2.6 PROJECT COMPONENTS AND ACTIVITIES

The proposed Project is an all-weather highway between Inuvik and Tuktoyaktuk, NWT. This section of the EIS will discuss the Project activities and components necessary for construction and operation of the proposed Inuvik to Tuktoyaktuk Highway.

The Highway will be a public, all-weather highway under the management and operation of the Government of Northwest Territories Department of Transportation. This will allow year-round use by haul trucks and passenger vehicles according to the size and weight limitations as defined in the Northwest Territories *Public Highways Act*. The posted speed limit on the Highway will be 80 km/hr.

The Highway will be a two lane gravel roadway (8 to 9 m wide with 3:1 sideslopes) with short span single lane bridges at major stream crossings. Culverts will be used to cross most smaller streams and to accommodate seasonal overland surface flows.

The stability of permafrost and the infrastructure built on it depend on maintaining ground temperatures that can minimize the thickness of the active layer, and impede thaw. Climate change or more specifically, climate warming is changing the air/surface temperature relationship in the Mackenzie Delta and this is having a negative impact on permafrost.

A risk-based approach for incorporating climate change into design of highway infrastructure on permafrost is now recommended practice. This approach is documented in the national guidelines entitled *Development and Management of Transportation Infrastructure in Permafrost Regions* published by the Transportation Association of Canada (TAC) in May 2010. The challenge for design and construction over thaw-sensitive permafrost terrain is to balance the capital cost of constructing the Highway, against the long term maintenance implications. The design parameters and construction techniques noted above are based on experience in the area and the case studies and lessons learned as presented in the TAC guideline. These parameters and techniques take the inherent risks into account and provide mitigative approaches in the Highway design. The most significant elements of the design are the use of non-woven geotextile fabric between the existing ground surface and the placed Highway embankment material, and maintaining a minimum thickness in the material placed based on terrain type, to insulate the permafrost. In addition, pit development and best management practices for the borrow sources will also be incorporated. The elements of the risk-based approach to design and construction are described in the following sections.

2.6.1 Construction Overview

Construction will proceed in stages over a four year period, using a model similar to that for construction of the Tuktoyaktuk to Source 177 Access Road. Most construction will take place in the winter, with some activities such as grading and compaction on the new Highway, adjustment of culverts or installation of certain culverts (to protect fish habitat) occurring in the summer and fall. Summer and fall activities will only be undertaken where access is provided by the newly constructed Highway. Construction phases include:

- Mobilizing crew (surveyers and drillers) to construction staging points;
- Surveying and staking the initial several kilometres of the Highway;
- Constructing a temporary winter access road parallel to the permanent alignment;
- Placing geotextile fabric from toe to toe along the Highway alignment embankment and material being directly dumped and spread onto the geotextile;
- Placing an initial lift of approximately 300 mm to 400 mm is placed, followed by smaller lifts, with the embankment being left some 150 to 200 mm higher than design to accommodate settlements;
- Surveying the next few kilometres of route alignment; and
- Ground-truthing the original ground surveys for the design team to adjust the design to match the actual ground elevations.

These phases will be repeated each winter season until completion of the entire Highway. Further information regarding construction phasing is found in Section 2.7.1 and further discussion of the sequencing and construction approach is presented in the following sections.

2.6.2 Winter Season Construction

A fundamental tenet of the construction methodology is to complete most of the construction activities during the winter months rather than more typical summer construction, as used in southern Canada.

The advantages of winter construction are:

- Allows the use of temporary ice/winter access to borrow sources, without the need to construct all-weather access roads.
- Allows the placement of construction material directly onto frozen ground. This approach enables the establishment of a frozen core for the Highway and helps protect sensitive and ice-rich terrain.
- Minimizes potential effects on vegetation and soils from construction equipment that might occur if working under snow-free or wet conditions.
- Promotes initial Highway stability through the placement of frozen borrow material directly onto frozen ground (with geotextile separation layer). Following each year of witner construction, it is anticipated that the majority of embankment settlement will occur in the top layers of the emplaced borrow material as it thaws, dries and consolidates. Little to no thaw is expected in the lower layers of the embankment, leading to greater Highway stability and less maintenance.

- Allows for an ice crossing component of the temporary winter road near the bridge installation site. Prefabricated bridge structures will be shipped to the individual bridge sites by truck along the constructed embankment or temporary winter road. Bridges will be installed with typical construction equipment that is in general use for the Highway construction.

The disadvantages of winter construction are:

- The work is difficult, with temperatures of -35°C or colder common at the beginning of construction in late December and early January. This is challenging for both personnel and equipment.
- There is little daylight.
- The excavation of frozen material in borrow sources may require the use of drill-and-blast methods to achieve the required volumes.
- The excavation and placement of frozen material makes it more difficult to achieve the desired compaction of the embankment layers.
- The available construction season from December to the beginning of May is short.

2.6.3 Construction Activities

Construction activities will be limited, to the extent possible, to the planned footprint of the Highway, with the exception of the temporary winter road that will parallel the alignment, and the temporary winter roads providing access to borrow sources. Prior to the commencement of construction, the route will be surveyed and staked, and temporary winter roads will be constructed to select borrow sources (Photo 2.6.3-1). Initially snow cats and small dozers will be used to clear snow from the staked footprint (Photos 2.6.3-1 and 2.6.3-2). Dozers used for snow clearing will be equipped with mushroom pads to avoid or minimize effects to the vegetative layer. After the route is staked, the snow is cleared, and adequate material is stockpiled at the borrow source, the construction activities will commence. The aggregate will be placed by end-dumping directly onto the existing ground surface without removal of the vegetative ground cover.

Photo 2.6.3-1
An example of winter road access constructed parallel to the road (Tuktoyaktuk to Source 177 Access Road, 2009)

Photo 2.6.3-2
The winter construction approach; note the grader in the distance clearing snow from the embankment footprint. (Tuktoyaktuk to Source 177 Access Road, 2009)

Geotextile will be placed between the existing ground and the embankment (fill) material (Photo 2.6.3-3). This is a common design technique in permafrost regions to assist in maintaining the integrity of the permafrost terrain beneath the Highway embankment. Workers will spread out rolls of non-woven geotextile fabric onto the cleared Highway footprint ahead of the placement of embankment materials.

Photo 2.6.3-3
An example of geotextile placement and the proposed end-dumping method of construction.
(Tuktoyaktuk to Source 177 Access Road, 2009)

Material will be loaded at the borrow sources using excavators and hauled along the temporary winter roads using both tractor-trailer units and articulated trucks. Material will be placed by end dump and spread with D6 and/or D7 Cats. An initial lift of approximately 300 mm to 400 mm is placed, followed by smaller lifts, with the embankment being left some 150 to 200 mm higher than design to accommodate settlements.

Culvert and bridge installation will proceed concurrently with the construction of the embankment. Since the bridge structures will be prefabricated single-span bridges, on binwall abutments, it is anticipated that access to bridge sites in advance of the embankment construction will not be necessary even if piling is required to supplement the binwall abutment foundations. Design, ordering and fabrication of bridges will need to be undertaken months in advance of the scheduled installation to ensure that shipping schedules are achieved, and that structures and binwall materials arrive on site in time for installation.

Access to both sides of the stream crossings will be required for binwall assembly prior to installation of the bridge structures. This will be accommodated with an ice crossing. Prefabricated bridge structures will be shipped to the individual bridge sites by truck along the constructed embankment or temporary winter road. Bridges will be installed with typical construction equipment that is in general use for the Highway construction.

Highway construction and drainage structure installation will be carried out each year in a similar manner. Final embankment compaction, adjustment of grade due to settlements and placement of surfacing gravel will be undertaken in the following summer.

Temporary winter roads that parallel the Highway or are used to access borrow sources will naturally decommission during the summer months, when the ice and snow melt.

2.6.4 Design Embankment

The embankment is the main component of the Highway to be constructed. Figure 2.6.5-1 shows a typical cross section of the Highway. Although the original work by PWC considered a balance of cuts and fills in the Highway design and construction (PWC 1981a), the Developer recognizes that, for this type of terrain, sufficient volumes of suitable material are not available. In addition, traditional cut-and-fill methods could result in future stability concerns for both the Highway and the cut slopes.

Using a method similar to that chosen for the access road recently constructed from Tuktoyaktuk to Source 177, the approach for the Highway will focus on using fills to build the Highway on existing ground.

When the Highway traverses drier, ice-poor upland terrain, then the minimum embankment height of 1.4 m will provide sufficient structural strength to carry the anticipated traffic loading. Increased embankment heights will be required through low lying, wet areas and areas of ice-rich polygonal patterned ground (Photo 2.6.4-1) that cannot be avoided and would most likely be in the 1.8 m to 2.0 m range. Table 2.6.4-1 summarizes the design parameters for fill embankment thickness.

Photo 2.6.4-1
Ice-rich polygonal patterned ground along the Primary 2009 Route

Some sensitive, slide prone locations were identified during the September 2009 field work along the alignments considered. The slides identified were described as retrogressive thaw flow slides. These occur in regions of high ice content soil, particularly where the active layer is thickening and slopes are over steepened. In this region the over-steepened slopes develop around expanding thermokarst lakes, along hummocky terrain and along stream channels and terraces (Photo 2.6.4-2).

Photo 2.6.4-2
Thermokarst lakes and hummocky terrain along the Primary 2009 Route

Table 2.6.4-1 provides the design parameters for embankment fill thickness by terrain type for the alignments considered.

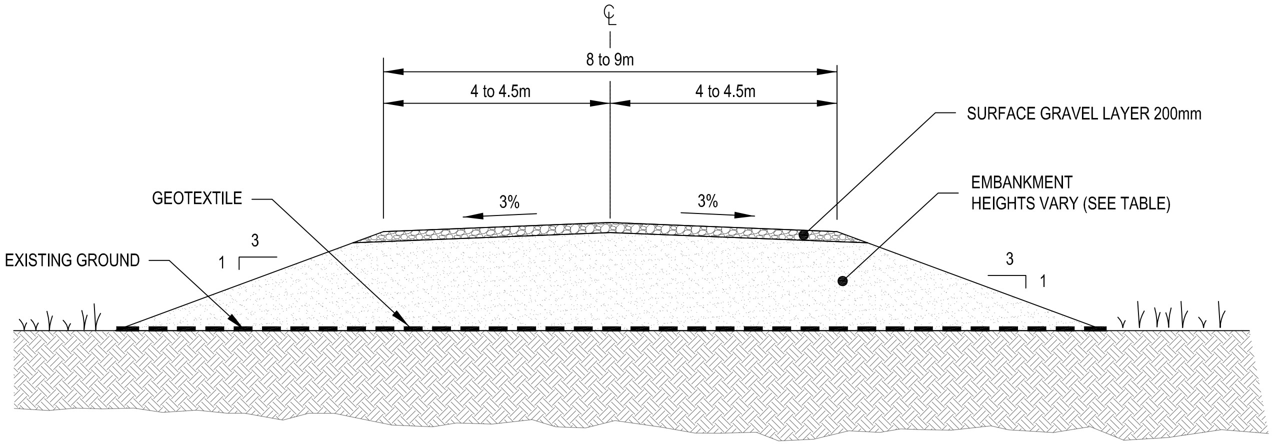
TABLE 2.6.4-1: DESIGN PARAMETERS FOR EMBANKMENT FILL THICKNESS

Terrain Type	Terrain Description	Embankment Fill Thickness
1	Dry (Ice-poor) Till & Outwash Deposits (relatively dry, stable, upland till and outwash deposits, overlain by a thin organic cover)	1.4 m
2	Wet (Ice-medium to Ice-rich) Till & Outwash Deposits (relatively wet, with some expression of ice-rich permafrost conditions, overlain by a thin to moderate organic cover)	1.4 m - 1.6 m
3	Wet Silts & Clays (Ice-rich) (lacustrine, silt and clay, deposits with distinct expressions of ice-rich permafrost conditions, moderate organic cover)	1.6 m - 1.8 m
4	Thick Organic Peatlands & Ice-Rich Permafrost	1.8 m

2.6.5 Geometric Design

The desired and minimum geometric design parameters for this Highway have been developed based on appropriate guidelines for public highways in the Northwest Territories. These parameters are presented in Table 2.6.5-1 and Figure 2.6.5-1 illustrates the design parameters in a typical highway cross section. The figure also shows the geotextile fabric to be installed between the existing ground and the Highway embankment. This is a feature that will be included along the entire alignment.

TABLE 2.6.5-1: GEOMETRIC DESIGN PARAMETERS FOR THE INUVIK TO TUKTOYAKTUK HIGHWAY	
Design Parameters	
Desired Design Speed	90 km/hr
Minimum Design Speed	80 km/hr
Horizontal Alignment	
Desired Curve Radius	440 m
Minimum Curve Radius	250 m
Desired Sight Distance	500 m
Minimum Sight Distance	180 m
Length of Spiral	160 m
Vertical Alignment	
Minimum Passing Sight Distance	605 m
Minimum Stopping Sight Distance	150 m
Minimum Sag K Value	40
Minimum Crest K Value	50
Minimum Distance between PVI	90 m
Desired Maximum Slope	3%
Maximum Slope Full Speed	6%
Cross-Section	
Desired Finish Top Shoulder Rounding to Shoulder Rounding	9 m
Minimum Finish Top Shoulder Rounding to Shoulder Rounding	7 m
Lane Cross Fall	3%
Superelevation	6%
Side Slopes - All Sections	3:1
Embankment Height	
Dry (ice poor) Till and Outwash Deposits	1.4 m
Wet (ice medium to ice rich) Till and Outwash Deposits	1.4 m to 1.6 m
Wet Silts and Clays (ice rich)	1.6 m to 1.8 m
Thick Organic Peatlands and Ice Rich Permafrost	1.8 m
Thickness of Surfacing Gravel	200 mm



TYPICAL HIGHWAY CROSS SECTION

TERRAIN TYPE	DESCRIPTION	EMBANKMENT HEIGHTS
1	DRY (ICE POOR) TILL AND OUTWASH DEPOSITS	1.4 m
2	WET (ICE-MEDIUM TO ICE-RICH) TILL AND OUTWASH DEPOSITS	1.4 to 1.6 m
3	WET SILTS AND CLAYS (ICE-RICH)	1.6 to 1.8 m
4	THICK ORGANIC PEATLANDS AND ICE-RICH PERMAFROST	1.8 m

LEGEND

PROPOSED INUVIK - TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

TYPICAL HIGHWAY CROSS SECTION

PROJECTION

DATUM

Scale 1:150

1 0 1 3m

Town of Inuvik

Northwest Territories

KIGGIAK - EBA

FILE NO.
V23201322 TYPICAL SECTIONS.dwg

PROJECT NO.	DWN	CKD	REV
V23201322	SM	RM	0

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DATE
March 16, 2011

Figure 2.6.5-1

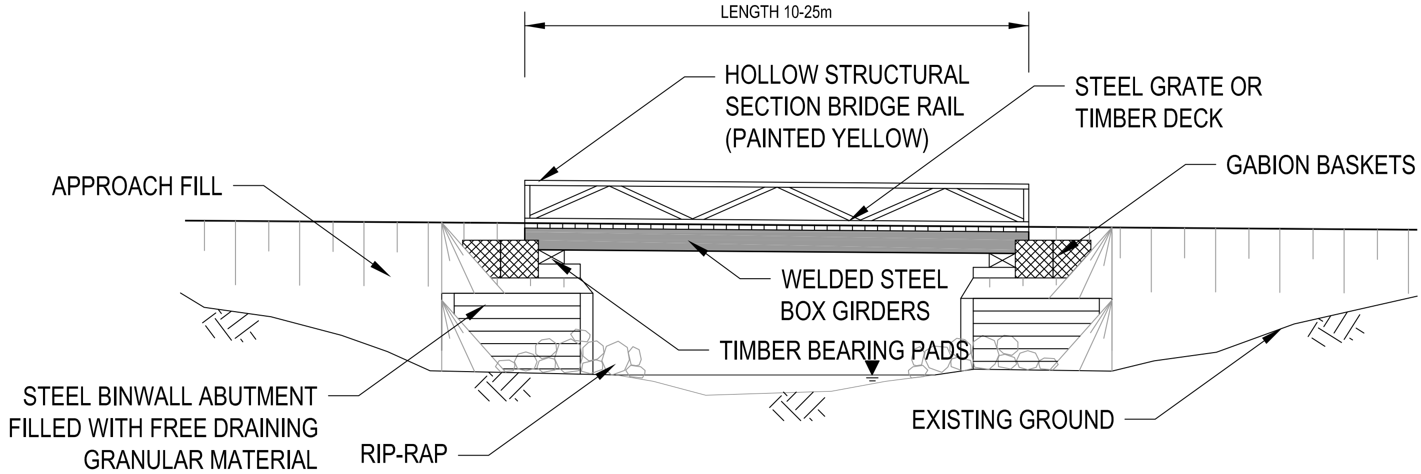
2.6.6 Stream Crossing Design Considerations

The drainage paths crossed by the Primary 2009 Route are typically minor, diffuse and/or ephemeral (seasonally dry). Defined but still minor stream crossings that do not comprise fish habitat will be accommodated using appropriately sized culverts. The major fish-bearing streams will be crossed using, simple prefabricated bridges.

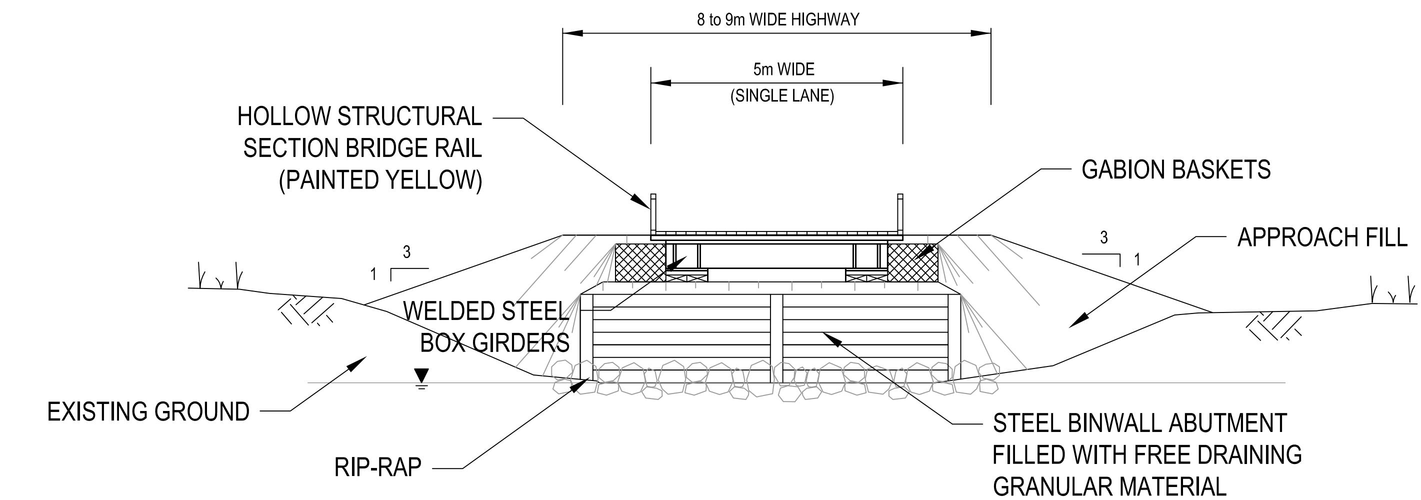
The concept for culvert installation is similar to that currently used on the Tuktoyaktuk to Source 177 Access Road. Culverts of appropriate size (typically 800 mm -900 mm) are laid in place with limited disturbance to the existing ground, at locations where drainage paths have been identified in the detailed design. Fill material is then placed around and over the culverts. In some cases, multiple smaller diameter culverts may be used instead of single large diameter culverts to avoid having to cut into the existing ground to maintain the vertical grade or creating a crest curve in the roadway where the embankment is constructed over the culvert. In addition, based on experience gained with construction of the Tuktoyaktuk to Source 177 access road, certain culverts (to protect fish habitat) may be installed during the summer season. Appropriate culvert sizing and location will be confirmed in the detailed design stages of the work.

The concept for the bridges, ranging from 10 to 25 m in length, is illustrated in Figure 2.6.6-1 and Photo 2.6.6-1.

Photo 2.6.6-1
Single span, prefabricated bridge on gravel filled binwall abutments



BRIDGE ELEVATION



ABUTMENT ELEVATION

LEGEND

PROPOSED INUVIK - TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

GENERAL ARRANGEMENT
PRE-FABRICATED STEEL BOX GIRDER BRIDGE

PROJECTION	DATUM

Scale: NTS

FILE NO.
V23201322 TYPICAL SECTIONS.dwg

PROJECT NO.	DWN	CKD	REV
V23201322	SM	RM	0

OFFICE	DATE
EBA-VANC	March 16, 2011

Town of Inuvik

Northwest Territories

KIGGIAK - EBA

Figure 2.6.6-1

Q:\Vancouver\Drafting\Environmental\V232\V23201098\Conceptual Design\Typical Sections\Environmental Impact Statement\V23201322 TYPICAL SECTIONS.dwg [FIGURE 2.6.6-1] March 16, 2011 - 10:15am adeepwell

Such bridges are used extensively throughout the Northwest Territories and Nunavut for both permanent and temporary installation. Each single lane bridge is approximately 5-6 m wide, made of prefabricated welded steel box girder with timber or steel grade deck. The prefabricated bridges will be:

- Placed on timber bearing pads on gravel filled corrugated steel binwall abutments (with addition of piling to supplement the foundation if required by the soil conditions);
- Shipped by road to Inuvik or by barge to Inuvik or Tuktoyaktuk then transported by truck or even dragged (on skids) to site; and
- Installed using typical construction equipment and local labour.

The bridges will be designed to span stream widths, but for some crossings may encroach on the floodplain (to minimize length) with approach fill construction.

Section 4.2.5 of this Environmental Impact Statement discusses the fish and fish habitat issues that have and will continue to be considered to ensure that the appropriate stream crossing structures are selected for each of the streams to be crossed by the Highway. Section 4.2.4 discusses potential erosion and sediment effects and the proposed mitigation measures.

To minimize risk of travel over single lane bridges, site selection and approach grades will be managed to assure appropriate site distance requirements.

2.6.7 Drainage and Thermal Erosion Considerations

Design parameters for the Highway were developed based on the operational needs of the Highway and the need to protect the permafrost layer below the Highway surface. In southern areas of the Northwest Territories it is common for road designs to incorporate both 'cuts and fills' to level terrain along the road alignment. However, in permafrost areas, cutting into the surface vegetation can disturb the permafrost regime, resulting in thaw and unstable ground. Therefore, the design includes only fills with heights based on terrain type. This will be sufficient to protect the permafrost layer below the Highway surface.

