the increased nutrients from sewage effluent can actually increase primary and secondary production (McVicar *et al.*, 1988). Thus, the addition of nitrogenous wastes to a system sometimes result in no significant changes in the distribution or abundance of fish species near the outfall sites (Gray *et al.*, 1992). It is expected that the effects of treated sewage effluent in streams and Contwoyto Lake during the Project will be **negligible**.

4.6.2.2 Arctic Grayling

Arctic grayling are expected to be the fish species most susceptible to changes in productive capacity of streams along the road route because of their abundance. The significance of post-mitigation production effects due to spills is predicted to be **low** during the construction phase and negligible during the other Project phases.

4.6.2.3 Arctic Char, Lake Trout, and Whitefish

The probability that spills will occur in Contwoyto Lake is negligible, so Arctic char, lake trout, and whitefish are not expected to be affected. Use of streams along the road by these species is very low so any changes in productivity are not likely to affect their populations.

4.6.3 Fish Habitat

Habitat loss refers to the removal of physical alteration of aspects of the environment that are used either directly or indirectly by fish. A summary of the effects of the road on fish habitat is presented in Table 4.3-3.

4.6.3.1 General

Incidental sediment pulses during construction may occur during construction; however, extensive sedimentation will be avoided through the application of sediment and erosion control measures. It is possible that a short pulse of sediment could have a low impact on stream habitat because of the generally low discharge of streams in the Project area. However, proper sediment controls will limit the induction of sediment to streams along the road during the operation phase by directing run-off away from stream channels.

Stream crossings associated with roads have historically acted as barriers to fish passage, isolating populations and hindering migration to key habitats, such as spawning grounds or overwintering habitat. Poorly designed or installed stream crossings may also lead to erosion, affecting downstream habitat by introducing excess quantities of fine sediment, and may ultimately lead to road failure and elevated road maintenance costs. In an effort to minimize impacts to fish migration along the proposed road, and to avoid the harmful alteration, disruption or destruction (HADD) of fish habitat wherever possible, fish presence was determined at each stream crossing and an appropriate crossing structure was designed according to the results of the fisheries survey and the bankfull width of the stream.

Three crossing types will be used along the proposed road: rock fords, arch culverts, and bridges. Rock fords will only be used in small drainages that are non-fish-bearing. Arch culverts will be installed at small fish-bearing crossings to avoid disturbing the natural streambed. Culvert width will be at least 1 m greater than the bankfull width of the stream, thereby avoiding disturbance of the bank. Larger fish-bearing crossings will be spanned by a bridge. Again, to minimize disturbance to the bank and allow the bridge abutments to be reinforced with riprap without the need for instream work, bridge length will be a minimum of 5 m greater than the bankfull width. Installation of clear-span bridges will adhere to the relevant DFO Operational Statement (DFO, 2007b). Table 4.6-1 provides details on the crossing structure to be installed at each of the 104 stream crossings along the proposed road.

Adherence to these protocols, along with a final survey of the route prior to construction, will avoid HADDs at all crossings except those at Amagok Creek (22.9 km) and the Mara River (128.8 km). A final survey of the road alignment will be undertaken to confirm fish absence at crossings classified as non-fish-bearing, and to identify the exact crossing location where culverts and bridges should be installed to minimize both disturbance and cost. Due to the size and bank morphology at Amagok Creek and the Mara River, some instream work will be required to provide the required stability. Both crossings will include abutments that encroach on the bankfull width, while the crossing of the Mara River will also involve two instream piers. A conservative estimate of the fish habitat disturbed is 110 m^2 at Amagok Creek and 900 m^2 at the Mara River. Fish habitat compensation will be undertaken to comply with the No Net Loss policy of fish habitat (DFO, 1986) (Section 5.3.3).

4.6.3.2 Arctic Grayling

All life history stages of Arctic grayling use streams along the road route. Therefore, this species is likely to be affected if spawning and rearing habitats are lost due to bridge construction or sedimentation during the construction phase. However, habitat lost to bridge construction will be compensated for (Section 5.3.3), and habitat disturbed by sedimentation is expected to recover during the operations phase of the Project.

Table 4.6-1
Proposed Crossing Structures along the Road

Final km	Fish-bearing Status	Average Bankfull Width (m)	Proposed Crossing
2.2	Fish-bearing	6.2	Bridge
2.8	Non-fish-bearing	3.8	Ford
7.8	Potentially fish-bearing	1.7	Culvert
14.1	Potentially fish-bearing	9.3	Culvert
18.3	Non-fish-bearing	n/a	Ford
22.9	Fish-bearing	46.7	Bridge
25.7	Non-fish-bearing	n/a	Ford
27.4	Non-fish-bearing	n/a	Ford
30.4	Non-fish-bearing	n/a	Ford
33.4	Non-fish-bearing	n/a	Ford
33.7	Fish-bearing	36.5	Bridge
33.8	Non-fish-bearing	9.9	Bridge
34.8	Fish-bearing	14.1	Bridge
35.9	Fish-bearing	34.0	Bridge
36.6	Potentially fish-bearing	18.0	Bridge
38.1	Non-fish-bearing	n/a	Ford
39.0	Fish-bearing	n/a	Culvert
40.6	Non-fish-bearing	n/a	Ford
42.3	Fish-bearing	6.2	Culvert
43.3	Potentially fish-bearing	13.0	Ford
44.5	Fish-bearing	28.8	Culvert
47.5	Non-fish-bearing	n/a	Ford
49.7	Fish-bearing	2.3	Culvert
52.0	Potentially fish-bearing	50.0	Bridge
54.3	Non-fish-bearing	n/a	Ford
56.9	Non-fish-bearing	n/a	Ford
58.7	Fish-bearing	6.7	Culvert
62.3	Non-fish-bearing	n/a	Ford
63.5	Non-fish-bearing	n/a	Ford
66.5	Non-fish-bearing	n/a	Ford
67.9	Potentially fish-bearing	2.2	Culvert
68.3	Potentially fish-bearing	4.0	Culvert
68.6	Fish-bearing	4.8	Culvert
69.4	Fish-bearing	0.7	Culvert
70.1	Fish-bearing	2.7	Culvert
72.2	Fish-bearing	10.8	Culvert
74.1	Non-fish-bearing	n/a	Ford

(continued)

Table 4.6-1
Proposed Crossing Structures along the Road (continued)

Final km	Fish-bearing Status	Average Bankfull Width (m)	Proposed Crossing
76.0	Fish-bearing	2.7	Culvert
77.0	Non-fish-bearing	1.2	Ford
78.9	Non-fish-bearing	n/a	Ford
80.4	Non-fish-bearing	n/a	Ford
83.7	Non-fish-bearing	n/a	Ford
84.2	Fish-bearing	6.1	Culvert
85.0	Non-fish-bearing	2.3	Ford
90.3	Non-fish-bearing	4.0	Ford
91.1	Non-fish-bearing	n/a	Ford
91.4	Potentially fish-bearing	n/a	Ford
92.3	Non-fish-bearing	n/a	Ford
94.1	Non-fish-bearing	n/a	Ford
97.2	Fish-bearing	79.8	Bridge
98.8	Non-fish-bearing	n/a	Ford
100.3	Non-fish-bearing	n/a	Ford
103.3	Fish-bearing	50.0	Bridge
103.3a	Fish-bearing	1.7	Culvert
106.7	Fish-bearing	44.0	Bridge
113.2	Non-fish-bearing	2.2	Culvert
113.8	Fish-bearing	1.1	Culvert
115.2	Fish-bearing	3.2	Culvert
117.4	Potentially fish-bearing	n/a	Culvert
119.4	Non-fish-bearing	n/a	Ford
123.3	Non-fish-bearing	n/a	Ford
123.8	Fish-bearing	n/a	Culvert
125.3	Non-fish-bearing	n/a	Ford
128.8	Fish-bearing	125.79	Bridge
134.6	Fish-bearing	57.6	Bridge
136.6	Non-fish-bearing	n/a	Ford
144.6	Non-fish-bearing	n/a	Ford
146.6	Non-fish-bearing	n/a	Ford
147.5	Non-fish-bearing	n/a	Ford
149.7	Non-fish-bearing	n/a	Ford
151.6	Non-fish-bearing	n/a	Ford
155.7	Non-fish-bearing	n/a	Ford
158.2	Non-fish-bearing	n/a	Ford

(continued)

Table 4.6-1
Proposed Crossing Structures along the Road (completed)

Final km	Fish-bearing Status	Average Bankfull Width (m)	Proposed Crossing
159.5	Fish-bearing	0.7	Culvert
159.7	Non-fish-bearing	n/a	Ford
160.7	Fish-bearing	2.1	Culvert
167.6	Non-fish-bearing	n/a	Ford
168.0	Fish-bearing	2.0	Culvert
168.3	Fish-bearing	n/a	Culvert
169.1	Fish-bearing	n/a	Bridge
169.4	Non-fish-bearing	n/a	Ford
169.6	Fish-bearing	1.0	Culvert
170.8	Fish-bearing	38.4	Culvert
173.1	Fish-bearing	4.0	Culvert
177.2	Non-fish-bearing	n/a	Ford
181.4	Fish-bearing	47.4	Bridge
182.8	Potentially fish-bearing	n/a	Ford
183.6	Fish-bearing	3.1	Culvert
186.5	Fish-bearing	0.2	Culvert
189.6	Non-fish-bearing	1.8	Culvert
192.4	Fish-bearing	4.6	Culvert
192.4a	Fish-bearing	1.9	Culvert
193.8	Non-fish-bearing	n/a	Ford
196.7	Fish-bearing	1.3	Culvert
197.0	Potentially fish-bearing	1.1	Culvert
197.4	Fish-bearing	1.9	Culvert
198.2	Non-fish-bearing	n/a	Bridge
201.9	Fish-bearing	60.2	Bridge
202.8	Fish-bearing	26.6	Bridge
204.3	Fish-bearing	14.4	Bridge
206.9	Fish-bearing	8.7	Culvert
208.2	Fish-bearing	1.7	Culvert
211.0	Non-fish-bearing	n/a	Ford

4.6.3.3 Arctic Char, Lake Trout, and Whitefish

These fish VECs are most prevalent in Contwoyto Lake and will not be affected by habitat loss at the stream crossings. Furthermore, major sedimentation events are unlikely to occur at Contwoyto Lake. Fish habitat may be affected by water withdrawal at Contwoyto Lake. However, effects are extremely unlikely because the volume of water will be limited to 6,000 litres per day, which represents < 1% of the volume of Contwoyto Lake, and is therefore below the guideline for daily withdrawal of 5% of the available water volume (DFO, 2005). Therefore, Project effects are predicted to be **negligible** for these populations of fish.

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5. MITIGATION AND MANAGEMENT PLANS

5. Mitigation and Management Plans

5.1 Introduction

As detailed in the effects assessment (Chapter 4), there are potential effects that may arise from the construction, operations and decommissioning of the Project. These effects include:

- smothering of gravel and cobble substrates due to sedimentation;
- contamination of watercourses as a result of spills of hazardous substances;
- alteration of water and/or sediment quality;
- alteration to the productive capacity of fish habitat; and
- habitat loss.

The potential impacts will be minimized through environmental engineering and road design. However, some effects on fish and fish habitat may be inevitable. This section details the mitigation and management strategies recommended to reduce or eliminate the effects associated with road construction, operations and decommissioning. Where mitigation is not possible (*i.e.*, due to habitat loss), a fish habitat compensation plan will be developed to ensure no net loss of fish habitat. This conceptual compensation plan is presented in Section 5.3.3. In addition, construction monitoring will be conducted at all stream crossings and at Contwoyto Lake to ensure no impacts to aquatic ecosystems.

5.2 Environmental Management System

5.2.1 Environmental Policy

The environmental policy for the Project is consistent with the Policy for the Management of Fish Habitat (DFO, 1986). The guiding principle of the DFO policy is “no net loss of fish habitat productive capacity” and a net gain if possible for all industrial developments in Canada affecting surface waters. Management of the Project will include stringent environmental protection policies and plans. Staff and management will work towards no net loss in fishery resources through a wide range of impact avoidance and mitigation measures, site reclamation and rehabilitation techniques, and habitat enhancement methods.

5.2.2 Environmental Management Objectives

The key to management objectives with respect to fishery resources in the Project area are to:

- ensure the continued and un-interrupted rearing, spawning and migration of fish in all fish-bearing streams of the Project area;
- avoid the harmful alteration, disruption or destruction (HADD) of fish habitat, unless authorized by DFO under Section 35 of the *Fisheries Act* (DFO, 1985);
- avoid the deposition of any substance, including sediments, that are deleterious to fish into waters frequented by fish; and

- protect, preserve, and enhance fisheries resources in the Project area from construction and operations activities, to decommissioning, closure and beyond.

5.2.3 Environmental Responsibilities

The primary environmental responsibility is to ensure that all environmental protection measures are implemented properly and effectively during the Project. To that end, senior and technical environmental staff, as well as environmental monitors (during installation of crossings in summer), will be employed throughout the life of the Project to supervise, direct, monitor and implement all of the protection measures required to ensure the above policies and objectives are met or exceeded. Environmental technicians will report to an Environmental Manager, who will report directly to the Project Manager about any significant concerns. Project staff and contractors will also be encouraged to report any potentially adverse incidents such as erosion, structural or functional failure, debris build-up at bridges and culverts, and spills/seepages/leaks.

5.3 Fisheries Management Plan

5.3.1 Objectives

5.3.1.1 HADD Avoidance

Section 35 of the *Fisheries Act* (DFO, 1985) states that allowing fish habitat HADDs without authorization of DFO is not permitted. Section 36 states that no one shall permit the introduction of substances deleterious to fish into waters frequented by fish.

The primary objective of the Fish and Fish Habitat Management Plan for the construction, operation, and closure of the Project is to avoid HADDs during all phases of the Project. Fish habitat, as defined by the *Fisheries Act*, includes "the spawning grounds, nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes," including both fish-bearing and non-fish-bearing waterbodies. The fisheries sensitive zone (FSZ) associated with streams and lakes includes not only the waterbody, but also the riparian area on either side of the waterbody.

To avoid and prevent HADDs and the introduction of deleterious substances to watercourses, and to minimize the adverse effects of any unavoidable disturbances to fish habitat, a range of specific and generally accepted techniques for sediment control, riparian care, site isolation, timing windows, reclamation and rehabilitation will be used. These are explained in this management plan and in related environmental protection plans for the Project. The Soil Erosion Management Plan (Section 5.1 of Appendix D-2 of the DEIS), Surface Water and Sediment Quality Management Plan (Section 5.2 of Appendix C-2 of the DEIS), Spill Response Plan (Appendix G-4 of the DEIS) and Fish Habitat Compensation Plans (Section 5.3.3) apply to the objectives for the protection of fish habitat.

5.3.1.2 No Net Loss Policy

The main policy objective of the federal government with respect to fish populations and fish habitat is that human activities should cause no net loss of fish productive capacity in Canadian waters. Productive capacity refers to the capability of fish habitat, including all of its physical, chemical and biological characteristics, to produce fish. In practice, productive capacity is measured in terms of aquatic habitat area, which includes both aquatic ecosystems and the associated riparian areas and vegetation.

5.3.1.3 Protection of Sensitive Species and Species at Risk

Particular attention will be paid to fish habitat containing or supporting regionally or locally sensitive species, including any rare or endangered species or locally threatened species. Although there are no endangered or threatened fish species in the Project area, there are several fish species of local and traditional importance (Appendix F-5 of the DEIS). Of the species identified in the Project area, Arctic char, lake trout and whitefish are used for Inuit subsistence fisheries, and Arctic grayling are sought by sport anglers. Lake trout and whitefish are particularly sensitive to disturbance and environmental change, and as such, extreme care should be taken when working in or near their typical habitat. Arctic grayling are the most abundant fish species in the Project area and have the highest potential to be directly affected by the Project. In particular, the workforce in the field during construction and operations of the road will be fully informed of the locations within and near the Project footprint, including all infrastructure, where these species occur or where water flows downstream into fish-bearing areas.

5.3.2 Fisheries Protection

There are numerous manuals and guidelines on the methods required to prevent HADDs of fish habitat. These include resources from provinces outside of Nunavut, such as the *Fish-Stream Crossing Guidebook* (BC MOF, 2002), the *Land Development Guidelines for the Protection of Aquatic Habitat* (Chilibeck *et al*., 1993) and *Standards and Best Practices for Instream Works* (BC MWLAP, 2004). These guidelines detail the purpose and practices of setting buffer zones, using erosion and sediment control measures, managing drainage water, working in streams, and designing stream crossings, in addition to recommending operating windows for construction in FSZs. By following the federal and territorial guidelines and others noted below, no significant residual impacts will occur to aquatic resources along the road or at the camp locations.

Comprehensive guidelines to protect fisheries resources include the following, which offer a range of effective measures that would, with proper supervision, ensure no net adverse impact to streams and lakes along the proposed road:

- *Operational Statement for Clear-span Bridges* (DFO, 2007b);
- *Operational Statement for Timing Windows* (DFO, 2007d);
- *Operational Statement for Bridge Maintenance* (DFO, 2007a);
- *Operational Statement for Culvert Maintenance* (DFO, 2007c);
- *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters* (Wright and Hopky, 1998); and
- *Fish Passage and Culvert Inspection Procedures* (Parker, 2000).

The proper application of these types of measures to each of the stream crossings along the road will prevent significant impacts to the aquatic and riparian habitat and fish populations in large river systems. Qualified and experienced environmental monitors will be employed to direct and supervise the impact avoidance and environmental protection procedures during installation of stream crossings in summer. The environmental monitors will provide quality assurance that Project environmental management commitments are being achieved.

Prior to construction activities for the road and related camp facilities, the following planning and implementation measures will be initiated:

- detailed engineering specifications for each stream crossing, including equipment staging/lay-down areas, footing locations and distances to streams.
- employment of an environmental monitor to detail the site-specific mitigation measures at each stream crossing or habitat encroachment site and monitor construction activities on-site. A qualified and experienced environmental monitor will supervise all near-stream and instream construction activities with respect to environmental protection. The monitor will direct and implement impact avoidance and mitigation measures on-site at each water crossing.
- detailed environmental protection protocols for any instream work at each crossing site, including runoff and drainage control measures to prevent any Project-generated sediment from entering surface drainages. The plans may include ditching, sedimentation ponds, pumping systems, silt fencing and geotextile lining over disturbed ground.
- approvals from the Nunavut Water Board, along with authorizations from DFO and Transport Canada. The regulatory agencies should be able to approve the stream crossings, provided all of the generally-applicable and site-specific requirements for environmental protection are implemented.
- fish salvages at any crossing site on a fish-bearing stream where it is necessary to divert or temporarily dewater a section of stream (*e.g.*, Mara River). All fish in the affected area will be captured and live-transported to another, unaffected part of the stream. Pre-planning of fish salvaging activities will be necessary to allow for the orderly processing of fish salvage permits from DFO.
- the scheduling of instream works generally follows the recommended periods of least risk to the key regional fish species as shown in Table 5.3-1. Due to the magnitude of the Project and construction schedule, the Project proponent will negotiate construction windows with the appropriate regulatory agencies.

Table 5.3-1
Instream Work Timing Windows for Fish Species in the Project Area

Species	Spawning Timing	Period When Work NOT Permitted[1]	Period of Least Risk[1]
Arctic char	Fall	August 15 to June 30	July 15 to August 15*
Arctic cisco	Fall	August 15 to June 30	July 15 to August 15*
Arctic grayling	Spring	May 1 to July 15	July 15 to August 15*
Burbot	Spring	May 1 to July 15	July 15 to August 15*
Lake trout	Fall	August 15 to June 30	July 15 to August 15*
Round whitefish	Fall	August 15 to June 30	July 15 to August 15*

[1]Source: DFO Operational Statement for Timing Windows (DFO, 2007d).
***Period used when both spring- and fall-spawning species co-exist.**

The best practical technology and most appropriate measures to protect fish populations and fish habitat will be used in the construction of the road and camp locations. These measures include:

- on-site education and environmental supervision of construction crews regarding the need to protect fisheries values and the means to accomplish that, including the measures outlined in the present report.
- restrictions on construction timing windows to comply with the periods of least risk to fisheries resources in the affected areas or approved windows by DFO.
- minimizing the areas of disturbance at all crossing sites to only those areas necessary for the road and crossing structures. Terrestrial vegetation will be retained as much as possible along the roadsides and especially at stream crossings to minimize ground disturbance, erosion and sediment transport in general.
- special attention should be paid to filled slopes at stream crossings and anywhere potential erosion and sediment transport to surface drainages may occur.
- effective and well-managed sediment control measures, including the isolation of work areas from surface waters, the use of temporary diversion methods (lined ditches, flumes, dam-and-pump) for work in the dry, and proper use of sediment traps, geotextile cloth, silt fences and gravel berms.
- isolation of construction activities from stream flows. For relatively small streams up to approximately 5 m wide (depending on flow), methods to dewater the construction area will be used. For larger crossings, such as the Mara River, where a bridge will be installed, work area isolation will be accomplished if required around the instream work area.
- blasting near watercourses will be stringently supervised and monitored. The federal guidelines for the use of explosives in or near fisheries waters (Wright and Hopky, 1998) will be followed in all blasting operations near fish-bearing streams.
- the use of properly sized stream crossing structures to enclose the entire width of the stream channels, contain the 25-year maximum flood event, provide natural substrates for fish, allow for fish migration where present, prevent sediments from entering streams,

and function properly in all seasons. Bridges will be used at all major crossings, while all other fish-bearing crossings will have open-bottomed oval-shaped steel culverts installed to preserve substrate types, minimize bank disturbance and allow fish passage.

- isolation, containment and careful management of fuels and other chemicals used during construction.
- establish a line of communication from construction sites to environmental managers for any incident or concern during the construction process. Any and all actual or potential environmental concerns, including erosion and sediment production, debris jams at stream crossings, or contaminant releases will be reported.

<u>Operations</u>

During operation of the road, regular inspection and maintenance measures will be implemented for the bridges and culverts, as well as all sediment control works and the status of reclamation sites. Any structural failures, erosion, sediment transport or other potential concerns for fish and fish habitat will be managed on an ongoing basis by environmental technicians. A reporting system also will be established wherein other personnel, such as drivers, can report any potential concerns.

The specific measures to protect fish and fish habitat during the operational years for the road will include the following:

- environmental monitors will conduct frequent and ongoing visual inspections of all stream crossing sites along the road.
- immediate attention to any incidents of ground erosion or sediment transport towards any watercourses or waterbodies, especially fish-bearing lakes and streams.
- continuous inspection, maintenance and repair of all runoff and sediment control works, including silt fencing, revegetated ground, sandbags, gravel berms or any other physical features that could compromise the protection of fish and fish habitat.
- special attention during inspections for blockages in culverts, including those caused by debris, ice and snow, in order to prevent road washouts.
- contingency plans for any structural or process failure, erosion/sedimentation incident or chemical spill will be in place and the equipment and materials will be made available to remedy any accidents or incidents.

<u>Decommission and Closure</u>

The decommissioning and closure process for the road will include a number of specific measures to protect and enhance fish habitat and fish populations in the area. In general, all areas of fish habitat affected by the Project area will be rehabilitated as much as possible, mainly by bank stabilization to prevent erosion and sediment transport. Any residual adverse impacts to fish and fish habitat will be addressed in the Conceptual Fish Habitat Compensation Plan (Section 5.3.3), that will offset any long-term effects of the Project on fisheries resources.

The impact avoidance and mitigation measures to protect fish populations and habitat during decommissioning and closure of the road will be very similar to those used during the construction phase: any instream work requirements will be completed during the periods of least risk to fish using work-site isolation and dewatering techniques and during periods agreed upon with regulatory agencies.

Specific measures to protect fish populations and fish habitat during the Project decommissioning phase will include:

- careful removal of all bridges and culverts where the road will be permanently closed. Similar techniques for working in the dry, isolating the work area, containing sediment and avoiding HADDs will be used during removal of the crossing structures.
- bank restoration and rehabilitation at all crossing sites. The crossing sites will be re-graded, stabilized with clean riprap and other methods used to ensure no erosion or sediment enters the watercourse at the crossing site.
- post-closure monitoring of each crossing site will be conducted at each crossing site via helicopter to ensure the reclamation measures are functioning properly.

Camp Location

<u>Construction</u>

During Project construction, the construction crews and associated management and support staff will be housed at Contwoyto Camp as well as two mobile camps. Contwoyto Camp will include accommodation and eating areas, offices, storage buildings, fuel storage tanks, maintenance shop and utilities trailers. The mobile camps will include accommodation and eating areas, and small fuel storage and general maintenance areas. The primary concerns for fish and fish habitat related to camp development include sediment generation and transport to streams and potential contamination from spilled fuel, sewage, or other potentially toxic substances. The Contwoyto Camp will be situated well away from the lake to avoid any sediment runoff to the aquatic environment. During placement of both the water intake pipe and the treated sewage effluent pipe, environmental monitors will be present to ensure that this activity does not cause significant disturbance of habitat. Most waterbodies in the Project area support fish populations that are extremely sensitive to population decline due to overfishing (*e.g.*, lake trout) so all sport fishing will be strictly ‘catch and release’.

<u>Operations</u>

Camp operations will include all of the domestic activities associated with a large camp, as well as other infrastructure detailed above. The specific measures that will be used to ensure no adverse impacts to fish and fish habitat from camp operations include:

- bulk fuel will be stored well away from streams and from camp. Bulk fuel storage will be stored in high capacity steel tanks with lined and bermed containments sized to store 110% of the capacity of the largest tank; and

- explosives will be stored well away from waterbodies.

Decommissioning and Closure

Upon decommissioning of the road, Contwoyto Camp will be closed and dismantled. The grounds will be re-graded, stabilized, and allowed to regenerate and return to productive terrestrial habitat.

5.3.3 Fish Habitat Compensation

Under Section 35(2) of the *Fisheries Act*, any Project or activity that causes a HADD requires authorization from DFO. Fish habitat is defined by the *Fisheries Act* as those parts of the environment "on which fish depend, directly or indirectly, in order to carry out their life processes." In addition, DFO's *Policy for the Management of Fish Habitat* promotes the objective of a "net gain of productive capacity of fish habitat" (DFO, 1986). This policy is to be achieved through the replacement and/or restoration of damaged or lost habitat through compensation.

The principle of no net loss is achieved through a hierarchy of preferences:

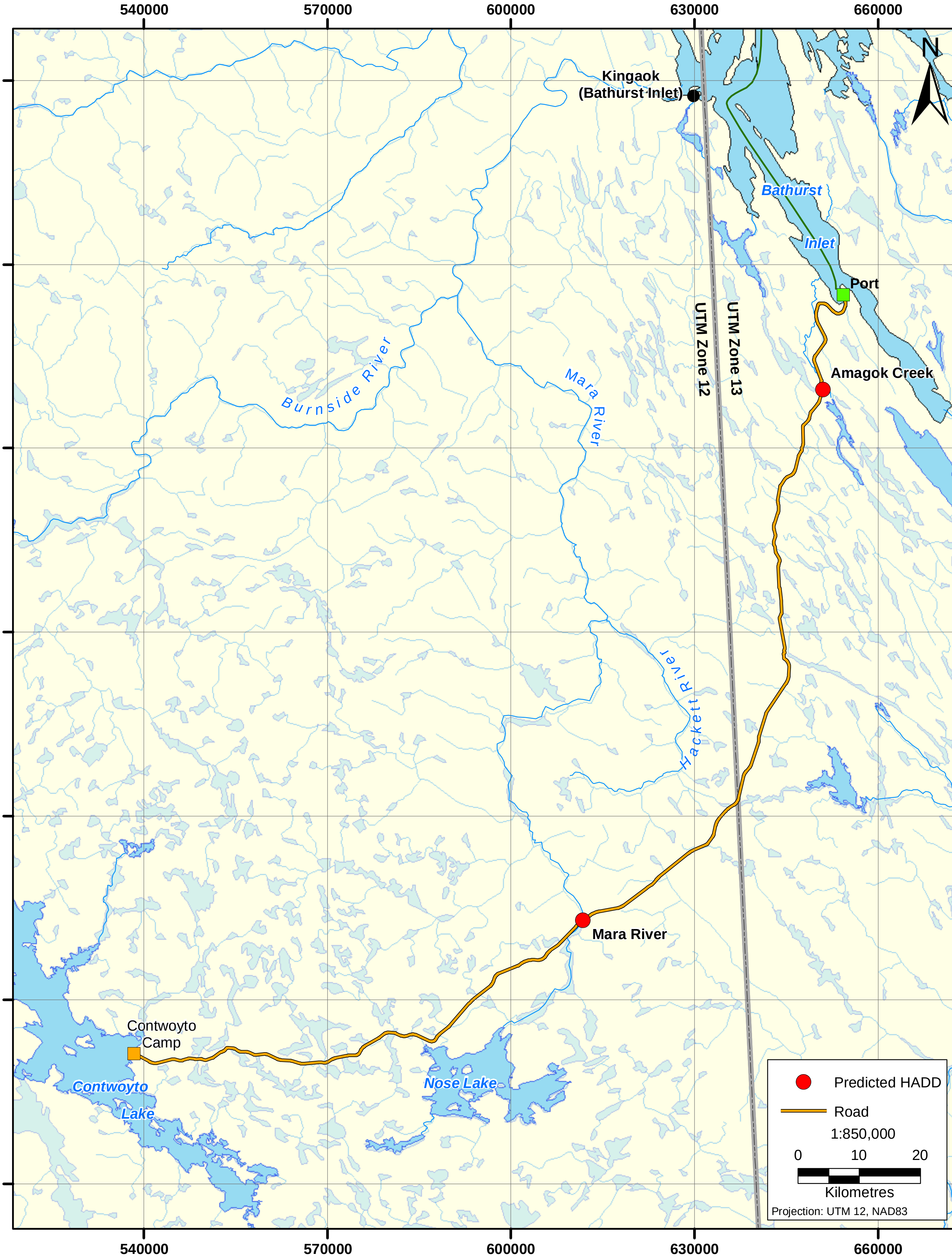
- Avoidance of a HADD through the redesign of the Project;
- Compensation by replacing lost habitat with natural habitat on site (*i.e.,* like-for-like compensation);
- Compensation by increasing the productive capacity of existing habitat on site (*i.e.*, compensating lost habitat with new habitat of a different type);
- Compensation by replacing lost habitat with natural habitat in another watershed; and
- Compensation by using artificial production (*i.e.*, building hatcheries or fertilizing lakes).