As stated previously, the embankment design also mitigates several potential effects related to permafrost, terrain and drainage. A minimum embankment (or fill) height of 1.4 m will be required to construct the Highway using ice-poor granular materials. Granular materials which are low in fine particles, less than 0.02 mm, will be used to reduce the potential for frost heave or seasonal thaw settlement.

The Highway will be constructed with sufficient cross drainage to prevent or minimize potential water ponding. Ponding conditions, if unmitigated, could lead to permafrost thaw which could cause ground disturbance, changes to existing drainage conditions and slope instability.

2.6.8 Borrow Sources

2.6.8.1 General Information on Borrow Sources in the Area

The early work in the investigation and evaluation of granular material resources in the Mackenzie Delta Region was carried out by Roger Brown and Hank Johnston of the National Research Council (NRC) during the planning, development and construction of the new town of Inuvik and its related infrastructure in the 1950s (Fujino 1993). The following description draws heavily upon the work reported by Fujino (1993).

Beginning in the 1960s, generic sources of granular materials were identified in the Mackenzie Delta Region as part of the surficial geology and terrain mapping activities by the Geological Survey of Canada (GSC). This mapping work served as a foundation for future studies and investigations for granular materials conducted by industry and government agencies. The most recent surficial geology mapping of the Project study area, and the one used to perform this work, was prepared by Rampton (1987).

In the 1970s and early 1980s, numerous, extensive granular material investigations were undertaken by private industry resource development groups and government agencies, primarily under the direction of the Department of Indian and Northern Affairs. Many industry groups had significant interests in the development of energy resources in the Mackenzie Delta Region with parallel demands for granular materials.

Granular material investigations carried out by Ripley Klohn Leonoff International Ltd. (RKL) in 1972-73 for Indian and Northern Affairs Canada (INAC) has served as a comprehensive data base for more recent granular material investigations by numerous groups (RKL 1972a, 1972b). Subsequent investigations by EBA Engineering Consultants Ltd. (EBA) (1976, 1983a, 1983b), Hardy Associates (1978) Ltd.(1979, 1980), Terrain Analysis and Mapping Services Ltd. (1975), Northern Engineering Services Company Ltd.(1974, 1977), Public Works Canada (1975, 1976, 1977, 1981a, 1981b, 1982a, 1982b), and Hardy BBT (1986, 1987a, 1987b, 1988a, 1988b, 1988c, 1989a,1989b, 1990a, 1990b, 1990c) have provided further ground-truthing and confirmation of selected granular material sources and quarry sites in the Mackenzie Delta Region.

During the 1980s and early 1990s, the focus of the various studies and investigations of granular materials was directed to issues dealing with Aboriginal land claims. In this regard, the work in the Mackenzie Delta Region was primarily directed to the *Inuvialuit Final Agreement* (IFA) (IRC 1987). The granular materials inventory work completed by EBA (1987a, 1987b) in 1987 for INAC formed part of the IFA. The comprehensive granular materials inventory was assembled for resources within the Inuvialuit Settlement Region (ISR) using the available information collected over the years.

Under the *IFA*, signed between the Government of Canada and the Inuvialuit in 1984, ownership of most of the accessible granular deposits in the Western Arctic Region was transferred to the Inuvialuit (IRC 1987). Management of this resource is now the responsibility of the ILA in consultation with local groups such as the Community Corporations and Hunters and Trappers Committees. Several studies of granular resources in the Inuvialuit Settlement Region have been conducted over the years to refine the database/inventory of the resource.

The comprehensive inventory of granular materials for the Inuvialuit Settlement Region (ISR) was provided to the Developer by the ILA. The inventory includes granular resources in the settlement region including areas outside of the Project area and the Mackenzie Delta Region. The material sources within proximity to the Project area are summarized in figures and tables herein and form the basis of the borrow areas identified for construction of the proposed Highway.

2.6.8.2 Available Information on Borrow Sources in the Area

Figure 2.6.8-1 shows all known borrow sources in the general area between Inuvik and Tuktoyaktuk based on information from the ILA, INAC, Geological Survey of Canada, and Public Works Canada.

The borrow sources shown on Figure 2.6.8-1 along the Primary 2009 Route could be selected as potential borrow areas for constructing the Highway along the current preferred alignment. These borrow sources were previously assessed by PWC (1981a; 1981b) and were deemed to be suitable and available. The materials identified for embankment construction were judged to be of generally fair to poor quality. Most of the materials contain high ice content that might be above the liquid limit of the soil, and could require select harvesting to obtain the best available material for use in construction. Thirty years later, these sources have not been further investigated. Except for a few sources in close proximity to Husky Lakes (which are not available for use), the borrow sources identified by PWC are assumed to still be acceptable.

The 2009 field program did not include further examination of the proposed borrow source areas that PWC had identified, but fly-overs were completed to confirm that the areas appeared to be viable borrow sources.

Table 2.6.8-1 summarizes available information on borrow sources along the Primary 2009 Route. Materials at prospective borrow sources have been graded into one of the five following classes:

- Class 1 – Excellent quality material consisting of clean, well-graded, structurally-sound sands and gravels suitable for use as high quality surfacing materials.
- Class 2 – Good quality material generally consisting of well-graded sands and gravels with limited quantities of silt. This material will provide good quality base and surface course aggregates or structure-supporting fill.
- Class 3 – Fair quality material consisting generally of poorly-graded sands and gravels with or without substantial silt content. This material will provide fair quality general fill for roads, foundation pads or laydown yards.

- Class 4 – Poor quality material generally consisting of silty, poorly-graded, fie-grained sand with minor gravel. These deposits may also contain weak particles and deleterious materials. These materials are considered suitable for marginal general (non-structural) fill.
- Class 5 – Bedrock of fair to good quality, felsenmeer or talus. Potentially excellent sources of construction material, ranging from general fill to concrete aggregate or building stone if quarried and processed. Also includes erosion control materials such as rip-rap or amour stone.

The calculated volumes of the various types of granular materials available at the examined sources have been divided into proven, probably and prospective certainty levels, as described below.

A 'proven' volume is one whose occurrence, distribution, thickness and quality is supported by ground truth information such as geotechnical drilling, test pitting and/or exposed stratigraphic sections. Usually the thickness of material encountered in a borehole is extrapolated to a radius not exceeding 50 m around the hole.

A 'probable' volume is one whose existence and extent is inferred on the basis of direct and indirect evidence, including topography, landform characteristics, airphoto interpretation, extrapolation of stratigraphy, geophysical data and/or limited sampling.

A 'prospective' volume is one whose existence is suspected on the basis of limited direct evidence, such as airphoto interpretation and/or general geological considerations.

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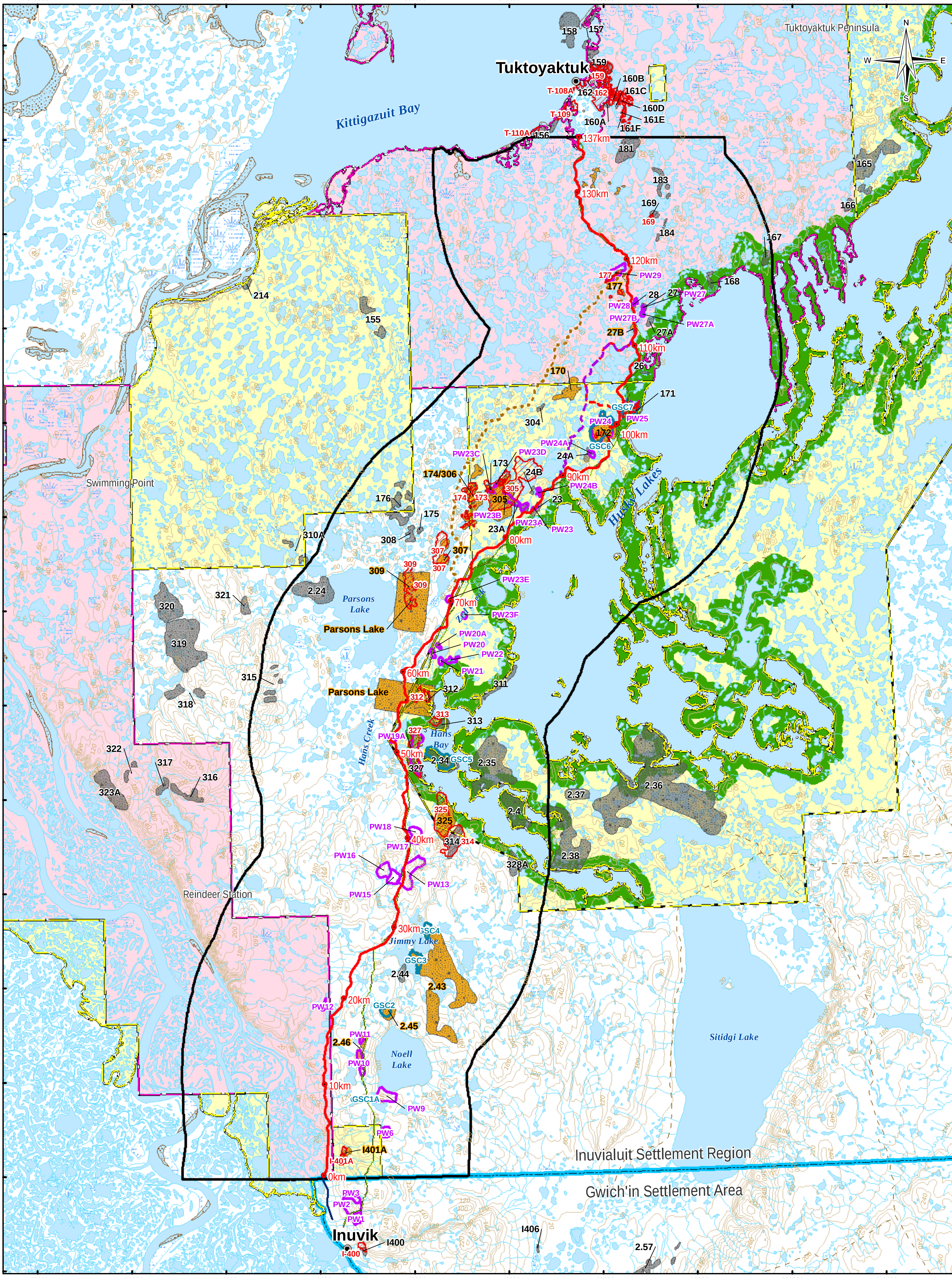

LEGEND

- Regional Study Area (15 km buffer)
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road
- Inuvialuit 7(1)(a) Lands
- Inuvialuit 7(1)(b) Lands
- Gwich'in / Inuvialuit Boundary
- Husky Lakes 1000m Setback
- INAC Borrow Sources
- Geological Survey Borrow Sources
- Public Works Borrow Sources
- Potential Highway Borrow Sources
- Borrow Sources
- Trail
- Contour
- Watercourse
- Waterbody
- Wetland
- Sand

NOTES
Base data source: NTS 1:250,000
Borrow Sources: ILA, Public Works, GSC, INAC

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

Available and Potential Borrow Sources Along the Proposed Route

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:400,000
5 2.5 0 5 10
Kilometres

FILE NO.
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PROJECT NO.	DWN	CKD	REV
V23201322	SL	TS	0

OFFICE	DATE
EBA-VANC	May 19, 2011

Town of Inuvik
Northwest Territories
KIGGIAK - EBA

Figure 2.6.8-1

TABLE 2.6.8-1: INFORMATION ON BORROW SOURCES ALONG THE PRIMARY 2009 ROUTE									
Source Name	**Land Owner**	**Location**	**Geo-morphologic Setting**	**Landform**	**Approx. Area (km²)**	**Recoverable Volume (m³)[1]**	**Quality/ Volume[2] (Proven)**	**Quality/ Volume[2] (Probable)**	**Quality/ Volume[2] (Prospective)**
2.43	Crown	28 km NE of Inuvik	Unknown	Outwash plain	12	180,000,000	Class 3 – 900,000 Class 4 – 900,000	Class 3 – 9,000,000 Class 4 – 9,000,000	Class 3 – 90,000,000 Class 4 – 90,000,000
2.44	Crown	30 km NE of Inuvik	Unknown	Glaciofluvial outwash	0.17	0	Class 3 – 25,000	Class 3 – 250,000	Class 3 – 1,000,000
2.45	Crown	25 km NE of Inuvik	Unknown	Glaciofluvial outwash	2	0	Class 2 – 800,000	Class 2 – 8,000,000	Class 2 – 25,000,000
2.46	Crown	20 km NE if Inuvik	Unknown	Kames/ crevasse filling	0.0125	0	Class 3 – 5,000 Class 4 – 5,000	Class 3 – 10,000 Class 4 – 10,000	Class 3 – 12,500 Class 4 – 12,500
I401A	Crown	10 km N of Inuvik	Hillblocks bisected by streams	Kame field	1.1	1,020,000	Class 4 – 20,000	Class 4 – 250,000	Class 4 – 750,000
170	Inuvialuit	32 km S of Tuktoyaktuk	Hummocky, thermokarst	Glaciofluvial outwash plain	2	4,580,000	NA	Class 3 – 4,560,000	NA
171	Inuvialuit	35 km S of Tuktoyaktuk	Hummocky, near Husky Lake	Glaciofluvial outwash/ kames	2	1,520,000	NA	Class 2 – 1,520,000	NA
172	Inuvialuit	37 km S of Tuktoyaktuk	Hummocky, near Husky Lake	Glaciofluvial outwash/ kames	2	918,000	NA	Class 4 – 912,000	NA
173	Inuvialuit	45 km S of Tuktoyaktuk	Hummocky plain	Kame complex	2	688,000	NA	Class 1 – 684,000	NA
174	Inuvialuit	48 km S of Tuktoyaktuk	Hummocky, rough terrain	Kame complex/ outwash	2	3,280,000	NA	Class 2 – 3,268,000	NA
175	Inuvialuit	50 km SW of Tuktoyaktuk	Hummocky, rolling terrain	Glaciofluvial outwash	1	1,530,000	NA	Class 2-3 – 1,500,000[3]	NA
176	Inuvialuit	50 km SW of Tuktoyaktuk	Thermokarst plain	Glaciofluvial outwash plain	2	6,100,000	NA	Class 1 – 1,525,000	Class 1 – 3,050,000
177	Inuvialuit	22 km S of	Hummocky	Glaciofluvial	1	1,902,000	NA	Class 2 – 19,000,000	NA

TABLE 2.6.8-1: INFORMATION ON BORROW SOURCES ALONG THE PRIMARY 2009 ROUTE									
Source Name	**Land Owner**	**Location**	**Geo-morphologic Setting**	**Landform**	**Approx. Area (km²)**	**Recoverable Volume (m³)[1]**	**Quality/ Volume[2] (Proven)**	**Quality/ Volume[2] (Probable)**	**Quality/ Volume[2] (Prospective)**
		Tuktoyaktuk	thermokarst plain	outwash					
23	Inuvialuit	42 km S of Tuktoyaktuk	Hummocky plain	Kames, outwash plain	0.115	350,000	NA	350,000[4]	350,000[4]
23A	Inuvialuit	42 km S of Tuktoyaktuk	Hummocky plain	Kame field	1.2	1,900,000	NA	1,900,000[4]	1,900,000[4]
24A	Inuvialuit	37 km S of Tuktoyaktuk	Hummocky plain	Kames, outwash plain	0.72	150,000	NA	Class 2 – 134,000	NA
27	Inuvialuit	42 km S of Tuktoyaktuk	Flat plain, polygonal	Glaciofluvial outwash	0.225	40,000	NA	Class 2 – 34,000	NA
27A	Inuvialuit	24 km S of Tuktoyaktuk	Flat plain, polygonal	Glaciofluvial outwash	0.18	190,000	NA	Class 2 – 191,000	NA
27B	Inuvialuit	24 km S of Tuktoyaktuk	Flat plain, polygonal	Glaciofluvial outwash	0.23	40,000	NA	Class 2 – 38,000	NA
304	Crown	35 km S of Tuktoyaktuk	Thermokarst plain	Esker remnants	0.018	46,000	NA	Class 3 – 45,600	Class 3 – 45,600
305	Inuvialuit	42 km S of Tuktoyaktuk	Hummocky with many ponds	Kames on outwash plain	20	230,000	NA	Class 2 – 228,000	Class 2 – 228,000
306	Inuvialuit	42 km S of Tuktoyaktuk	Thermokarst plain	Kame field	11.5	115,000	NA	NA	NA
307	Crown	55 km S of Tuktoyaktuk	Hillocks, small ponds	Kame field	5	115,000	Class 3 – 30,000	Class 3 – 300,000	Class 3 – 650,000
308	Crown	50 km S of Tuktoyaktuk	Outwash plain	Terrace remnants and kames	0.55	15,000	Class 3 – 5,000	Class 3 – 300,000	Class 3 – 1,500,000
309	Crown	56 km S of Tuktoyaktuk	Ponds, low lying	Kame field	7.5	1,500,000	Class 2 – 350,000	Class 2 – 1,000,000	Class 2 – 4,000,000
314	Inuvialuit	79 km S of Tuktoyaktuk	Terrace adjacent to stream	Post-glacial fluvial terraces	1.1	2,300,000	Class 3 – 30,000	Class 3 – 3,000,000	Class 3 – 30,000,000

TABLE 2.6.8-1: INFORMATION ON BORROW SOURCES ALONG THE PRIMARY 2009 ROUTE									
Source Name	**Land Owner**	**Location**	**Geo-morphologic Setting**	**Landform**	**Approx. Area (km^2)**	**Recoverable Volume (m^3)[1]**	**Quality/ Volume[2] (Proven)**	**Quality/ Volume[2] (Probable)**	**Quality/ Volume[2] (Prospective)**
325	Inuvialuit	76 km S of Tuktoyaktuk	Lake shore deposit	Glaciofluvial terrace	7.5	750,000	Class 3 – 600,000	Class 3 – 6,000,000	Class 3 – 25,000,000
Parsons Lake 1	Inuvialuit	60 km S of Tuktoyaktuk	Riverbanks	River terrace	0.25	1,000,000	NA	NA	NA
Parsons Lake 10	Inuvialuit	60 km S of Tuktoyaktuk	Low lying plain	Kame/outwash plain	0.02	135,000	NA	NA	NA
Parsons Lake 2	Inuvialuit	60 km S of Tuktoyaktuk	Low terrace	River terrace	0.1	230,000	NA	NA	NA
Parsons Lake 3	Inuvialuit	60 km S of Tuktoyaktuk	Low lying terrace	River terrace	0.2	400,000	NA	NA	NA
Parsons Lake 4	Inuvialuit	60 km S of Tuktoyaktuk	Flat lying terrace	River terrace	0.05	150,000	NA	NA	NA
Parsons Lake 5	Inuvialuit	60 km from Tuktoyaktuk	Lake shoreline	Small kame	0.0225	30,000	NA	NA	NA
Parsons Lake 6	Inuvialuit	60 km S of Tuktoyaktuk	Lake shoreline	Small kame	0.03	7,500	NA	NA	NA
Parsons Lake 7	Inuvialuit	60 km S of Tuktoyaktuk	Flat lying terrace	River terrace	0.28	20,000	NA	NA	NA
Parsons Lake 8	Inuvialuit	60 km S of Tuktoyaktuk	Flat-lying terrace	River terrace	0.7	75,000	NA	NA	NA
Parsons Lake 9	Inuvialuit	60 km S of Tuktoyaktuk	High river terrace	River terrace	0.045	38,000	NA	NA	NA

Notes:
1 – ILA Inventory
2 – Hardy BBT Ltd. 1991; EBA 1987
3 – Not stated if proven, probable or prospective.
4 – No quality rating provided.

2.6.8.3 Borrow Material Requirements

These preliminary material volume estimates are based on preliminary horizontal and vertical geometric designs using the embankment cross section presented in Figure 2.6.5-1.

Figure 2.6.8-1 shows all known potential borrow sources in the general area between Inuvik and Tuktoyaktuk. Many sources that are not near the preferred alignment will not be considered for use in the construction as they are inefficient to haul from due to the distance that they are away from the alignment. Borrow sources proposed for construction of the Highway are highlighted in Figure 2.6.8-2 and estimated quantities from each source based on the conceptual design are presented in Table 2.6.8-2. It is important to note that all borrow source development would respect the 1 km Husky Lakes setback.

TABLE 2.6.8-2: ESTIMATED QUANTITIES FROM POTENTIAL BORROW SOURCES

Highway Segment	Potential Borrow Source	Estimated Borrow Quantity[1]	Land Owner	Quality
KM 0 - KM 5	I401A	198,000	Crown	Class 4
KM 5 - KM 10	2.46	198,000	Crown	Class 3, 4
KM 10 – KM 21	2.45	351,000	Crown	Class 2
KM 21 - KM 34	2.43	351,000	Crown	Class 3, 4
KM 34 - KM 45	325 (outside of Husky Lakes setback)	329,000	Crown	Class 3
KM 45 - KM 56	Parsons Lake – (west of alignment only)	445,000	Crown	NA
KM 56 - KM 69	309	671,000	Crown	Class 2
KM 69 - KM 83	307	516,000	Crown	Class 3
KM 83 - KM 100	173/305, 174/306	563,000	Inuvialuit	Class 1, 2
KM 100 - KM 112	172, 170	363,000	Inuvialuit	Class 3, 4
KM 112 - KM 118	27B	244,000	Inuvialuit	Class 2
KM 118 – KM 137 (Tuktoyaktuk)	177	510,000	Inuvialuit	Class 2

Note: 1 – rounded to nearest 1,000 m^3

Sources of competent borrow materials that can be used at in-situ ice contents are limited along the alignments and as a whole throughout the Project area.

The Project area has been extensively studied over the years and the likelihood of locating additional sources of quality granular material near the alignment is considered to be limited. Efforts will be undertaken in the future in a phased annual manner to collect additional information, qualitative and quantitative, from the known borrow areas to confirm material volumes, quality and ground ice conditions to confirm that the material can be used as planned.

The estimated construction costs presented earlier, in this section of the EIS, do not include royalties or administrative fees paid on materials extracted from borrow sources on Inuvialuit owned lands.

Ongoing negotiations regarding the use of borrow sources on Inuvialuit owned lands will include discussion of royalties and administrative fees.

2.6.8.4 Further Investigation of Borrow Sources

Borrow sources are required to provide materials needed to construct the proposed Highway. The sources would likely be developed during the fall and winter months when the ground is frozen. Temporary winter access roads and work pads would be used. Drill and blast methods may be used to excavate the required volumes of material for construction from frozen borrow sources.