Where a HADD may occur to fish habitat anywhere in the Project area, compensation will be completed to ensure that there is no net loss of potential fish production. The planned compensation measures will more than offset the residual adverse impacts and produce a marginal net gain in fish production over the long term.

5.3.3.1 Residual HADD of Fish Habitat

A total of 1,010 m^2 of freshwater fish habitat will be lost during the construction of the Project. The habitat loss is associated with two major stream crossings along the proposed road alignment, Amagok Creek and the Mara River (Figure 5.3-1). To compensate for this loss of habitat, and to comply with DFO's National *Policy for the Management of Fish Habitat* (DFO, 1986), new habitat will be created or enhanced to ensure that there is no net loss of productive capacity. Compensation habitat will be created within the Project area.

At Amagok Creek, approximately 110 m^2 of fish habitat will be affected by the construction of the stream crossing. Much of this habitat loss will be due to the placement of riprap armouring the bridge abutments. Amagok Creek has a mean bankfull width of nearly 47 m, and a bankfull depth of 0.9 m (Appendix C-6 of the DEIS).



the BATHURST INLET PORT AND ROAD PROJECT

Locations of Predicted HADDs along the BIPR Road

FIGURE 5.4-2

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Boulder and cobble dominate the substrate and the gradient of the stream is low (1%). Very few pools are present, and glides and riffles make up most of the habitat units at the crossing location. Boulders provide almost all of the instream cover for fish. Amagok Creek is considered to be of high value to fish due to its large size, despite the fact that no fish were captured there during baseline studies in 2001 (Appendix C-6 of the DEIS), and it is not reported as a traditional fishing area by Inuit (Appendix F-5 of the DEIS).

At the Mara River, approximately 900 m^2 of instream habitat will be lost due to the placement of riprap along the banks and installation of mid-stream pilings. The Mara River is a wide (125 m bankfull width), shallow (0.9 m bankfull depth) river that is dominated by boulder substrate (Appendix C-6 of the DEIS). Like Amagok Creek, it has a low gradient (1%), and riffles and glides make up most of the habitat units in the river. Pools are rare, and cover is primarily provided by boulders. Habitat is rated as high due to the size of the river and its importance to migrating large-bodied fish species (Appendix C-6 of the DEIS). The Mara River is fed by Nose Lake, which is an important fishing site for subsistence fishermen in the area, and the river is reported to contain Arctic char (Appendix F-5 of the DEIS).

5.3.3.2 General Approach to Compensation Planning

This section presents a conceptual fish habitat compensation plan for freshwater fish habitat lost during construction of the Project. A detailed compensation plan will be developed in collaboration with the DFO and other regulators during the permitting process.

Freshwater fish habitat lost during the construction of the Project will be compensated for on a minimum 2:1 ratio. This ratio is based on the number of habitat units lost. Habitat units were developed by the US Fish and Wildlife Service in response to initiatives by the US government for sustainable management of water resources, and are indices of both habitat quantity and quality. The first step in calculating the number of habitat units lost is to apply a habitat suitability index (HSI) to each section of lost habitat. This is based on the value of the lost habitat to important fish species; in this case, VEC species will likely be used. The HSI is then multiplied by the area of the habitat to be compensated for to achieve the number of habitat units. This ensures HADDs are adequately compensated for, even if some of the compensation habitat does not work, or is not as productive as the original habitat. It also meets the requirements of DFO's National *Policy for the Management of Fish Habitat* (DFO, 1986) which promotes no net loss of productive capacity of habitat and, if possible, a net gain in productivity.

Compensation effort will focus on enhancing lake habitat, especially that in Contwoyto Lake. Lakes are generally more productive than streams, but less productive than ocean ecosystems (Keeley and Grant, 2001). This is most likely due to the higher productivity of invertebrate prey in lakes relative to streams. Lakes provide overwintering habitat for several species of freshwater fish in the Project area, including Arctic char, lake trout and Arctic grayling (Scott and Crossman, 1973). Lake trout and Arctic char also spawn in lakes, utilizing gravel shoals in shallow water. Hence, the creation of lake habitat will provide habitat for 12 months of the year, whereas streams in the Arctic freeze to the bottom.

During baseline studies in 2001, lake trout were the most abundant species captured in Contwoyto Lake, followed by Arctic char (Appendix C-6 of the DEIS). Lake trout are the dominant species in most Arctic lakes and are an important food source for local people. It is a cold-water species, preferring temperatures between 4 and 12°C (Martin and Olver, 1976). It is a slow growing fish, reaching maturity at 6 to 11 years in the northern part of its range (Scott and Crossman, 1973). They spawn in the autumn over boulder and cobble areas along lakeshores at depths of 0.3 m to 4 m (Martin and Olver, 1976); however, in the Arctic, depths shallower than 2 m are avoided due to the presence of ice in the winter. Icing of spawning and incubating habitat will kill eggs and juvenile fish. Embryos incubate over the winter and emerge from the spawning grounds in the spring. Adult lake trout are primarily piscivorous, while juveniles feed on benthic organisms, terrestrial insects, and zooplankton (Scott and Crossman, 1973).

Arctic char have similar spawning habitat preferences to lake trout; however, they spawn on slightly smaller substrates. Information on the spawning requirements of Arctic char is extremely limited, and few compensation activities involving this species have been undertaken. Therefore, this compensation plan will focus on the creation of lake trout spawning habitat.

5.3.3.3 Site Selection

Contwoyto Lake is an important fish-bearing lake in the Kitikmeot Region. It is fished by subsistence fishers and sport fishers alike, and is therefore an important economic resource in the area (Appendix F-5 of the DEIS).

Compensation activities will be located close to the camp on Contwoyto Lake to allow for easy access and monitoring. The habitat around the Contwoyto Camp is primarily composed of sand, followed by boulder and cobble (Appendix C-6 of the DEIS). Boulder and bedrock dominated the exposed peninsulas and headlands while sand and silt dominated the sheltered bays. Emergent vegetation was also present in high densities in the bays. The peninsula has a slightly steep slope, with water depths dropping off to 5 m within 100 m of the shoreline.

The rocky habitat on Contwoyto Lake is preferred by lake trout, Arctic char, and burbot, while the sandy substrate in the bays and sheltered areas is preferred by lake cisco, ninespine stickleback, burbot and sculpin species. While rocky habitat is abundant at the site, it is located on moderately steep slopes surrounding the peninsula and may not be of optimal quality for lake trout and Arctic char spawning. Compensation activities will attempt to create more level areas for spawning and egg development.

5.3.3.4 Potential Compensation Methods

Lake trout and Arctic char spawning habitat will be enhanced in Contwoyto Lake through the construction of artificial spawning reefs and rock spurs (Figure 5.3-2). Artificial spawning reefs will be designed primarily for lake trout, although it is possible that Arctic char will also use them as they share similar habitat preferences. Rock spurs will be constructed to provide shelter for small-bodied and juvenile fish, which are preyed upon by lake trout and other large-bodied fish.

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FIGURE 5.3-2

Proposed Habitat Compensation for Contwoyto Lake

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Artificial Reefs

Artificial spawning reefs have been a successful method of improving lake trout production. Artificial reefs constructed in the Great Lakes have consistently higher abundance of eggs, fry, and young-of-the-year lake trout associated with them than non-man made structures; however, more research is needed on spawning habitat preferences and the suitability of such reefs for spawning (Fitzsimons, 1996).

The most important factors in the design of lake trout spawning reefs appear to be the presence of adequate (but not excessive) water currents and deep, large diameter substrate. The most successful spawning reefs measure no more than 4 m across at the top of the reef, and are constructed of angular or sub-angular cobbles 10 to 20 cm in diameter (Fitzsimons, 1996). Reef depth must be at least 1 m to create sufficient interstitial spaces to support high densities of lake trout eggs. Reefs should be constructed in water between 3 and 5 m in depth, close to the shoreline. Artificial spawning reefs have been constructed throughout the Arctic in recent years. Projects that included the creation of lake trout spawning habitat in their compensation plans include High Lake (Gartner Lee, 2007), Meadowbank Gold (Cumberland, 2005), and Snap Lake (De Beers, 2003).

Artificial reefs will be constructed of clean, non-acid-generating rock sourced from local quarries and construction activities. Rock will be placed using an excavator working from the shore or from a barge to ensure accurate placement of substrate. The tops of the reefs will be levelled off to provide a stable spawning surface for fish, and the slopes of the reefs will be angled at 35 to 40% to ensure stability and adequate water flow. Sediment control measures will be used to limit the impact of fine sediment on surrounding habitats. Fish salvage will be conducted within the sediment control structures to prevent unnecessary mortality of fish.

Rock Spurs

Rock spurs (or shelter reefs) will also be constructed to provide shelter for juvenile fish. Predation has been found to be a limiting factor in the production of Arctic char in northern lakes (Nilsson, 2005). Increased shelter from predators significantly improves juvenile char survival, enhancing the productivity of lake habitat. Unlike spawning reefs, rock spurs will be constructed of large, angular boulders and riprap in order to provide abundant interstitial spaces that can be used by fish of varying sizes.

To create rock spurs, non-acid generating rock will be placed in water depths ranging from 2 to 10 m using an excavator. Alternatively, rocks may be placed on top of the ice during winter and allowed to fall through when the ice melts in spring. The latter method may require additional monitoring to ensure that the rock placement has created the intended habitat type. If examination of the structures reveals that the habitat is not suitable for juvenile fish, replacement of rocks may be required using an excavator working from the shore or from a barge. Rock spurs will be constructed in water greater than 3 m deep to avoid scouring by ice, which can measure up to 2 m thick in the winter. Construction of rock spurs will require work to be conducted in the water, and will therefore require sediment and erosion control measures to prevent impacts to adjacent habitat. Boom-mounted silt curtains will be installed around the compensation site during construction, and only clean, non-acid generating rock with low metal-leaching potential will be used for construction of rock spurs. Fish salvage will be undertaken within the boundaries of the silt curtain to prevent unnecessary mortality of resident fish. These methods are similar to those used in marine environments (Appendix E-5 of the DEIS). Rock spurs and shelter reefs have been constructed in marine environments for the Deltaport Expansion Project (Williams and Millar, 2005), and Doris North Project (Golder Associates, 2005).

6. MONITORING AND EVALUATION

6. Monitoring and Evaluation

Several potential effects to fish and fish habitat were identified which may arise from the construction, operations and decommissioning of the Project. These effects include:

- smothering of important gravel and cobble substrates due to sedimentation;
- contamination of watercourses as a result of spills of hazardous substances or explosives residues;
- alteration of water and/or sediment quality;
- alteration to the productive capacity of fish habitat; and
- loss of fish habitat.

In order to ensure that freshwater fish communities and their habitat are not affected by activities of the project, the following monitoring will be conducted:

1. Construction monitoring of water quality at all road crossings during summer installation;
2. Construction monitoring of water quality at Contwoyto Lake during installation of water intake pipe and treated effluent discharge pipe;
3. Water quality monitoring of quarry sites that experience surface flows to assess potential ML/ARD issues;
4. Water quality monitoring in the case of an accidental spill;
5. Surveys of the road and particularly all culverts and bridges (during the freshet period) to assess and avoid blockages of water flows; and
6. Monitoring of compensation projects.

During installation of all culverts and bridges along the BIPR road, both upstream and downstream points will be monitored for water quality (turbidity, TSS, conductivity) in order to assess disturbance effects during open water season. Construction monitoring will involve trained environmental monitors observing instream work to ensure that fish and fish habitat resources are not degraded or destroyed. As culvert installation will occur on the banks of the streams (and not instream), sedimentation effects are expected to be minimal.

Installation of the water intake and treated sewage effluent pipes in Contwoyto Lake will be done using a boat to haul lines out to selected positions of appropriate depths, and pipes will be slowly lowered to the bottom. No digging or burying activity is associated with these pipes. However, an environmental monitor will be present to monitor water quality (turbidity, TSS) during installation.

At quarries that experience surface flows which travel to surrounding waterbodies, water quality will be monitored to assess potential ML/ARD issues.

In the case of an accidental spill of fuel or other material, water quality would be surveyed in adjacent waterbodies to assess potential effects to fish and fish habitat.

During operations, treated effluent will be discharged into Contwoyto Lake and routine water quality monitoring would therefore be conducted in accordance with Nunavut Water Board permit requirements.

The condition of the road will be surveyed during each summer period to assess any locations where road failure or erosional/depression zones are forming. Corrective action (filling, grading) will be carried out to maintain the integrity of the road. During freshet, there exists a potential for culverts or bridge crossings to become blocked by ice and debris. Surveys of these structures during this spring period will be used to avoid blockages which could lead to road washout and sedimentation of aquatic habitat, and could also impede fish passage through waterways.

The following section describes in detail the monitoring of fish habitat compensation projects.

6.1.1.1 Monitoring of Compensation Projects

Monitoring, evaluation, maintenance, and remediation are necessary to ensure the long-term success of constructed fish habitat. Compensation sites in freshwater will need to be monitored for a period of time to prove their effectiveness. This will be a requirement under the Fisheries Authorization that will be obtained from DFO, and the period will be determined by consultation with regulatory agencies.

Monitoring of compensation projects will include fish community and habitat assessments, and each site will be compared to a reference site to gauge the relative success of the compensation works. Fish habitat will be monitored to ensure the ongoing functionality of the constructed habitat. Key habitat variables that will be measured are substrate composition and habitat complexity. Substrate will be monitored to ensure that compensation habitat is not being inundated by fine sediment. For most of the proposed compensation projects, the functionality of the habitat is dependent upon the complexity supplied by interstitial spaces between rocks and within artificial reefs. If these spaces become filled with silt and clay, the habitat will not function as designed. Therefore, substrate composition and habitat complexity will be evaluated periodically to ensure that the functionality of constructed habitat is maintained.

Fish community composition around compensation sites will also be monitored periodically to ensure that the habitat is suitable for the target species. Spawning reefs will be monitored in the early summer to detect the presence of young-of-year lake trout and char. Because lake trout are highly mobile as adults, only the presence of very young fish will indicate that the habitat is actually being used for spawning (Fitzsimons, 1996). Rock spurs will also be monitored in order to detect whether they are being used by juvenile char.

Following the initial two-year period after compensation projects are complete, monitoring will occur on a five-year cycle. In the event that constructed habitat compensation sites do not function properly, remedial actions will include improvements to the existing compensation areas, or establishment of additional sites. Once it is determined that productivity around the compensation sites has reached its target level and is stable, long-term monitoring may cease.

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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 C-5
Navigable Waters Effects Assessment

Author: Rescan Environmental Services Ltd.
Date: November 2007

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Bathurst Inlet Port and Road Project Navigable Waters Effects Assessment

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

BIPR	Bathurst Inlet Port and Road
DEIS	Draft Environmental Impact Statement
DOJ	Department of Justice
NTKP	Naonaiyaotit Traditional Knowledge Project
the Project	the Bathurst Inlet Port and Road Project
Rescan	Rescan Environmental Services Ltd.
VEC	valued ecosystem component

1. INTRODUCTION

1. Introduction

The Bathurst Inlet Port and Road (BIPR) Project (the Project) is located in the Kitikmeot region of Nunavut. The proposed marine port is located on the west side of Bathurst Inlet, about 40 km south of the community of Bathurst Inlet. This effects assessment for the proposed all-weather road considers the construction and use of the 211 km road from the proposed port site at Bathurst Inlet south-west to its end at Contwoyto Lake, and its potential effect on navigable waterways.

Baseline studies of the road route were conducted by SNC-Lavalin and Rescan Environmental Services Ltd. (Rescan). The road will be used while the ground is frozen from January to April. Road maintenance activities will occur late in the summer and in early autumn. Truck traffic from January to April will primarily carry fuel and cargo to operating mines in the area. Prospective users of the road include the EKATI, Diavik, Jericho and Snap Lake diamond mines. The 20-person camp at Contwoyto Lake will serve as the connecting and staging point between the proposed road from Bathurst Inlet and the existing ice road to Yellowknife (Appendix A-3 of the Draft Environmental Impact Statement (DEIS)) (SNC Lavalin, 2007).

The proposed road is located southwest of Bathurst Inlet and runs through several large drainage basins (Figure 1-1). Moving west from Bathurst Inlet, the 211 km road traverses Amagok Creek, Western River, Siorak River, and the Mara River watersheds before reaching the drainages for Contwoyto Lake.

The area receives approximately 250 to 350 mm of annual precipitation, about 50% of which occurs in the form of snow. Environment Canada historical temperature for the community of Bathurst Inlet ranged from a maximum temperature of 17.9ºC to a minimum of -43.7ºC. Temperatures are coldest from December to March, the calendar period with the least amount of precipitation. Glaciation events have significantly contributed to the rugged terrain and the numerous small and large waterbodies covering the landscape. The watercourses in the area range in size from large, continually running rivers (*i.e.,* Mara River) to small, ephemeral streams with undefined channels.

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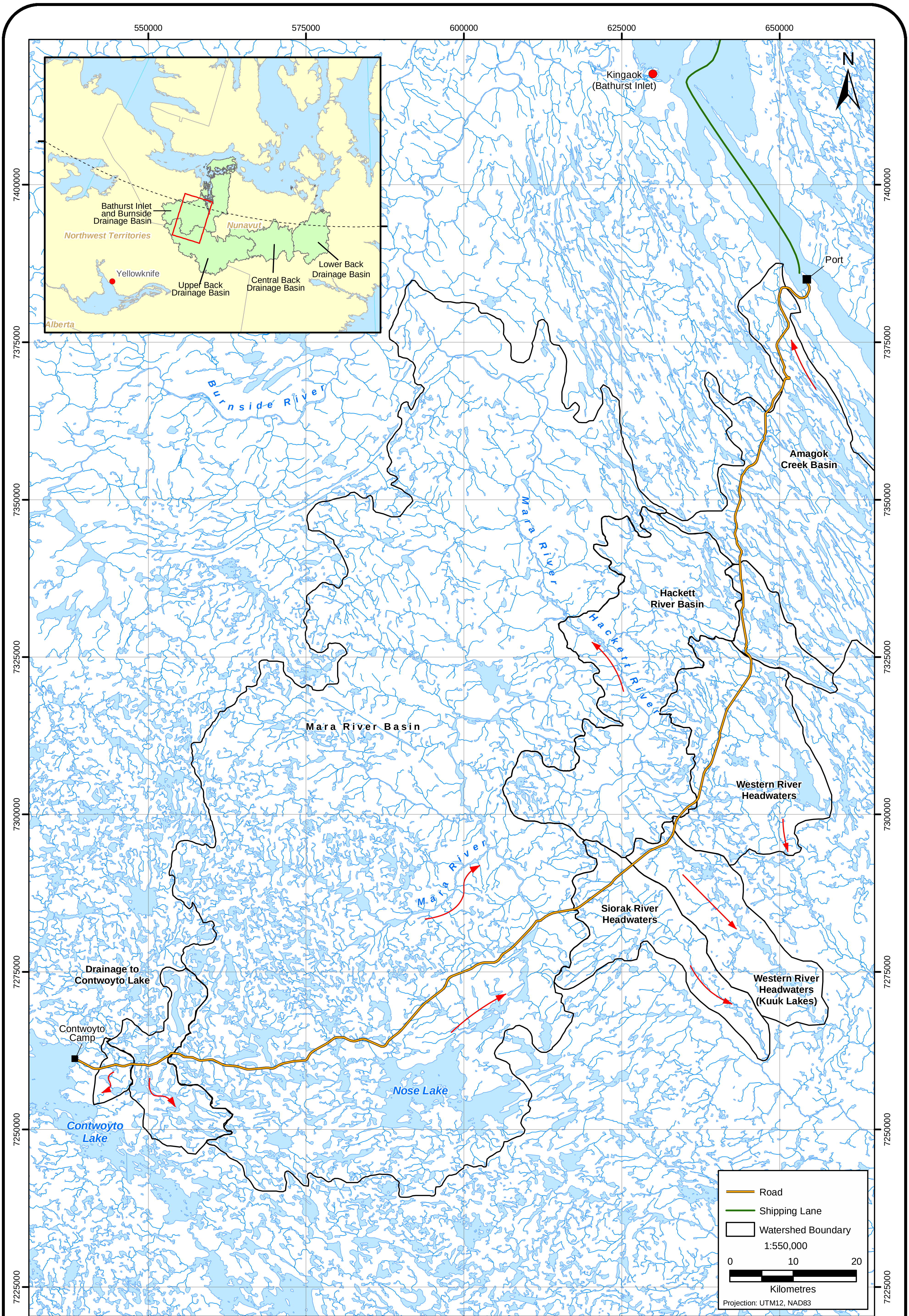


FIGURE 1-1

the Bathurst Inlet Port and Road Project

Large Watersheds of the Bathurst Inlet Road

Rescan

2. ENVIRONMENTAL SETTING

2. Environmental Setting

Preserving the quality of freshwater systems is very important to the Inuit in the area. This is the case not only in the context of providing good quality habitat for fish and aquatic resources but also to fulfil the need for navigable waterways. As summarized in the Naonaiyaotit Traditional Knowledge Project (NTKP), waterways such as the Mara River were used as travel routes by the Inuit (Appendix F-5 of the DEIS).

There is a limited human requirement for navigation at the majority of stream crossings along the proposed road corridor. Many of the streams that would intersect the road are narrow, shallow, or ephemeral, and thus have limited navigable value as recreational or commercial waterways. However, there are some streams and rivers along the proposed road corridor that are either navigable or have the potential to be navigable. Presently, some of these waterways, such as the Mara River, are used for eco-tourism related activities (*e.g.*, canoeing and kayaking).

Photo documentation was provided to Transport Canada for all proposed stream crossings where the mean bankfull width exceeded 3 m. These photos were used to confirm the navigability of each waterway by Transport Canada. Navigability was based on the potential for the waterway to be navigated by a kayak. A summary of the road crossing location (latitude and longitude), bankfull width and bankfull depth of each stream crossing that may be navigable is presented in Table 2-1. The above information and photographs are also provided for each potentially navigable stream in Appendix 1.

Among the waterways that were assessed as potentially navigable (based on bankfull width), only four were deemed suitable for navigation by Transport Canada (Table 2-1; Figure 2-1; Appendix 2). The four navigable waterways were:

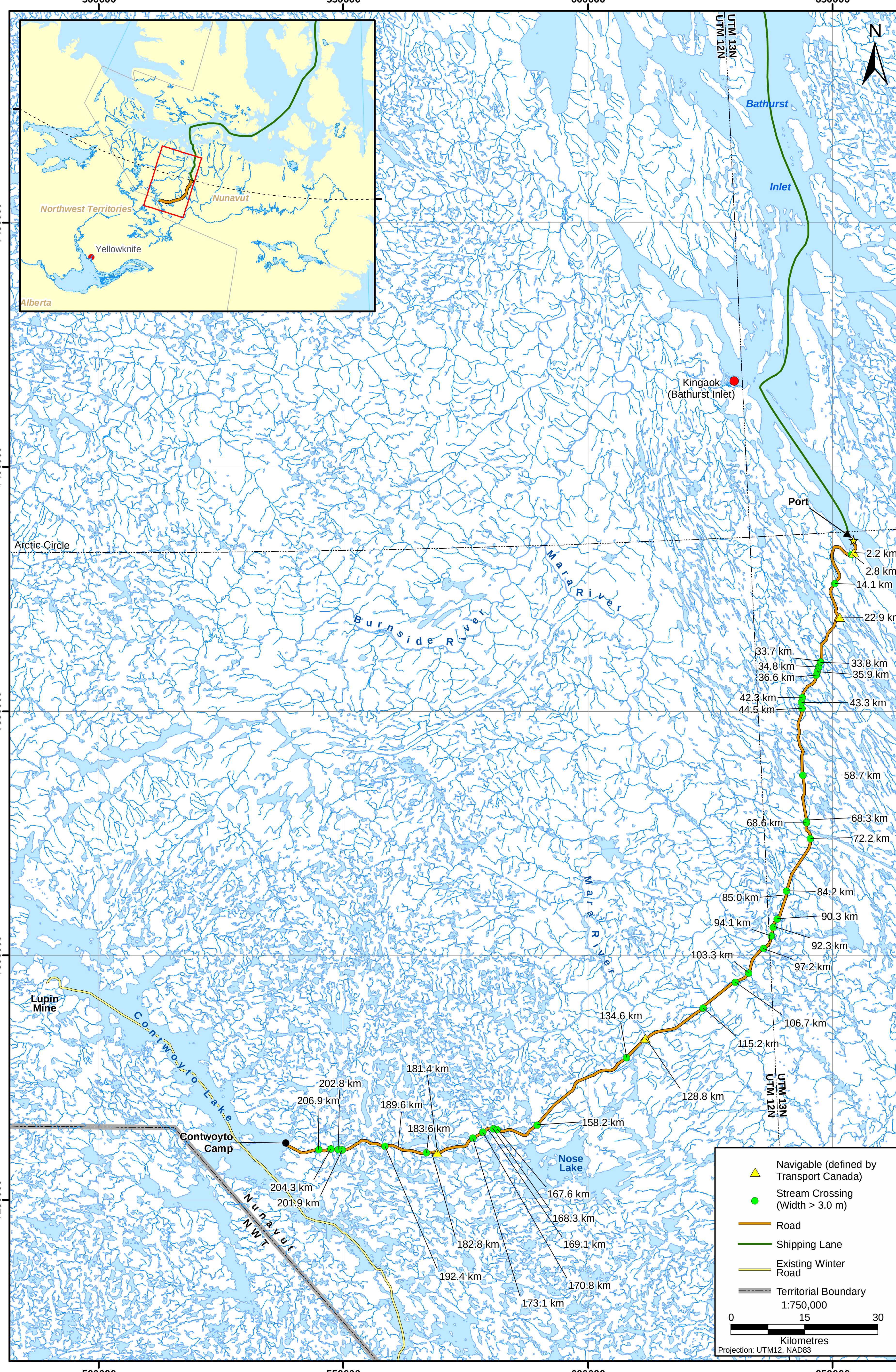
- **No Name Creek** (km 2.2; 4.5 m wetted width; 6.2 m channel width);
- **Amagok Creek** (km 22.9; 40.7 m wetted width; 46.7 m channel width);
- **Mara River** (km 128.8; 113.9 m wetted width; 125.8 m channel width); and
- **No Name Creek** (km 181.4; 43.7 m wetted width; 47.4 m channel width).

Additional information and photographs for each of the four navigable waterways can be found in Appendix 1.

Table 2-1
Summary of Potentially Navigable Stream Crossings

Crossing No.	Actual km	Latitude	Longitude	Survey Length (m)	Slope (%)	Wetted Depth (m)	Bankfull Depth (m)	Wetted Width (m)	Bankfull Width (m)	Watershed Area (km^2)	Wetted Stream Discharge (m^3/s)	Estimated Bankfull Discharge (m^3/s)	Fish Bearing	Comments
1	**2.2**	66° 31' 22.74" N	107° 31' 35.93" W	200	0.5	0.45	0.75	4.5	6.2	66.4	0.139	3.240	Y	long wadable stream
2	**2.8**	66° 31' 11.39" N	107° 32' 10.01" W	200	0.5	0.29	0.38	0.5	3.8	1.1	0.003	0.620	N	standing water with deep pools, no barrier downstream to ocean
3	**14.1**	66° 28' 5.56" N	107° 37' 14.87" W	204	0.4	0.67	1.00	8.1	9.3	75.3	0.128	7.080	N	flowing large stream, no fish, long distance (10 km) to upstream lake
4	**22.9**	66° 24' 21.87" N	107° 36' 23.73" W	405	1.0	0.55	0.85	40.7	46.7	1,143.1	9.506	45.000	Y	Amagok Creek, large, high flow
5	**33.7**	66° 19' 34.08" N	107° 42' 19.03" W	146	0.8	0.13	0.47	25.0	36.5	N/A	0.019	11.010	Y	lake east connected downstream, 2-3 ft deep
6	**33.8**	66° 19' 29.79" N	107° 42' 24.11" W	91	0.5	0.20	0.45	3.7	9.9	42.7	0.047	2.280	Y	upstream small waterfall and lake 2-3 ft deep, large section of subsurface flow, connected
7	**34.8**	66° 19' 1.31" N	107° 42' 51.90" W	200	1.2	0.17	0.31	9.9	14.1	60.5	0.426	2.660	Y	shallow ponds at both ends
8	**35.9**	66° 18' 29.58" N	107° 43' 24.83" W	200	0.5	0.15	0.25	32.0	34.0	43.0	0.205	2.950	Y	wide channel with upstream pond and downstream barrier falls
9	**36.6**	66° 18' 9.18" N	107° 43' 40.47" W	200	0.6	0.25	0.55	0.5	18.0	2.7	0.000	6.560	Y	flowing, lake downstream deep
10	**42.3**	66° 15' 43.68" N	107° 47' 50.23" W	155	0.7	0.21	0.33	2.7	6.2	9.5	0.010	0.990	Y	subsurface flow upstream, lake
11	**43.3**	66° 15' 12.62" N	107° 48' 6.56" W	100	0.1	0.00	0.40	0.0	13.0	6.1	0.000	0.780	N	lakes, lake downstream deep
12	**44.5**	66° 14' 34.37" N	107° 48' 5.24" W	200	0.4	0.20	0.35	20.3	28.8	2.0	0.041	3.750	Y	no water upstream, possibly used for rearing
13	**58.7**	66° 7' 12.19" N	107° 48' 43.06" W	200	0.8	0.16	0.29	6.6	6.7	5.2	0.059	0.980	Y	flowing water connected downstream to shallow lakes
14	**68.3**	66° 2' 5.65" N	107° 48' 20.21" W	200	0.8	0.20	0.41	3.3	4.0	N/A	0.360	1.020	Y	flowing water
15	**68.6**	66° 1' 57.10" N	107° 48' 22.55" W	209	0.7	0.20	0.58	4.0	4.8	6.2	0.080	1.920	Y	flowing water
16	**72.2**	66° 0' 10.94" N	107° 47' 36.73" W	200	0.7	1.71	2.02	10.8	10.8	39.8	0.198	32.900	N	flowing water
17	**84.2**	65° 54' 33.05" N	107° 54' 42.92" W	200	0.7	0.33	0.58	5.7	6.1	81.0	0.490	2.420	Y	well established drainage, large area of rocky relief up to crossing
18	**90.3**	65° 51' 31.66" N	107° 57' 35.65" W	74	1.9	0.17	0.29	2.0	4.0	2.6	0.290	0.870	N	downstream lake not connected, impassable barrier, standing pools/subsurface flow
19	**92.3**	65° 50' 37.61" N	107° 58' 48.37" W	N/A	N/A	N/A	N/A	N/A	N/A	2.2	N/A	N/A	N	low flow with standing pools, upstream boulder garden
20	**94.1**	65° 49' 40.88" N	107° 59' 26.74" W	N/A	N/A	N/A	N/A	N/A	N/A	4.2	N/A	N/A	N	good flow, upstream boulder garden, subsurface sections downstream
21	**97.2**	65° 48' 20.74" N	108° 1' 41.35" W	114	0.5	0.48	0.68	77.8	79.8	4.4	18.500	36.730	Y	large bay of a shallow lake
22	**103.3**	65° 45' 44.44" N	108° 5' 57.87" W	200	3.0	0.20	0.49	50.0	50.0	3.9	6.900	32.650	N	channel between 2 streams, multiple channels
23	**106.7**	65° 44' 46.12" N	108° 9' 36.99" W	200	1.0	0.45	0.71	31.0	44.0	13.4	1.860	30.760	Y	shallow ponds along flowing channel, upstream and downstream boulder gardens
24	**115.2**	65° 42' 5.47" N	108° 18' 35.34" W	200	1.2	0.25	0.37	2.2	3.2	18.1	0.125	0.790	Y	flowing, grassy
25	**128.8**	65° 39' 2.07" N	108° 34' 15.07" W	202	1.1	0.58	0.88	113.9	125.8	1,825.6	32.500	133.170	Y	Mara River
26	**134.6**	65° 36' 57.57" N	108° 39' 27.52" W	200	6.8	0.14	0.34	39.4	57.6	71.0	2.728	30.830	Y	large, wide wadable
27	**158.2**	65° 29' 54.52" N	109° 3' 48.32" W	N/A	N/A	N/A	N/A	N/A	N/A	0.3	N/A	N/A	N	water flows subsurface at upstream end, connected to lake downstream
28	**167.6**	65° 29' 31.52" N	109° 14' 29.86" W	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N	no fish, very low flow (0.2 L/sec), water subsurface after 370m
29	**168.3**	65° 29' 38.24" N	109° 15' 25.12" W	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Y	low flow (1.5 L/sec), water subsurface after 250m, temporary barriers
30	**170.8**	65° 29' 13.82" N	109° 18' 13.73" W	200	0.5	0.25	0.50	29.1	38.4	13.5	0.068	10.580	N	meandering channels
31	**173.1**	65° 28' 37.71" N	109° 20' 53.91" W	205	0.6	0.27	0.42	2.4	4.0	9.8	0.108	0.860	N	flowing, lake downstream deep
32	**181.4**	65° 27' 10.17" N	109° 30' 22.25" W	200	1.9	0.35	0.55	43.7	47.4	352.5	6.330	29.790	N	large channel
33	**183.6**	65° 27' 8.16" N	109° 33' 14.69" W	167	0.7	0.10	0.23	0.7	3.1	4.1	0.065	0.280	Y	multiple channels, no flow, temporary barriers between upstream and downstream lakes
34	**192.4**	65° 27' 57.69" N	109° 44' 13.48" W	216	0.9	0.24	0.44	3.9	4.6	11.3	0.450	1.380	N	flowing water
35	**201.9**	65° 27' 38.33" N	109° 55' 33.73" W	196	0.7	0.39	0.84	52.0	60.2	65.6	7.088	44.670	Y	flowing, lake downstream is deep
36	**202.8**	65° 27' 41.57" N	109° 56' 36.86" W	200	3.0	0.30	0.53	26.6	26.6	34.4	1.370	19.780	Y	flowing water
37	**204.3**	65° 27' 45.18" N	109° 58' 36.55" W	218	0.5	0.42	0.84	11.6	14.4	1.0	2.500	9.420	N	lakes north and south are deep, lake downstream is disconnected
38	**206.9**	65° 27' 43.12" N	110° 1' 48.72" W	183	0.5	0.36	0.45	8.5	8.7	12.4	0.088	2.010	Y	flowing water, no barriers

Fish Bearing : Y = fish-bearing, N = no fish found.
N/A = not available.



the Bathurst Inlet Port and Road Project

FIGURE 2-1

Potentially Navigable Streams Crossing the Bathurst Inlet Road

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3. METHODOLOGY

3. Methodology

3.1 Valued Ecosystem Component Selection

In Canada, navigable waters include any body of water capable of being navigated by any type of floating vessel for the purposes of transportation, recreation or commerce. The *Navigable Waters Protection Act* (DOJ, 1985) was adopted to protect the public right to navigate. The Act ensures that any interference created by the Project does not alter the navigability of the waterway, and that the rights of other waterway users are respected. There are a total of 38 potentially navigable waterways (streams >3 m) that are proposed to be crossed by the road that may potentially influence the public to access to navigable water. However, only four of these waterways were determined navigable by Transport Canada. Navigable waters were selected as a valued ecosystem component (VEC) to protect navigable waterways in the Project area as per the *Navigable Waters Protection Act*. In addition, navigable waterways are important for traditional forms of travel as identified in the NTKP (Appendix F-5 of the DEIS).

3.2 Boundaries

3.2.1 Spatial Boundaries

The main Project infrastructure will be the port and related facilities at Bathurst Inlet and the road to Contwoyto Lake. The road will cross streams in the Burnside and Western river basins as well as smaller basins draining directly into Bathurst Inlet, and will terminate on the east side of Contwoyto Lake. Therefore, all watersheds bisected by the road and streams downstream of the road make up the spatial boundary for the regional study area.

3.2.2 Temporal Boundaries

For the purposes of this effects assessment, impacts to navigable waters will be assessed using several temporal boundaries. The temporal boundary for the navigable waters effects assessment includes the Project timelines, as follows:

- **construction:** approximately 2.5 years;
- **operation:** estimated at 19 years; and
- **decommissioning and closure of the Project:** approximately 1 year.

3.3 Approach and Methods

The environmental assessment approach used in this effects assessment is similar to that described for the Project as a whole (Chapter 5 of the DEIS). The assessment uses all currently available information on project design and existing environmental conditions (from baseline data) to provide realistic and plausible characterization of potential effects to navigation.

4. EFFECTS ASSESSMENT

4. Effects Assessment

There is limited human use of surface water as a resource for navigation within the study area. The Mara River may be used for navigation, but the two No Name creeks and Amagok Creek are less likely to be used as navigable waterways. However, the bridges at these crossings will be built to accommodate current navigational requirements.

Given the inaccessibility of most of this region, limited current or historical use of waterways in the region, and the accommodating design of bridge heights over water, the Project is not anticipated to incur adverse effects on navigable waters.

No residual effects on navigable waters are predicted to occur; however, the following mitigation, management, and monitoring practices should be conducted over the full span of the Project timeline:

- ensure design of bridges offer sufficient freeboard to ensure crossing does not impede navigability. The height of minimum freeboard at 1:25 year flood levels will be set as follows:
  - Mara River, 1.6 m;
  - Amagok Creek, 1.8 m; and
  - the No Name creeks will each be set at 1.5 m.
- routine maintenance of bridges to ensure crossing does not impede navigability.

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SNC-Lavalin. 2007. Bathurst Inlet Port and Road Project Navigable Waters Report. Prepared for the Bathurst Inlet Port and Road Project, Nunavut, Canada. June, 2007.

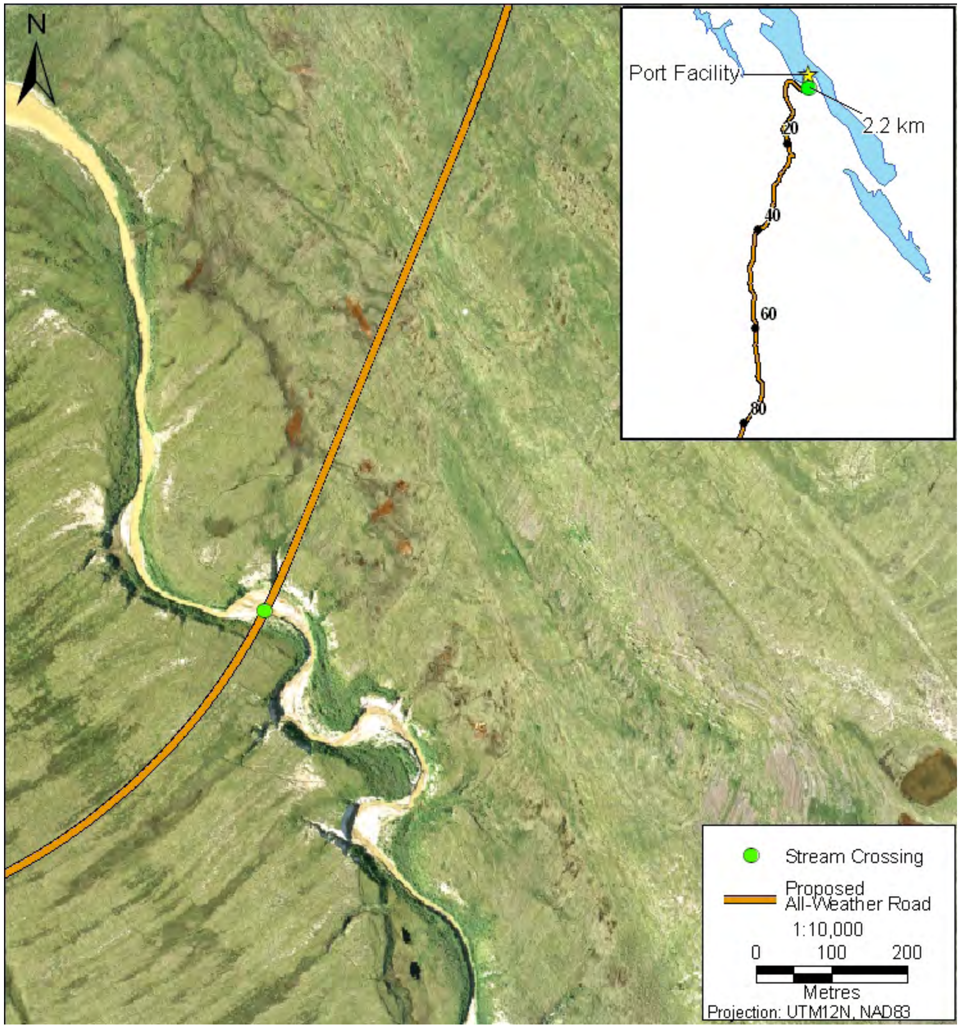
APPENDIX 1
BATHURST PROJECT POTENTIALLY NAVIGABLE WATERS, INDIVIDUAL STREAM CROSSING INFORMATION

Rescan™

Bathurst Project Potentially Navigable Waters Crossing 2.2 km

Latitude	66° 31' 22.74" N	Wetted Width (m)	4.50	Bankfull Width (m)	6.20	Watershed Area (km^2)	66.4
Longitude	107° 31' 35.93" W	Wetted Depth (m)	0.45	Bankfull Depth (m)	0.75	Slope	0.5 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.139	Estimated Bankfull Discharge (m^3/s)	3.240	Fish Bearing	Yes

Watercourse:
Long wadable stream.



Upstream aerial view

Aerial view

Bathurst Project Potentially Navigable Waters Crossing 2.8 km

the Bathurst Inlet Port and Road Project

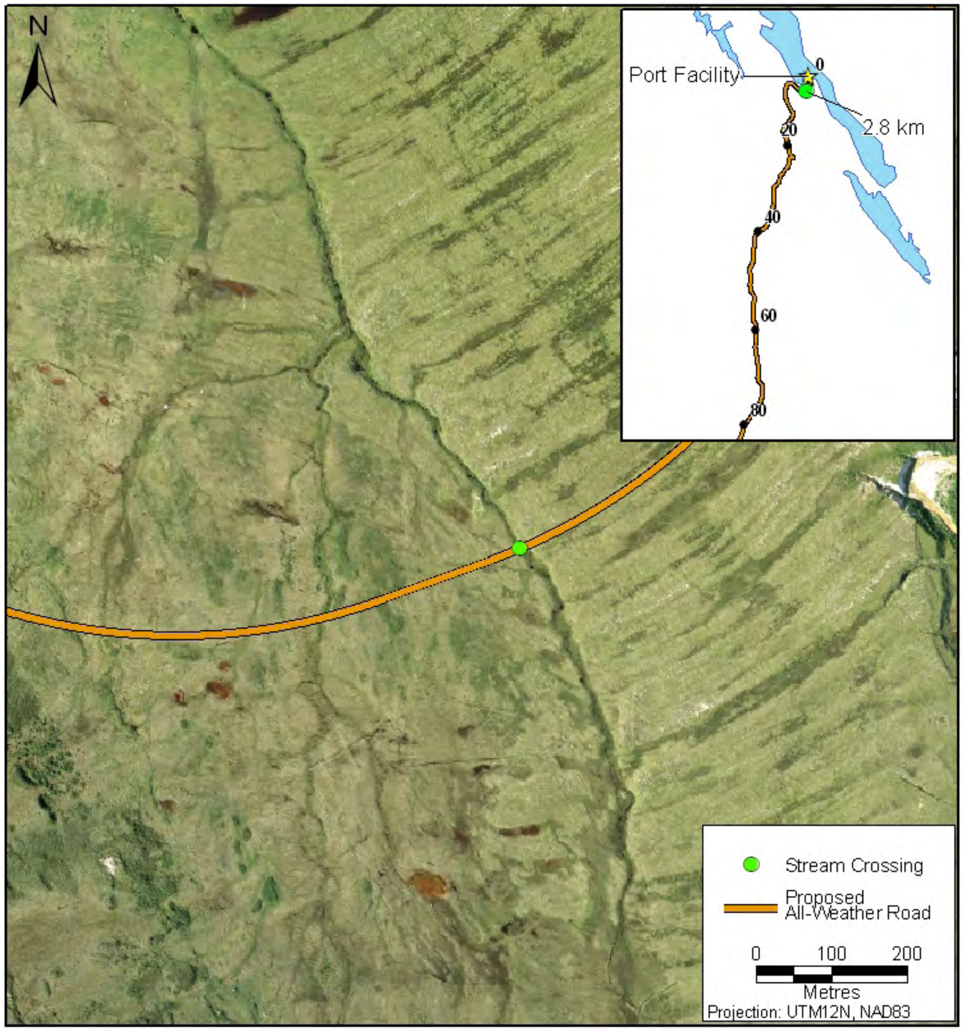
Rescan

SNC•LAVALIN Engineers & Constructors

Latitude	66° 31' 11.39" N	Wetted Width (m)	0.47	Bankfull Width (m)	3.82	Watershed Area (km^2)	1.1
Longitude	107° 32' 10.01" W	Wetted Depth (m)	0.29	Bankfull Depth (m)	0.38	Slope	0.5 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.003	Estimated Bankfull Discharge (m^3/s)	0.620	Fish Bearing	No

Watercourse:

Standing water with deep pools, no barrier downstream to ocean.



Downstream aerial view

Upstream aerial view

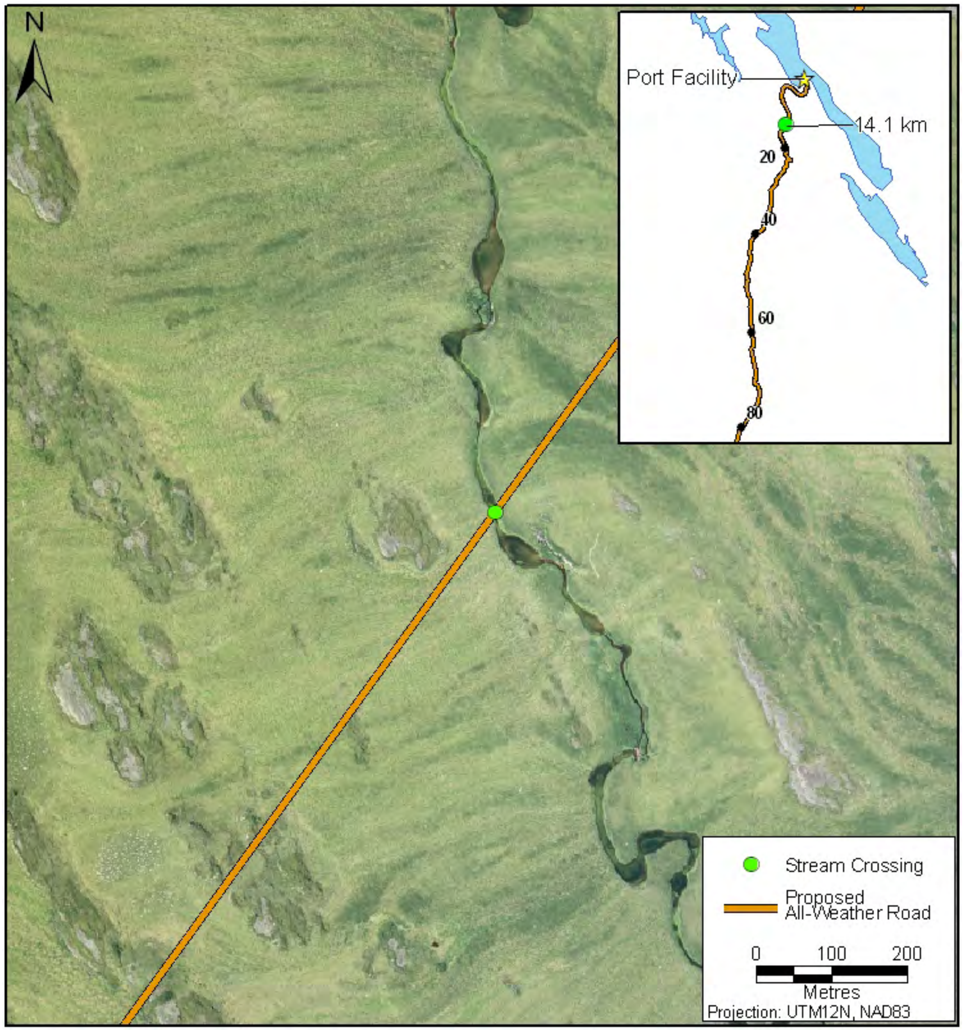

Upstream view of first glide

Bathurst Project Potentially Navigable Waters Crossing 14.1 km

Latitude	66° 28' 5.56" N	Wetted Width (m)	8.10	Bankfull Width (m)	9.30	Watershed Area (km²)	75.3
Longitude	107° 37' 14.87" W	Wetted Depth (m)	0.67	Bankfull Depth (m)	1.00	Slope	0.4 %
Survey Length	204 m	Wetted Stream Discharge (m^3/s)	0.128	Estimated Bankfull Discharge (m^3/s)	7.080	Fish Bearing	No

Watercourse:

Flowing large stream, no fish, long distance (10 km) to upstream lake.



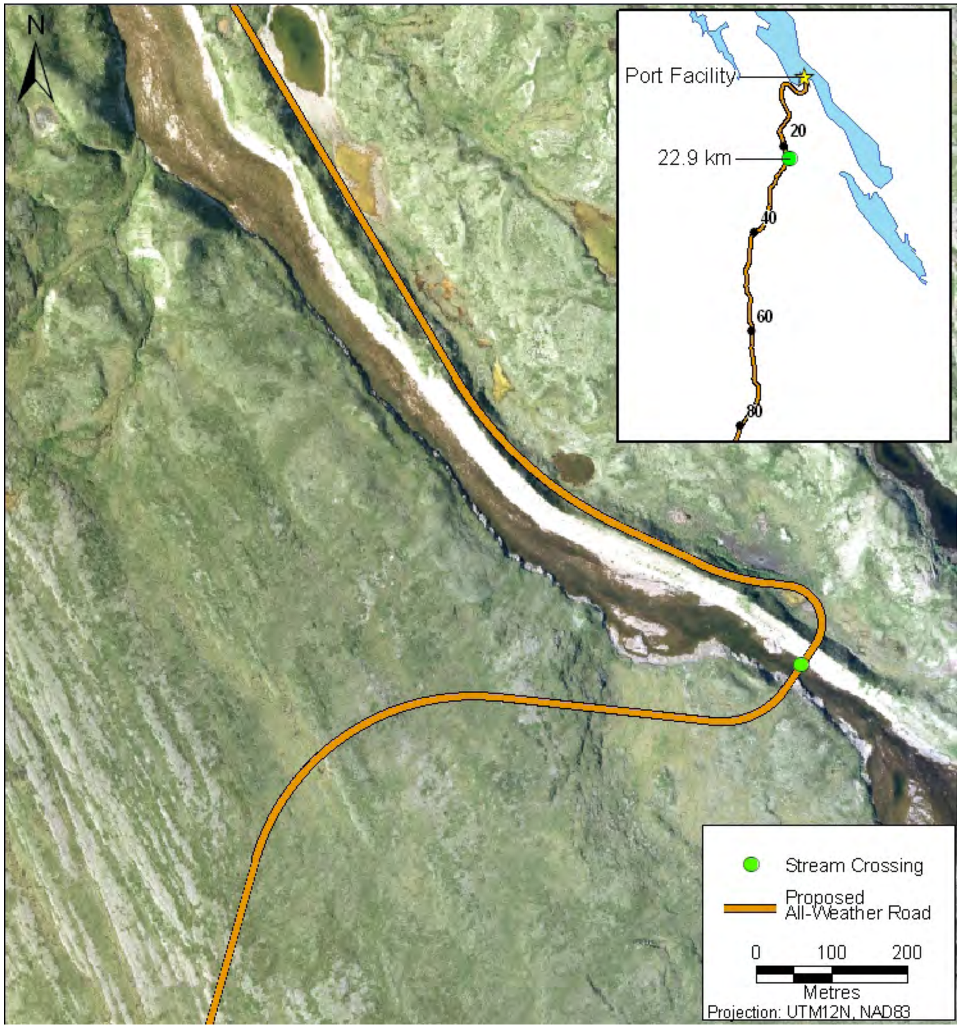
Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 22.9 km

Latitude	66° 24' 21.87" N	Wetted Width (m)	40.73	Bankfull Width (m)	46.73	Watershed Area (km^2)	1,143.1
Longitude	107° 36' 23.73" W	Wetted Depth (m)	0.55	Bankfull Depth (m)	0.85	Slope	1.0 %
Survey Length	405 m	Wetted Stream Discharge (m^3/s)	9.506	Estimated Bankfull Discharge (m^3/s)	45.000	Fish Bearing	Yes

Watercourse:

Amagok Creek, large, high flow.



Upstream view

Upstream view

Aerial view

ble of Contents

Bathurst Project Potentially Navigable Waters Crossing 33.7 km

the Bathurst Inlet Port and Road Project

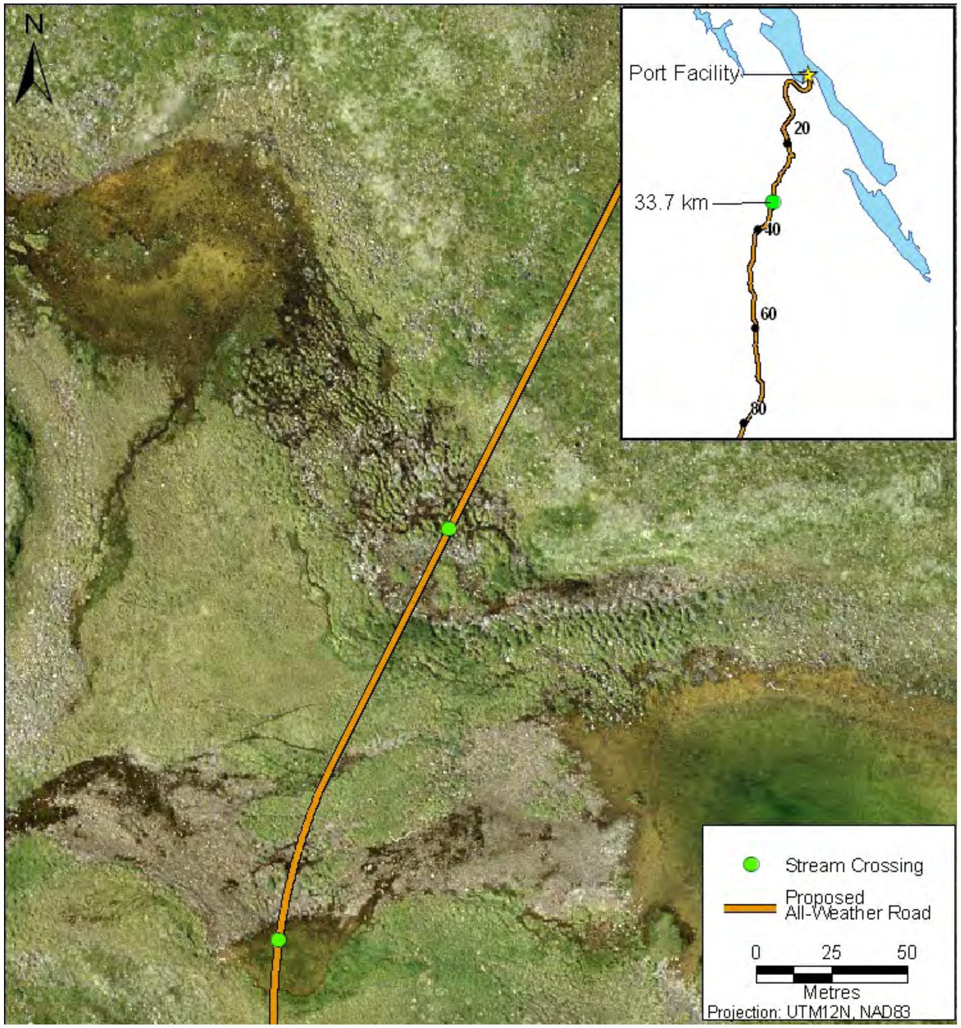
Rescan

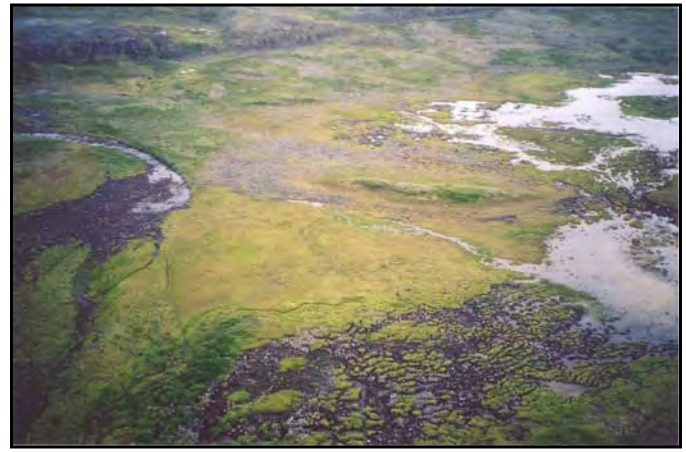
SNC·LAVALIN Engineers & Constructors

Latitude	66° 19' 34.08" N	Wetted Width (m)	24.99	Bankfull Width (m)	36.45	Watershed Area (km²)	N/A
Longitude	107° 42' 19.03" W	Wetted Depth (m)	0.13	Bankfull Depth (m)	0.47	Slope	0.8 %
Survey Length	146 m	Wetted Stream Discharge (m^3/s)	0.019	Estimated Bankfull Discharge (m^3/s)	11.010	Fish Bearing	Yes

Watercourse:

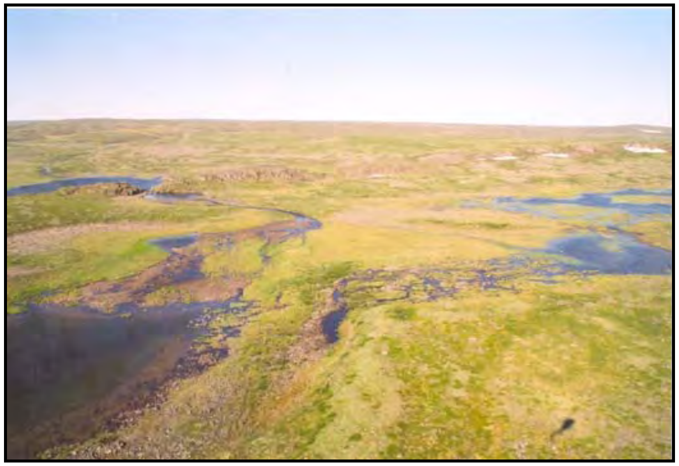
Lake east connected downstream, 2-3 ft deep.