Potential borrow sources have been identified along the Primary 2009 Route, Alternative 1 (2009 Minor Realignment) and Alternative 3 (2010 Minor Realignment) based on the granular material studies and investigations that have been undertaken over the years by industry and government agencies discussed in the previous Section.

The resources near the communities of Inuvik and Tuktoyaktuk have been ground-truthed and proven to a spatial extent. Many of the resources along the Primary 2009 Route are not proven and are described as probable or prospective (i.e., material resources whose existence and extent have been inferred or speculated). The use of these materials and access to them will need to be proved up through additional site investigation (Figure 2.6.8-2).

2.6.8.5 Site Evaluation Criteria

Criteria used to identify borrow sources included the following:

- Proximity to the proposed alignment;
- Quantity, quality and availability of borrow materials required;
- Geographic distribution of sites;
- Geographic location of sites outside the 1 km Husky Lakes setback;
- Environmental considerations;
- Supply needs along route; and
- Potential to expand and supply Project needs.

Prior to opening a borrow pit, the sites will be surveyed and investigated to ensure the expected quantity and quality of material is available. Borrow pits will be developed, operated and decommissioned in full compliance with all regulatory requirements.

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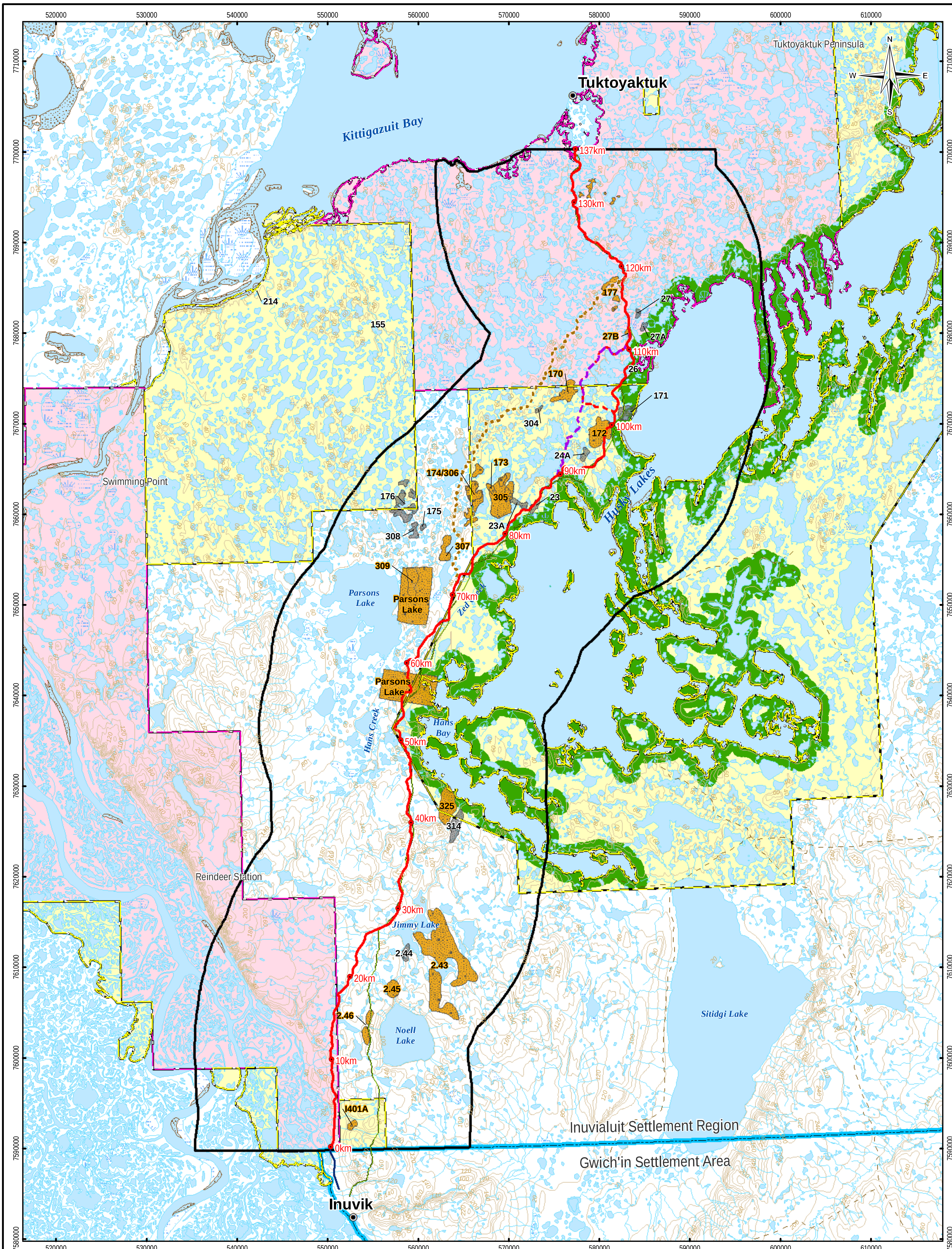

LEGEND

- Regional Study Area (15 km buffer)
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road
- Inuvialuit 7(1)(a) Lands
- Inuvialuit 7(1)(b) Lands
- Gwich'in / Inuvialuit Boundary
- Husky Lakes 1000m Setback
- Borrow Sources
- Potential Highway Borrow Sources - (further investigation and potential use in construction)
- Trail
- Contour
- Watercourse
- Waterbody
- Wetland
- Sand

NOTES
Base data source: NTS 1:250,000
Borrow Sources, ILA Lands, Husky Lakes 1000m Setback: Inuvialuit Land Administration

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

Potential Borrow Sources Requiring Further Investigation For Potential Use

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:400,000
5 2.5 0 5 10
Kilometres

FILE NO.
V23201322_EIS_Map020_Dev_GranInvest.mxd

PROJECT NO.	DWN	CKD	REV
V23201322	SL	TS	0

OFFICE	DATE
EBA-VANC	May 19, 2011

Town of Inuvik
Northwest Territories
KIGGIAK - EBA

Figure 2.6.8-2

2.6.8.6 Pit Development Plans

Pit development plans, also known as pit management plans, will conform to the approving authority's regulations and permitting requirements. For borrow sources on Inuvialuit-owned land, the pit development plan will conform to the ILA's *Granular Management Plan* and requirements for a Quarry Permit. For borrow sources on Crown-lands, the pit development plan will conform to INAC's (2010d) *Northern Land Use Guidelines Access: Pits and Quarries,* TAC's (2010) guide for *Development and Management of Transportation Infrastructure in Permafrost Regions,* and the pit/quarry development plan requirements.

A typical pit development plan includes the following topics (INAC 2010d):

1. 1:5000 scale site map.
2. Description of proposed mitigation measures to address all identified environmental concerns.
3. Site Conditions:
   - Full delineation of granular material resource;
   - Contours, elevations and drainage features;
   - Environmentally sensitive areas (e.g. streams, wildlife habitat);
   - Extent of permafrost and ground ice;
   - Adjacent land uses.
4. Site Design and Development:
   - Adequate room for all activities;
   - Topsoil, overburden and granular pile locations;
   - Proposed site development techniques (e.g. clearing trees, windrowing brush);
   - Proposed or existing access routes;
   - Proposed or existing infrastructure (e.g. camps, refuelling areas);
   - Design for water management and erosion control; and
   - Design for progressive reclamation.
5. Operations:
   - Resource extraction and processing techniques;
   - Single-season or multi-year operation;
   - Spill contingency plan;
   - Monitoring and maintenance plans; and
   - Contingencies if changes to the original development scenario are required.

6. Reclamation:
   - Closure objectives;
   - Removal of all garbage, debris, equipment and buildings;
   - Overburden replacement for site contouring;
   - Re-establishment of natural drainage;
   - Replacement of all salvaged topsoil;
   - Revegetation activities; and
   - Reclamation of access roads.

Proposed borrow sources will typically be developed during the fall and winter months when the ground is frozen. Winter pit development will employ drilling and blasting, if required. The decision to use these methods will depend on the quality and moisture content of the granular material in the source and the quantity of material needed from the source. Drilling patterns and powder factors will be adjusted as required to optimize the size of blasted material being produced.

Borrow pits will be closed as soon as they are no longer required and reclaimed in a progressive manner by the GNWT DOT's contractors as soon as possible. Areas required for the maintenance of the Highway during operation will remain open while in use, and will be reclaimed after they are no longer required. The disturbed areas will be contoured, at closure. Borrow pits will be designed to prevent entrapment of wildlife at closure.

2.6.8.7 Winter Access Roads

Temporary winter access roads will be constructed to access borrow sources since most of the earth moving construction activities will take place during the winter months when the frozen ground is more accessible. The winter access roads will be constructed in accordance with the GNWT DOT *Field Guide to Ice Construction Safety* (2007).

Winter access roads are designed to provide an effective road access while minimizing environmental disturbance to the ground surface. First the access route is dragged with a low-ground-pressure rubber tracked machine such as a snow cat. After dragging, an initial flood of the surface with water is undertaken using a low pressure rubber tired vehicle such as a Delta 3 with a mounted water tank. After the surface is made passable, water trucks are used to flood the access. Snow is moved into depressions as required with either a loader or with small dump trucks. The snow and water is mixed together. Several layers of the snow/water mixture are applied to the surface. The surface is continually dragged with either a loader or low ground pressure tracked machine. Through the application of successive layers of snow and ice the winter road is constructed.

2.6.9 Construction Camps

This Project proposes a number of 15-20-person construction camps in the first year, although in the second year, at least one camp of greater than 50 persons may be added. Typical temporary camp facilities will include:

- Dining trailer;
- Accommodation trailers for personnel;
- Toilet and bathing facilities;
- Waste storage facility; and
- Fuel storage facility.

Construction camps will be typically located at the borrow site(s) being used in each year of construction, near the Highway construction area, to minimize the Project footprint. Once a new borrow source is approved and in use, it is anticipated that the construction camp will move to that borrow source, closer to the construction activities.

Camp facilities are trailers on sleighs, which will be towed to and from the camp location during the winter months. Temporary camps will be installed during each winter construction period and then decommissioned until the following winter construction season, for the duration of the four year construction period.

For the more limited construction activities taking place in the snow-free seasons, it is anticipated that workers will be transported to/from the work site daily, along the constructed Highway embankment.

2.6.9.1 Locations

Temporary camps and associated infrastructure will be constructed at the designated borrow site(s) to be used for each winter construction season. Construction maintenance areas, for the storage and maintenance of equipment and fuel, will be located within the camps. Detailed camp siting information will be submitted to the appropriate land management agency prior to each season of winter construction.

2.6.9.2 Domestic Water

Domestic water for the camps will be drawn from nearby lakes. The *Northwest Territories Waters Regulations* indicate that a Type B Water Licence would be required to authorize the anticipated camps. The specific locations of drinking water sources will be submitted annually prior to each season of winter construction. A minimal amount of potable water may be trucked from Inuvik and/or Tuktoyaktuk for the construction camps during the winter construction stages.

2.6.9.3 Domestic Waste

The main type of waste produced during construction of the Highway will be domestic waste from the camps. All waste products will be properly secured, stored and transported to either Inuvik or Tuktoyaktuk for disposal in approved facilities. This includes the use of bear-proof storage containers that reduce odours at all times. Waste removal crews will be sent out to areas surrounding each construction site before the arrival of breeding birds in the spring to collect and properly dispose of any waste material that have blown off site. Further information regarding waste management is located in Sections 4.2.7 and 4.4.3.

2.6.9.4 Wastewater

Standard sanitation collection and disposal methods will be employed at the construction camps. Acceptable practice for sanitary collection treatment will include the use of stationary/ portable sewage collection systems. Sewage will be hauled on a regular basis to either the Inuvik or Tuktoyaktuk sewage lagoons depending on the location of the camps (see Section 4.4.3).

2.6.9.5 Power Supply

Electricity will be generated using on-site diesel generators.

2.6.9.6 Safety

Camps and associated infrastructure will be designed to incorporate proper bear safety, including installing adequate lighting, incorporating proper waste management, cleaning and maintaining the kitchen and dining area, and wildlife detection.

2.6.9.7 Decommissioning

The skid mounted temporary camps and associated infrastructure will be completely removed from the site during decommissioning.

2.6.9.8 Water Usage

The overall daily water usage for winter road construction is expected to range from 500 m^3/day to more than 1,000 m^3/day. Water use is anticipated to be 1,000 m^3 or more per day during peak phases of construction, particularly when establishing temporary winter access roads.

The *Northwest Territories Waters Regulations* indicate that the direct use of 300 m^3 or more per day for industrial undertakings requires a Type A Water Licence. In addition, the DFO (2005) *Protocol for Winter Water Withdrawal in the Northwest Territories* will be followed. This will include identification of suitable water withdrawal sources (lakes and streams), assessment of allowable withdrawal quantities per source, unique source identification, and water withdrawal volume tracking.

The detailed water requirement estimates and water source identification would be submitted during the detailed design phase for each of the four years of Project construction.

2.6.10 Construction Infrastructure

2.6.10.1 Construction and Equipment Staging Areas

There are likely to be four construction equipment spreads working in any given construction period, two from the north and two from the south, each with sufficient equipment and personnel to haul and place material at a rate of over 400,000 m3 per season. Equipment would initially be positioned in place at Source 177 and at the end of Navy Road once permitting is in place, and then re-positioned in advance of the next winter season construction phase. The specific locations of construction and equipment staging areas will be submitted following detailed design of this Project.

2.6.10.2 Construction Material Storage

Borrow material produced each winter will be stored at the borrow sites until used for Highway embankment construction purposes. Bridge and culvert components will be stored at contractor yards in Inuvik and Tuktoyaktuk prior to being transported to the construction sites for installation.

2.6.10.3 Excavation Equipment Storage Areas

Excavation and Highway construction equipment will generally be stored at the construction contractor's yards in Inuvik and Tuktoyaktuk during the summer period. Equipment needed to initiate early borrow development may be pre-positioned in the borrow sites to be used for the next season of construction, if necessary.

2.6.10.4 Fuel and Oil Storage

Fuel and oil needed for the aggregate borrow and Highway construction activities will be stored in double-walled storage tanks. All fuel and oil will be stored in accordance with CCME's (2003) *Environmental Code of Practice for Aboveground and Underground Storage Tank Systems Containing Petroleum and Allied Petroleum Products,* INAC's (2011b) *Northern Land Use Guidelines: Camp and Support Facilities,* and to the extent applicable, and the *CEPA Storage Tank System for Petroleum Products and Allied Petroleum Products Regulations.*

2.6.10.5 Equipment Maintenance and Refueling Areas

Equipment maintenance and refuelling areas will be located a minimum of 100 m from waterbodies, following INAC's (2011b) *Northern Land Use Guidelines: Camp and Support Facilities*.

2.6.10.6 Resupply of Personnel, Material, Food and Equipment

Due to the end-dumping construction method and the use of a parallel winter road, access to the construction sites and temporary camps is available during the construction season.

Resupply of personnel, material, food and equipment is possible throughout the construction season by way of the parallel winter road and on completed portions of the

Highway. Effective logistics planning will be used to minimize vehicle movements, such as the use of vans or extended cab pick-up trucks to transport workers.

2.6.11 Operation and Maintenance

Once construction of the Highway is completed, it is anticipated that the Highway will continue to operate for the foreseeable future. The GNWT DOT, using local contractors to the extent possible, will be responsible for the ongoing operation, maintenance, and safety of the Highway.

The operations and maintenance phase would begin upon completion of the construction program. All maintenance activities will proceed in compliance with established road maintenance policies and programs, such as GNWT DOT's Highway Maintenance Manual (GNWT DOT 1993). The manual comprises standards for highway maintenance, and provides details regarding rationale, responsibility, scheduling, and methods for specific maintenance activities.

Maintenance activities typically involve regular inspection of the roadway and associated facilities. Particular attention will be given to maintenance of all cross drainage installations and watercourse crossings to ensure that drainage is not impeded and that the roadbed is not being eroded. In addition, the traffic surface will be inspected to ensure that it is retaining its grade and material surface and to correct any problems in a timely manner. During the winter, snow removal will be required.

Maintenance activities that are typically undertaken on gravel highways in the NWT are identified in Table 2.6.11-1. In addition, repair works, such as re-grading, re-surfacing and bridge or culvert repair or installation, is expected to be required over the life of the Project.

TABLE 2.6.11-1: TYPICAL HIGHWAY MAINTENANCE ACTIVITIES

Highway Component	Maintenance Activity
Highway Surface and Shoulders	Wet and dry blading Gravel surfacing and repairs Grade repairs Dust treatment
Drainage	Culvert cleaning and inspection Culvert repair and replacement
Bridges	Bridge inspection Bridge cleaning and maintenance
Roadside	Brush, debris and litter removal, as needed
Winter	Snow plowing Sanding
Traffic Services	Sign installation and maintenance Traffic counting
Service Functions	Highway patrols Equipment servicing and repair Material stockpiling

Operations and maintenance depots likely would be located in Tuktoyaktuk and Inuvik. These depots would serve as support centres for maintenance contractors and likely would include an office, maintenance building, and laydown area for materials.

During the operations phase of the Highway, water will be used for dust control, as needed, in accordance with the *Guideline for Dust Suppression* (GNWT 1998). The average daily water usage during the summer is anticipated to be in a similar range as during construction (500 m^3/day to 1,000 m^3/day). Procedures and mitigative measures for water usage and water extraction are described in later sections of this document.

2.7 DEVELOPMENT PHASES AND SCHEDULE

2.7.1 Production Rate, Construction Staging and Overall Schedule

The proposed construction timing and staging is based on the premise that construction will proceed from both the north (Source 177) and south (Inuvik) ends of the Highway concurrently. Embankment construction will include the installation of culverts and bridges. It is anticipated that the contractor could achieve approximately 20 km of construction per year at both the north and south ends of the Highway, for a total of 40 km per year.

Subject to completion of the EIRB review process, regulatory approvals and funding, the high level milestones by month and year are:

Spring 2012: Initiate upgrading of the Tuktoyaktuk to Source 177 Access Road to highway standards.

Summer 2012: Field studies and plans, including biophysical (e.g., rare plant, wildlife, and fish), archaeological, and engineering, will be conducted during the summer months, as needed, to prepare the permit applications for the upcoming year of construction activities.

Position equipment at Source 177 and an Inuvik source when permitting is in place and continue development of this active borrow source for initial construction requirements.

November/December 2012: Construct winter access and haul roads to borrow sources at both north and south ends of the Highway. Commence with development of borrow sources and stockpiling of material.

January to April 2013: Construct Highway, moving both northward from Inuvik area and southward from Source 177. Geotextile fabric is placed from toe to toe of the embankment and material is directly dumped and spread onto the geotextile. An initial lift of approximately 300 mm to 400 mm is placed, followed by smaller lifts, with the embankment being left some 150 to 200 mm higher than design to accommodate settlement.

Equipment at borrow sources will include drilling/sampling equipment for further geotechnical investigation, drilling/blasting/excavating equipment for working frozen material, loaders, dozers, water trucks and 15 to 24 person camps.

It is anticipated that there will be three to four borrow sources under development and being worked in any given construction period. There are likely to be four construction equipment spreads working in any given construction period, two from the north and two from the south, each with sufficient equipment and personnel to haul and place material at a rate of over 400,000 m^3 per season.

June to September 2013: Summer construction activities include grading and compaction of the embankment that was constructed during winter months, and installation of certain culverts (to protect fish habitat) or adjustments to previously installed culverts.

Field studies and plans, including biophysical (e.g., rare plant, wildlife, and fish), archaeological, and engineering, will be conducted during the summer (snow-free) months, as needed, to prepare the permit applications for the upcoming year of construction activities.

Fall 2013 to Fall 2015: Construction will continue in the same manner described above. Additional work will include placing the surfacing gravel on the embankment that was constructed, graded and compacted in the previous year.

Spring to Summer 2016: Placement of remaining surfacing gravel on embankment and upgrade of Tuktoyaktuk to Source 177 Access Road.

2.7.2 Schedule

The proposed Project review and approvals schedule and generalized construction schedule for the Highway is provided in Table 2.7.2-1. The Project schedule is cyclical, with field studies, detailed planning, and construction activities occurring on an annual basis over four years, until construction of the Highway is completed. Data required for annual permits, such as archaeology studies and pit management plans, will be conducted and/or prepared in advance of the annual permitting requirements and construction activities.

TABLE 2.7.2-1: PROPOSED SCHEDULE OF ACTIVITIES

Approximate Dates	Activities
Environmental Assessment	
May 2011	Submit Environmental Impact Statement
November 2011	EIRB Review Process
December 2011	EIRB Decision
Sept 2011 – Summer 2012	Apply for and obtain permits, licences and other approvals (i.e., scientific, archaeology, and regulatory, etc.)
Field Investigations and Highway Design	
Summer 2012 to Summer 2015	Conduct biophysical (e.g., rare plant, wildlife, and fish), archaeological, and engineering surveys and plans, as necessary, for permitting needed for the upcoming year of work
2012	Detailed Highway design

TABLE 2.7.2-1: PROPOSED SCHEDULE OF ACTIVITIES

Approximate Dates	Activities
Upgrade Access Road	
Spring 2012	Initiate upgrading of Tuktoyaktuk to Source 177 Access Road to Highway Standards
Construction	
October 2012	Strip and develop initial borrow source(s) Pre-position equipment at next borrow source (e.g., pit located south of Source 177)
Nov - Dec 2012	Continue work at borrow sources, construct winter access and haul roads
Jan - April 2013	Transport, spread borrow material, construct Highway and install bridge(s) and culverts
June - Sept 2013	Complete installation of bridges and culverts. Compact and grade Year 1 embankment
Fall 2013 - Summer 2016	Repeat cycle of construction similar to Year 1

2.7.3 Anticipated Construction Equipment and Personnel

The equipment proposed for construction of the Highway will be similar to that used on the current Tuktoyaktuk to Source 177 Access Road construction, while the number of personnel required will likely double. There will likely be four (4) equipment spreads or operations. Each spread is expected to consist of the following equipment:

(2) D8T or D9N bulldozers with rippers

(2) D6R and/ or D6N bulldozers (drop D7G and D6D bulldozers)

(2) BR-180 or BR-400 snowcats

(2) EX-300 excavators

(2) 966 or 950 loaders

(8) to (12) tractor trucks with end-dump trailers

(2) 140 or 14 graders

(2) vibratory self-propelled packers

(4) water trucks with 3000 g tanks

(2) Delta 3 all-terrain vehicles with water tanks

(4) light stands

(2) to (4) 13,000 litre double walled fuel sloops

(10) to (14) dump trucks (either tandem trucks or articulated dump trucks)

(4) to (8) crew cab trucks

(1) to (2) service trucks

(1) crew bus

(2) to (4) snowmachines

As stated in the equipment estimate, the Highway will be constructed using four (4) spreads, two working at the Tuktoyaktuk end and the other working at the Inuvik end.