Aerial view

Aerial view


Aerial view

Bathurst Project Potentially Navigable Waters Crossing 33.8 km

the Bathurst Inlet Port and Road Project

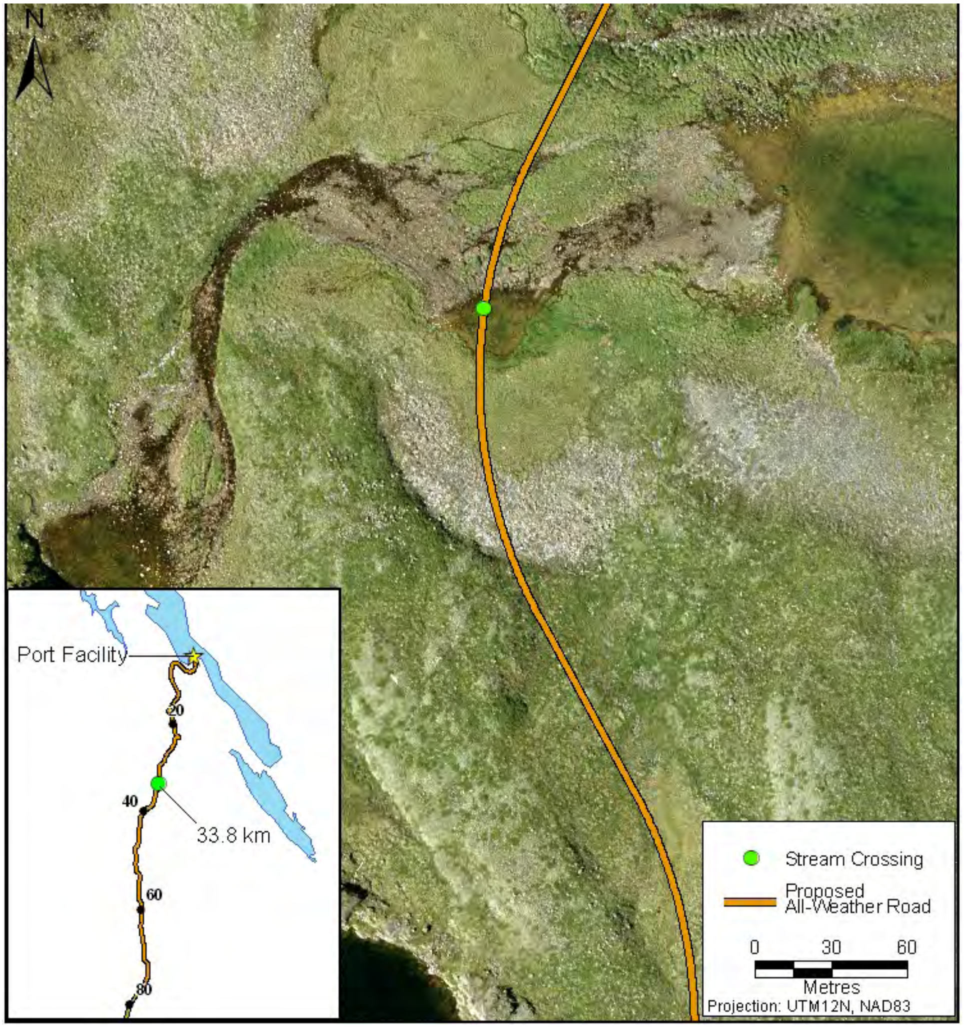
Rescan

SNC-LAVALIN Engineers & Constructors

Latitude	66° 19' 29.79" N	Wetted Width (m)	3.70	Bankfull Width (m)	9.90	Watershed Area (km^2)	42.7
Longitude	107° 42' 24.11" W	Wetted Depth (m)	0.20	Bankfull Depth (m)	0.45	Slope	0.5 %
Survey Length	91 m	Wetted Stream Discharge (m^3/s)	0.047	Estimated Bankfull Discharge (m^3/s)	2.280	Fish Bearing	Yes

Watercourse:

Upstream small waterfall and lake 2-3 ft deep, large section of subsurface flow, connected at higher flows.



Aerial view

Downstream aerial view

Aerial view – halfway up reach

Bathurst Project Potentially Navigable Waters   Crossing 34.8 km

the Bathurst Inlet Port and Road Project

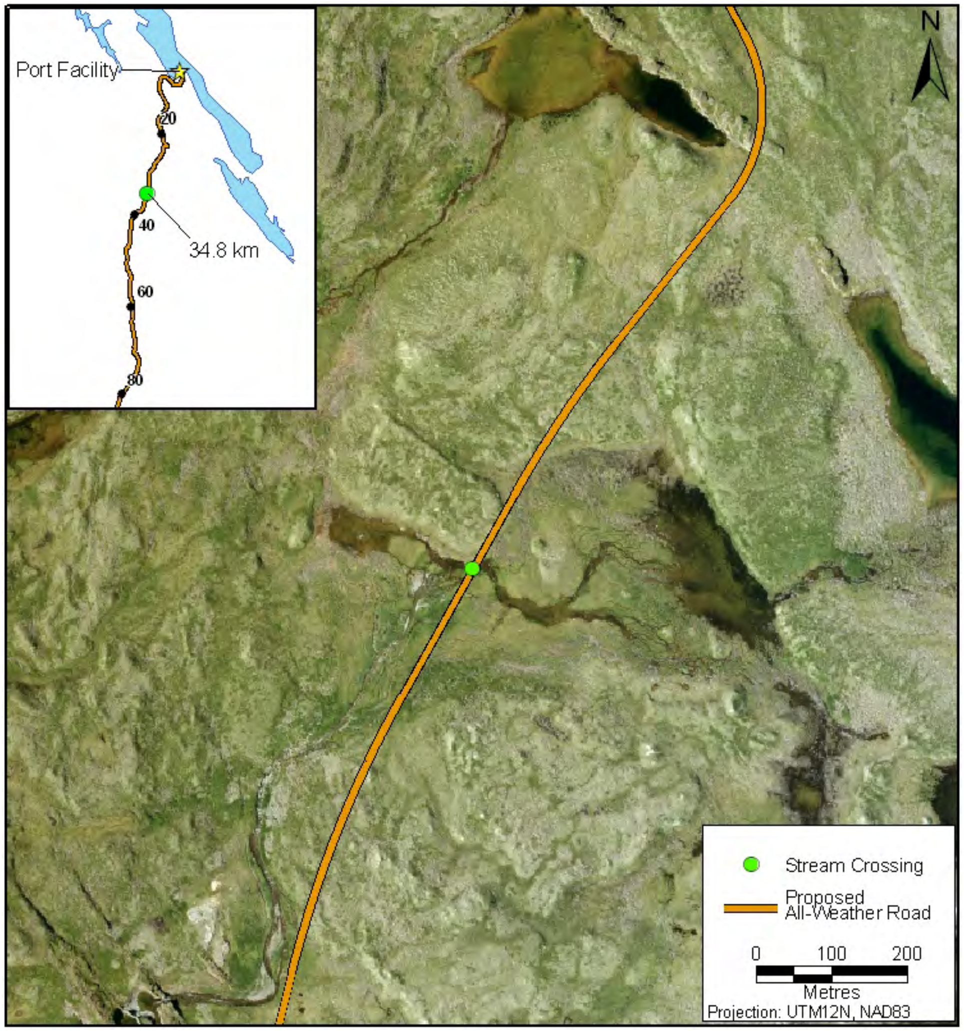
Rescan

SNC-LAVALIN Engineers & Constructors

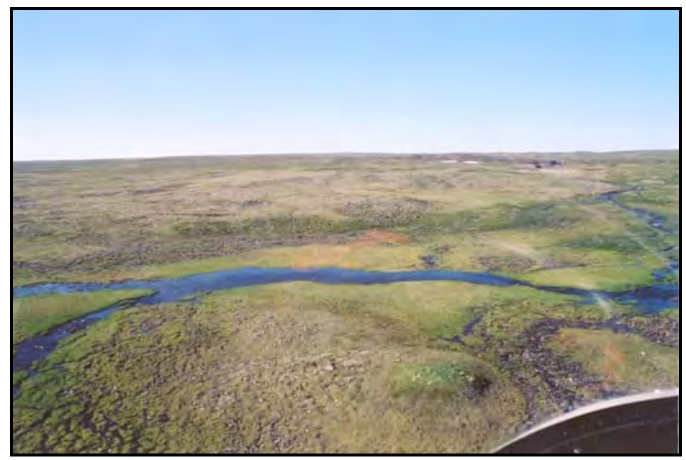
Latitude	66° 19' 1.31" N	Wetted Width (m)	9.89	Bankfull Width (m)	14.13	Watershed Area (km²)	60.5
Longitude	107° 42' 51.90" W	Wetted Depth (m)	0.17	Bankfull Depth (m)	0.31	Slope	1.2 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.426	Estimated Bankfull Discharge (m^3/s)	2.660	Fish Bearing	Yes

Watercourse:

Shallow ponds at both ends.



Aerial view



Aerial view

Downstream end of reach

Downstream middle of reach

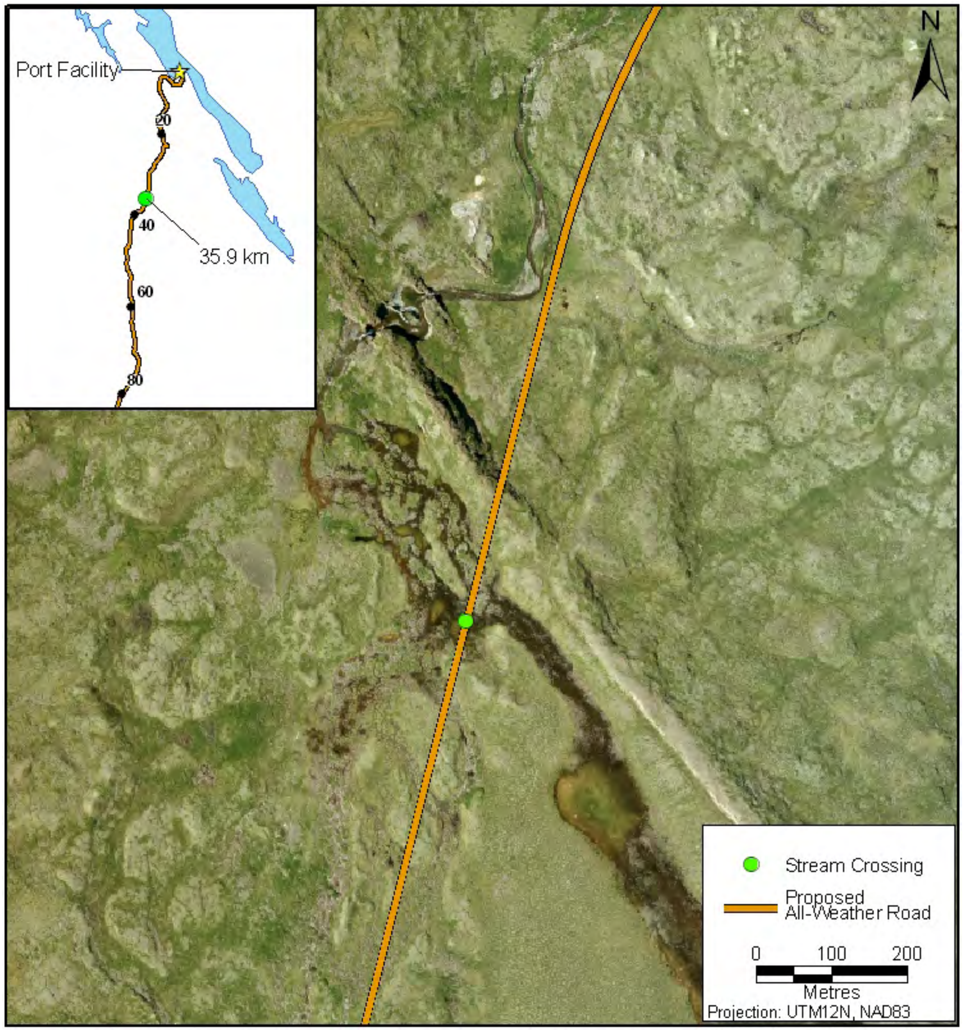
Glide Habitat

Bathurst Project Potentially Navigable Waters   Crossing 35.9 km

Latitude	66° 18' 29.58" N	Wetted Width (m)	32.00	Bankfull Width (m)	34.00	Watershed Area (km^2)	43.0
Longitude	107° 43' 24.83" W	Wetted Depth (m)	0.15	Bankfull Depth (m)	0.25	Slope	0.5 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.205	Estimated Bankfull Discharge (m^3/s)	2.950	Fish Bearing	Yes

Watercourse:

Wide channel with upstream pond and downstream barrier falls.



Aerial view

Downstream waterfall

Glide habitat

Bathurst Project Potentially Navigable Waters   Crossing 36.6 km

the Bathurst Inlet Port and Road Project

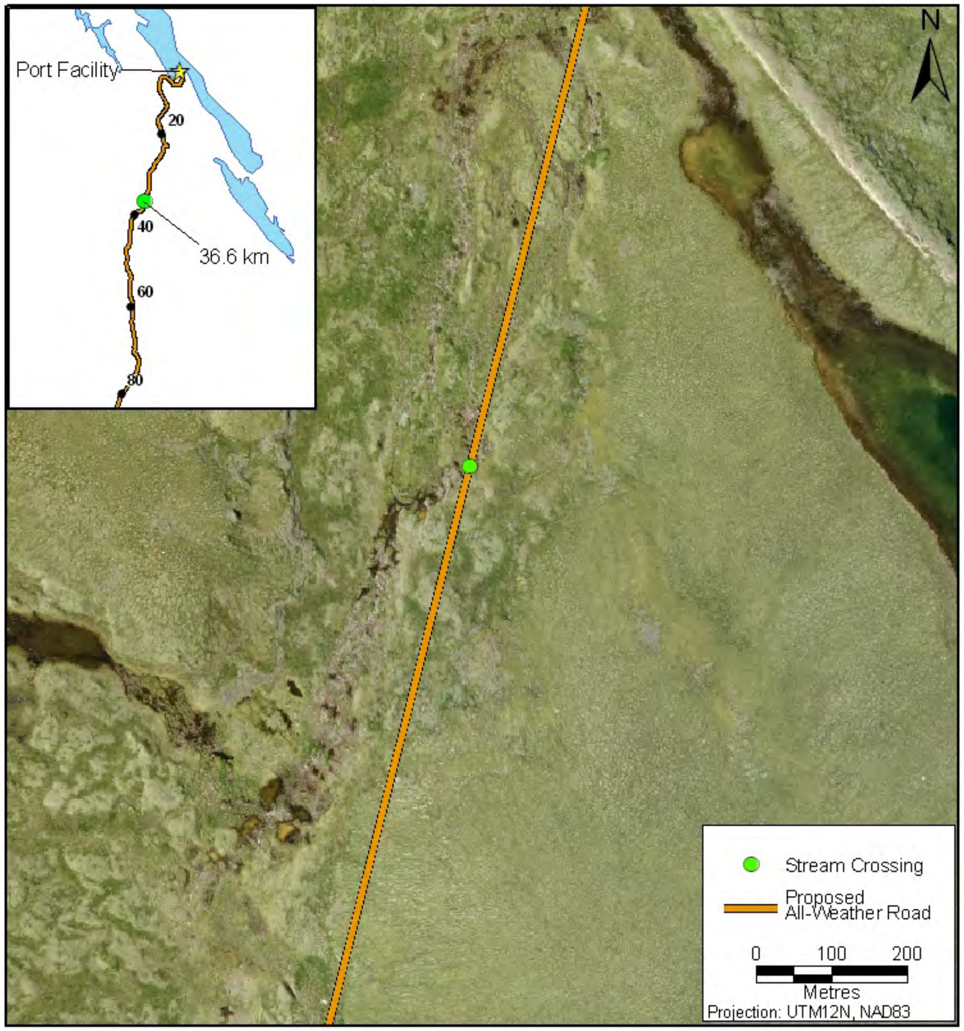
Rescan

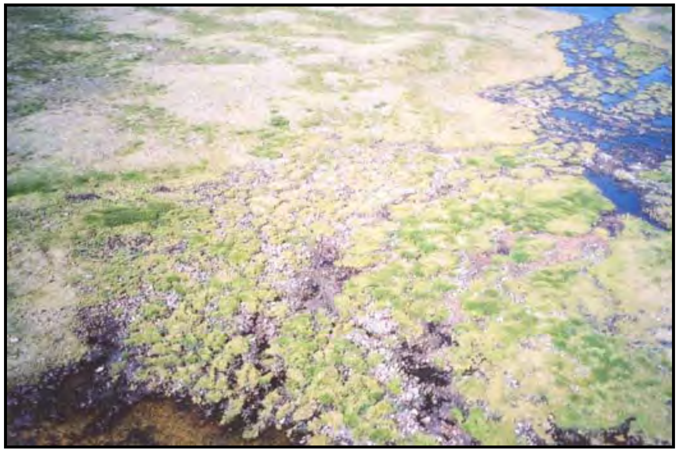
SNC·LAVALIN Engineers & Constructors

Latitude	66° 18' 9.18" N	Wetted Width (m)	0.50	Bankfull Width (m)	17.99	Watershed Area (km^2)	2.7
Longitude	107° 43' 40.47" W	Wetted Depth (m)	0.25	Bankfull Depth (m)	0.55	Slope	0.6 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.000	Estimated Bankfull Discharge (m^3/s)	6.560	Fish Bearing	Yes

Watercourse:

Flowing, lake downstream deep.





Aerial view

Aerial view

First riffle

Bathurst Project Potentially Navigable Waters   Crossing 42.3 km

the Bathurst Inlet Port and Road Project

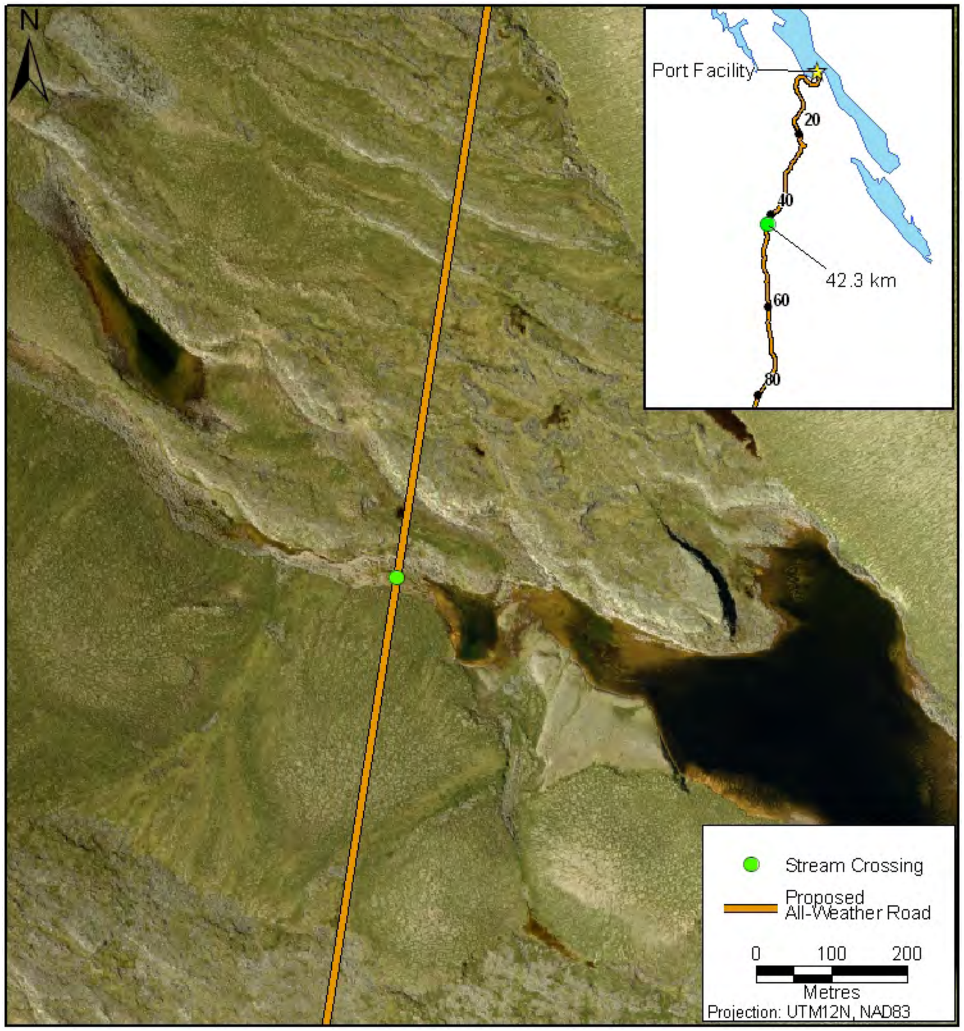
Rescan

SNC·LAVALIN Engineers & Constructors

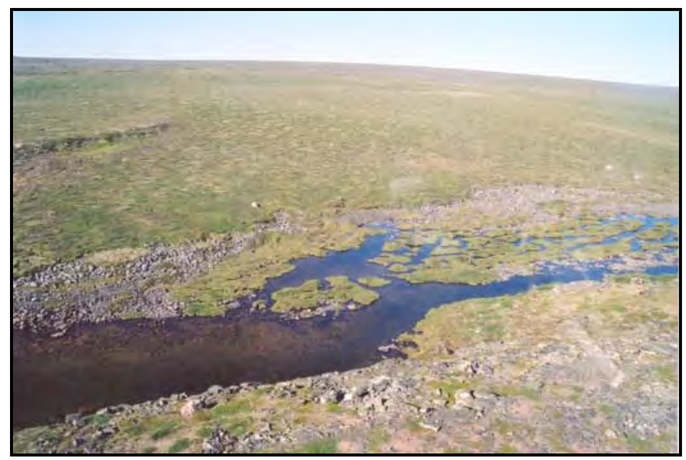
Latitude	66° 15' 43.68" N	Wetted Width (m)	2.69	Bankfull Width (m)	6.15	Watershed Area (km^2)	9.5
Longitude	107° 47' 50.23" W	Wetted Depth (m)	0.21	Bankfull Depth (m)	0.33	Slope	0.7 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.010	Estimated Bankfull Discharge (m^3/s)	0.990	Fish Bearing	Yes

Watercourse:

Flowing, lake downstream deep.



Aerial view



Aerial view – upstream to right

Bathurst Project Potentially Navigable Waters Crossing 43.3 km

the BATHURST INLET PORT AND ROAD PROJECT

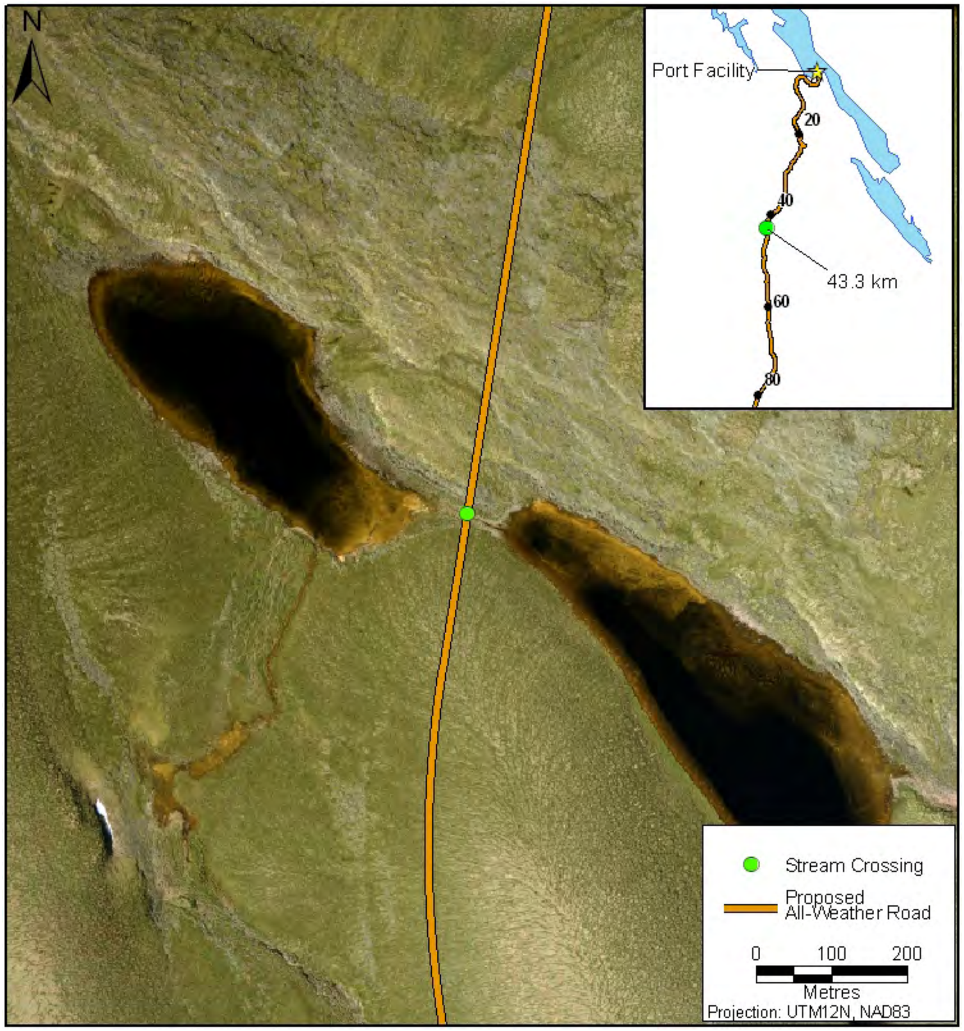
Rescan

SNC·LAVALIN Engineers & Constructors

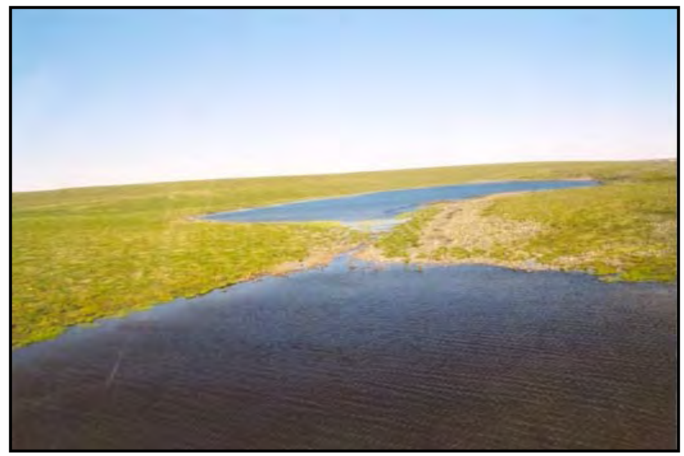
Latitude	66° 15' 12.62" N	Wetted Width (m)	N/A	Bankfull Width (m)	13.00	Watershed Area (km^2)	6.1
Longitude	107° 48' 6.56" W	Wetted Depth (m)	N/A	Bankfull Depth (m)	0.40	Slope	0.1 %
Survey Length	100 m	Wetted Stream Discharge (m^3/s)	N/A	Estimated Bankfull Discharge (m^3/s)	0.780	Fish Bearing	No

Watercourse:

Flowing, lake downstream deep.