Table 2.7.3-1 identifies the personnel estimate per spread. A wide variety of positions will be available, including supervisors, environmental and wildlife monitors, scouts, clerks, engineers, and a variety of other positions.

TABLE 2.7.3-1: ESTIMATED PERSONNEL REQUIREMENT PER SPREAD

Activity		Personnel
I.	Winter Road Construction	30 to 35
II.	Winter Gravel Haul	55 to 65
III.	Summer Grade and Compact	10 to 15
IV.	Fall/Early Winter Pit Development and Material Production	15 to 20

2.7.4 Labour Requirements

The number of workers required by occupation or skill will be determined during the detailed design phase of this Project. Typical types of work and skills involved in highway construction include: surveying, environmental and wildlife monitoring, environmental field studies, heavy duty equipment operators, truck drivers, heavy duty mechanics, and camp cooks. Consultants will be retained to complete the engineering design for the Project.

Depending on the occupation, work is likely to be seasonal full-time (i.e., heavy duty equipment operator) or on a per project basis (i.e., environmental field studies).

The education requirements will vary depending on the occupation. The GNWT DOT's hiring practices will meet the standards required for a safe work environment. Most of the work will be seasonal (during the winter period). Management staff will be more permanent as they will be involved in the planning and preparations associated with the anticipated four year construction process.

During the Tuktoyaktuk to Source 177 Access Road construction, approximately 70% of the workers were from local communities. It is estimated that a similar percentage may be achieved for the Inuvik to Tuktoyaktuk Highway. The Developer is committed to hiring local, regional, and NWT residents, where possible, to fill these positions.

For the construction of the Tuktoyaktuk to Source 177 Access Road, a number of training programs were implemented. For example, the contractor conducted a successful heavy equipment operator course. Likewise, the ILA sponsored an environmental monitor training program.

It is anticipated that funding for training programs will become available in association with this Project. Training local workers will be beneficial for the Project and for the region as it increases the overall skill and competence of the workforce. It is also anticipated that a number of the contractors and employees involved during the construction phase will also be involved during the operations and maintenance phase of the Highway.

2.7.5 Roles and Responsibilities

The Developers or Project Team for the proposed Inuvik to Tuktoyaktuk Highway are the Hamlet of Tuktoyaktuk, the Town of Inuvik and the GNWT Department of Transportation. The Hamlet of Tuktoyaktuk and Town of Inuvik provide political and administrative support for the Project, particularly during the permitting process. The GNWT DOT is responsible for the design and construction of the Highway, including field studies, data collection, and future funding, similar to other NWT highways. Typically, construction, operation and maintenance activities are contracted to local and regional businesses.

2.7.6 Cost

The overall capital cost for the construction of the Project, depending on the route option selected, is currently estimated to range between $220 million (Primary 2009 Route) to $260 million (Alternative 2 (Upland Route)).

The operations and maintenance costs will depend on the route selected. As previously discussed, Alternative 2 (Upland Route) is anticipated to have substantially higher operations and maintenance costs compared to the Primary 2009 Route.

Reclamation costs are considered to be minimal, and included in the construction costs. Reclamation will be conducted at the borrow sources, upon completion of the activities.

2.7.7 Recent Studies Completed and Additional Field Studies Required

Since the Project Description Report was completed in February 2010, additional field work was completed for fish and fish habitat. In particular, field work was completed in June 2010 and the studies were focused on the first 25 km north of Inuvik and the first 25 km south of Granular Source 177. The study resulted in a watercourse assessment with detailed analysis of fish presence, habitat features, water quality, and hydrology.

Additional field studies and detailed highway design will be conducted prior to construction of the Highway. These activities would be initiated pending the selection of a route alignment and approval of this Project.

Additional field studies, designs and plans include:

- Surveying;
- Engineering studies for the final route alignment selected;
- Pre-construction wildlife surveys;
- Complete biophysical surveys (e.g. rare plants, wildlife habitat);
- Fish and fish habitat studies for the final route alignment selected;
- Archaeology studies along the final route alignment;
- Borrow site investigation to confirm the quantity and quality of materials, and delineate the source;
- Pit development plans for borrow sources;
- Spill contingency plan;
- Erosion and sedimentation control plan;
- Waste management plan;
- Hazardous waste management plan; and
- Detailed environmental management plans.

2.8 LIFE OF THE PROJECT

The October 1999 GNWT Department of Transportation Highway Strategy described the completion of the Highway as a major policy objective of the GNWT. Building upon the Highway Strategy, the GNWT included the Inuvik to Tuktoyaktuk Highway as a prominent component of succeeding proposals to Canada for infrastructure development including "Investing in Roads For People and Economy" (2000), "Corridors For Canada" (May 2002) and "Connecting Canada – Coast to Coast to Coast" (2005). Recent interest from the federal government has reinvigorated the Project.

As well, the Beaufort-Delta region is a territorial and national asset of strategic importance. It provides the only potential NWT and Canadian deep-sea port location in the Western Arctic, and the development of oil and gas resources in Alaska may create additional and as yet unrealized opportunities, particularly if all-weather road access is available. The region is strategically located to assist shipping to/from Alaska, Asia, and the continental United States. It could receive goods from Asia for trans-shipment south to the rest of Canada (GNWT DOT 2010).

Arctic sovereignty concerns over the Northwest Passage could lead to the establishment and investment of an amplified Canadian presence. In the past few years the issue of protecting Canadian sovereignty in the Arctic has received prominent national attention. Construction of the Inuvik to Tuktoyaktuk Highway will establish a permanent transportation link to Canada's arctic coastline, which is a comparatively low-cost assertion of Canadian sovereignty in Canada's Arctic without significant on-going expenses and risks.

Furthermore, commercial and non-commercial shipping into and through the Northwest Passage is expected to increase. The Inuvik to Tuktoyaktuk Highway would allow easier and cheaper access for sovereignty and security related operations in the western Arctic Ocean, which could be based in Tuktoyaktuk and/or Inuvik. With experts predicting that Arctic channels could be open to unimpeded summer navigation by 2015, Canada's ability to exercise its sovereignty in the Western Arctic becomes more urgent (GNWT DOT 2010a).

The Highway is intended for permanent, long-term use. Highway users are anticipated to fall into one of the following categories: residents of Inuvik and Tuktoyaktuk; regional residents; tourists; and hauling companies.

The winter road currently experiences annual daily traffic of 139 vehicles (GNWT DOT 2009b). It is anticipated that with increased shipping of goods and increased tourism, that short-term use of the Highway will range between 150 to 200 vehicles per day. It is projected that without major development in the region, that this may increase slightly over time. However, if major development occurs in the region, such as the Mackenzie Gas Project, the amount of traffic may increase.

Assuming that the Mackenzie Gas Project proceeds, GNWT DOT, the Inuvialuit Regional Corporation, and other interested parties will need to work with the Mackenzie Gas proponents to ensure that increasing traffic usage of the Highway is effectively managed.

Photo 2.1.2-4
Looking south along Alternative 2 (Upland Route) at typical terrain.

Photo 2.1.2-5
Looking south along Alternative 2 (Upland Route) at typical terrain

3.0 EXISTING ENVIRONMENT

The description of the biophysical and human environment focuses on the relevant issues identified by the EIRB, with guidance from the IFA and the Inuvik and Tuktoyaktuk CCPs. A description of the local setting is provided to allow the Review Board and others to clearly understand the rationale for assessment decisions. Baseline data represent current conditions, to the extent possible.

In general, data were gathered from publicly available sources. Efforts were made to present community level and regional data where possible. In the absence of such data, data are presented at the territorial or federal level. Both quantitative and qualitative data are presented.

3.1 BIOPHYSICAL ENVIRONMENT

The following sections provide a description of the biophysical conditions and resources existing in the Inuvik to Tuktoyaktuk Peninsula area. This background information is subsequently considered in Section 4.0 of this Environmental Impact Statement to identify potential environmental effects and proposed mitigation measures to avoid or minimize potential negative effects.

3.1.1 Terrain, Geology, Soils and Permafrost

This section provides baseline information on terrain, geology, soils, and permafrost for use in assessing potential effects to ground conditions by the Project. To describe the diversity of ground conditions, information was collected using available information and data collected during the field reconnaissance program for the Project.

The Project is located in the Taiga Plans level II Ecoregion near Inuvik and beyond the treeline, just north of Inuvik, the area transitions into the Tundra Plains Level II Ecoregion (Ecosystem Classification Group 2007, revised 2009). The proposed Highway is within the Pleistocene Coastal Plain which borders the eastern side of the Mackenzie Delta (IOL et al. 2004).

3.1.1.1 Bedrock Geology

Bedrock in the Mackenzie Delta is sedimentary, comprised of Tertiary shale and sandstone. Preglacial, glacial and post-glacial deposits overlie the bedrock. Depth to bedrock in the Delta ranges from about 50 m near Inuvik to greater than 150 m near the seaward limit of the modern delta.

In the northern and eastern parts of the Caribou Hills, north of Inuvik and adjacent to the Parsons Lake area, Tertiary shale lays beneath glacial and post-glacial deposits, and occasionally is near surface with rare exposures. The bedrock consists of weathered, poorly indurated shale, sandstone and mudstone. The bedrock in the southern part of the Caribou Hills more commonly consists of Cretaceous shale and regularly outcrops.

The proposed Highway is located within the Cenozoic Sedimentary Rock (Tertiary) (IOL et al. 2004). Quaternary glacial deposits overlie the Tertiary bedrock, which overlies Cretaceous strata.

3.1.1.2 Surficial Geology

Figure 3.1.1-1, originally generated by Rampton (1987, 1979), illustrates the surficial geology of the Tuktoyaktuk Peninsula and general Project area. The surficial geology and landforms along the proposed Highway corridor are primarily the result of glacial activity in the region. The main glacial deposits along the corridor are glacial moraine, glaciofluvial and lacustrine in origin. Fluvial, colluvial, organic and aeolian units are the result of ongoing and sometimes active processes subsequent to deposition by glaciers.

The proposed alignment crosses two distinct physiographic regions between Inuvik and Tuktoyaktuk. From Inuvik to south of Husky Lakes, the alignment crosses the eastern extension of the Caribou Hills on the edge of the Anderson Plain, which consists of mostly unconsolidated materials with varying amounts of ground ice overlying relatively shallow bedrock. Much of the topographic relief is a direct reflection of the bedrock surface, but bedrock is rarely exposed. North of this area to Tuktoyaktuk, the alignment is situated within onto the Pleistocene Coastal Plain, which is characterized by thick unconsolidated sediments, moraines, ice-contact, glaciofluvial and organic lacustrine deposits (Rampton 1987, 1979). The area also contains varying quantities of ground ice and massive ice layers. Bedrock is not near surface in the Pleistocene Coastal Plain.

Surface deposits along the more westerly Alternative 2 (Upland Route) from Parsons Lake to Source 177 are primarily hummocky glacial moraine and undulating terrain studded with numerous lakes of the Pleistocene Coastlands region. The terrain is hummocky and irregular due to ice-contact deposits, glacial depositional features, and thermokarst activity. Depressions are typically post-glacial lakes, or are infilled with organic-rich bogs and post-glacial lacustrine silt and clay sediments. Retrogressive thaw flow slides occur along the shores and banks of lakes and streams between Parsons Lake and Tuktoyaktuk. Low and high-centre ice-wedge polygons are present in moraine and lacustrine deposits.

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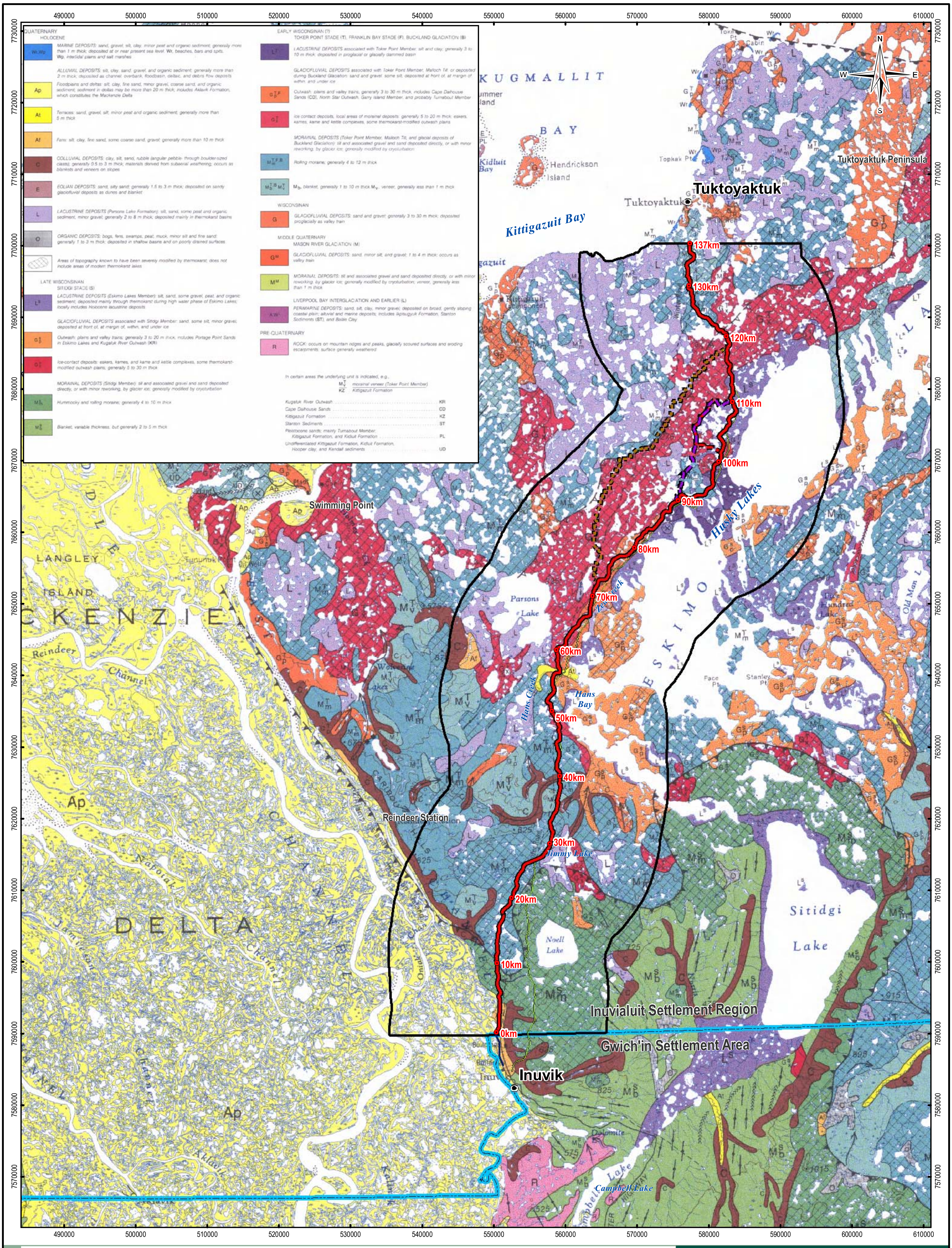


LEGEND

- Regional Study Area (15 km buffer)
- Gwich'in / Inuvialuit Boundary
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road

NOTES

Surfacial Geology: Natural Resources of Canada, gscmap-a_1647a_e_1987_mn01.jp2, Rampton (1974 and 1987)

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY ENVIRONMENTAL IMPACT STATEMENT

Surficial Geology

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:500,000

5 2.5 0 5 10 15

Kilometres

FILE NO.
V23201322_EIS_Map015_Ter_SurfGeology.mxd

PROJECT NO.	DWN	CKD	REV
V23201322	SL	RH	0

OFFICE	DATE
EBA-VANC	May 2, 2011

Town of Inuvik

Northwest Territories

KIGGIAK - EBA

Figure 3.1.1-1

Quaternary History

The Quaternary is the present geological time period, often referred to as the glacial age, and the time during which geological processes fashioned the surface of the Earth as it is known today. Quaternary events are largely responsible for the deposition of the surface materials and development of landforms present in the Inuvik to Tuktoyaktuk Highway area.

The Quaternary Period is subdivided into Pleistocene and Holocene epochs with the Holocene defined as roughly the last ten thousand years before present. The predominant characteristics of the Quaternary period are marked climatic change, glacial advances and retreats, and the activity of other processes fuelled by climatic oscillations.

Terrain Units

Terrain units common along the proposed routes vary from relatively dry upland and hummocky conditions, to wet, ice-rich lacustrine and thick organic conditions. Thick organic and ice-rich polygonal terrain was avoided where possible. Routing focused on traversing the most favorable terrain with minimal footprint size.

The surficial geology along the proposed Highway alignment has been generalized into four distinct landforms (terrain units); glacial moraine, glaciofluvial outwash, lacustrine, and alluvial/colluvial deposits. The route corridor contains many seasonal watercourses, wet lowlands, peatlands, and lakes, many of which are remnants of glacial outwash channels.

Through the remainder of the Holocene Period, periglacial processes resulted in the mechanical breakdown of materials and contributed to gravity transport of both glacial soils and products of periglacial grinding. Thin alluvial soil deposits formed along watercourses, and pond (lacustrine) deposits have accumulated in shallow depressions. Thicker organic deposits have formed on poorly drained floodplains and low, flat areas.

Table 3.1.1-1 provides a summary of the terrain units present within the Project area. Units are based on observations recorded during the field investigation, a review of orthophotographs and LIDAR topographic surveys along the Primary 2009 Route, and existing surficial geology mapping by Rampton (1987) and Aylsworth et al. (2000). The majority of the route traverses Terrain Types 1 and 2, with Terrain Types 3 and 4 comprising the remainder of the route.

TABLE 3.1.1-1: TERRAIN UNITS ALONG THE PROPOSED ALIGNMENT

Terrain Unit	Terrain Description	Approximate Percent Distribution Along Proposed Alignment
1	Glacial Moraine Deposits – deposited directly, or with minor reworking, by glacier ice; generally modified by cryoturbation. (relatively dry, stable, upland tills, overlain by a thin organic cover)	40

TABLE 3.1.1-1: TERRAIN UNITS ALONG THE PROPOSED ALIGNMENT		
Terrain Unit	Terrain Description	Approximate Percent Distribution Along Proposed Alignment
2	Glaciofluvial Outwash and Ice-Contact Deposits – deposited at front of, at margin of, within, and under glacier ice. (kame and kettle complexes and thermokarst modified plains, dry to wet, overlain by a thin to moderate organic cover)	35
3	Lacustrine Deposits – deposited in proglacial or glacially dammed basis, during high water phases of Husky Lakes, in thermokarst basins and recent lacustrine deposits. (wet, silt and clay, fine sand and organic sediments, moderate organic cover)	20
4	Alluvial/ Colluvial Deposits – deposited channel, floodplain, deltaic, and debris flow deposits, along ancient channels, present-day streams and steep slopes.	5

Soils containing fine grains in all four terrain units of the Project area are frost susceptible. A frost susceptible soil is defined in terms of its frost-heaving and thaw-weakening behaviour. The U.S. Army Corps of Engineers frost design and soil classification system bases the frost susceptibility of a soil on three factors: the percentage of particles smaller than 0.02 mm, the soil type (based on the Unified Soil Classification System), and a field laboratory test (Andersland and Ladanyi 2004).

Terrain Unit 1

Morainal deposits, also known as "till", consist of well-compacted to non-compacted material that is non-stratified and contains a heterogeneous, variable mixture of particle sizes, often in a matrix of sand, silt, and clay that is deposited by direct glacial action. Morainal deposits are generally moderately-well-drained, relatively ice-poor within the active layer, and smooth to rolling topography, with little surface expression of ice-rich permafrost conditions. Morainal deposits can also include wet till and till with ice-rich permafrost features indicative of more thermally sensitive terrain; these less favorable conditions were avoided where possible.

Morainal deposits can be subdivided into moraine veneer and hummocky and rolling moraine. Moraine veneer is generally less than 2 m in thickness while the hummocky and rolling moraine is generally between 4 and 10 m thick. Permafrost within the moraine veneer takes the form of 10-25% segregated ice in thin, irregular, discontinuous seams. Ice content within hummocky moraine is likely low. In rolling moraine, permafrost takes the form of 10-25% segregated ice as thin, irregular, discontinuous seams in the upper 2-3 m. As well, irregularly distributed large masses of segregated ice are common at greater depths in rolling moraine (Aylsworth 2000).

Terrain Unit 2

Glacial outwash and ice-contact deposits dominate the middle section of the route. Materials in these depositional environments are usually interbedded mixes of sand and gravel with some silt and typically range between 3 and 30 m in thickness. Materials have generally been transported away from a glacier by a stream of meltwater. Deposition patterns can vary; however, with materials deposited as a floodplain along a preexisting valley bottom, broadcast over a preexisting plain, or deposited in ridges, terraces, and hummocky terrain along glacial ice contacts.

The ground ice contents of these deposits vary greatly and are usually dependent on topographic location. Crests of prominent ridges and hummocks are typically well-drained and ice free to depths of 2-5 m. Below this depth the till is generally icy with ice lenses, and massive ice is common at depth. The deposits are moderately susceptible to thermokarst activity with signs of subsidence and ground ice slumping and gullying. Local drainage patterns tend to be deranged or contorted, draining to local ponds. The potential of these deposits to serve as borrow material is limited by ice content. Typically high crests and hummocks yield useful material.

Ice-contact deposits are often hummocky and irregular, characteristic of the kettle lake and thermokarst terrain. Drainage in most instances is good over the irregular terrain, however imperfect to poorly drained outwash materials are found where groundwater seepage is pronounced. Textures are quite variable and range from silt to subrounded gravels. There is generally a low ice content in the near surface (active layer), but ice content increases with depth and massive ice can be encountered. These deposits represent essentially the only source of useful borrow material on the Pleistocene Plain.

Terrain Unit 3

Lacustrine deposits include wet silt, clay, and fine sand, pond/lake bottom sediment deposits that occur in low-lying wet lowland terrain and old lakebeds. They are defined as sediments that have settled from suspension, and occasionally by underwater gravity flows in bodies of standing fresh water. In general, this terrain type is poorly drained with standing water, overlain by a moderate to thick organic cover. Permafrost is usually present under this terrain unit, except adjacent to large waterbodies.

Permafrost, when present, is generally composed of 10-25% segregated ice by volume and occurs as thin, irregular, discontinuous seams in the upper 1-3 m. Segregated ice or thick tabular bodies of nearly pure ice is common at greater depth. Growth of massive ice can result in the formation of pingos in drained thermokarst lake basins in the far north. Lacustrine deposits are subject to thermokarst processes and active layer detachment slides. Retrogressive thaw-flow slides are common on slopes in the area.

Lacustrine deposits are generally found in low-lying areas and depressed topography where slopes are nearly flat. Such deposits are present along the entire shoreline of Husky Lakes and in the coastal lowlands of the Pleistocene Plain. Because of the fine textured nature of these sediments, combined with imperfectly to poorly drained conditions, these sediments are usually ice-rich and highly susceptible to compaction and rutting.

Terrain Unit 4

Post-glacial alluvial and colluvial deposits are materials transported and deposited by streams and gravity, respectively. Alluvial deposits are found along many of the watercourses in the area, while colluvial materials are indicative of instability on steeper slopes, as noted along the Hans River valley where thick sediments have slumped into the valley. Alluvial sediments are commonly moderately-to-well sorted and display stratification. Colluvial materials are unsorted surficial deposits that have moved downslope because of gravity-induced movement. Colluvial deposits are typically less than 5 m in thickness, whereas alluvial deposits can vary in thickness between 2 and 5 m.

Ice content within this unit varies greatly and depends on the texture of the material and the depth to bedrock. For example, deposits that directly overlay impervious bedrock are more likely to have high ice content.

From an engineering perspective, many of the alluvial deposits, such as those identified along the north terrace of Hans Creek, represent potential aggregate sources. These sediments are generally well drained, however, areas with poor drainage or groundwater springs are more vulnerable to disturbance.

3.1.1.3 Borrow Materials

Potential borrow sources have been identified along the Primary 2009 Route based on the granular material studies and investigations that have been undertaken over the years by ILA, INAC, Geological Survey of Canada, and Public Works Canada.

The resources near the communities of Inuvik and Tuktoyaktuk have been ground-truthed and proven to a spatial extent. However, many of the resources along the Primary 2009 Route are not proven and are described as probable or prospective material resources whose existence and extent have been inferred or speculated. Additional site investigation is necessary prior to using these materials.

The following information regarding borrow sources is described in Section 2.6.8:

- Location;
- Type of material;
- Size of deposit;
- Quantity and quality of deposit; and
- Ownership and availability.

Further information regarding the depth of deposit, permafrost conditions and ice content within deposits will be identified during future site investigations.

3.1.1.4 Permafrost Conditions

The Inuvik to Tuktoyaktuk Highway corridor is located entirely within the zone of continuous permafrost (NRC 2007a; Heginbottom 2000). Ground temperatures are within the range of -3˚C to -7˚C (Burn and Kokelj 2009).

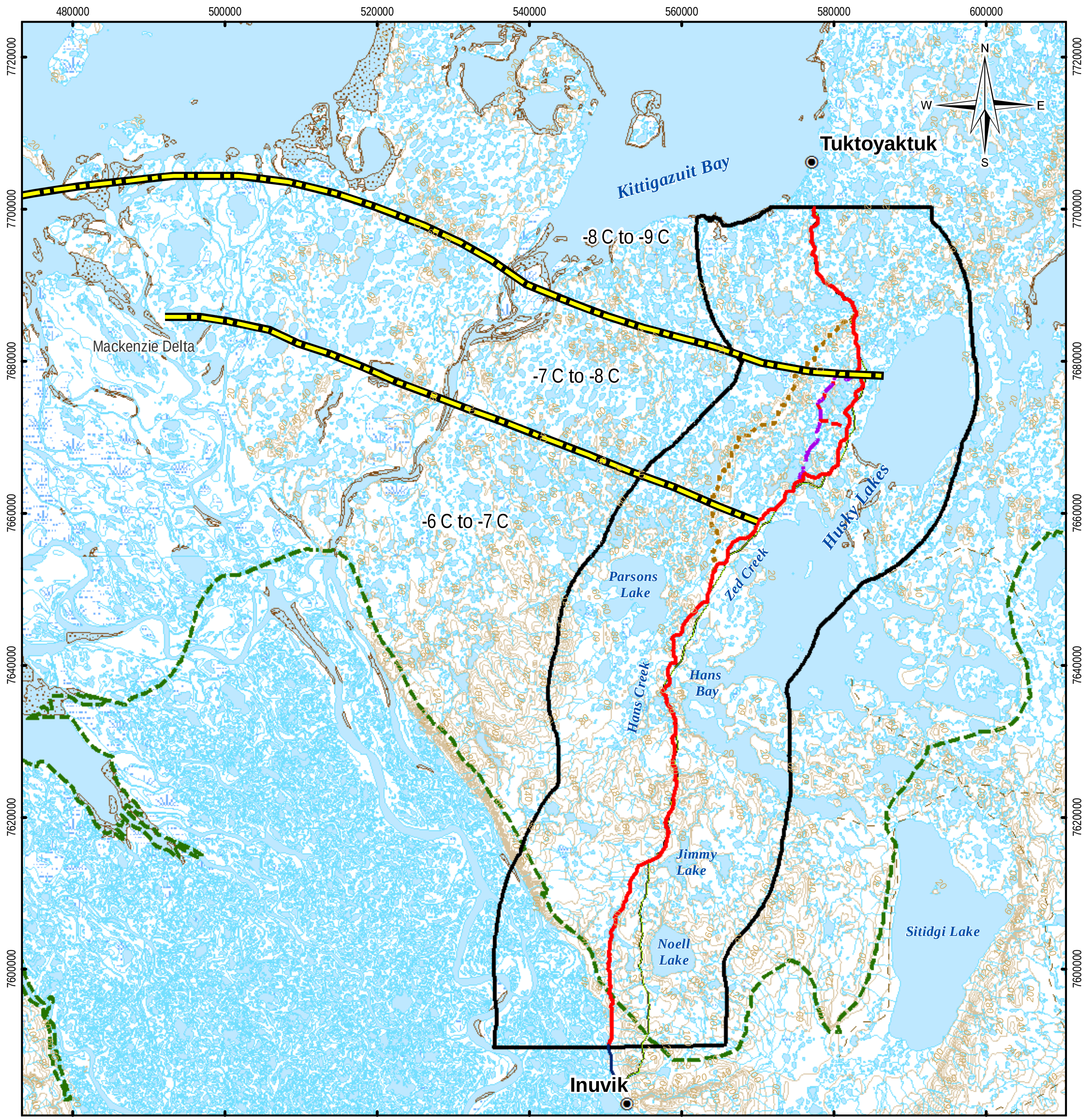
Spatial Variation in Ground Temperatures

The mean annual ground temperatures in the region vary due to climatic and ecological factors. Near-surface ground temperatures are similar in the uplands north and south of the treeline in summer, but diverge in winter due to varying snow depths south of the treeline.

Figure 3.1.1-2 summarizes ground temperature data from the 1960s and 1970s compiled from borehole temperature measurements at about the depth of zero annual amplitude. These data show a clear difference in mean annual ground temperatures between the uplands and the delta. In the uplands, the ground tends to cool with proximity to the coast. The warmer ground in the delta is due to the extent of waterbodies. In the delta, the lower temperatures measured south of the treeline can be attributed to the interception of snow by the forest canopy, which reduces snow depth in comparison to accumulations in the tall willows north of the treeline. The temperatures also decline in the sedge wetlands near the north coast of the delta. These data serve as a benchmark against which the effects of climate change on ground temperatures in the region can be measured (Burn and Kokelj 2009).

Figure 3.1.1-3 presents a composite map of mean annual ground temperatures in the area with data compiled by INAC during 2003 to 2007. These data are from a more extensive distribution of ground temperature records from the central and southern delta and near Inuvik than the data used to create Figure 3.1.1-2. The data presented in Figure 3.1.1-3 include borehole temperature measurements taken at the top of permafrost throughout the year.

A comparison of Figures 3.1.1-2 and 3.1.1-3 shows that the increase in near surface ground temperatures due to climate warming has been 1˚C to 2˚C in the uplands.



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LEGEND

- Temparature Boundaries (approximate)
- Treeline
- Regional Study Area (15 km buffer)
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road
- Trail
- Contour
- Watercourse
- Waterbody
- Wetland
- Sand

NOTES
Base data source: NTS 1:250,000
Temperature boundaries: Burn and Kokelj (2009).

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

Near-surface Ground Temperatures, late 1960s to early 1970s

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:750,000
10 5 0 10 20
Kilometres

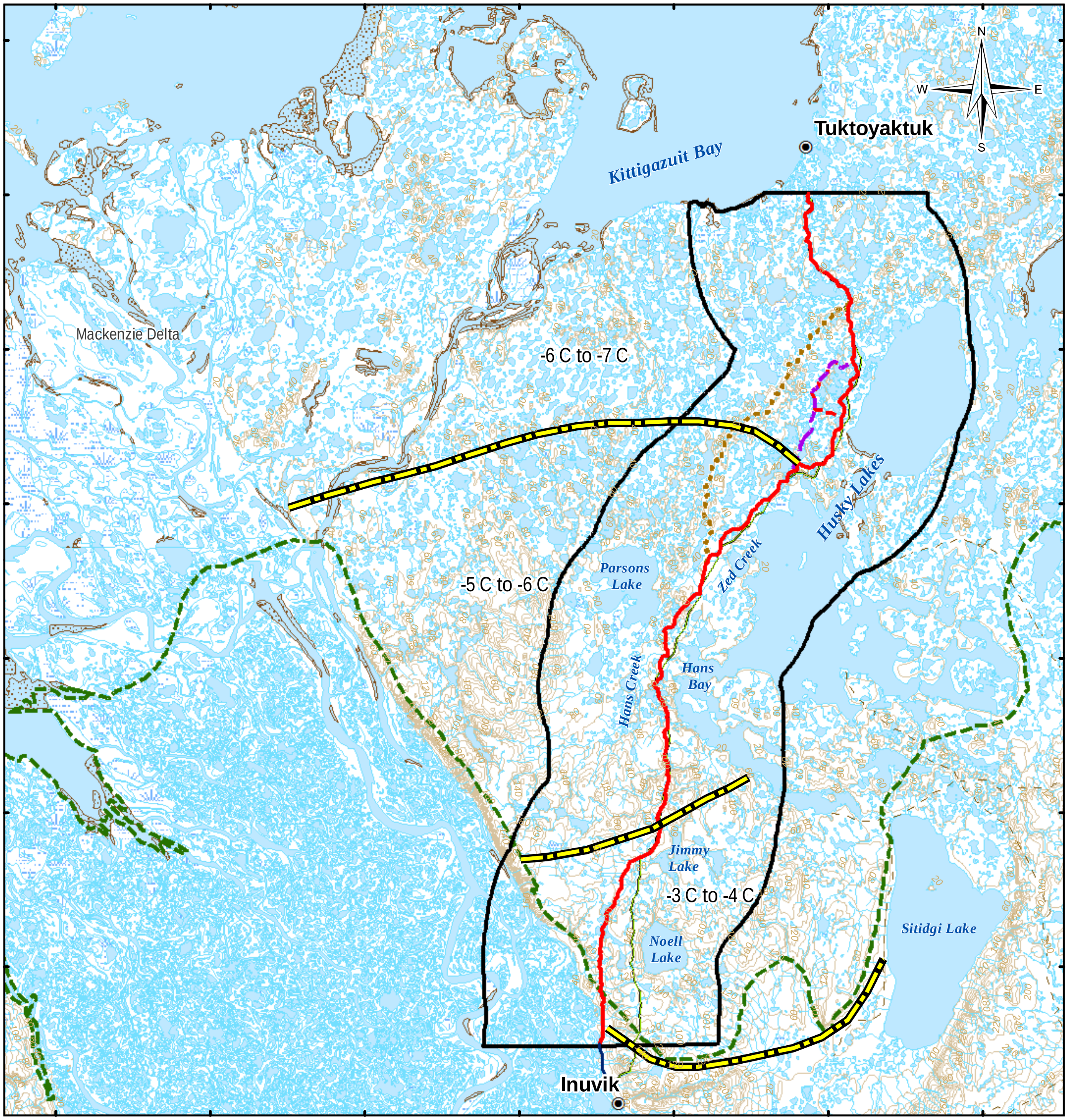
FILE NO.
V23201322_EIS_Map049_Temp1970.mxd

PROJECT NO.	DWN	CKD	REV
V23201322	SL	TS	0

OFFICE	DATE
EBA-VANC	May 19, 2011

Town of Inuvik
Northwest Territories
KIGGIAK - EBA

Figure 3.1.1-2



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LEGEND

- Temparature Boundaries (approximate)
- Treeline
- Regional Study Area (15 km buffer)
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road
- Trail
- Contour
- Watercourse
- Waterbody
- Wetland
- Sand

NOTES
Base data source: NTS 1:250,000
Temperature boundaries: Burn and Kokelj (2009).

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

Near-surface Ground Temperatures, 2003 to 2007

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:750,000
10 5 0 10 20
Kilometres

FILE NO.
V23201322_EIS_Map050_Temp2007.mxd

PROJECT NO.	DWN	CKD	REV
V23201322	SL	TS	0

OFFICE	DATE
EBA-VANC	May 19, 2011

Town of Inuvik
Northwest Territories
KIGGIAK - EBA

Figure 3.1.1-3

Permafrost

Permafrost is defined as any rock or soil material that has remained below 0˚C continuously for two or more years, without consideration of material type, ground ice distribution, or thermal stability. The two-year minimum stipulation is meant to exclude from the definition the overlying ground surface layer which freezes every winter and thaws every summer (called the "active layer" or "seasonal frost").

The upper portion of the permafrost layer experiences an annual range in ground temperature which fluctuates with the seasons. With increasing depth, the seasonal difference in temperature decreases. The point at which there is no discernable change in temperature is termed the "depth of zero annual amplitude" (NRC 2007b). Within the Project area, the depth of zero annual amplitude ranges from 10-20 m; below this depth, temperatures change very little during the year (Burgess et al. 2000).

Despite the proposed Highway being located in the continuous permafrost zone, talik zones of unfrozen ground are expected to exist under deeper lakes in the area such as Parsons Lake and Husky Lakes. Since the Highway will be set back from such large waterbodies, potential talik zones will be effectively avoided.

The underlying permafrost is typically a few hundred metres thick, but depends on various factors including proximity to lakes, slope, aspect, and other site-specific conditions. To the north and east of Parsons Lake, the permafrost thickness has been shown to range from 354 m to 378 m (IOL et al. 2004).

The extent of permafrost is a result of past and present climates, hydrological characteristics in the ground, mineralogy, surface organic cover, and annual snow cover (Nixon 2000). The proposed Highway alignment is within an area of continuous permafrost (Heginbottom 2000). The thickness of the active layer in the Project area is typically between 0.6 m and 0.8 m, but varies from less than 0.5 m to greater than 2.0 m on elevated, slopes with little to no organic cover.

Soil type and ground cover are key elements that help determine the depth of the active layer. In thick organic peats and silts, the active layer can be more than 30 cm thick and greater than 1 m in sparsely vegetated glaciofluvial gravels and sands.

Wildfire can greatly affect the permafrost layer by removing the insulating properties provided by the organic layer, without which the rate of permafrost melting increases. Melting of permafrost can result in substantial thaw settlement, loss of soil structural integrity, and can potentially affect the Highway foundation. Minimizing disturbance to permafrost is integral in maintaining Highway stability.

Common permafrost-related features in the Project area include ice-rich polygonal ground, retrogressive thaw-flow slides, thermokarsts, and peatlands.

Permafrost is reflected in well-developed patterned ground and periglacial processes. Mineral soils in the region, that promote capillary flow, generally have high ice content and are sensitive to disturbance. In this periglacial condition there are several forms of frozen ground that can occur. Frozen ground can contain excess ice, where the amount of water contained in the soil matrix in a frozen state is higher than would be retained in the soil in an unfrozen state. The excess ice can be found mixed (disseminated, non-visible) within the soil matrix, or can be in the form of pure ice, ice lenses, or ice wedges. Soil ice content by volume within the RSA ranges between 0-5% near the Husky Lakes and 5-15% south of the Husky Lakes, and in some areas near Tuktoyaktuk (Heginbottom 2000). The presence of perennially frozen ground limits the percolation of water and promotes the accumulation of organic material. The importance of these ice inclusions is the susceptibility of these materials to melt, the resultant ground disturbance, and the suitability for use as construction material (NRC 2007b).

Fluvial Geomorphology

Ice decay in lakes begins once snow is melted from the ground surface. The increase in lake water storage lags behind snowmelt due to meltwater retention within the snow cover and in small depressions on the land surface (Kiggiak-EBA 2010a). During the melt, snow dams generally cause water levels in lakes to rise above outlet elevations. Breaching of these dams causes rapid increases in downstream discharge. The freshet recharges tundra ponds, creating surface flow connections typically for a period of two weeks (Kiggiak-EBA 2010a).

The spring freshet is the peak period of fluvial geomorphological events. The spring freshet results in a sudden peak in the hydrograph as meltwater fills the many depressions on the land surface and flows over-land in sheets or rills (Kiggiak-EBA 2010a). The shallow active layer is not able to retain much water, causing the water table to rise rapidly, delivering runoff to the lower slopes and stream channels. Over the spring and summer, the active layer increases in depth due to heating from the surface, causing the water table to drop and resulting in a decline in surface flows. Summer rainfall causes short-period rises in water levels above base flows, the magnitude of which is a function of the ability of the ground to receive and attenuate flow.

Sensitive Terrain

The majority of the proposed alignment is located in the Mackenzie Delta of the Pleistocene Plain, a region of limited topographic relief. The southern portion of the route is located on the Caribou Hills, with rolling terrain and steeper slopes. There are various landforms and specific areas along the alignment that would be considered as being sensitive to construction activities.

A major routing design consideration was to avoid problematic or sensitive areas and to design accordingly to mitigate potential issues. Also, construction over ice rich permafrost terrain requires substantial quantities of materials to maintain a grade with continuous thick fill over thaw-sensitive terrain.

This has been confirmed by the recent construction of the Tuktoyaktuk to Source 177 Access Road. Mr. R. Newmark (CEO, E. Gruben's Transport Ltd., pers. comm., May 8, 2011) indicated that the construction of the Tuktoyaktuk to Source 177 Access Road traversed similar terrain and that the construction techniques employed (e.g., thicker road embankments and use of geotextile fabric) were sufficient to address these challenges.

The following subsections describe the relevant landforms identified as being sensitive to construction activities and disturbance.

Polygons

Polygons are a type of patterned ground found primarily in low-lying, poorly drained areas (i.e., drained lakebeds). These features are commonly classified as high- or low-centered. Low-centered polygons consist of flat terrain enclosed by relatively dry ridges.

Frost cracking begins when thermally derived stresses generated upon cooling, typically when temperatures reach their annual minimum, exceed the strength of the surface materials (Mackay 1986; Trenhaile 2007). During spring and early summer, water (from thawed snow, surface water, or water released by active layer thawing) may fill the crack and eventually freeze and subsequently crack during the fall and winter (Mackay 1986; Trenhaile 2007). In this manner ice wedges grow progressively.

Ice wedge growth pushes up the surface soil to form linear ridges. Intersecting ridges give the surface of the ground a polygonal appearance. Over time low-centered polygons can become high-centered polygons. Ice-rich patterned ground was avoided, where possible, along the Highway alignment.

Thick Organics (Peatland)

Generally these deposits occur as peat deposits or fens on flat terrain and usually cover underlying mineral soil. Peatlands are wetlands with massive deposits of peat that are typically greater than 0.5 m thick and may be several metres thick. There are many classes of peatland, but most in the Mackenzie Valley are bogs and fens. Bogs are a form of peatland, having a water table at or near the surface, where the waters are virtually isolated from nutrient rich groundwater from the surrounding terrain. Most bogs contain permafrost and take the form of peat plateaus, polygonal peat plateaus, and plazas (Tarnocai et al. 2003). Fens support nutrient rich waters that originate from mineral soil. Peatlands identified during the field reconnaissance and from orthophotos have been avoided.

Thermokarst

Thermokarst refers to surface subsidence and expression resulting from the melting of ice rich permafrost, particularly massive ice lenses. Thermokarst is a slow natural process that can be aggravated and accelerated if not cautious. As ground ice thaws and the resulting water cannot drain away and contributes to further degradation of the permafrost, the result is the creation of small ponds and lakes, expressing in the numerous kettle lake topography seen along the route. Old thermokarst lake beds occur where fine-grained clay, silt, peat, and local sand deposited in low, flat areas previously occupied by lakes/ponds become exposed. These lake beds often support an organic cover and the areas tend to be very wet. Ice content is generally high is these fine-grained, organic materials. These areas often exhibit thermokarst subsidence with erosion along ice wedge cracks and pingos are commonly associated with this environment. These areas have been avoided when possible.

Retrogressive Thaw Flow Slides

These are characterized by landslides that occur only in ice-rich soils in permafrost regions. Retrogressive thaw flows develop in ice-rich, fine-grained sediments and result from the thawing and subsequent flow of water-saturated ground. These failures can occur on very gentle slopes and hundreds of these features line the river banks and tundra lakes in the Project area. These landslides are typically relatively small, but over time can continue retreating back from the rim and from the escarpment. Such landslides would be of significant consequence to a road if they were to occur. The likelihood of a retrogressive thaw slide occurring along the Highway is reduced by purposely routing away from existing slides and steeper slopes that would be susceptible to failure.

Figure 3.1.1-4 identifies the distribution of recorded landslides on the Tuktoyaktuk Peninsula and the proposed Highway alignments (Aylsworth et al. 2001).

Pingos

Pingos are ice-cored hills that are forced up by the hydrostatic pressure in a wet area underlain by permafrost. Pingos may be up to 50 m high and have a base of up to 600 m in diameter. Mackay (1963) reported the existence of some 1,400 pingos in the Delta Area. Several particularly large pingos are located near Tuktoyaktuk and to the west of the proposed Highway alignment near the Beaufort coastline. Pingos are cultural and heritage resources that have been avoided entirely.

The drainages of Hans Creek and Zed Creek, and the wetland north of Zed Lake have been identified as being particularly sensitive to disturbance and construction activities given their environmental settings. Particularly careful design and construction will be undertaken in these areas.