Aerial view – joined lakes



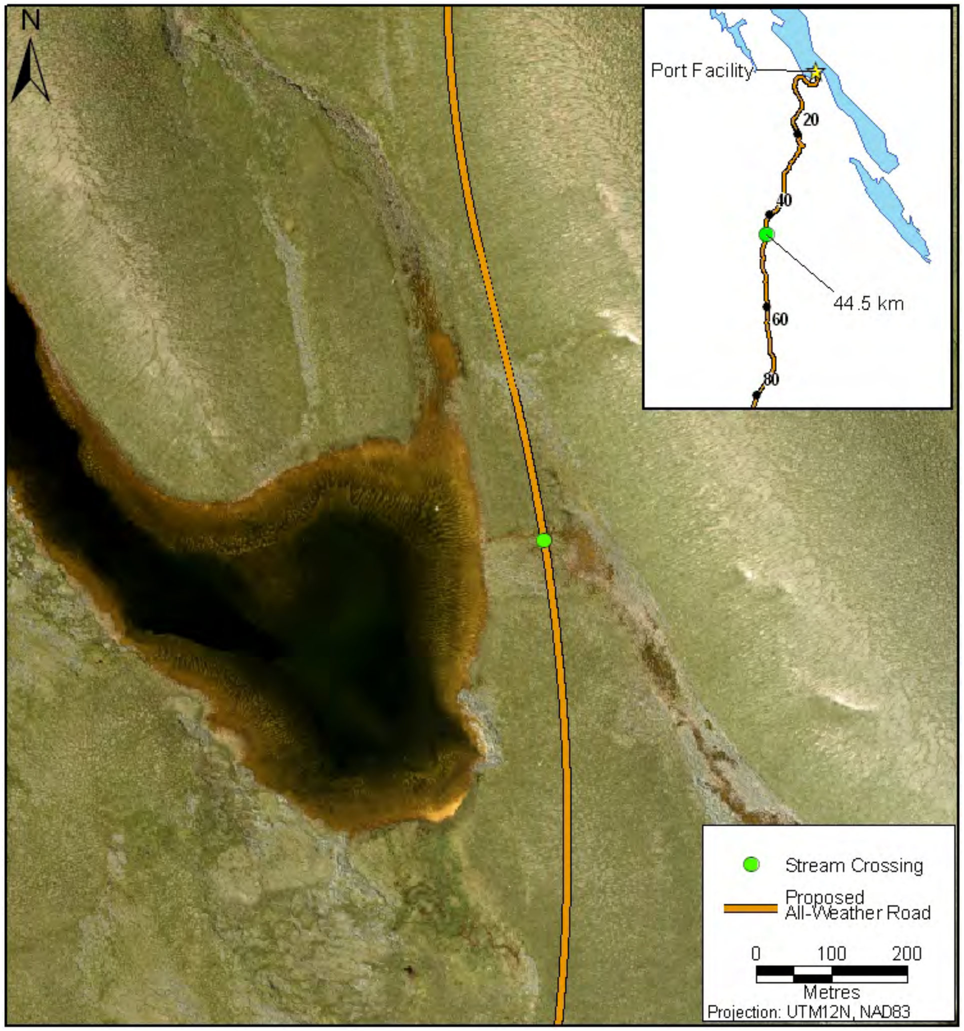
Aerial view – downstream

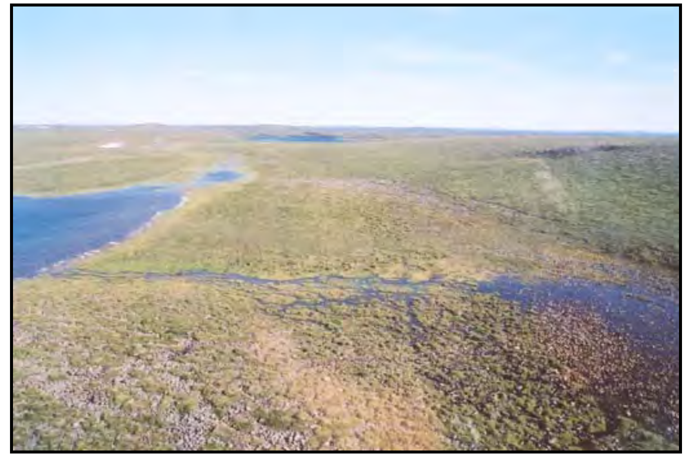
Bathurst Project Potentially Navigable Waters   Crossing 44.5 km

Latitude	66° 14' 34.37" N	Wetted Width (m)	20.28	Bankfull Width (m)	28.84	Watershed Area (km^2)	2.0
Longitude	107° 48' 5.24" W	Wetted Depth (m)	0.20	Bankfull Depth (m)	0.35	Slope	0.4 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.041	Estimated Bankfull Discharge (m^3/s)	3.750	Fish Bearing	Yes

Watercourse:

Flowing, lake downstream deep.





Aerial view

Aerial view

Aerial view – boulder field

Bathurst Project Potentially Navigable Waters   Crossing 58.7 km

The Bathurst Inlet Port and Road Project

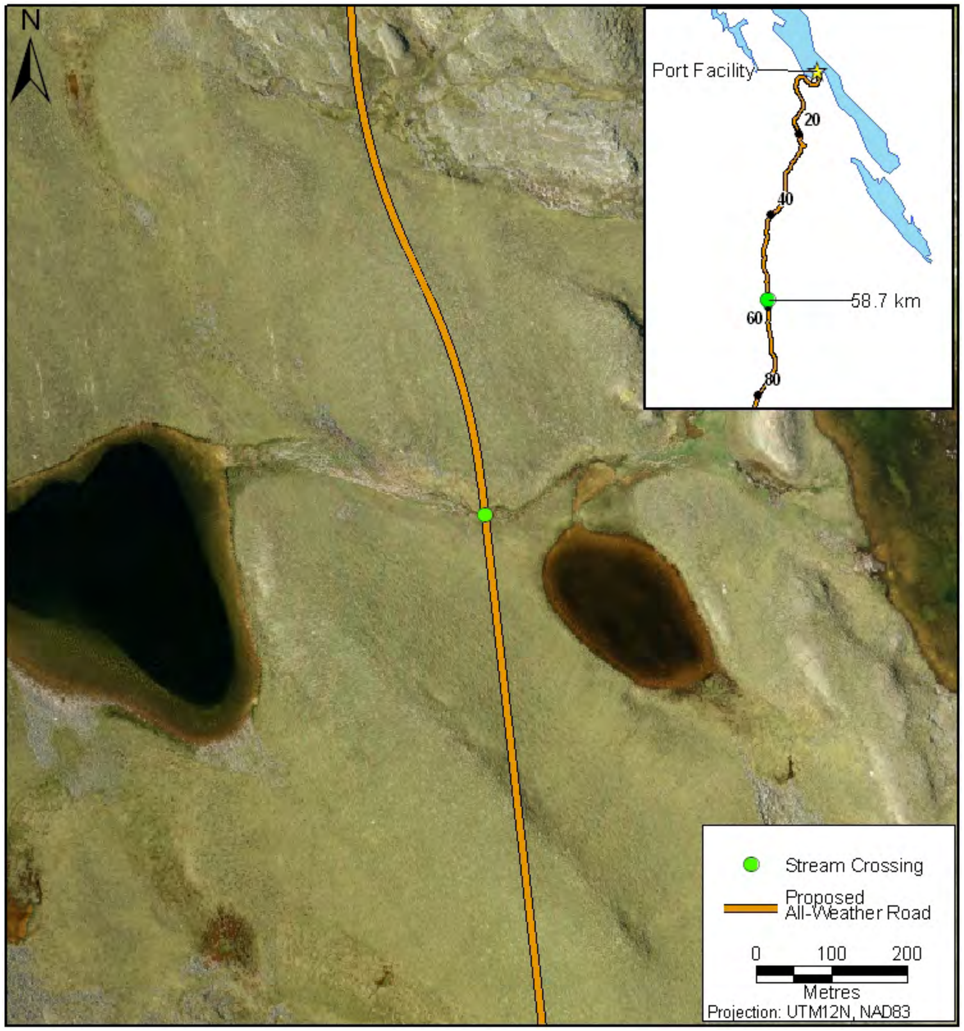
Rescan

SNC•LAVALIN Engineers & Constructors

Latitude	66° 7' 12.19" N	Wetted Width (m)	6.58	Bankfull Width (m)	6.66	Watershed Area (km²)	5.2
Longitude	107° 48' 43.06" W	Wetted Depth (m)	0.16	Bankfull Depth (m)	0.29	Slope	0.8 %
Survey Length	200 m	Wetted Stream Discharge (m³/s)	0.059	Estimated Bankfull Discharge (m³/s)	0.980	Fish Bearing	Yes

Watercourse:

Flowing water connected downstream to shallow lakes.



Aerial view

Downstream view

Upstream view of reach

Bathurst Project Potentially Navigable Waters   Crossing 68.3 km

the Bathurst Inlet Port and Road Project

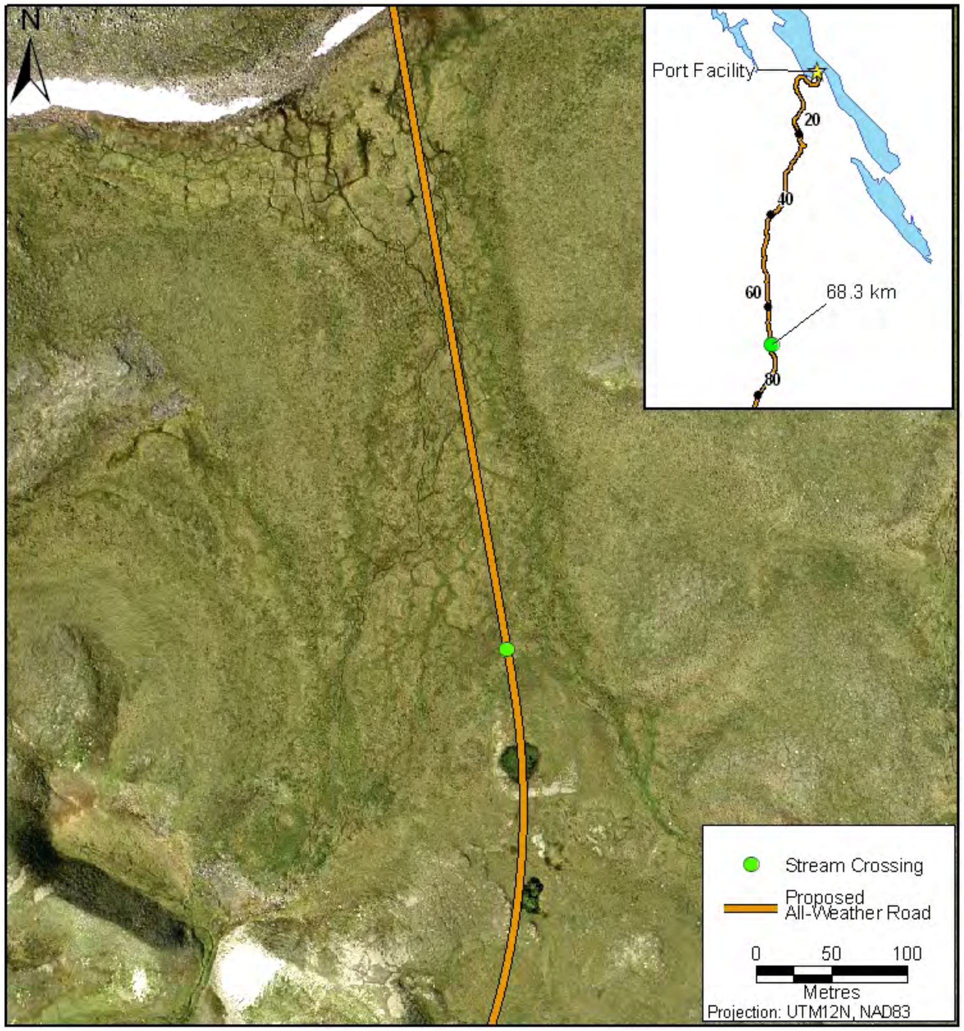
Rescan

SNC·LAVALIN Engineers & Constructors

Latitude	66° 2' 5.65" N	Wetted Width (m)	3.26	Bankfull Width (m)	4.00	Watershed Area (km^2)	N/A
Longitude	107° 48' 20.21" W	Wetted Depth (m)	0.20	Bankfull Depth (m)	0.41	Slope	0.8 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.360	Estimated Bankfull Discharge (m^3/s)	1.020	Fish Bearing	Yes

Watercourse:

Flowing water.



Aerial view

Across braided stream near start

Across braided stream near start

Bathurst Project Potentially Navigable Waters   Crossing 68.6 km

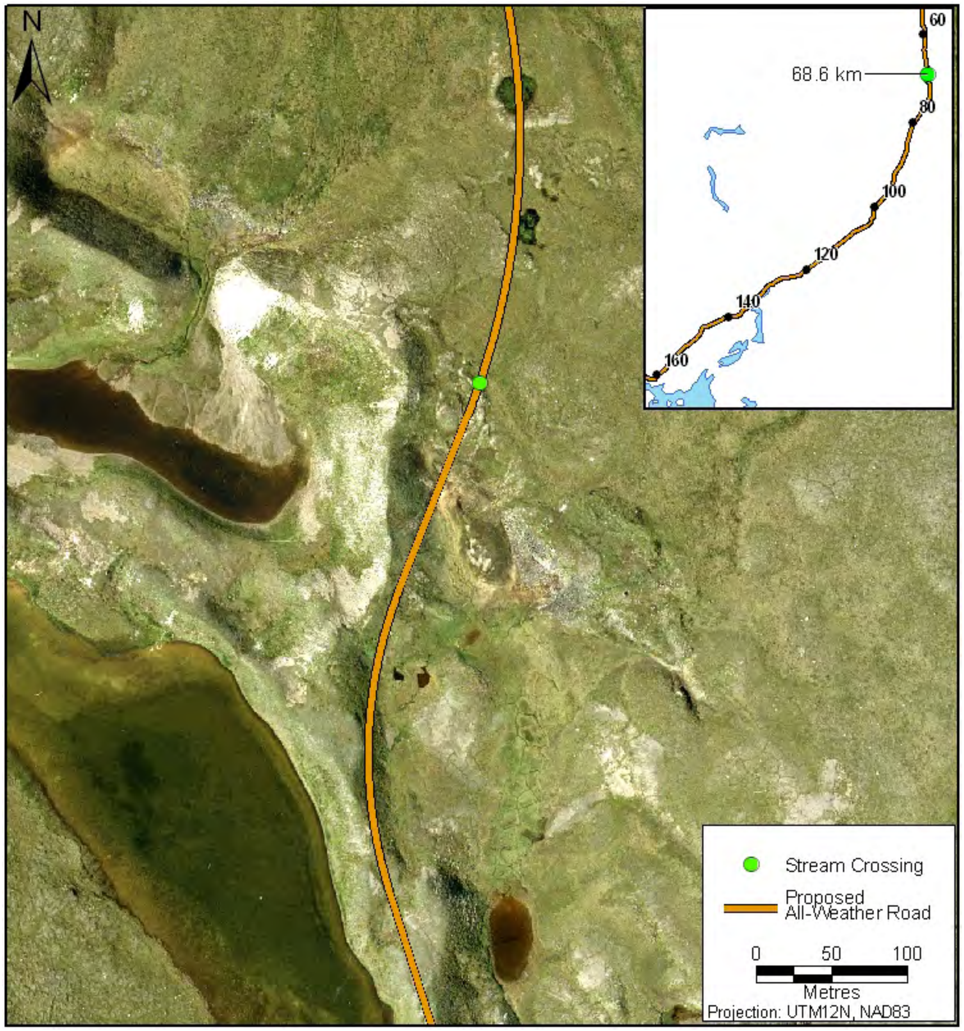
the Bathurst Inlet Port and Road Project

Rescan

SNC•LAVALIN Engineers & Constructors

Latitude	66° 2' 5.65" N	Wetted Width (m)	3.97	Bankfull Width (m)	4.82	Watershed Area (km^2)	6.2
Longitude	107° 48' 20.21" W	Wetted Depth (m)	0.20	Bankfull Depth (m)	0.58	Slope	0.7 %
Survey Length	209 m	Wetted Stream Discharge (m^3/s)	0.080	Estimated Bankfull Discharge (m^3/s)	1.920	Fish Bearing	Yes

Watercourse:
Flowing water.



Aerial view

Aerial view

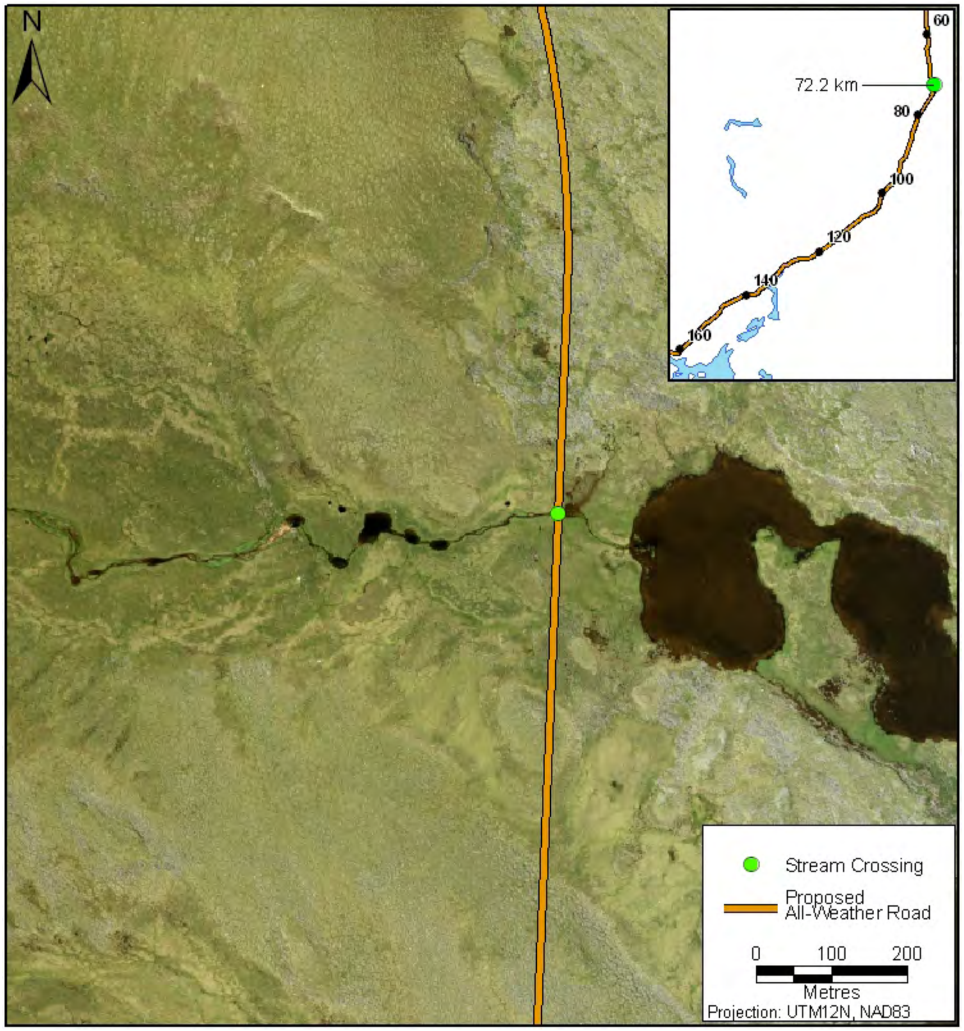
Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 72.2 km

the Bathurst Inlet Port and Road Project — Rescan — SNC·LAVALIN Engineers & Constructors

Latitude	66° 0' 10.94" N	Wetted Width (m)	10.81	Bankfull Width (m)	10.83	Watershed Area (km²)	39.8
Longitude	107° 47' 36.73" W	Wetted Depth (m)	1.71	Bankfull Depth (m)	2.02	Slope	0.7 %
Survey Length	200 m	Wetted Stream Discharge (m³/s)	0.198	Estimated Bankfull Discharge (m³/s)	32.900	Fish Bearing	No

Watercourse:
Flowing water



Aerial view

First pool upstream

200 m upstream of reach

Bathurst Project Potentially Navigable Waters   Crossing 84.2 km

the Bathurst Inlet Port and Road Project

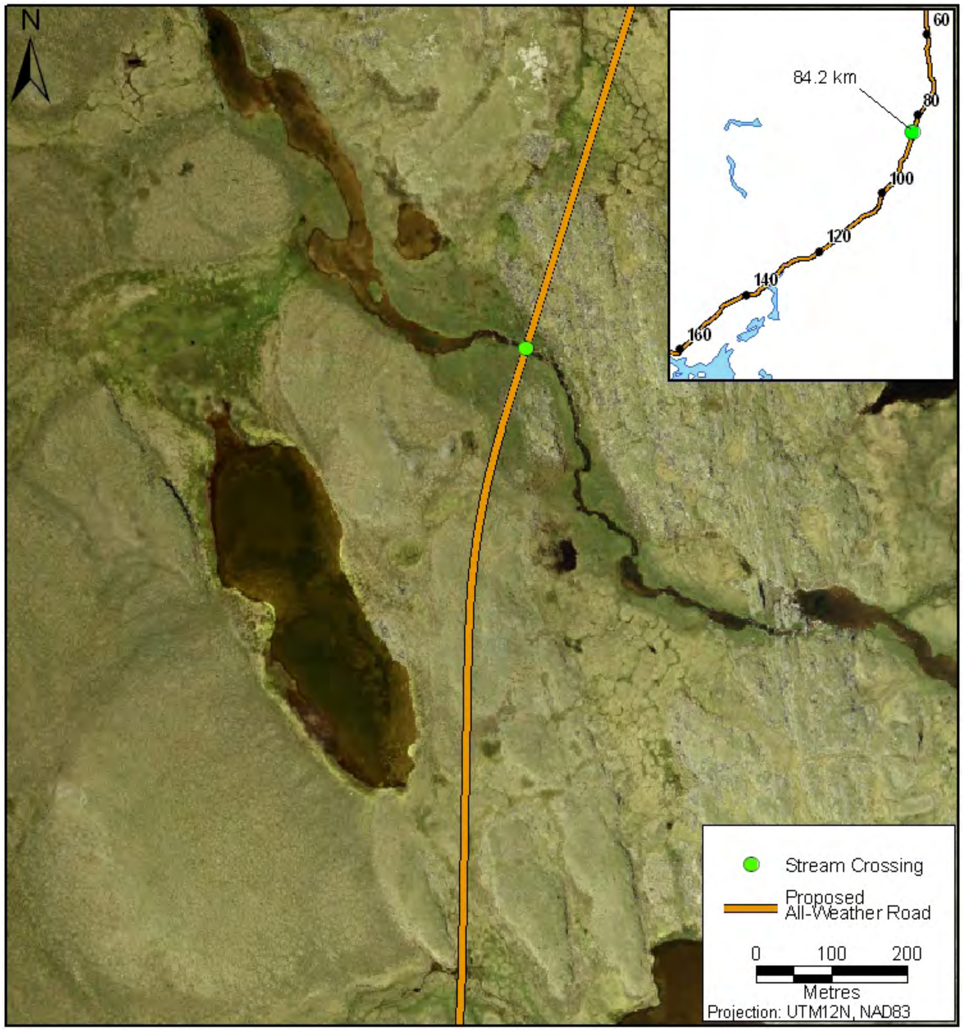
Rescan

SNC·LAVALIN Engineers & Constructors

Latitude	65° 54' 33.05" N	Wetted Width (m)	5.72	Bankfull Width (m)	6.14	Watershed Area (km^2)	81.0
Longitude	107° 54' 42.92" W	Wetted Depth (m)	0.33	Bankfull Depth (m)	0.58	Slope	0.7 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	0.490	Estimated Bankfull Discharge (m^3/s)	2.420	Fish Bearing	Yes

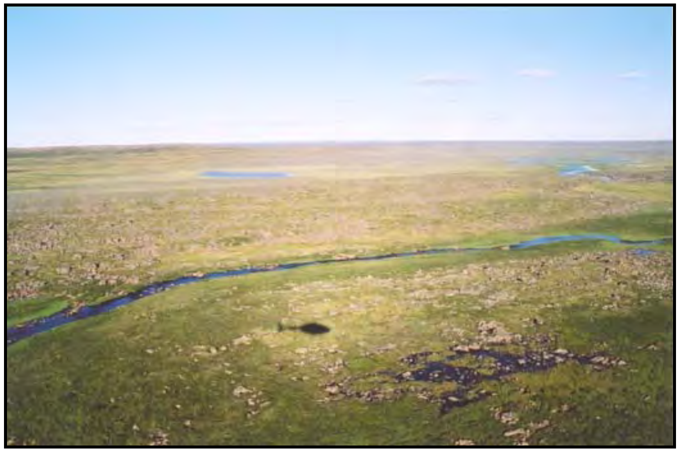
Watercourse:

Well established drainage, large area of rocky relief up to crossing.



Aerial view

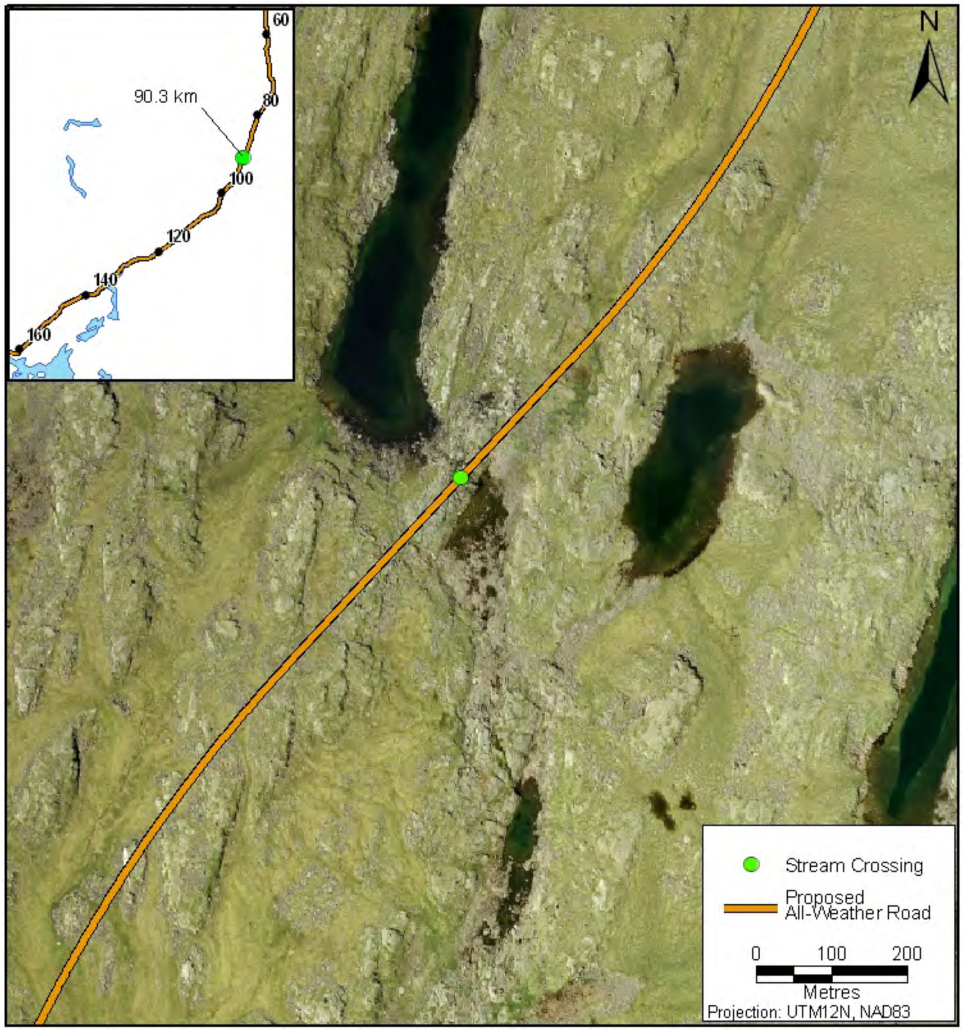
Aerial view



Aerial view

Bathurst Project Potentially Navigable Waters Crossing 90.3 km

Latitude	65° 51' 31.66" N	Wetted Width (m)	2.03	Bankfull Width (m)	4.02	Watershed Area (km^2)	2.6	
Longitude	107° 57' 35.65" W	Wetted Depth (m)	0.17	Bankfull Depth (m)	0.29	Slope	1.9 %	**Watercourse:**
Survey Length	74 m	Wetted Stream Discharge (m^3/s)	0.290	Estimated Bankfull Discharge (m^3/s)	0.870	Fish Bearing	Yes	Downstream lake not connected, impassable rock face barrier, standing pools and subsurface flow.