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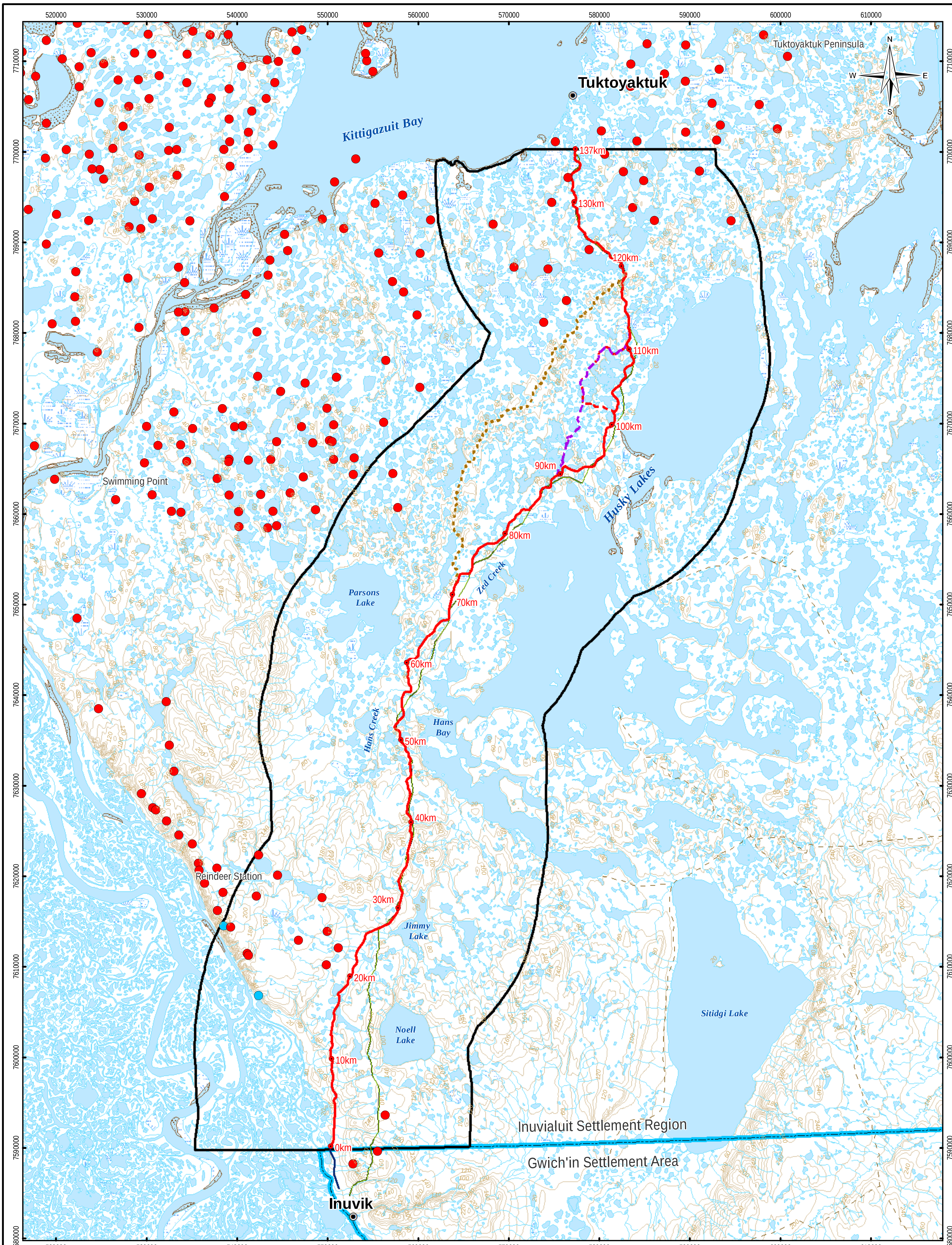

LEGEND

Landslide Class

- Flow
- Slide

- Regional Study Area (15 km buffer)
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road
- Gwich'in / Inuvialuit Boundary
- Trail
- Contour
- Watercourse
- Waterbody
- Wetland
- Sand

NOTES
Base data source: NTS 1:250,000
Landslide data: Geological Survey of Canada Open File 3917 (2001)

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY
ENVIRONMENTAL IMPACT STATEMENT

Distribution of Landslides
on the Tuktoyaktuk Peninsula

PROJECTION: UTM Zone 8
DATUM: NAD83

Scale: 1:400,000
5 2.5 0 5 10
Kilometres

FILE NO.: V23201322_EIS_Map031_Landslides.mxd

PROJECT NO.: V23201322
DWN: SL
CKD: TS
REV: 0

OFFICE: EBA-VANC
DATE: May 19, 2011

Town of Inuvik
Northwest Territories
KIGGIAK - EBA

Figure 3.1.1-4

Other Geotechnical Hazards

Other geotechnical hazards that were reviewed during the planning stage of the Project include karst structures, fault zones and active seismic areas. The seismic hazard within the Project area is considered low based on the 2005 Seismic Hazard Map produced by the Geological Survey of Canada (NRC 2010b). While thermokarsts are expected in the Project area, karst structures are not expected as they form in carbonate rocks, which are not present in the Project area.

3.1.2 Climate

3.1.2.1 Location of Recording Stations and Length of Record

Climate data from two meteorological stations operated by Environment Canada, Tuktoyaktuk-A and Inuvik-A are used for the discussion of climate for the Inuvik and Tuktoyaktuk areas. Inuvik climate normals between 1971-2000 and 1976-2005 are summarized in Tables 3.1.2-1 and 3.1.2-2, respectively. Tuktoyaktuk climate normals between 1971-2000 and 1978-2007 are summarized in Tables 3.1.2-3 and 3.1.2-4, respectively.

3.1.2.2 Spatial and Temporal Boundaries

The spatial boundaries of the Project are defined by the climatic area that can be reasonably represented by each weather station, while considering the influence of geography. Each station can be assumed to generally represent a radius of 10 km, although the actual area of representation is dependent on local geography (L. Coldwells, Environment Canada Meteorologist – Arctic Region, personal communication February 1, 2011). Features such as mountain ranges, large lakes, etc. will have an influence on climate and climate data. The terrain located within a 10 km radius of the Tuktoyaktuk-A and Inuvik-A weather stations is representative of what is present along the entire route and therefore this climatic data is generally representative of the entire route.

The temporal boundaries for the description of climate conditions are based on climate normals from 1971-2005 for Inuvik and climate normals from 1971-2007 for Tuktoyaktuk.

The spatial boundary between the Tuktoyaktuk and Inuvik data sets is the treeline (Figure 3.1.2-1), located just north of Inuvik. The area beyond the treeline more closely represents that of Tuktoyaktuk.

TABLE 3.1.2-1: CLIMATE DATA, INUVIK-A STATION*, NWT (1971-2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature:													
Daily Average (˚C)	-27.6	-26.9	-23.2	-12.8	0.2	11.3	14.2	11.0	3.7	-8.2	-21.0	-25.7	-8.8
Standard Deviation	4.8	4.7	3.7	4.0	3.0	1.6	1.8	2.0	2.2	2.7	4.8	3.4	1.9
Daily Maximum (˚C)	-23.2	-22.0	-17.5	-7.1	5.0	17.3	19.8	16.1	7.8	-4.8	-16.8	-21.3	-3.9
Daily Minimum (˚C)	-31.9	-31.7	-28.8	-18.4	-4.7	5.3	8.5	5.9	-0.4	-11.6	-25.1	-30.1	-13.6
Extreme Maximum (˚C)	5.4	5.2	6.1	13.8	25.0	32.8	32.8	32.5	26.2	15.0	10.6	5.0	
Extreme Minimum (˚C)	-54.4	-49.4	-47.6	-46.1	-26.6	-5.1	-2.2	-5.9	-20.1	-32.9	-42.8	-47.2	
Precipitation:													
Rainfall (mm)	0.1	0.0	0.0	0.0	6.1	20.2	32.9	37.5	18.7	1.3	0.0	0.0	117.0
Snowfall (cm)	17.4	15.0	14.6	13.5	13.1	1.9	0.3	2.4	10.7	34.9	23.7	20.4	167.9
Precipitation (mm)	13.8	11.6	11.0	10.5	17.0	22.1	33.2	39.9	28.0	28.0	17.8	15.7	248.4
Average Snow Depth (cm)	46	54	57	54	20	0	0	0	0	11	29	39	
Median Snow Depth (cm)	47	54	57	55	19	0	0	0	0	10	29	39	
Snow Depth at Month-end (cm)	51	56	59	41	1	0	0	0	2	23	34	42	51
Extreme Daily Rainfall (mm)	1.8	0.2	0.8	.04	19.3	19.1	41.0	33.0	22.9	13.2	0.8	0.4	
Extreme Daily Snowfall (cm)	11.4	13.7	13.0	17.8	24.9	10.2	4.8	22.6	12.2	44.2	22.0	18.6	
Extreme Daily Precipitation (mm)	10.4	13.7	10.8	17.8	24.2	19.3	41.0	42.9	30.7	29.2	16.9	15.8	
Extreme Snow Depth (cm)	89	97	96	99	**87**	8	3	5	16	81	79	81	
Wind:													
Maximum Hourly Speed (km/hr)	65	56	61	46	47	46	46	56	50	56	56	64	54
Direction of Maximum Hourly Speed	E	E	E	E	NE	NE	NE	E	E	E	E	E	E

Source: Environment Canada (2010a)
Note *: Location: 68°18' N, 133°28.8' W; Elevation: 68.3 m. Climate Station ID: 2202570

TABLE 3.1.2-2: CLIMATE DATA, INUVIK-A STATION*, NWT (1976-2005)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature:													
Daily Average (˚C)	-26.7	-26.0	-22.8	-12.0	0.2	11.4	14.0	11.0	3.9	-7.6	-20.4	-24.9	-8.3
Standard Deviation													
Daily Maximum (˚C)	-22.5	-21.3	-17.2	-6.5	5.0	17.5	19.5	16.1	7.9	-4.3	-16.4	-20.7	-3.6
Daily Minimum (˚C)	-30.8	-30.6	-28.3	-17.6	-4.6	5.3	8.5	5.9	-0.1	-10.9	-24.4	-29.1	-13.1
Extreme Maximum (˚C)	5.4	5.2	4.7	13.8	25.0	32.8	32.8	32.5	26.2	20.9	6.9	4.3	
Extreme Minimum (˚C)	-50.0	-49.1	-47.6	-40.0	-26.6	-5.1	-1.0	-5.9	-20.1	-32.9	-42.6	-47.2	
Precipitation:													
Rainfall (mm)	0.1	0.0	0.0	0.5	6.6	19.0	31.5	35.9	19.7	0.8	0.0	0.0	114.2
Snowfall (cm)	15.4	15.1	14.4	12.2	14.1	1.9	0.2	2.5	11.5	30.2	21.9	18.9	158.2
Precipitation (mm)	13.6	12.1	11.5	9.9	17.0	20.6	32.0	38.5	28.5	23.8	16.5	14.1	237.9
Average Snow Depth (cm)													
Median Snow Depth (cm)													
Snow Depth at Month-end (cm)	50	55	58	37	0	0	0	0	2	20	32	40	
Extreme Daily Rainfall (mm)													
Extreme Daily Snowfall (cm)													
Extreme Daily Precipitation (mm)													
Extreme Snow Depth (cm)													

Source: Environment Canada (2010b)
Note *: Location: 68°18' N, 133°28.8' W; Elevation: 68.3 m. Climate Station ID: 2202570

TABLE 3.1.2-3: CLIMATE DATA, TUKTOYAKTUK-A STATION*, NWT (1971-2000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature:													
Daily Average (˚C)	-27.0	-26.6	-25.7	-16.8	-4.8	6.0	11.0	8.9	2.8	-8.1	-21.0	-25.4	-10.6
Standard Deviation	4.5	4.6	3.5	3.0	2.6	1.6	2	1.9	1.9	2.9	4.0	3.1	
Daily Maximum (˚C)	-23.4	-22.6	-21.8	-12.2	-1.1	10.5	15.2	12.3	5.3	-5.6	-17.5	-21.8	-6.9
Daily Minimum (˚C)	-30.8	-30.8	-29.7	-21.2	-8.4	1.5	6.8	5.5	0.3	-10.9	-24.5	-29.1	-14.3
Extreme Maximum (˚C)	0.6	0.7	-0.5	4.8	20.9	28.2	29.4	27.6	20.4	11.7	2.2	0.8	
Extreme Minimum (˚C)	-48.9	-46.6	-45.5	-42.8	-28.9	-8.9	-1.7	-2.5	-12.8	-28.5	-40.1	-46.7	
Precipitation:													
Rainfall (mm)	0.2	0.0	0.0	0.0	1.3	8.1	21.4	27.2	15.6	1.2	0.1	0.3	75.2
Snowfall (cm)	10.1	10.6	6.3	8.9	5.6	1.6	0.1	1.9	8.9	19.2	12.3	9.8	95.2
Precipitation (mm)	9.8	10.2	6.2	8.6	6.8	9.7	21.5	29.1	24.2	19.9	12.2	9.6	167.8
Average Snow Depth (cm)			35	35	21	1	0	0	1	7		18	
Median Snow Depth (cm)			35	35	23	0	0	0	0	6		19	
Snow Depth at Month-end (cm)	30	35	37	32	9	0	0	0	2	11	21	21	
Extreme Daily Rainfall (mm)	2.5	0.4	0.0	0.4	4.0	11.5	19.6	14.7	24.2	8	1	4.8	
Extreme Daily Snowfall (cm)	8.8	9.8	6.5	7.1	9.6	7.6	1	7.4	12.8	9.1	15	9.4	
Extreme Daily Precipitation (mm)	7.1	9.8	6.5	7.1	10.8	11.5	19.6	14.7	24.2	9.1	15	9.4	
Extreme Snow Depth (cm)	61	62	72	72	**61**	45	0	0	21	26	34	49	
Wind:													
Maximum Hourly Speed (km/hr)	78	89	63	60	67	56	74	74	77	69	74	87	72
Direction of Maximum Hourly Speed	W	W	W	NE	NE	NE	W	SW	NW	W	NW	NW	W

Source: Environment Canada (2010c)

Note *: Location: 69°25.8' N, 133°1.8' W; Elevation: 4.6 m. Climate Station ID: 2203912

TABLE 3.1.2-4: CLIMATE DATA, TUKTOYAKTUK -A STATION*, NWT (1978-2007)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature:													
Daily Average (˚C)	-26.4	-26.8	-25.4	-16.0	-4.7	6.2	11.0	8.9	3.2	-7.3	-20.0	-24.1	-10.1
Standard Deviation													
Daily Maximum (˚C)	-22.8	-22.7	-21.3	-11.8	-1.2	10.8	15.0	12.3	5.7	-4.7	-16.5	-20.3	-6.5
Daily Minimum (˚C)	-30.1	-30.9	-29.3	-20.4	-8.2	1.6	6.9	5.5	0.7	-9.8	-23.3	-27.8	-13.8
Extreme Maximum (˚C)	0.0	0.7	-0.5	4.8	20.9	28.2	29.3	27.6	20.9	17.4	0.5	0.8	
Extreme Minimum (˚C)	-46.0	-46.6	-45.5	-39.0	-28.9	-8.9	-1.5	-2.5	-11.2	-28.5	-40.1	-42.9	
Precipitation:													
Rainfall (mm)	0.0	0.0	0.0	0.0	1.6	9.6	22.8	25.8	15.2	1.5	0.0	0.2	76.8
Snowfall (cm)	12.6	9.7	9.3	9.8	6.3	1.3	0.1	1.4	8.9	20.2	13.0	11.6	104.1
Precipitation (mm)	10.0	8.6	7.7	8.8	7.1	10.9	22.8	27.2	23.1	19.1	10.9	9.4	165.6
Average Snow Depth (cm)													
Median Snow Depth (cm)													
Snow Depth at Month-end (cm)	29	32	36	31	6	0	0	0	2	11	18	23	29
Extreme Daily Rainfall (mm)													
Extreme Daily Snowfall (cm)													
Extreme Daily Precipitation (mm)													
Extreme Snow Depth (cm)													

Source: Environment Canada (2010d)
Note *: Location: 69°25.8' N, 133°1.8' W; Elevation: 4.6 m. Climate Station ID: 2203912

3.1.2.3 Climate Related Extreme Events

Climate related extreme events are included in Table 3.1.2-1 and 3.1.2-2 for Inuvik and in Table 3.1.2-3 and 3.1.2-4 for Tuktoyaktuk. Data are recorded for the following types of extreme events: low or high temperatures, daily rainfall, daily snowfall, daily precipitation and snow depth. Data are reported as climate normals for the period 1971-2000 and 1976-2005 for Inuvik, and 1971-2000 and 1978-2007 for Tuktoyaktuk. Therefore, the frequency of occurrence of extreme events is not available.

3.1.2.4 Current Climatic Conditions for Baseline

The current baseline period was based on climate data obtained from two meteorological stations located near the Project site at Tuktoyaktuk-A and Inuvik-A (Figure 3.1.2-1). Climate normals (or averages) are used to summarize or describe the average climatic conditions of a particular location. At the end of each decade, Environment Canada updates its climate normals for as many locations and as many climatic characteristics as possible (Environment Canada 2010e).

For both locations the climate is characterized by long, cold winters followed by short summers.

Air Temperature

The Inuvik climate normals for the periods of 1971-2000 and 1976-2005 are summarized in Tables 3.1.2-1 and 3.1.2-2, respectively. July is the warmest month with a daily average of 14.1˚C. The lowest average daily winter temperatures occur in February and the two sets of climate normals indicate that these temperatures have increased over time from -26.9˚C (1971-2000) to -26.0˚C (1976-2005). The average annual temperature has also increased from -8.8˚C (1971-2000) to -8.3˚C (1976-2005).

The Tuktoyaktuk climate normals for the periods of 1971-2000 and 1978-2007 are summarized in Tables 3.1.2-3 and 3.1.2-4, respectively. July is the warmest month with a daily average of 11.0˚C. This is 3.1˚C cooler than equivalent Inuvik temperatures. The lowest average daily winter temperatures based on the 1971-2000 climate normals occur in January. These temperatures have increased over time from -27.0˚C (1971-2000) to -26.4˚C (1978-2007). The average annual temperature has also increased from -10.6˚C (1971-2000) to -10.1˚C (1978-2007).

In general the temperature data indicate that the Tuktoyaktuk climate is 2-3˚C cooler than Inuvik.

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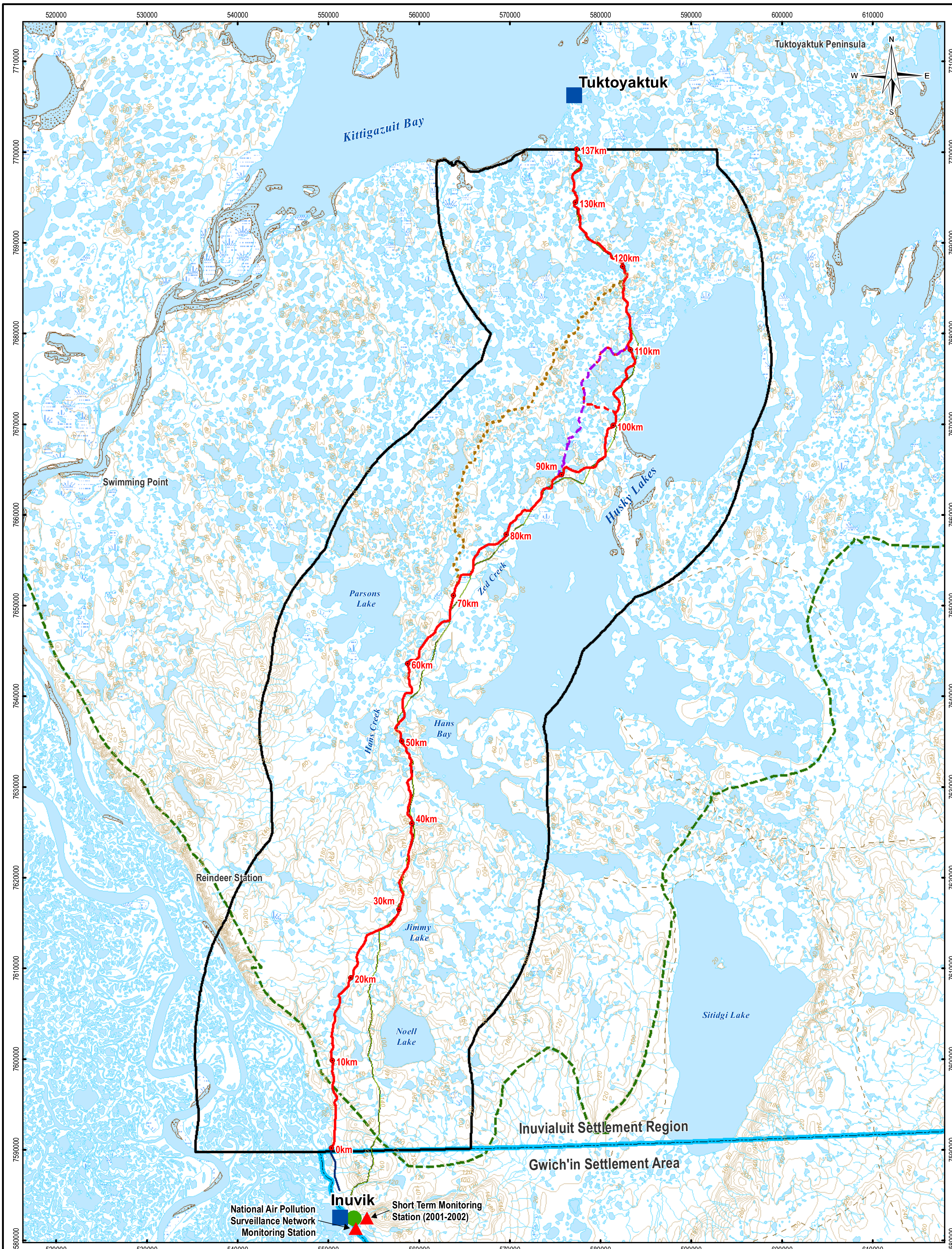


LEGEND

- Air Quality Monitoring Site
- Climate Station
- Meteorological Station
- Regional Study Area (15 km buffer)
- Primary 2009 Route
- Alternative 1 (2009 Minor Realignment)
- Alternative 2 (Upland Route)
- Alternative 3 (2010 Minor Realignment)
- PWC 1977
- Navy Road
- Gwich'in / Inuvialuit Boundary
- Treeline
- Trail
- Contour
- Watercourse
- Waterbody
- Wetland
- Sand

NOTES
Base data source: NTS 1:250,000
Air Quality, Climate, and Meterological Stations: Mackenzie Gas Project EIS (Vol 3 Figure 2-5); locations are approximate.