Aerial view

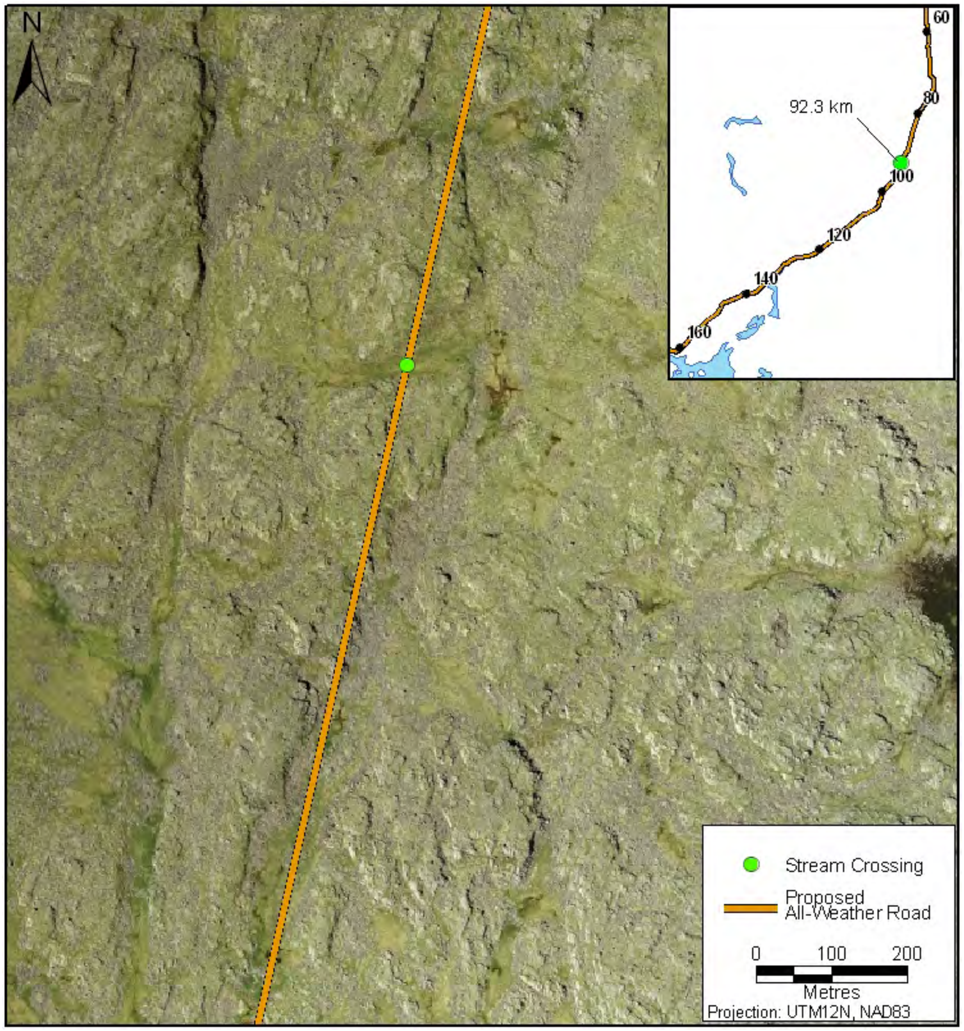
Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 92.3 km

Latitude	65° 50' 37.61" N	Wetted Width (m)	N/A	Bankfull Width (m)	N/A	Watershed Area (km^2)	2.2
Longitude	107° 58' 48.37" W	Wetted Depth (m)	N/A	Bankfull Depth (m)	N/A	Slope	N/A
Survey Length	N/A	Wetted Stream Discharge (m^3/s)	N/A	Estimated Bankfull Discharge (m^3/s)	N/A	Fish Bearing	No

Watercourse:

Low flow with standing pools, upstream boulder garden.



Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 94.1 km

the Bathurst Inlet Port and Road Project

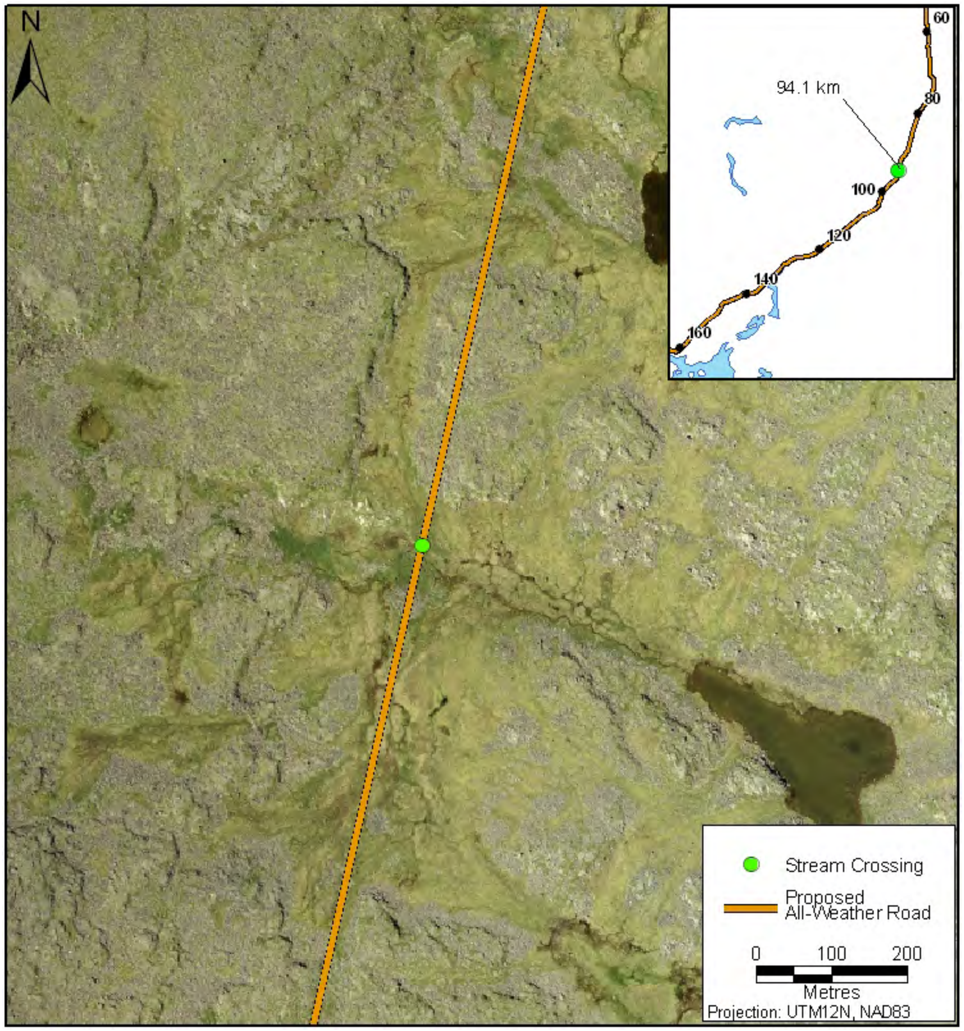
Rescan

SNC·LAVALIN Engineers & Constructors

Latitude	65° 51' 31.66" N	Wetted Width (m)	N/A	Bankfull Width (m)	N/A	Watershed Area (km^2)	4.2
Longitude	107° 57' 35.65" W	Wetted Depth (m)	N/A	Bankfull Depth (m)	N/A	Slope	N/A
Survey Length	N/A	Wetted Stream Discharge (m^3/s)	N/A	Estimated Bankfull Discharge (m^3/s)	N/A	Fish Bearing	No

Watercourse:

Good flow, upstream boulder garden, subsurface sections downstream.

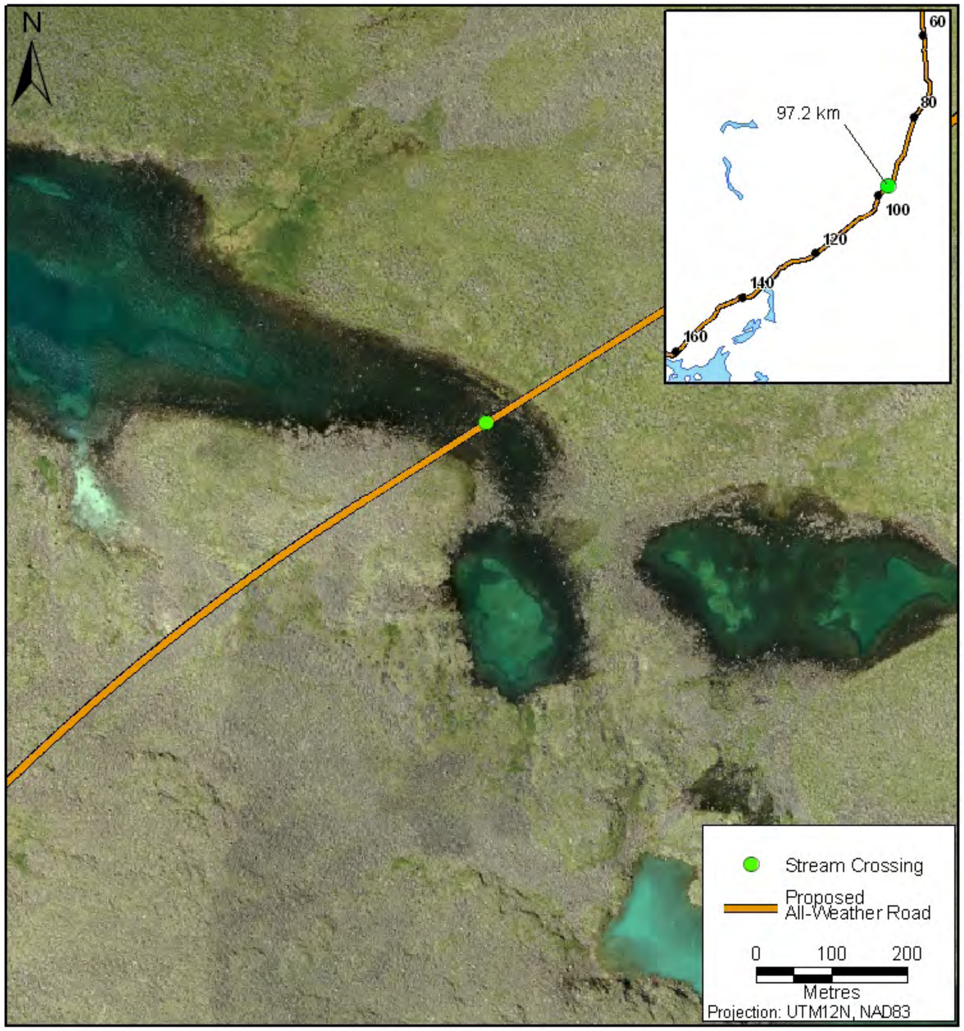


Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 97.2 km

Latitude	65° 48' 20.74" N	Wetted Width (m)	77.80	Bankfull Width (m)	79.80	Watershed Area (km^2)	4.4
Longitude	108° 1' 41.35" W	Wetted Depth (m)	0.48	Bankfull Depth (m)	0.68	Slope	0.5 %
Survey Length	114 m	Wetted Stream Discharge (m^3/s)	36.730	Estimated Bankfull Discharge (m^3/s)	36.730	Fish Bearing	Yes

Watercourse:
Large bay of a shallow lake.



Aerial view

Upstream aerial view

Bathurst Project Potentially Navigable Waters Crossing 103.3 km

the Bathurst Inlet Port and Road Project

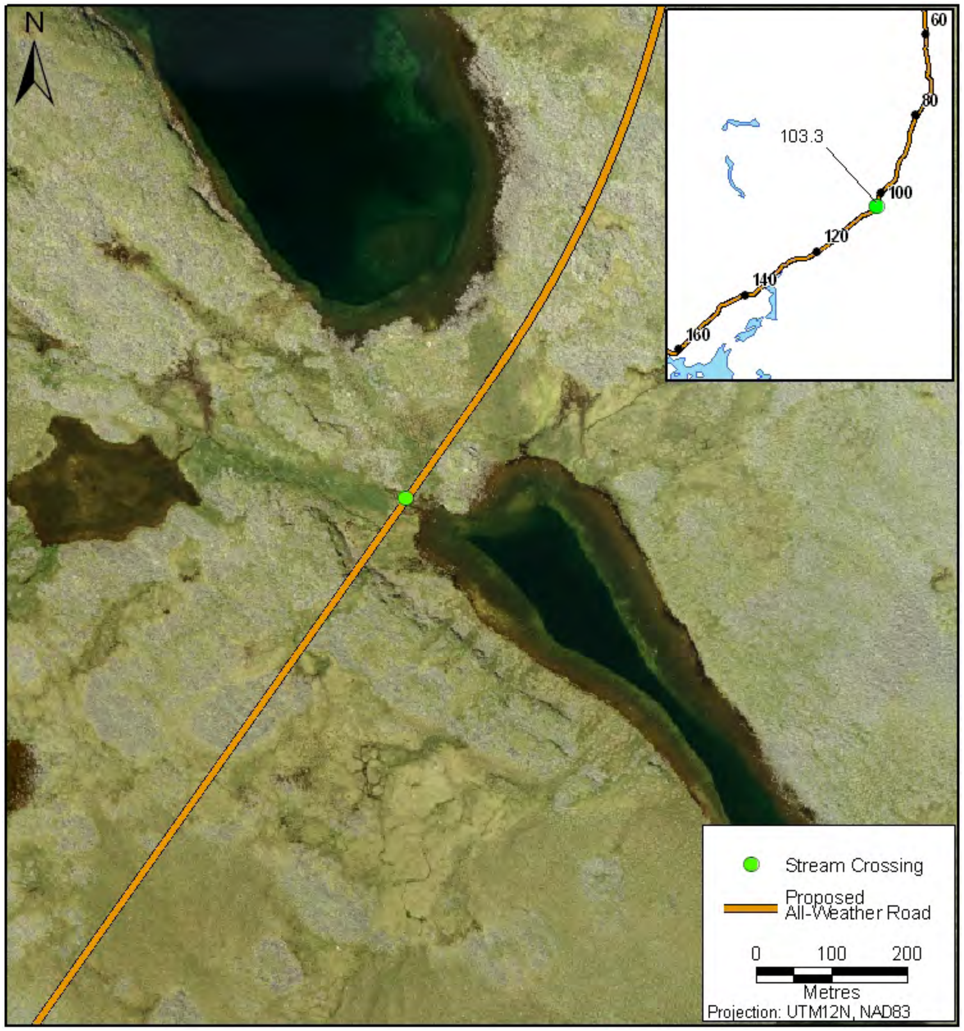
Rescan

SNC·LAVALIN Engineers & Constructors

Latitude	65° 45' 44.44" N	Wetted Width (m)	50.00	Bankfull Width (m)	50.00	Watershed Area (km^2)	3.9
Longitude	108° 5' 57.87" W	Wetted Depth (m)	0.20	Bankfull Depth (m)	0.49	Slope	3.0 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	6.900	Estimated Bankfull Discharge (m^3/s)	32.650	Fish Bearing	No

Watercourse:

Channel between two streams, multiple channels.



Downstream aerial view

Upstream towards boulder field

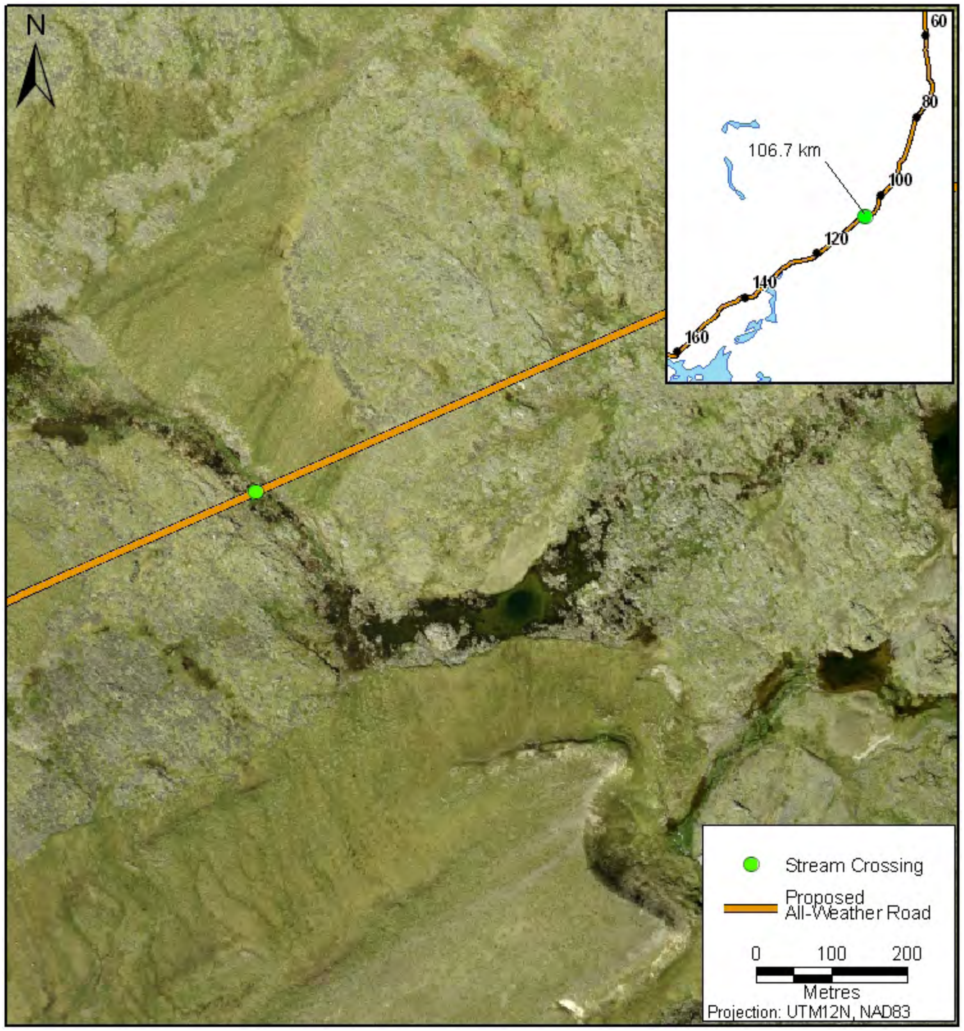
Downstream view

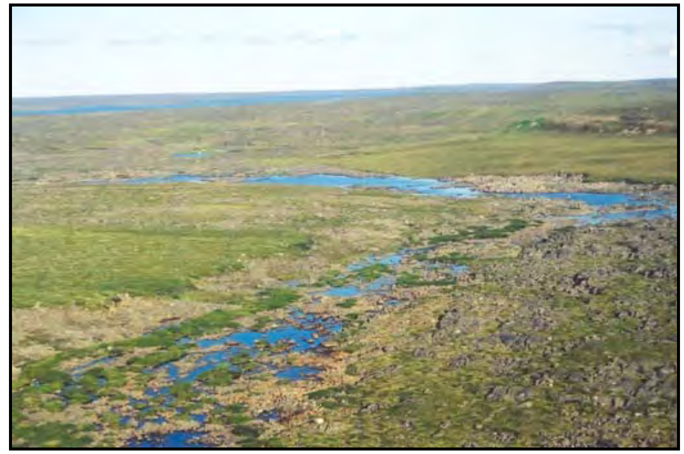
Bathurst Project Potentially Navigable Waters   Crossing 106.7 km

Latitude	65° 44' 46.12" N	Wetted Width (m)	31.00	Bankfull Width (m)	44.00	Watershed Area (km^2)	13.4
Longitude	108° 9' 36.99" W	Wetted Depth (m)	0.45	Bankfull Depth (m)	0.71	Slope	1.0 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	1.860	Estimated Bankfull Discharge (m^3/s)	30.760	Fish Bearing	Yes

Watercourse:

Shallow ponds along flowing channel, upstream and downstream boulder gardens.





Aerial view

Upstream from end

Upstream from mid-point

Bathurst Project Potentially Navigable Waters   Crossing 115.2 km

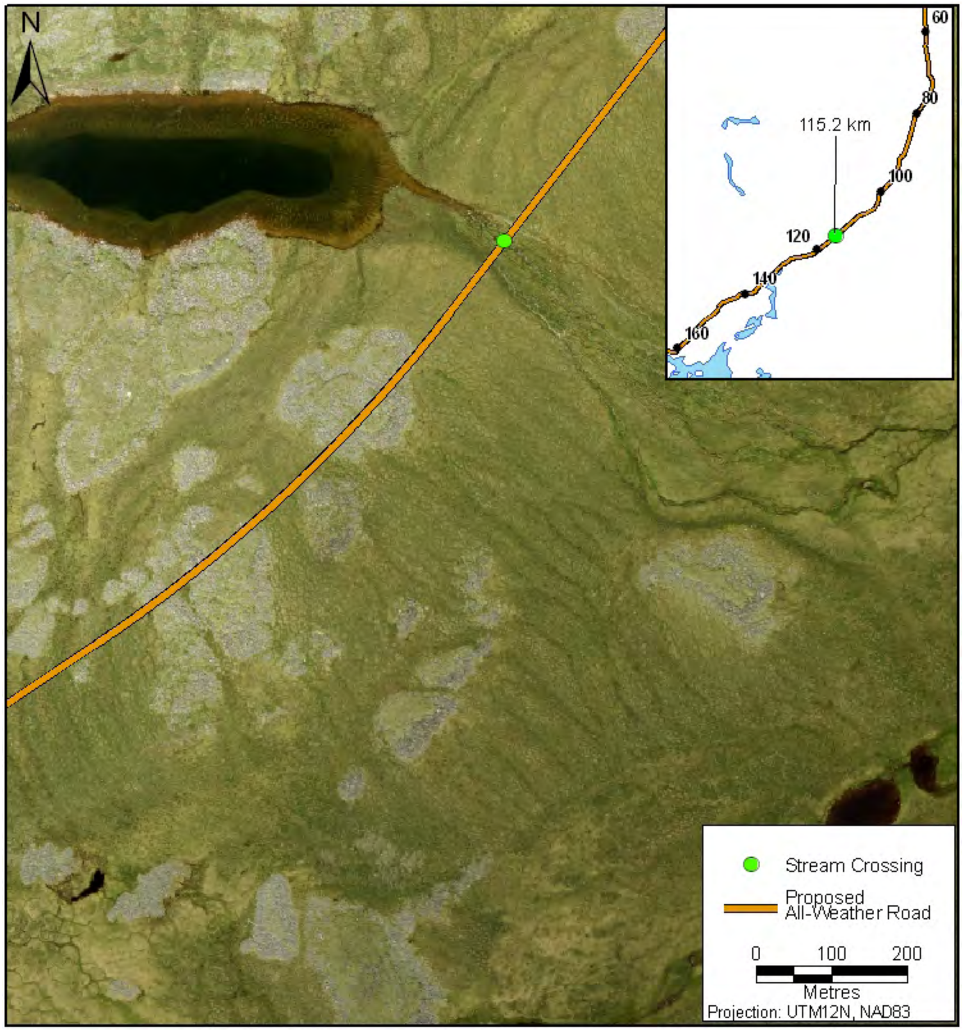
the Bathurst Inlet Port and Road Project

SNC•LAVALIN Engineers & Constructors

Latitude	65° 42' 5.47" N	Wetted Width (m)	2.22	Bankfull Width (m)	3.16	Watershed Area (km²)	18.1
Longitude	108° 18' 35.34" W	Wetted Depth (m)	0.25	Bankfull Depth (m)	0.37	Slope	1.2 %
Survey Length	200 m	Wetted Stream Discharge (m³/s)	0.125	Estimated Bankfull Discharge (m³/s)	0.790	Fish Bearing	Yes

Watercourse:

Flowing water, grassy.



Aerial view

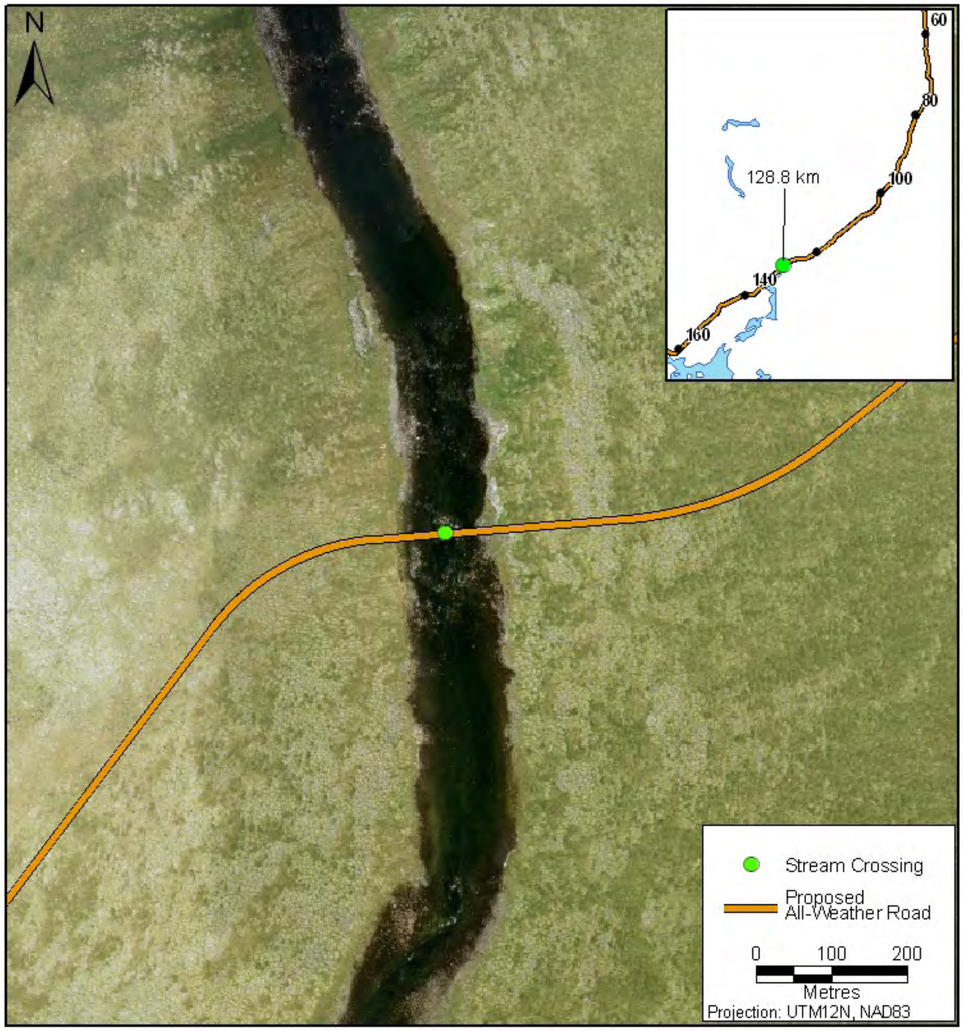
Upstream cascades

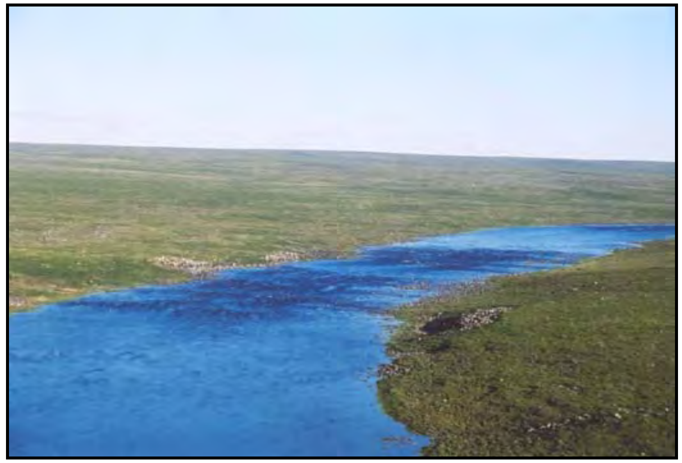

Upstream cascades

Bathurst Project Potentially Navigable Waters   Crossing 128.8km

Latitude	65° 39' 2.07" N	Wetted Width (m)	113.86	Bankfull Width (m)	125.79	Watershed Area (km^2)	1,825.6
Longitude	108° 34' 15.07" W	Wetted Depth (m)	0.58	Bankfull Depth (m)	0.88	Slope	1.1 %
Survey Length	202 m	Wetted Stream Discharge (m^3/s)	32.500	Estimated Bankfull Discharge (m^3/s)	133.170	Fish Bearing	Yes

Watercourse:
Mara River.





Aerial view

Upstream aerial view

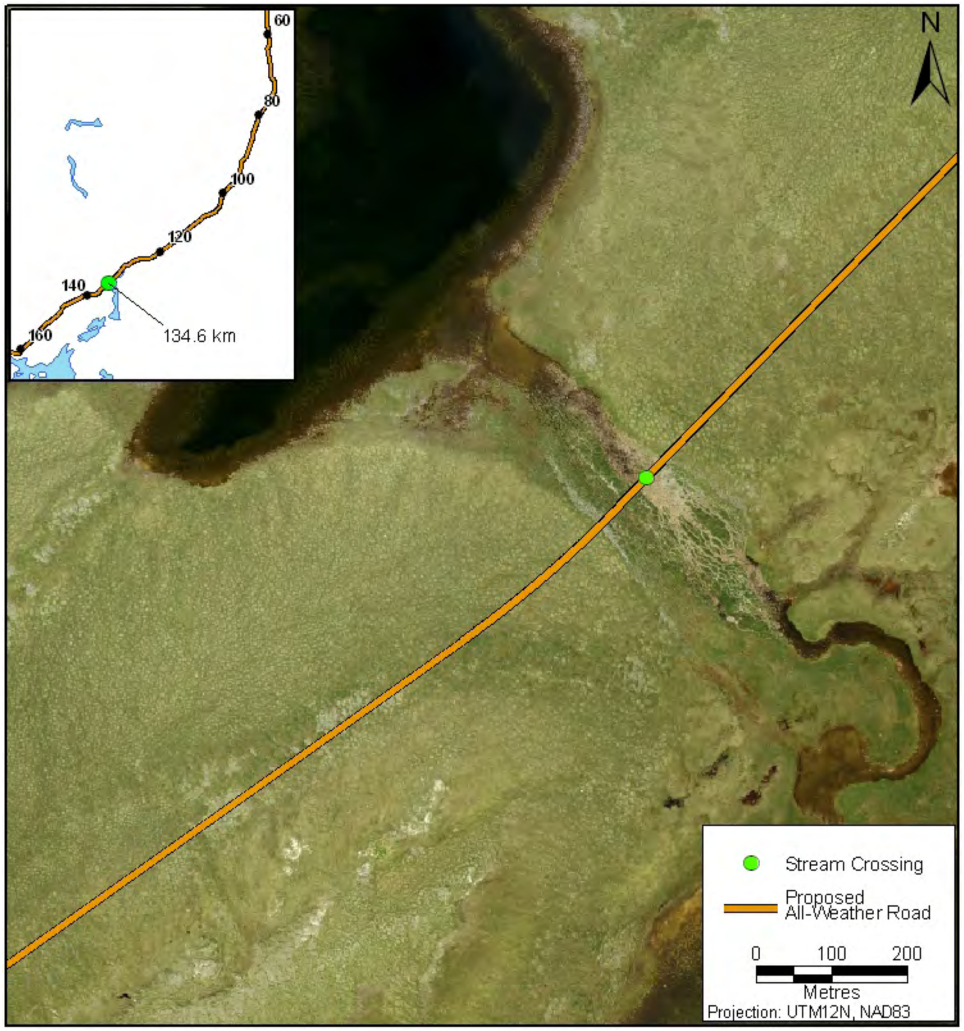
Upstream aerial view

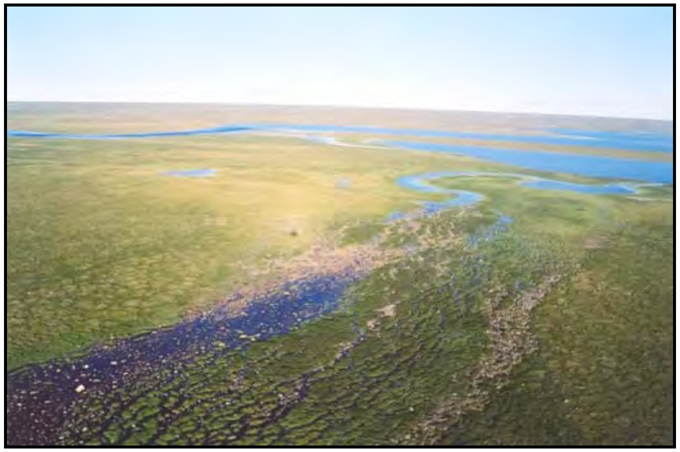
Bathurst Project Potentially Navigable Waters Crossing 134.6km

Latitude	65° 36' 57.57" N	Wetted Width (m)	39.43	Bankfull Width (m)	57.61	Watershed Area (km²)	71.0
Longitude	108° 39' 27.52" W	Wetted Depth (m)	0.14	Bankfull Depth (m)	0.34	Slope	6.8 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	2.728	Estimated Bankfull Discharge (m^3/s)	30.830	Fish Bearing	Yes

Watercourse:

Large, wide and wadable.





Aerial view

Downstream view from start


Upstream view from end

Bathurst Project Potentially Navigable Waters   Crossing 158.2km

the BATHURST INLET PORT AND ROAD PROJECT

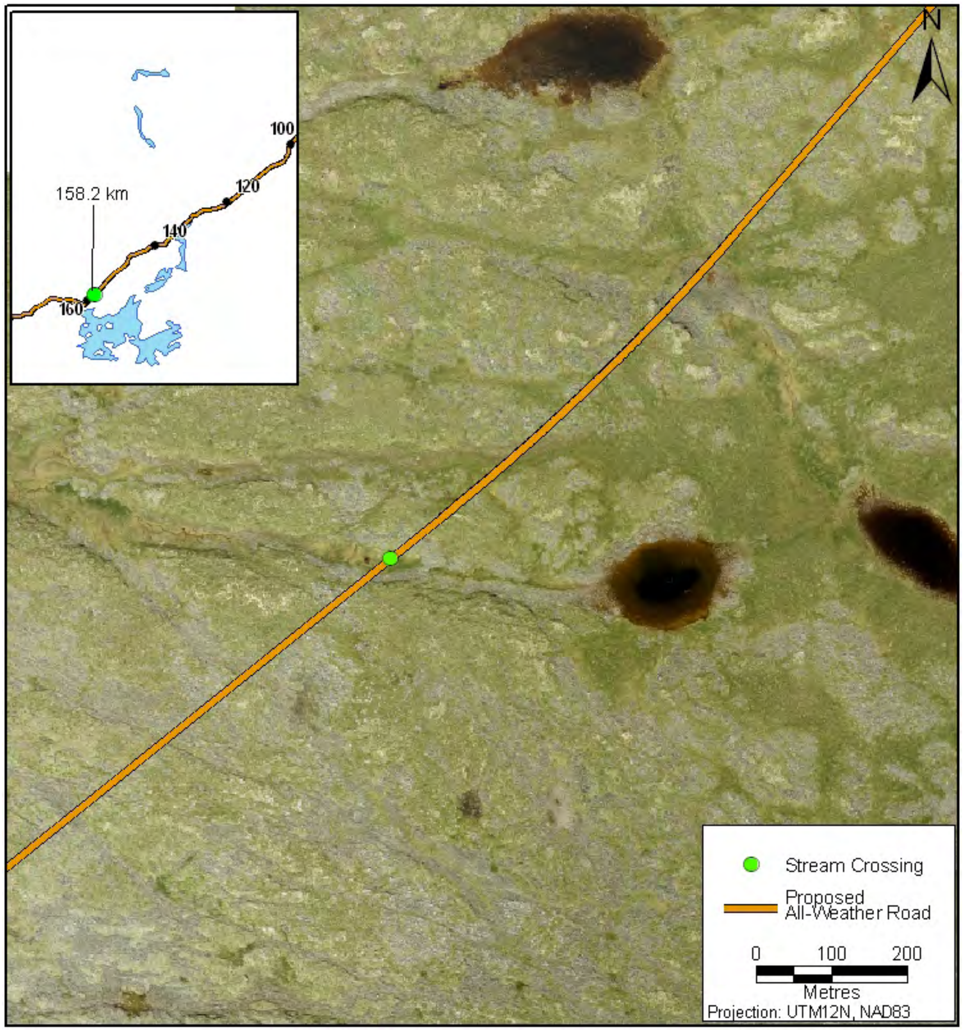
Rescan

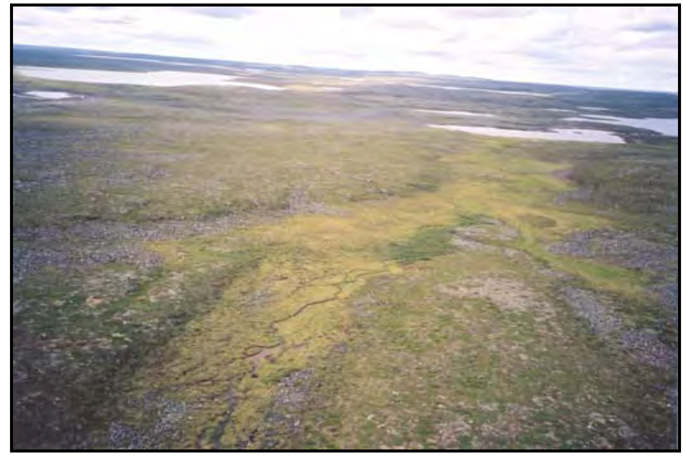
SNC•LAVALIN Engineers & Constructors

Latitude	65° 29' 54.52" N	Wetted Width (m)	N/A	Bankfull Width (m)	N/A	Watershed Area (km²)	0.3
Longitude	109° 3' 48.32" W	Wetted Depth (m)	N/A	Bankfull Depth (m)	N/A	Slope	N/A
Survey Length	N/A	Wetted Stream Discharge (m³/s)	N/A	Estimated Bankfull Discharge (m³/s)	N/A	Fish Bearing	No

Watercourse:

Water flows subsurface at upstream end, connected to lake downstream.





Aerial view

Bathurst Project Potentially Navigable Waters Crossing 167.6km

the BATHURST INLET PORT AND ROAD PROJECT

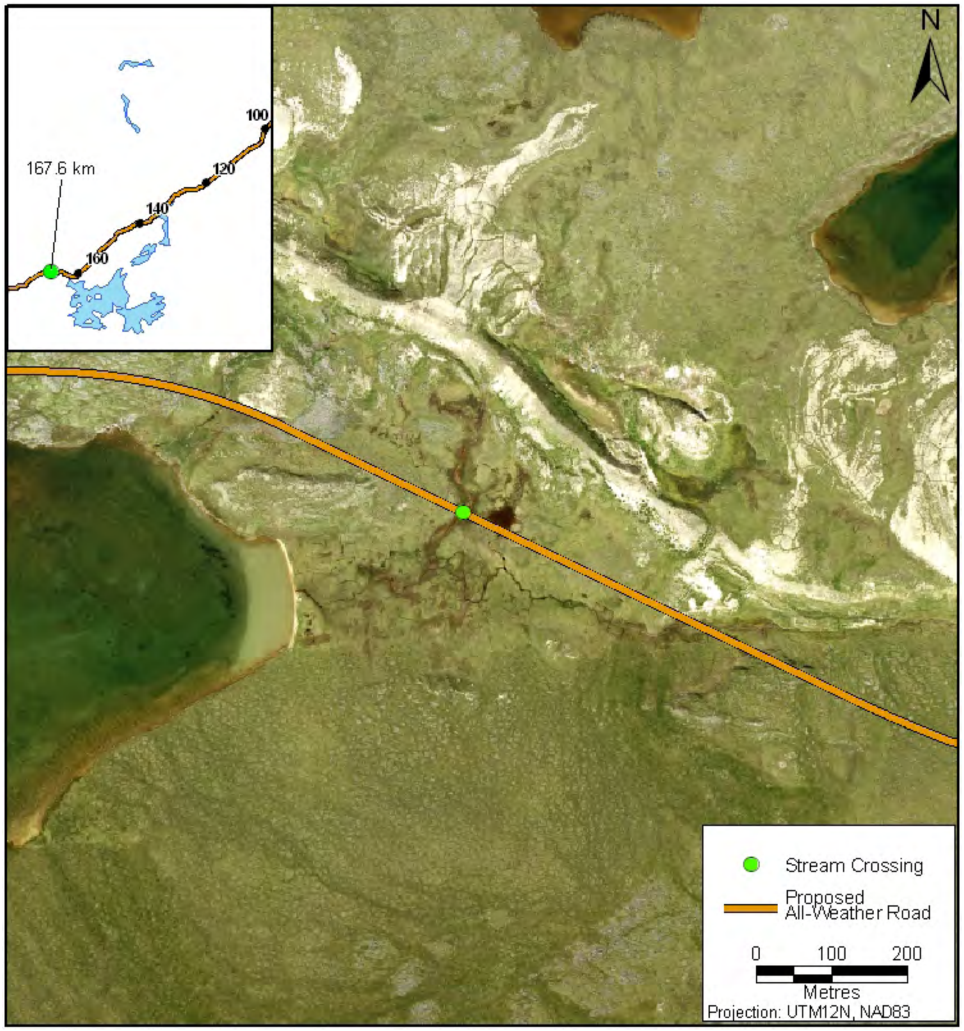
Rescan

SNC·LAVALIN Engineers & Constructors

Latitude	65° 29' 31.52" N	Wetted Width (m)	N/A	Bankfull Width (m)	N/A	Watershed Area (km²)	N/A
Longitude	109° 14' 29.86" W	Wetted Depth (m)	N/A	Bankfull Depth (m)	N/A	Slope	N/A
Survey Length	N/A	Wetted Stream Discharge (m³/s)	N/A	Estimated Bankfull Discharge (m³/s)	N/A	Fish Bearing	No

Watercourse:

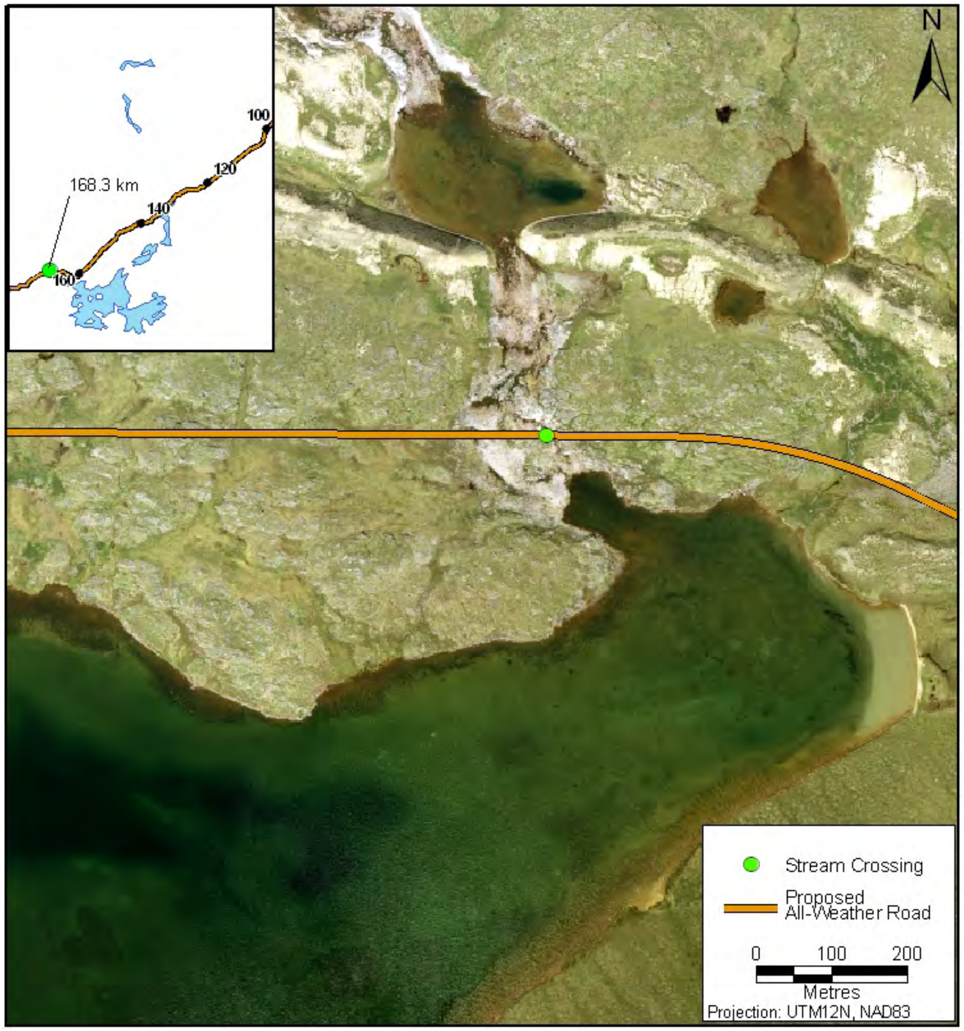
No fish, very low flow (0.2 L/sec), water subsurface after 370 m.



Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 167.6km

Latitude	65° 29' 38.24" N	Wetted Width (m)	N/A	Bankfull Width (m)	N/A	Watershed Area (km^2)	N/A	
Longitude	109° 15' 25.12" W	Wetted Depth (m)	N/A	Bankfull Depth (m)	N/A	Slope	N/A	**Watercourse:**
Survey Length	N/A	Wetted Stream Discharge (m^3/s)	N/A	Estimated Bankfull Discharge (m^3/s)	N/A	Fish Bearing	Yes	Low flow (1.5 L/sec), water subsurface after 250 m, temporary barriers.



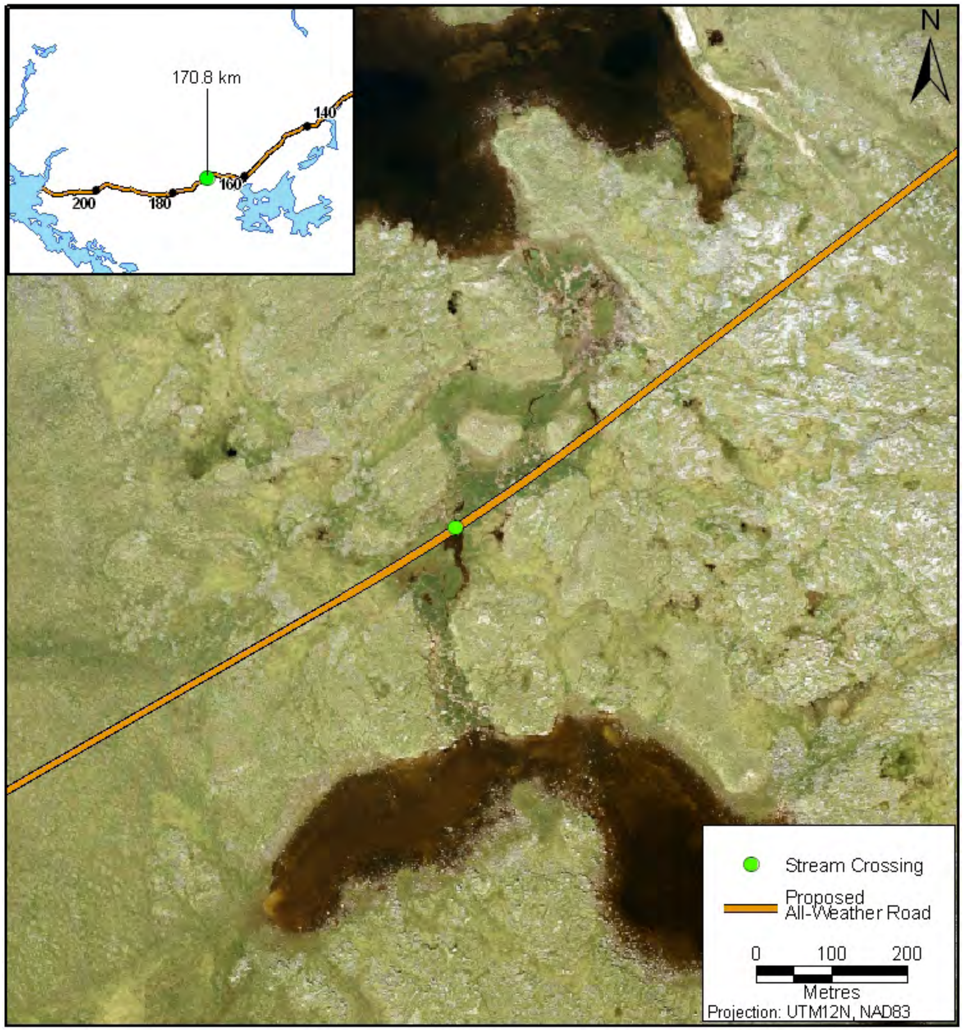
Aerial view

Bathurst Project Potentially Navigable Waters   Crossing 170.8km

the Bathurst Inlet Port and Road Project · Rescan · SNC-LAVALIN Engineers & Constructors

Latitude	65° 29' 13.82" N	Wetted Width (m)	29.08	Bankfull Width (m)	38.43	Watershed Area (km²)	13.5
Longitude	109° 18' 13.73" W	Wetted Depth (m)	0.25	Bankfull Depth (m)	0.50	Slope	0.5 %
Survey Length	200 m	Wetted Stream Discharge (m³/s)	0.068	Estimated Bankfull Discharge (m³/s)	10.580	Fish Bearing	No

Watercourse:
Meandering channels.



Aerial view

Upstream glide and boulder garden

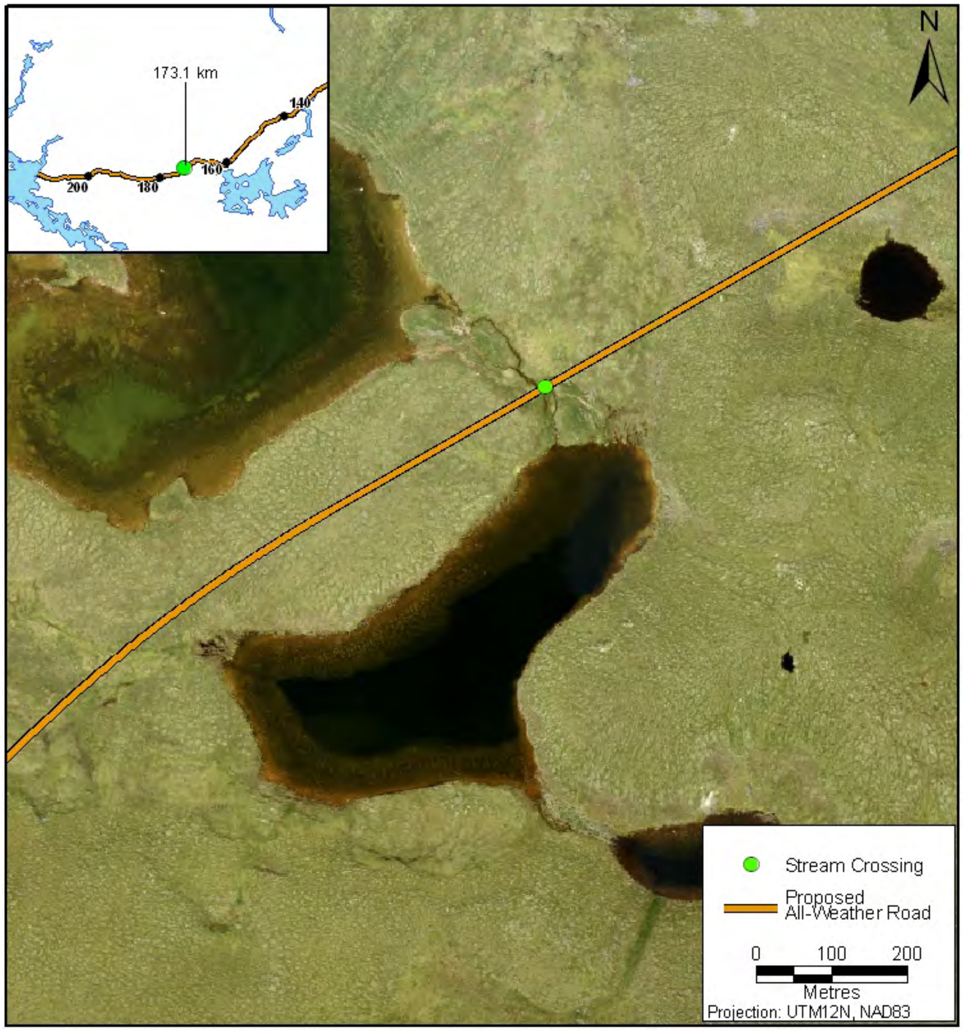
Downstream boulder garden

Bathurst Project Potentially Navigable Waters   Crossing 173.1km

Latitude	65° 28’ 37.71” N	Wetted Width (m)	2.41	Bankfull Width (m)	3.96	Watershed Area (km^2)	9.8
Longitude	109° 20’ 53.91” W	Wetted Depth (m)	0.27	Bankfull Depth (m)	0.42	Slope	0.6 %
Survey Length	205 m	Wetted Stream Discharge (m^3/s)	0.108	Estimated Bankfull Discharge (m^3/s)	0.860	Fish Bearing	No

Watercourse:

Flowing, lake downstream deep.



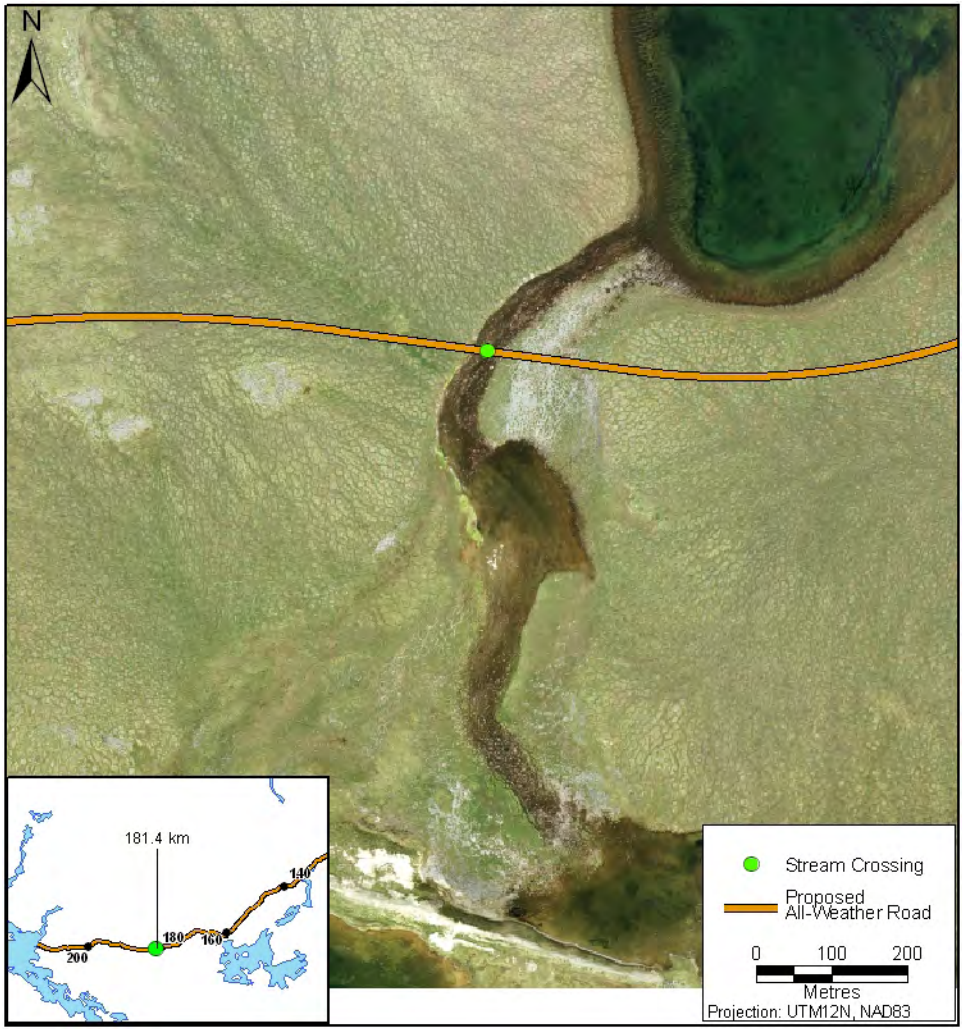
Aerial view

Upstream aerial view

Downstream aerial view

Bathurst Project Potentially Navigable Waters   Crossing 181.4km

Latitude	65° 27' 10.17" N	Wetted Width (m)	43.68	Bankfull Width (m)	47.36	Watershed Area (km^2)	352.5	
Longitude	109° 30' 22.25" W	Wetted Depth (m)	0.35	Bankfull Depth (m)	0.55	Slope	1.9 %	**Watercourse:**
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	6.330	Estimated Bankfull Discharge (m^3/s)	29.790	Fish Bearing	No	Large channel.