ISSUED FOR USE

PROPOSED INUVIK-TUKTOYAKTUK HIGHWAY ENVIRONMENTAL IMPACT STATEMENT

Climate and Air Quality Monitoring Stations

PROJECTION	DATUM
UTM Zone 8	NAD83

Scale: 1:400,000
Kilometres

FILE NO.
V23201322_EIS_Map029_AirQuality.mxd

PROJECT NO.	DWN	CKD	REV
V23201322	SL	TS	0

OFFICE	DATE
EBA-VANC	May 2, 2011

Town of Inuvik
Northwest Territories
KIGGIAK - EBA

Figure 3.1.2-1

Precipitation

Rainfall generally occurs throughout June through September; while snowfall generally occurs from September through May (Tables 3.1.2-1 through 3.1.2-4).

The mean annual total precipitation measured at Inuvik has decreased from 248.4 mm (1971-2000) to 237.9 mm (1976-2005). The proportion of rainfall to precipitation has increased from 47.0% (1971-2000) to 48.0% (1976-2005). There has been a decrease in the mean annual total snowfall recorded from 169.9 cm (1971-2000) to 158.2 cm (1976-2005). This indicates that slightly less winter precipitation (snowfall) is occurring over time.

The mean annual total precipitation measured at Tuktoyaktuk has decreased from 167.9 mm (1971-2000) to 165.6 mm (1978-2007). The proportion of rainfall to precipitation has increased from 44.8% (1971-2000) to 46.4% (1978-2007). There has been an increase in the mean annual total snowfall recorded from 95.2 cm (1971-2000) to 104.1 cm (1978-2007). This indicates that slightly greater winter precipitation (snowfall) is occurring over time.

On an average annual basis, Inuvik receives 67% more precipitation that Tuktoyaktuk.

Wind Speed and Direction

The mean annual maximum hourly wind speed at Inuvik between 1971 and 2000 was 54 km/hr, with winds generally from the east. The period with the lowest maximum hourly wind speeds (46 km/hr) occur during April through July. During this period the winds shift direction from east to northeast. The period with the highest maximum hourly wind speed occurs from December to March, (>60 km/hr) typically blowing from the east.

The mean annual maximum hourly wind speed at Tuktoyaktuk between 1971 and 2000 was 72 km/hr, with winds generally from the west. The period with the lowest maximum hourly wind speeds (61 km/hr) occur during March through June where the winds shift direction from west to northeast. The period with the highest maximum hourly wind speeds (85 km/hr) occurs from December to February, typically from the west.

Tuktoyaktuk is located close to the Beaufort Sea and its topography and vegetation leave it less sheltered and more susceptible to greater wind speeds than other communities further inland, such as Inuvik. This is reflected in the average annual winds of 72 km/hr for Tuktoyaktuk compared to Inuvik where the average is 54 km/hr.

Visibility

Visibility in the region is primarily affected by atmospheric humidity. Typically, the greater the humidity, the lower the visibility. Two humidity conditions that can affect visibility in the region are fog and ice fog. Fog is formed when moisture in the air condenses and can restrict aircraft and other transportation. Ice fog is a uniquely northern situation that occurs below -30'C. Ice fog events are typically associated with local temperature inversions. Table 3.1.2-5 summarizes the fog and ice fog events that have been observed (IOL et al. 2004).

TABLE 3.1.2-5: SUMMARY OF AVAILABLE FOG AND ICE FOG DATA (INUVIK)					
Parameter	Average				
	Dec -Feb	March - May	June - August	Sept - Nov	Annual
Normal number of days with fog[1]	3	5[3]	6[3]	8	24
Number of days with fog[2]	5	13	22	22	60
Fog frequency (number of hours)	19	67	106	111	303
Number of days with ice fog[2]	23	7	0	6	35
Ice fog frequency (number of hours)	156	28	0	20	203

Notes:
The days with fog in the climate normals include only days where the visibility is reduced to less than 1 km.
The number of days with fog and ice fog include all days when fog is recorded for at least 1 hour.
March through July data missing.
Source: IOL et al. (2004)

3.1.2.5 Variability/Trends within the Current Climate Normal Period

Several studies have documented a slight warming of air temperatures in the Mackenzie River Delta. It is anticipated that the Canadian Arctic will continue to experience greater warming and generally higher precipitation, according to the General Circulation Model. The General Circulation Model is one of Environment Canada's Global Climate Models that "Provide quantitative estimates of potential climate change by "modeling" the physical climate system". Any changes in mean annual temperature would most certainly affect the distribution of permafrost and thermokarst processes (Lawford and Cohen 1989). Environment Canada (1997a, 1997b) agrees with these observations.

In northern regions, warming is expected to be greatest on land, during winter. Winter precipitation and soil moisture are expected to increase over much of the North. Over the past 100 years, the average temperature of the Mackenzie Basin has risen by approximately 2.5˚C, with the greatest warming occurring in winter and spring (Environment Canada 1997a, 1997b; IOL et al. 2004).

3.1.2.6 Climate and Meteorological Conditions Relating to Air Quality

Data specific to air quality are discussed in the following paragraphs.

The meteorological conditions near the Project areas will determine how Project emissions are transported in the atmosphere and, as a result, how these emissions might change the air quality. These meteorological conditions describe the assimilative capacity of the environment with respect to air emissions. Data from Inuvik are used to describe the meteorological conditions in the airshed, as described in Sections 3.1.2.2 and 3.1.3.1).

Dispersion models are based on five full years of hourly meteorological input data to simulate the dispersion and transport of Project emissions. The specific parameters are wind speed and direction, temperature, precipitation, atmospheric stability and turbulence and mixing height.

Atmospheric stability can be viewed as a measure of the atmosphere's ability to disperse emissions. The amount of turbulence is important in determining how a plume is dispersed as it is transported by the wind. Turbulence can be generated either thermally or mechanically. Surface heating or cooling by radiation contributes to generating or suppressing thermal turbulence, and high wind speeds contribute to generating mechanical turbulence.

The Pasquill-Gifford (PG) stability classification is one method for classifying atmospheric stability. The classification ranges as follows: unstable (Stability classes A, B and C); neutral (Stability class D); and stable (Stability classes E and F).

Unstable conditions are primarily associated with daytime heating that results in enhanced turbulence, i.e., enhanced dispersion. Stable conditions are associated primarily with night-time cooling that result in suppressed turbulence, i.e., poorer dispersion. Neutral conditions are primarily associated with higher wind speeds or overcast conditions.

The mixing height is a measure of the depth of the atmosphere through which mixing of emissions can occur. The mixing height often exhibits a strong diurnal and seasonal variation. During the night, heights are lower, whereas during the day they are higher. Heights are typically lower in the winter and higher in the late spring and early summer.

To describe the meteorological conditions and dispersion in the airshed, data are summarized from IOL et al. (2004) using Inuvik data from 1994 to 1998.

Winds

The hourly winds at Inuvik were predominantly from the east, and most of the strong winds were from the northwest. The average speed of winds from the east is 10 km/h. The strong winds from the northwest can reach up to 109 km/h (IOL et al. 2005). Prevailing winds were easterly during the fall, winter and spring seasons. During summer, wind directions were more variable (IOL et al. 2004).

Temperature

The average temperature between 1994 and 1998 was -7.0°C (from 1994 to 1998), slightly higher than the long-term climate normal of -9.5°C. Hourly temperature data were used for the dispersion modelling.

Precipitation

There is a high annual and monthly variability in precipitation in Inuvik. Most of the precipitation occurred as rain in the summer, July and August.

Atmospheric Stability

Unstable conditions (Stability classes A, B and C) of the Pasquill-Gifford scheme occur in Inuvik about 20% of the time. Neutral conditions (Stability class D) occur about 46% of the time. Stable conditions (Stability classes E and F) occur about 34% of the time.

Mixing Height

Average mixing heights in Inuvik are typically higher during summer, at about 1,500 m. The most frequent mixing heights are in the 300 to 900 m range. These occur about 40% of the time. Mixing heights less than 300 m occurred only 4% of the time. Mixing heights greater than 3,000 m occur about 1% of the time.

3.1.2.7 Contribution of Traditional Knowledge

Research conducted by the Arctic Borderlands Ecological Knowledge Coop amongst northern communities in Alaska, the Yukon and the Northwest Territories over the last 10 years details many of the changes that northerners are witnessing in their environment. The findings of these studies are reflected in the comments of Traditional Knowledge interview participants, as summarized in the document entitled *Inuvialuit Settlement Region Traditional Knowledge Report* (ICC et al. 2006). The Traditional Knowledge, which is described in brief, in the following paragraphs, was used by the Developer to further understand climate conditions and variability from the local perspective, and to learn about potential conditions or issues that relate to Project design and implementation.

There were consistent observations of weather change and its effects from all three ISR communities (Inuvik, Tuktoyaktuk, and Aklavik); these include warmer and shorter winters, hotter summers, earlier breakup of river ice, later freeze-up, more wind, particularly west wind, and increased erosion due mostly to melting permafrost.

In addition, some Elders have noted more dampness in the air. Elders have become prone to pneumonia. Some participants report an unusual degree of variability in recent weather:

Some winters are mild, some winters are cold, some springs are short, some are long. Now you notice summer is really hot, next summer is really cold and last fall was mild fall - we were driving boat in November 2003, this year (2004) come around almost 40 below November 1st. When I was growing up July 1st there used to still be ice.

However, the last couple of winters suggest to some that intense winters are possibly returning to the area. Elders stated that long ago there would be storms that lasted three or four days, and that this trend appears to be coming back.

The fall months can bring rain and mud. Later in the fall, overflow can make travel on frozen water extremely dangerous. Fall-weather conditions impact fishing and therefore the ease of using the resources in the study area.

3.1.2.8 Synthetic Climate Data

No synthetic climate data has been generated for establishing the baseline climate conditions as the historical climate data was considered sufficient for determining the baseline condition.

3.1.2.9 Climate Change

Information collected over many years at northern climate stations, indicates that the climate in the Mackenzie Delta and the Mackenzie Valley region has been changing. Communities and other stakeholders are concerned about the potential effects of climate change on the northern environment and the economy.

Natural variability, expressed as averages over the last 30 years, shows variations in average annual temperatures of 3˚C to 6˚C in the Mackenzie Delta. Depending on the climate model scenario used, these exceed (by two to three times) the average annual temperature increases obtained from the model. Nonetheless, based on observed trends and future modeled predictions, there is a consistent and gradual warming trend. Generally, modeling results indicate a warming trend in air temperature of up to 2.5˚C and an increase in precipitation of up to 11.8% in the 30 years between 2010 and 2039 (IOL et al. 2004).

Inuvialuit Settlement Region

Table 3.1.2-6 summarizes the current climatic conditions as well as past and future climate trends in the Inuvialuit Settlement Region. Expected future temperature changes will be comparable to the changes that have occurred over the last 30 years. For example, the future predicted change in average temperature is between +1.3˚C and +2.5˚C. These values are similar to the +1.5˚C increase observed between 1971 and 2000. The current average annual temperature is -10.3˚C and the annual average winter temperature is -26.5˚C (IOL et al. 2004).

TABLE 3.1.2-6: CLIMATE CONDITIONS AND CHANGE IN THE INUVIALUIT SETTLEMENT REGION

Parameter	Current[1] Conditions	Trend (1971-2000)	Forecasted Trend[2] (2010- 2039)		
			Low	Medium	High
Average annual temperature (˚C)	-10.3	+1.5	+1.3	+1.6	+2.5
Average winter temperature[3] (˚C)	-26.5	+2.1	+1.3	+2.1	+2.2
Total precipitation[4,5] (mm)	191.0	+5.2	+2.1%	+7.4%	+11.8%

Notes:
1. Current conditions are based on observations from 1996-2000.
2. Trend estimate ranges (Burn 2003).
3. Winter temperatures include the months of December, January and February.
4. Total precipitation is presented as millimetres of equivalent rainfall.
5. Future trends are presented as percentage change from the 1961 to 1990 climate normals.
Source: IOL et al. (2004)

The future trend in total precipitation in this region ranges from 2.1 to 11.8% above the 1961-1990 climate normals. Total precipitation in the Inuvialuit Settlement Region has increased by 5.2 mm during the past 30 years. Current annual total precipitation is 191 mm (IOL et al. 2004). Section 4.5.1 of this Environmental Impact Statement discusses the possible effects of climate change on the future integrity of the Highway and current approaches to the mitigation of this concern.

Potential Climate Change and the Project

A risk-based approach for incorporating climate change into design of highway infrastructure on permafrost is now recommended practice. The challenge for design and construction over thaw sensitive permafrost terrain is to balance the capital cost of constructing the Highway, against long-term maintenance implications. The design parameters and construction techniques consider these risks and provide mitigative approaches in the Highway design and are discussed in Sections 3.1.1 and 4.2.1 of the document.

3.1.3 Air Quality

Air quality is determined by the concentrations of pollutants in the atmosphere, which are, in turn, affected by the dispersion of pollutants from emission sources.

The air quality baseline section addresses the interrelated subjects of ambient air quality, air emissions, and climate and meteorology. Ambient air quality is measured according to the concentration of airborne constituents in the environment or the rate at which these constituents are deposited. Air emissions are releases of gases or particles in the atmosphere that can contribute to changes in air quality that can result from anthropogenic (human) activities or natural sources. Climate is a measure of key atmospheric variables including temperature, precipitation and wind, while meteorology refers to the variability of these atmospheric variables, which determines how emissions might affect air quality (IOL et al. 2004).

Regulatory agencies have established standards and objectives to which ambient measurements are compared to determine the air quality (IOL et al. 2004).

3.1.3.1 Airshed Spatial boundaries

An airshed represents the space in which air emissions interact and defines the limits over which air quality models might meaningfully predict potential changes in air quality. There are no formal airshed designations or management areas used for government monitoring purposes. However, the proposed Highway falls within an area designated as the "northern airshed" by Imperial Oil and its partners for the environmental assessment of the Mackenzie Gas Project. This assessment included detailed model predictions for various pipeline facilities and the area encompasses the proposed Inuvik to Tuktoyaktuk Highway; therefore, the model predictions were deemed relevant for this Project (see Figure 3.1.2-1).

The northern airshed is a 150 km by 200 km area. The area extends from west of the Mackenzie River delta, north of Tuktoyaktuk, east of the Husky Lakes, and south of Inuvik. The northern airshed encompasses the Project's Regional Study Area (RSA) (defined as the area within 15 km of the Highway (30 km total width)) and Local Study Area (LSA) (defined as the area within 0.5 km of the Highway (1 km total width)). Most Project emission effects are expected to occur in this LSA.

3.1.3.2 Emission Sources and Factors Affecting Air Quality

Emission sources can have three different configurations, which have significantly different atmospheric dispersion characteristics. Point sources are emissions from well-defined stacks/exhausts or vents within industrial plants and electric utilities. Area or volume sources are emissions that come from a relatively large area such as windblown dust, emissions from furnaces in a residential area. Line sources are emissions from vehicles along a highway, which are the anticipated emission configuration for this proposed Project during the Operations Phase.

Due to the relatively remote location of the proposed Highway, there are very limited sources of emissions currently. Existing emission sources in the RSA include:

- Aviation, including all air traffic, i.e., fixed wing and rotary-wing aircraft;
- Marine sources, including seasonal boat traffic on the Mackenzie River or Husky Lakes;
- Community sources, including local and winter road traffic, off-road (i.e., snowmachines) traffic, vehicle refuelling and residential heating (e.g., fuel oil, natural gas, wood combustion);
- Other industrial sources, including existing oil and gas operations in the region (IOL et al. 2004); and
- Natural sources, including forest fires (GNWT ENR 2009e).

Air emissions undergo one or more of the following processes: atmospheric dispersion, atmospheric chemistry, and/or atmospheric deposition. Atmospheric dispersion is the physical process that transports and disperses air emissions, resulting in increased ground-level concentrations and direct effects on air quality. Atmospheric chemistry involves the processes that transform emissions as they are dispersed in the atmosphere, resulting in increased acid deposition. Atmospheric deposition is the process associated with removal of emissions dispersed in the atmosphere and their deposition onto the ground, e.g., dust deposition and acid deposition. The result of these processes can cause three possible changes in air quality: increased ambient concentrations, acid deposition, and/or dust deposition (IOL et al. 2004).

Factors that affect the concentration of air pollutants in the atmosphere include:

- The geometric configuration (e.g., point/line/area source), and geography in the vicinity of the emission site (e.g., lakes, valleys);
- The total amount of pollutant emitted;
- The meteorological conditions; and
- The amount of pollutant emitted (SENES 2005).

Weather plays an important role in the dispersion of air pollutants. Meteorology is a vital part of predicting both the current air quality as well as developing any strategies to improve the future situation. The parameters of particular importance are wind speed and direction, and atmospheric stability. The amount of sunshine also directly influences photochemical production of secondary pollutants (SENES 2005).

Air quality issues such as regional scale smog, acid deposition, and the concentration of hazardous air pollutants in the lower levels of the atmosphere are linked to climate through temperature, precipitation, humidity, solar radiation, cloudiness and the large scale circulation of the atmosphere which acts to re-distribute air pollutants through long range transport (SENES 2005).

3.1.3.3 Ambient Air Quality Standards

The *Canadian Environmental Protection Act* (CEPA) is the principal Act for the regulation of environmental contaminants. The CEPA allows the federal government to regulate and control substances through national quality objectives, guidelines and/or standards (Health Canada 2006). Under CEPA, the federal government can assess air pollutants and control their impact through the setting of National Ambient Air Quality Objectives (NAAQOs) and Canada-wide Standards (CWSs).

National Ambient Air Quality Objectives (NAAQOs) identify benchmark levels of protection for people and the environment. NAAQOs guide federal, territorial and regional governments in making risk-management decisions, such as local source permitting and air quality index, and are viewed as effects-based long-term air quality goals. The current framework establishes a national goal for outdoor air quality that protects health, the environment, or aesthetic properties of the environment. NAAQOs are established under CEPA but may be used differently in each province or territory (Health Canada 2006).

In June 2000, the Canadian Council of Ministers of the Environment[1] (CCME) endorsed a Canada-wide Standards (CWS) Agreement for Particulate Matter (PM) and Ozone in air, in accordance with the 1990 *Canada-wide Accord on Environmental Harmonization* and its *Canada-wide Environmental Standards Sub-Agreement*. The CWSs are intended to be achievable targets that will reduce health and environmental risks within a specific timeframe (Health Canada 2006).

Airborne particulates (or particulate matter) and ground-level ozone have been identified as priority substances for the development of CWS. In particular, the Agreement established numerical ambient concentration targets for $PM_{2.5}$ (fine particulate matter) and ozone that are to be met by 2010 (CCME 2007).

The CWS Agreement commits jurisdictions to implementation of programs under CCME's Guidance Document on Continuous Improvement and Keeping-Clean-Areas-Clean (CCME 2007). The programs must address the following pollutants:

- In the ambient environment:
  - ozone and $PM_{2.5}$
- In emissions:
  - direct $PM_{2.5}$ emissions
  - the $PM_{2.5}$ and ozone precursor pollutants NOx and VOCs
  - the $PM_{2.5}$ precursor pollutants SO_2 and NH_3

[1] With the exception of Quebec.

Although there is evidence of health effects due to the coarse fraction, the current Canada-wide Standards do not include a target for particulates larger than $PM_{2.5}$ (i.e., $PM_{2.5-10}$) as available information is not sufficient to suggest a standard at this time (CCME 2007). However, it is recommended by CCME (2007) that where monitoring facilities are in place, ambient $PM_{2.5-10}$ data be reported in at least one of the statistical forms similar to that specified for $PM_{2.5}$.

CCME (2007) acknowledges that despite the absence of local significant anthropogenic sources, such as a large city, the ambient levels of $PM_{2.5}$ and ozone in a given area may be close to or may exceed the levels of the Canada-wide Standard.

The GNWT, under the NWT *Environmental Protection Act*, developed the *Guideline for Ambient Air Quality Standards in the Northwest Territories: Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) Ground Level Ozone (O_3), Total Suspended Particulate (TSP), Fine Particulate Matter ($PM_{2.5}$)* (GNWT ENR 2011). The guideline sets standards for the maximum concentrations of CO, SO_2, NO_2, O_3, TSP and $PM_{2.5}$ acceptable in ambient air throughout the Northwest Territories. These standards are applied as a long term management goal for air quality (GNWT ENR 2011).

Table 3.1.3-1 identifies the territorial and federal ambient air quality standards.

TABLE 3.1.3-1: TERRITORIAL AND FEDERAL AMBIENT AIR QUALITY STANDARDS

Parameter and Averaging Time	NWT Ambient Air Quality Standards	National Ambient Air Quality Objectives (NAAQO)			Canada-wide Standards
		Max. Desirable Level	Max. Acceptable Level	Max. Tolerable Level	
Fine Particulate Matter ($PM_{2.5}$)					
24-hours	30 μg/m³	--	--	--	30 μg/m³
Total Suspended Particulate (TSP)					
24-hours	120 μg/m³	--	120 μg/m³	400 μg/m³	--
Annual	60 μg/m³	60 μg/m³	70 μg/m³	--	--
Carbon Monoxide (CO)					
1-hour	13,000 ppb 15,000 μg/m³	13 ppm	31 ppm	--	--
8-hours	5,000 ppb 6,000 μg/m³	5 ppm	13 ppm	--	--
Ground Level Ozone (O_3)					
1-hour	--	51 ppb	82 ppb	153 ppb	--
8-hours	65 ppb 130 μg/m³	--	--	--	65 ppb
24-hours	--	15 ppb	25 ppb	--	--
Annual	--	--	15 ppb	--	--

TABLE 3.1.3-1: TERRITORIAL AND FEDERAL AMBIENT AIR QUALITY STANDARDS					
Parameter and Averaging Time	NWT Ambient Air Quality Standards	National Ambient Air Quality Objectives (NAAQO)			Canada-wide Standards
		Max. Desirable Level	Max. Acceptable Level	Max. Tolerable Level	
Sulphur Dioxide (SO_2)					
1-hour	172 ppb 450 μg/m³	172 ppb	334 ppb	--	--
24-hours	57 ppb 150 μg/m³	57 ppb	115 ppb	306 ppb	--
Annual	11 ppb 30 μg/m³	11 ppb	23 ppb	--	--
Nitrogen Dioxide (NO_2)					
1-hour	213 ppb 400 μg/m³	--	213 ppb	532 ppb	--
24-hours	106 ppb 200 μg/m³	--	106 ppb	160 ppb	--
Annual	53 ppb 60 μg/m³	32 ppb	53 ppb	--	--

Units: μg/m³ = Micrograms per cubic metre
ppb = parts per billion by volume
ppm = parts per million by volume
Sources: GNWT ENR (2011); Health Canada (2006); CCME (2007)

3.1.3.4 Air Quality Monitoring Stations

The GNWT ENR monitors air quality in the Northwest Territories (NWT). ENR maintains and operates the NWT Ambient Air Quality Monitoring Network, consisting of four monitoring stations located in Yellowknife, Inuvik, Fort Liard and Norman Wells. Each station is capable of continuously sampling and analyzing a variety of air pollutants and meteorological conditions. The Yellowknife and Inuvik stations are operated in partnership with the National Air Pollution Surveillance (NAPS) program, a joint federal/provincial/territorial monitoring network, with the objective of tracking urban air quality trends throughout Canada. A secondary overall objective of the stations is to establish baseline levels of SO_2, H_2S, NOx, O_3 and PM ahead of development as well as track the trends and cumulative impacts from source emissions should they occur (GNWT ENR 2009e).