Aerial view

Upstream view of downstream end

Downstream view of reach end

Bathurst Project Potentially Navigable Waters   Crossing 183.6 km

the BATHURST INLET PORT AND ROAD PROJECT

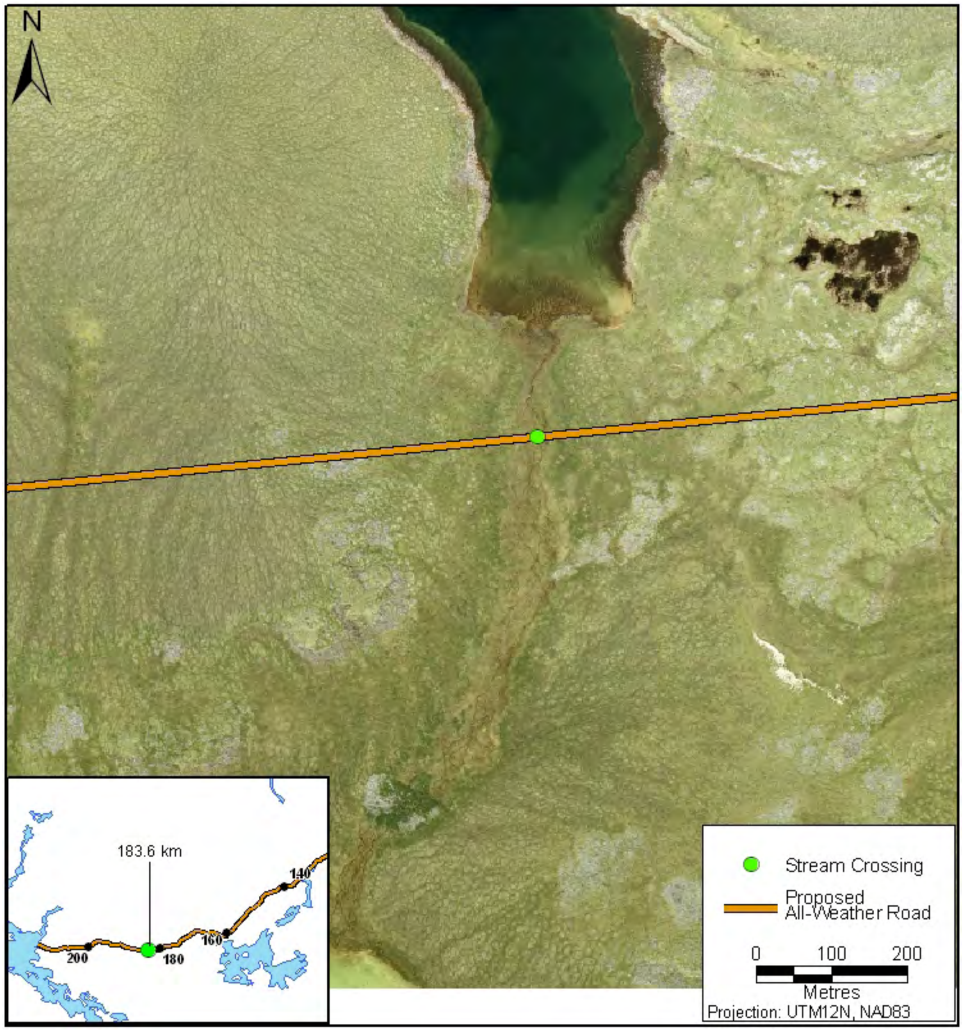
Rescan

SNC•LAVALIN Engineers & Constructors

Latitude	65° 27' 8.16" N	Wetted Width (m)	0.69	Bankfull Width (m)	3.06	Watershed Area (km^2)	4.1
Longitude	109° 33' 14.69" W	Wetted Depth (m)	0.10	Bankfull Depth (m)	0.23	Slope	0.7 %
Survey Length	167 m	Wetted Stream Discharge (m^3/s)	0.065	Estimated Bankfull Discharge (m^3/s)	0.280	Fish Bearing	Yes

Watercourse:

Multiple channels, no flow, temporary barriers between upstream and downstream lakes.



Upstream aerial view

Upstream aerial view – close-up

Aerial view – close-up

Bathurst Project Potentially Navigable Waters Crossing 192.4 km

the Bathurst Inlet Port and Road Project

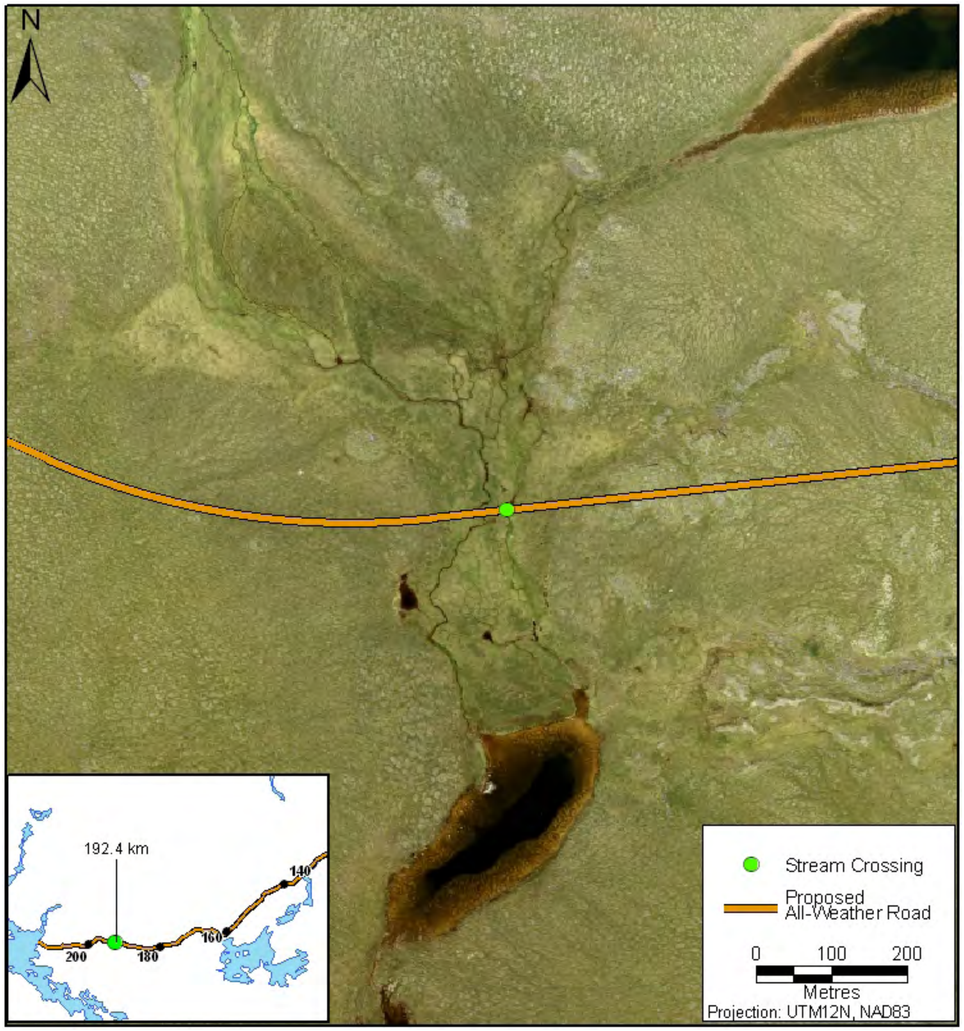
Rescan

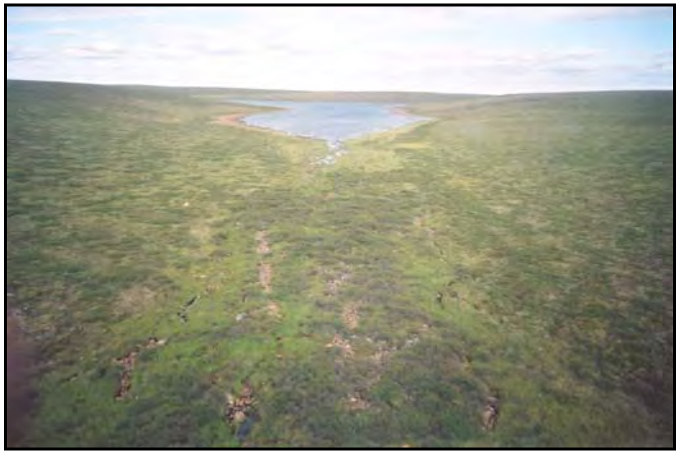
SNC•LAVALIN Engineers & Constructors

Latitude	65° 27' 57.69" N	Wetted Width (m)	3.86	Bankfull Width (m)	4.64	Watershed Area (km^2)	11.3
Longitude	109° 44' 13.48" W	Wetted Depth (m)	0.24	Bankfull Depth (m)	0.44	Slope	0.9 %
Survey Length	216 m	Wetted Stream Discharge (m^3/s)	0.450	Estimated Bankfull Discharge (m^3/s)	1.380	Fish Bearing	No

Watercourse:

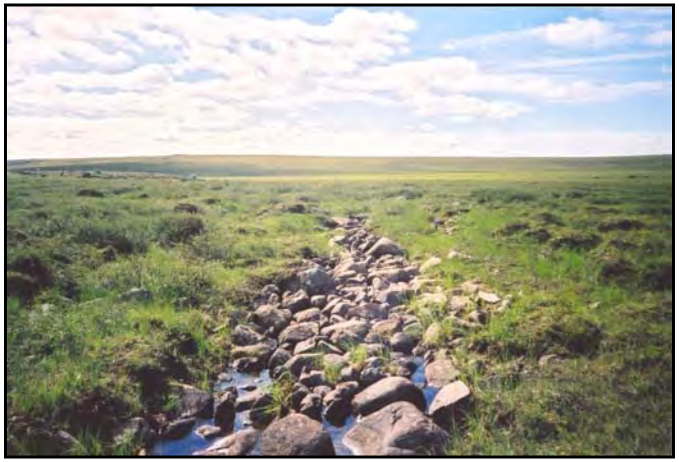
Flowing water.





Upstream aerial view of reach to lake

Last downstream glide



Downstream glide and boulder field

Bathurst Project Potentially Navigable Waters Crossing 201.9 km

the Bathurst Inlet Port and Road Project

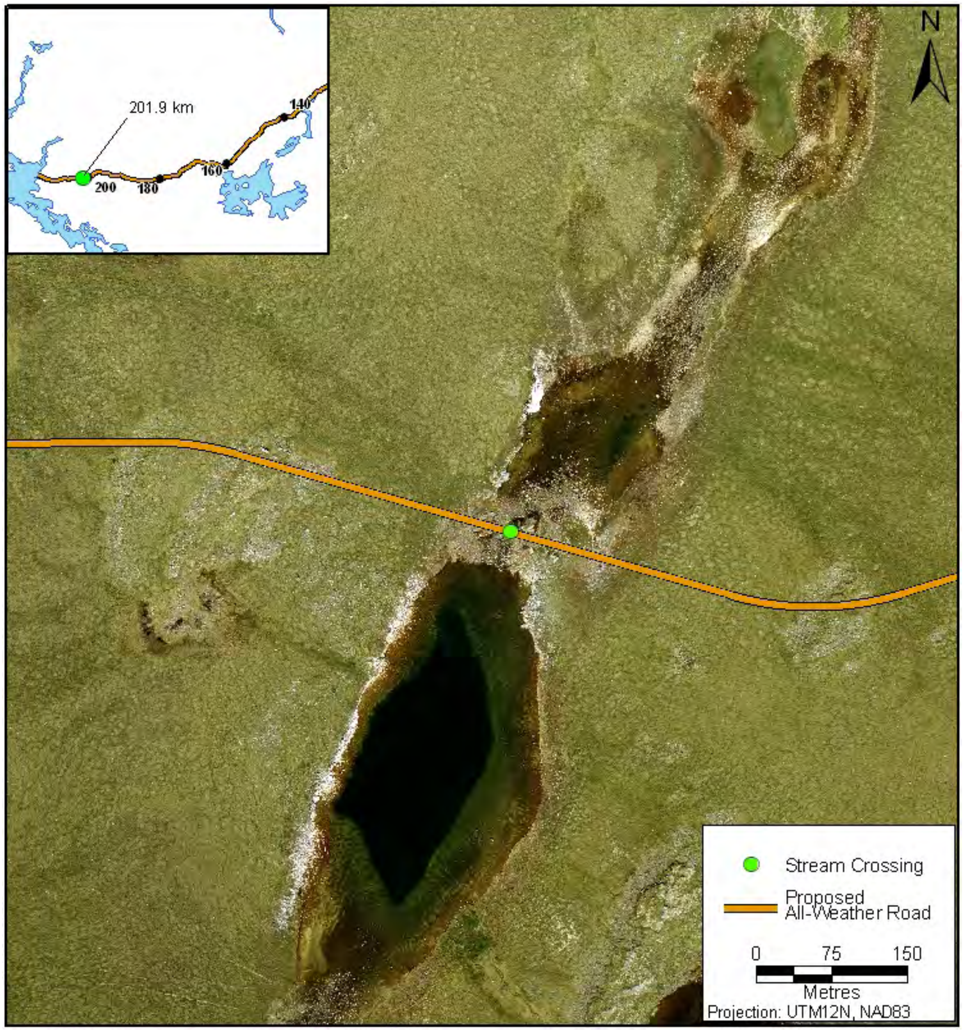
Rescan

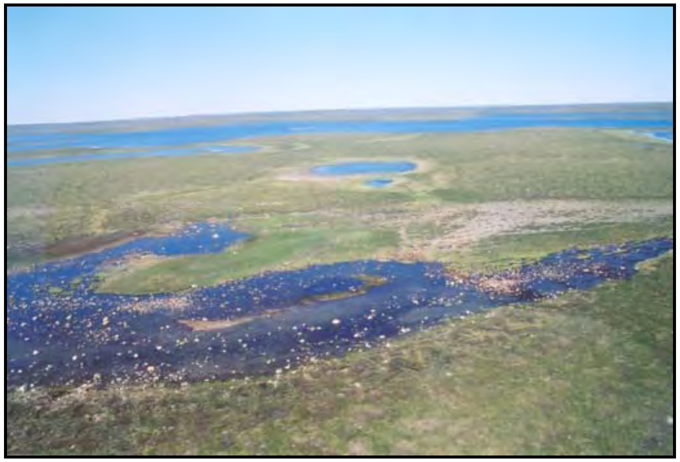
SNC·LAVALIN Engineers & Constructors

Latitude	65° 27' 38.33" N	Wetted Width (m)	57.98	Bankfull Width (m)	60.19	Watershed Area (km^2)	65.6
Longitude	109° 55' 33.73" W	Wetted Depth (m)	0.39	Bankfull Depth (m)	0.84	Slope	0.7 %
Survey Length	196 m	Wetted Stream Discharge (m^3/s)	7.088	Estimated Bankfull Discharge (m^3/s)	44.670	Fish Bearing	Yes

Watercourse:

Flowing water, lake downstream is deep.





Lateral aerial view – downstream to right

Downstream aerial view

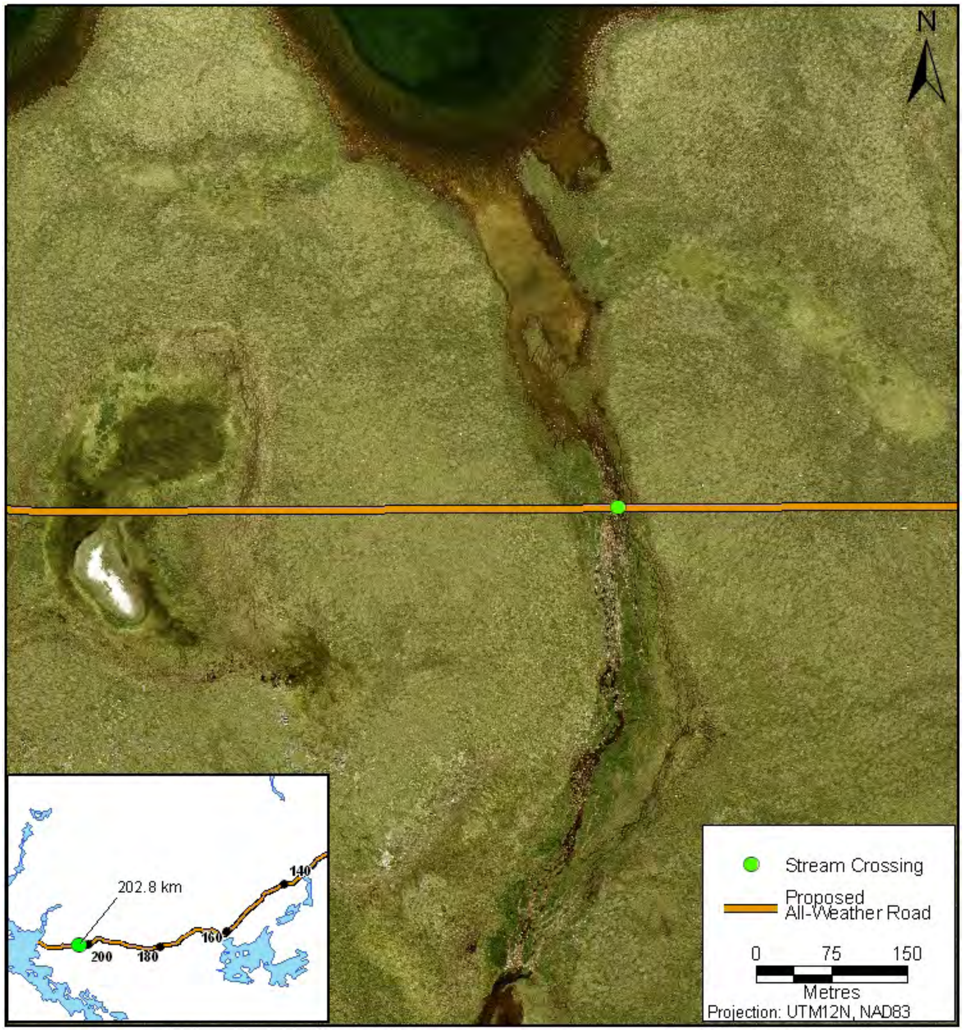
Downstream from start of reach

Bathurst Project Potentially Navigable Waters   Crossing 202.8 km

Latitude	65° 27' 41.57" N	Wetted Width (m)	26.60	Bankfull Width (m)	26.60	Watershed Area (km^2)	34.4
Longitude	109° 56' 36.86" W	Wetted Depth (m)	0.30	Bankfull Depth (m)	0.53	Slope	3.0 %
Survey Length	200 m	Wetted Stream Discharge (m^3/s)	1.370	Estimated Bankfull Discharge (m^3/s)	19.780	Fish Bearing	Yes

Watercourse:

Flowing water.



Aerial view

Upstream from start of reach

Downstream from start of reach

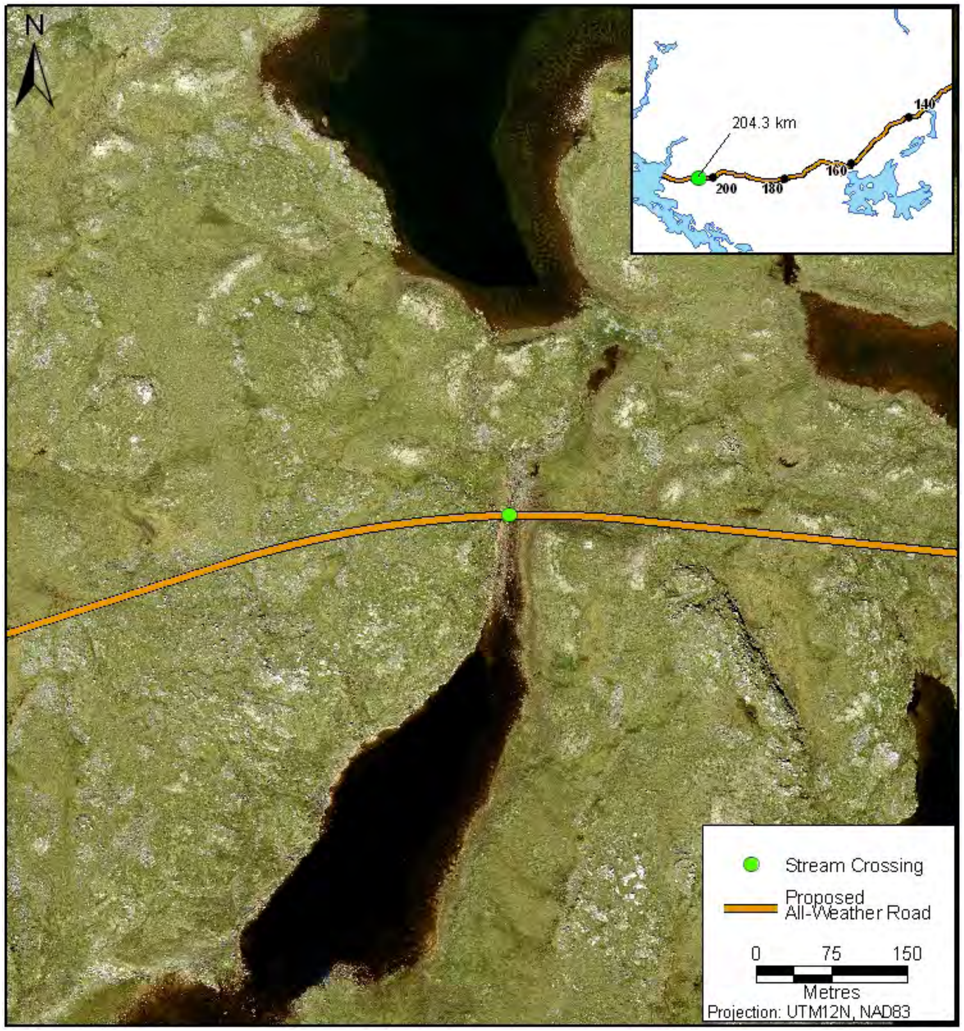
Bathurst Project Potentially Navigable Waters   Crossing 204.3 km

the Bathurst Inlet Port and Road Project | Rescan | SNC-LAVALIN Engineers & Constructors

Latitude	65° 27’ 45.18” N	Wetted Width (m)	11.60	Bankfull Width (m)	14.40	Watershed Area (km^2)	1.0
Longitude	109° 58’ 36.55” W	Wetted Depth (m)	0.42	Bankfull Depth (m)	0.84	Slope	0.5 %
Survey Length	218 m	Wetted Stream Discharge (m^3/s)	2.500	Estimated Bankfull Discharge (m^3/s)	9.420	Fish Bearing	No

Watercourse:

Lakes north and south are deep, lake downstream is disconnected.



Aerial view

Glide at end of reach

Boulder garden at reach start

Bathurst Project Potentially Navigable Waters Crossing 206.9 km

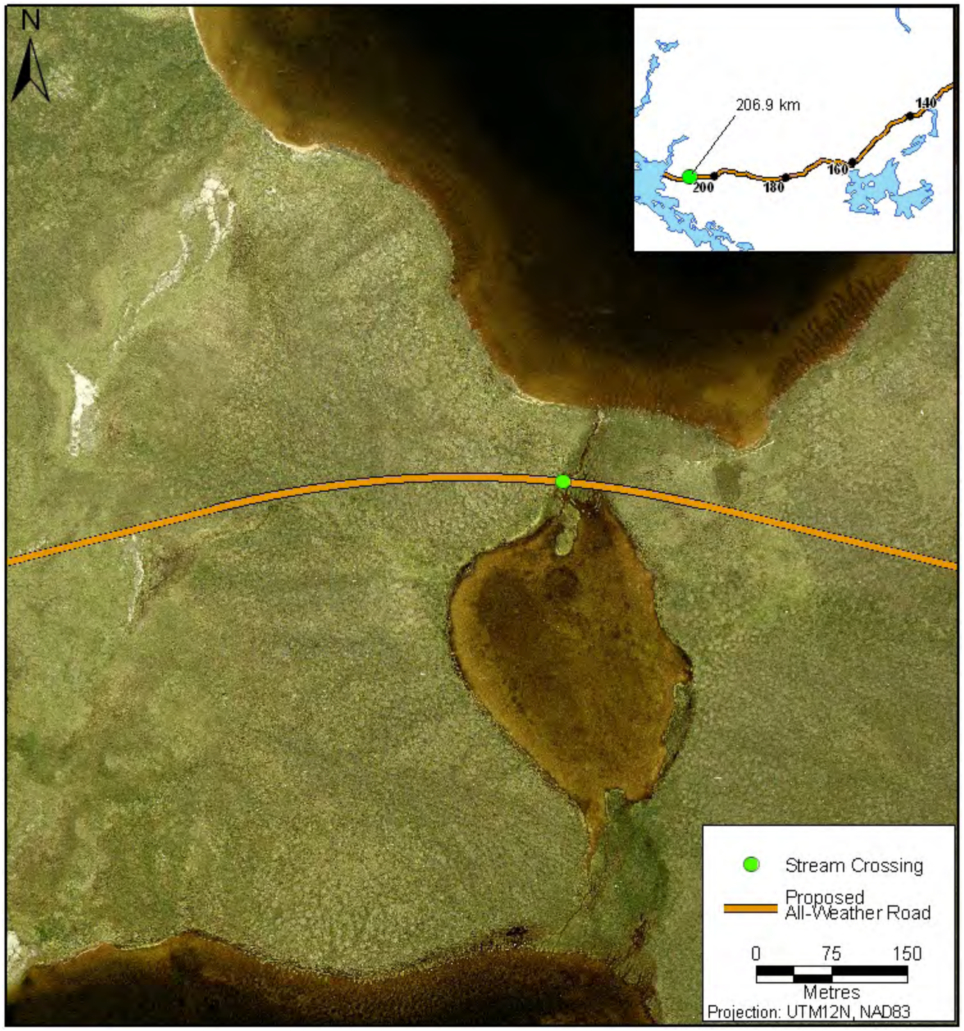
the Bathurst Inlet Port and Road Project

Rescan

SNC·LAVALIN Engineers & Constructors

Latitude	65° 27' 43.12" N	Wetted Width (m)	8.53	Bankfull Width (m)	8.68	Watershed Area (km^2)	12.4
Longitude	110° 1' 48.72" W	Wetted Depth (m)	0.36	Bankfull Depth (m)	0.45	Slope	0.5 %
Survey Length	183 m	Wetted Stream Discharge (m^3/s)	0.088	Estimated Bankfull Discharge (m^3/s)	2.010	Fish Bearing	Yes

Watercourse:
Flowing water, no barriers.



Aerial view

Middle glide

Final glide

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APPENDIX 2
NAVIGABILITY ENQUIRIES OF BATHURST INLET PORT AND ROAD PROJECT, LETTER FROM TRANSPORT CANADA, OCTOBER 26, 2007

Transport Canada / Transports Canada

Prairies and Northern Region
Région des Prairies et du Nord

Navigable Waters Protection
1100 9700 Jasper Avenue
Edmonton AB T5J 4E6

SNC-Lavalin-V
RECEIVED
NOV 02 2007

Your file Votre référence

October 26, 2007

Our file Notre référence
8200-02-6668

Bathurst Inlet Port and Road
c/o SNC Lavalin
2515 – 1075 West Georgia Street
Vancouver, B.C. 6E 3C9

Attention: Phoebe Chung

RE: Navigability Enquiries of Bathurst Inlet Port and Road Project, NWT

Reference is made to your correspondence dated July 3, 2007.

Please be advised that our office has determined that the proposed/existing works at the crossings which you had numbered sequentially 1- 38 have been deemed non-navigable except for 1, 4, 25 and 32. These 4 crossings are subject to the provisions of the Navigable Waters Protection Act (NWPA). Consequently, applications for approval are required. Please provide an Application for each of these crossings.

Transport Canada is also required to ensure that the project meets the requirements of the Canadian Environmental Assessment Act (CEAA) prior to making any decision to authorize the construction. If necessary, the environmental assessment will be conducted parallel with the navigational impact assessment, which is a prerequisite for NWPA approval. Enclosed is an Application Guide which will assist you in making an application under the Navigable Waters Protection Act.

Should you have any questions, please contact this office at (780) 495-6508.

Greg Black
NWPP Officer
Navigable Waters Protection Program