No long-term historic air quality measurements have been made near the Project. Limited, historic, short-term air quality measurements for SO_2, NO_2, and O_3 were conducted in 1972 and 1973 near Inuvik and Richards Island (F.F. Slaney and Co. Ltd. 1973b, 1973c). Continuous air quality monitoring has been in place in Inuvik since October 1, 2004.

The Inuvik monitoring station collects continuous data using a 60 minute timebase. Information for this indicator is obtained from the NWT Air Quality Monitoring Network, which is operated by GNWT ENR in collaboration with Environment Canada.

The National Pollutant Release Inventory (NPRI) is Canada's legislated, publicly-accessible inventory of pollutant releases (to air, water and land), disposals and transfers for recycling. Over 8,600 facilities across Canada reported to the NPRI on more than 300 listed substances, including facilities in Inuvik and Tuktoyaktuk. Monitoring data are reported for Inuvik (from the NWT Air Quality Monitoring Network) and release data are reported for the NWT (NPRI) (Environment Canada 2010f). Air quality data will be reported for the northern airshed and not divided into RSA and LSA for this proposed Project.

Parameters Monitored

Parameters monitored at the Inuvik Air Quality Monitoring Station include: fine and coarse particulate matter ($PM_{2.5}$ and PM_{10}); sulphur dioxide (SO_2), hydrogen sulphide (H2S), nitrogen oxides (NOx), and ground level ozone (O_3). Wind speed and direction and precipitation are also monitored (GNWT ENR 2009e). Data have been recorded at this station continuously since October 1, 2004.

Table 3.1.3-2 compares the parameters monitored at Inuvik compared to substances listed in NWT Ambient Air Quality Objectives, National Ambient Air Quality Objectives and Canada-wide Standards.

TABLE 3.1.3-2: COMPARISON OF PARAMETERS MONITORED AT INUVIK TO FEDERAL AND TERRITORIAL STANDARDS AND OBJECTIVES

	Parameters Monitored at Inuvik	Parameters Listed Under:		
		NWT Ambient Air Quality Objectives	National Ambient Air Quality Objectives	Canada-wide Standards
Fine Particulate Matter ($PM_{2.5}$)	✓	✓		✓
Coarse Particulate Matter (PM_{10})	✓			
Total Suspended Particulate (TSP)		✓	✓	
Hydrogen Sulphide (H_2S)	✓			
Carbon Monoxide (CO)		✓	✓	
Ground Level Ozone (O_3)	✓	✓	✓	✓
Sulphur Dioxide (SO_2)	✓	✓	✓	
Nitrogen Dioxide (NO_2)	✓	✓	✓	

Sources: GNWT ENR (2011); Health Canada (2006); CCME (2007)

Total suspended particulate (TSP) is a general term for dust. TSP includes a wide variety of solid and liquid particles found floating in the air, with a size range of approximately 50 micrometres (µm) in diameter and smaller (a human hair is approximately 100 µm in diameter). While TSP can have environmental and aesthetic impacts, it is the smaller particles contained within TSP that are of concern from a human health. Road dust, forest fires, mining activities and combustion products from vehicles, heating and electricity generation contribute to TSP levels.

Total suspended particulates are not monitored at the Inuvik station.

Fine Particulate Matter ($PM_{2.5}$) is the fraction of particulate matter with a diameter of 2.5 microns or less. It can be directly emitted, usually from combustion sources, or formed in the atmosphere due to reaction of precursor pollutants such as NOx, SO_2 and ammonia (NH3). Smoke from forest fires can result in widespread high concentrations of $PM_{2.5}$ at great distances from the fire source. Due to its microscopic size, $PM_{2.5}$ can be inhaled deep into the lungs and is associated with a range of human health concerns, especially heart and respiratory effects. It also causes visibility degradation (GNWT ENR 2009e).

Coarse Particulate Matter (PM_{10}) is the fraction of particulate matter with a diameter of 10 microns or less (i.e., the sum of the coarse and fine fractions). It is comprised of coarser material than $PM_{2.5}$ but is still inhalable. It is therefore associated with the same health concerns as $PM_{2.5}$. Some of the sources of PM_{10} include dirt and dust from roads and industrial activities, natural deposition of sand and soil, and pollen (GNWT ENR 2009e).

Carbon monoxide (CO) is a colourless, odourless gas emitted from numerous sources associated with burning of fuel (i.e., industrial activities, commercial and home heating, vehicle use). Natural sources such as forest fires also contribute to ambient carbon monoxide concentrations. Carbon monoxide affects humans and animals by interfering with the ability of the blood to carry oxygen around the body (GNWT ENR 2009e). Carbon monoxide is not monitored at the Inuvik station.

Ground level ozone (O_3) should not be confused with stratospheric O_3, which occurs at much higher elevations and forms a shield that protects life on the planet from the sun's harmful ultraviolet radiation. The gas is the same, but at ground level O_3 is regarded as undesirable due to its association with a variety of human health concerns, environmental impacts and property damage. O_3 is a highly reactive gas and is defined as a secondary pollutant. It is not emitted in large quantities from any source, but is formed through a series of complex chemical reactions involving other pollutants called precursors (e.g. NOx and volatile organic compounds or VOCs) in the presence of sunlight.

Sulphur dioxide (SO_2) is a colourless gas, with a pungent odour at elevated concentrations, which can have negative effects on human and environmental health. Certain types of vegetation (especially lichens) are very sensitive to SO_2 impacts. SO_2 also plays a role in acid deposition and formation of secondary fine particulate through chemical reactions with other pollutants in the air.

There are some natural sources of SO_2 in ambient air (forest fires, volcanoes), but human activity is the major source. Emissions of SO_2 primarily result from the burning of fossil fuels containing sulphur. Sources include natural gas processing plants, gas plant flares and oil refineries, metal ore smelting, power generating plants and commercial or residential heating.

Nitrogen oxides (NOx) consist of a mixture of nitrogen-based gases, primarily nitric oxide (NO) and nitrogen dioxide (NO_2). Emissions of both NO and NO_2 results from the high temperature combustion of fossil fuels. The predominant emission is NO, which then rapidly converts to NO_2 through chemical reaction in the atmosphere. NO is a colourless and odourless gas, whereas NO_2 is a reddish-brown colour with a pungent, irritating odour.

Greenhouse Gas (GHG) is a group of gases collectively referred to as greenhouse gases (GHGs), which primarily include carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O). GHG in the atmosphere absorbs and emits radiation within the thermal infrared range. Burning fossil fuels has increased the levels of carbon dioxide in the atmosphere. Increasing concentrations of greenhouse gases in the atmosphere are likely contributing to a rise in global temperatures, with potentially adverse effects to human and environment health.

For the purpose of this assessment, the rationale used to select key indicators includes:

- Substance emissions are monitored at the regional level, in Inuvik;
- Substance emissions have territorial and/or federal standards and objectives; and/or
- Substance emissions are directly related to this Project, such as coarse particulate matter and greenhouse gas (as it relates to vehicle emissions).

The key indicators selected for this Project include:

- Fine particulate matter ($PM_{2.5}$);
- Coarse particulate matter (PM_{10});
- Sulphur dioxide (SO_2);
- Nitrogen oxides (NOx);
- Ground level ozone (O_3);
- Greenhouse gas; and
- Visibility.

3.1.3.5 Air Quality Baseline Data

To establish a basis for consideration of ambient air quality conditions expected to occur in the Project area, a review of ambient air quality monitoring data for the Inuvik area was conducted. The following subsections summarize data from the 2009 NWT Air Quality Report (GNWT ENR 2009e). Due to mechanical failure of nitrogen oxide monitoring equipment at Inuvik in 2009, additional data from the 2008 NWT Air Quality Report are also reported (GNWT ENR 2008a). Territorial level greenhouse gas emissions are also summarized from the 2009 NWT State of the Environment Report (GNWT ENR 2009a). Where possible, historic or comparative data for the region or the territory are provided.

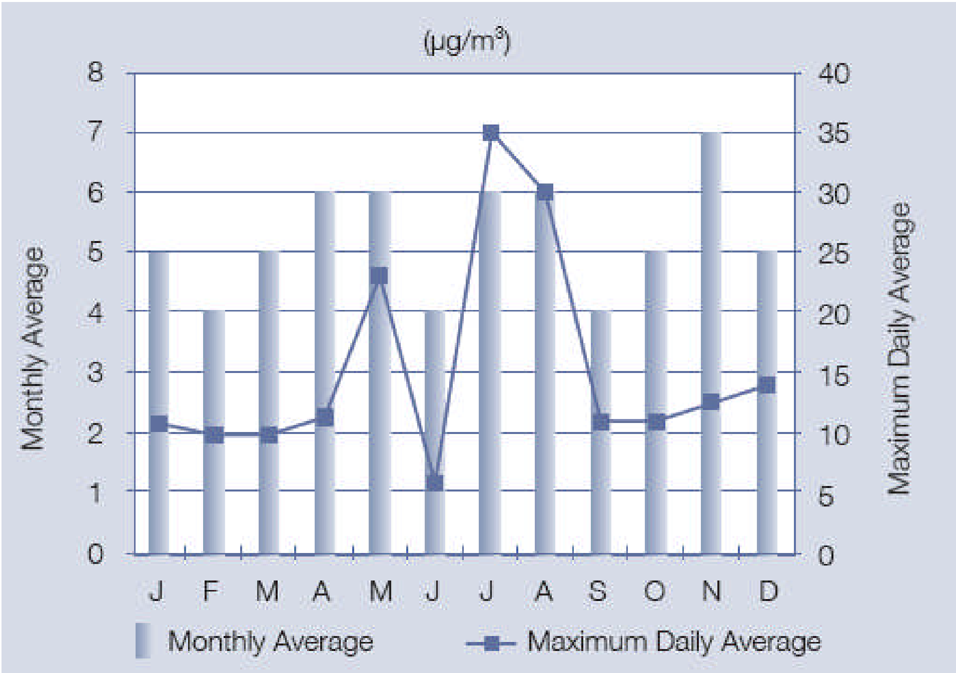
The overall air pollutant emissions for Northwest Territories, per sector and source are identified in Table 3.1.3-3 (Environment Canada 2010f). Data specific to Inuvik are discussed in the following subsections.

Overall, air quality in Inuvik in 2009 remained excellent for the most part, although the effects of dust were noticeable throughout the summer. Forest fire smoke, measured as fine 'dust' ($PM_{2.5}$), was elevated in the air in Inuvik on occasion in July and August. The coarse particle 'dust' (PM_{10}) monitor showed some high readings in the spring months related to the residual gravel on the roads following the snow melt (GNWT ENR 2009f).

Fine Particulate Matter ($PM_{2.5}$)

The 2009 Beta Attenuation Monitor (BAM) readings produced an annual $PM_{2.5}$ average of 5 $\mu g/m^3$. There were only two exceedances of the NWT 24-hour standard (30 $\mu g/m^3$) for $PM_{2.5}$, which occurred in July. These exceedances are attributed to long distant transport of smoke from forest fires burning in Alaska and the Yukon at that time. Relative to previous years, impacts from forest fires were negligible in 2009.

Figure 3.1.3-1 shows the monthly averages and maximum daily averages of $PM_{2.5}$ measured at the Inuvik station in 2009. The maximum 24-hour $PM_{2.5}$ value of 35 $\mu g/m^3$ occurred during the month of July and was attributed to forest fire smoke.



Source: Figure 11, 2009 NWT Air Quality Report (GNWT ENR 2009e)

Figure 3.1.3-1: Fine Particulate Matter ($PM_{2.5}$) at Inuvik, 2009

This substance was not monitored in the region prior to October 2004. However, historic data from Yellowknife, monitored from 2000 to 2002, indicates that the average $PM_{2.5}$ levels ranged from 3 to 5 $\mu g/m^3$ (IOL et al. 2004).

TABLE 3.1.3-3: AIR POLLUTANT EMISSIONS FOR NORTHWEST TERRITORIES, 2008

SECTORS	TPM (tonnes)	PM_{10} (tonnes)	$PM_{2.5}$ (tonnes)	SOx (tonnes)	NOx (tonnes)	VOC (tonnes)	CO (tonnes)
Industrial Sources							
Cement and Concrete Industry	71	22	10				
Mining and Rock Quarrying	564	239	91	9	4275	300	1469
Upstream Petroleum Industry	14	13	13	61	271	262	93
Downstream Petroleum Industry						35	
Petroleum Product Transportation and Distribution	2	2	2				
TOTAL INDUSTRIAL SOURCES	**651**	**276**	**116**	**70**	**4546**	**597**	**1562**
Non-Industrial Sources							
Commercial Fuel Combustion	10	8	7	4	110	4	56
Electric Power Generation (Utilities)	126	99	99	320	2,663	39	176
Residential Fuel Combustion	7	4	3	6	76	2	19
Residential Fuel Wood Combustion	266	251	251	3	24	387	1,576
TOTAL NON-INDUSTRIAL SOURCES	**407**	**361**	**360**	**334**	**2,873**	**432**	**1,827**
Mobile Sources (v6.7)							
Air Transportation	19	19	19	35	389	123	1,561
Heavy-duty diesel vehicles	11	11	11	1	345	13	83
Heavy-duty gasoline trucks	0	0	0	0	21	9	173
Light-duty diesel trucks	1	1	0	0	6	3	4
Light-duty diesel vehicles	0	0	0	0	1	0	1
Light-duty gasoline trucks	1	1	1	1	122	170	2,964
Light-duty gasoline vehicles	0	0	0	1	139	194	3,108
Marine Transportation	0	0	0	1	6	1	1
Motorcycles	0	0	0		2	3	24
Off-road use of diesel	69	69	67	9	990	84	447
Off-road use of gasoline/LPG/CNG	41	41	38	0	236	1,140	7,039
Rail Transportation	2	2	2	1	63	2	10
Tire wear & Brake Lining	4	4	1				
TOTAL MOBILE SOURCES	**150**	**150**	**140**	**49**	**2,319**	**1,742**	**15,414**
Incineration Sources							
Industrial & Commercial Incineration	0	0	0	0	0	0	1
TOTAL INCINERATION	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Miscellaneous Sources							
Cigarette Smoking	1	1	1			0	4
General Solvent Use						187	
Meat Cooking	11	11	11				
Refined Petroleum Products Retail						24	
Printing						2	
Structural Fires	1	1	1			1	5
Surface Coatings						52	
TOTAL MISCELLANEOUS	**13**	**13**	**13**			**265**	**8**
Open Sources							
Agriculture	2	0	0				
Construction Operations	190,276	56,382	10,996	0	1	0	0
Dust from Paved Roads	2,749	527	126				
Dust from Unpaved Roads	7,866	2,358	312				
Waste	11	6	6	0	2	28	31
Mine Tailings	898	72	18				
TOTAL OPEN SOURCES	**201,801**	**59,345**	**11,459**	**1**	**3**	**28**	**31**
Natural Sources							
Biogenics (vegetation, soils) and Forest Fires	52,034	44,229	36,424	31	20,816	2,282,518	428,515
TOTAL NATURAL SOURCES	**52,034**	**44,229**	**36,424**	**31**	**20,816**	**2,282,518**	**428,515**
GRAND TOTAL	**255,057**	**104,375**	**48,511**	**485**	**30,557**	**2,285,583**	**447,359**
WITHOUT OPEN AND NATURAL SOURCES	**1,222**	**801**	**629**	**454**	**9,738**	**3,037**	**18,813**

Notes:
1. A blank space indicates that no emissions data is available or applicable.
2. "0" indicates that the value was approximated to zero, as the value was very small in the context of the sector and pollutant.
3. The emission totals and sub-totals may not add up exactly, due to rounding.
4. The air pollutant emissions data was compiled in collaboration with provincial, territorial and regional environmental agencies using the latest emission estimation methodologies. It represents the most comprehensive information on emissions of key air pollutants available in Canada.
5. Emission summaries and trends for a given year may be different from those previously published by Environment Canada, other governmental agencies and international organizations.
6. A portion of emissions from the Marine Transportation sector is attributed to movement ("innocent passage") of domestic and international commercial vehicles through provincial waters. These emissions have been proportionally allocated to the provinces nearest to the release of the emissions in the different waterways.

Source: Environment Canada (2010f)

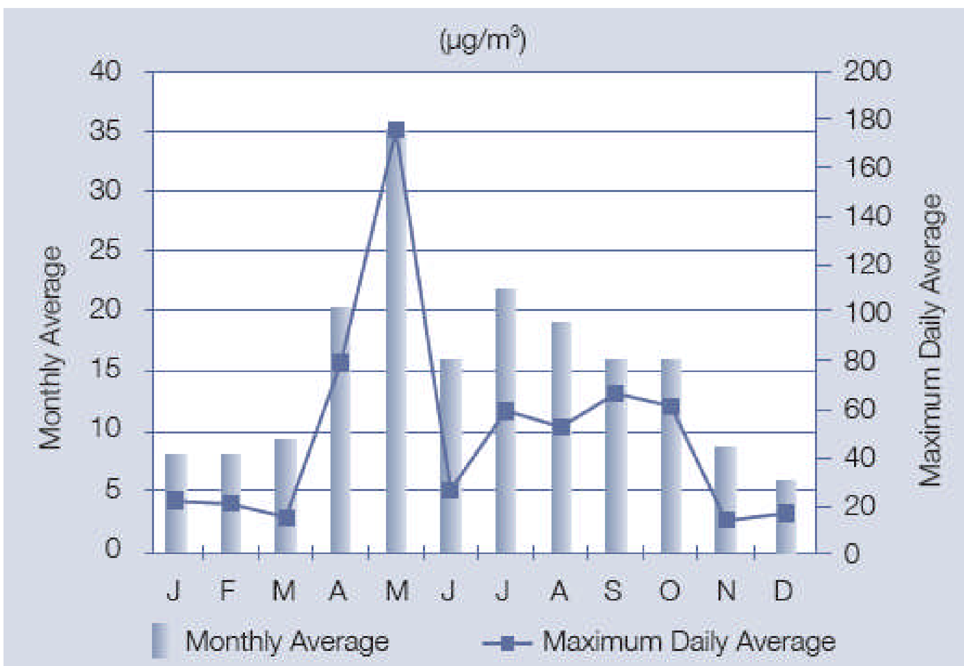
Coarse Particulate Matter (PM_{10})

The maximum daily average measured from the PM_{10} BAM in Inuvik in 2009 was 175µg/m^3, recorded in May, which coincided with the highest hourly maximum (415µg/m^3). There were 10 exceedances of the adopted 24-hour standard (50µg/m^3), which generally occurred in the snow-free months. Similar to previous years, the spring-time levels were elevated and were representative of the typical 'spring-time dust event' associated with residual winter gravel.

The PM_{10} exceedances were more numerous than previous years, which may be attributed to influences from local construction activities.

Figure 3.1.3-2 shows the monthly averages and the maximum daily average concentrations of PM_{10} from the BAM in Inuvik. The spring spike is attributed to the residual winter gravel following the thaw.

Historic or comparative data is not available for the region or territory.



Source: Figure 12, 2009 NWT Air Quality Report (GNWT ENR 2009e)

Figure 3.1.3-2: Coarse Particulate Matter (PM10) at Inuvik, 2009

Sulphur Dioxide (SO_2)

The 2009 annual average was less than 1 µg/m^3, the maximum 1-hour average was 8 µg/m^3. The SO_2 concentrations measured in 2009 were very low and similar to previous year's results, with no exceedances of the NWT hourly (450 μg/m³), 24-hour (150 μg/m³) and annual average (30 μg/m³) standards.

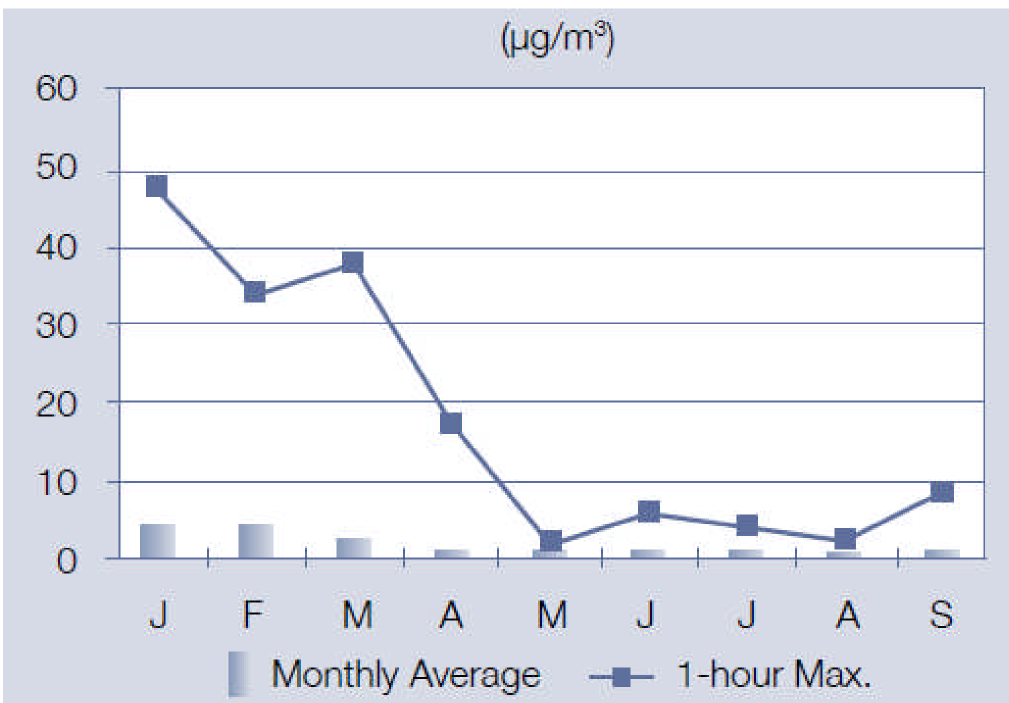
In comparison, IOL et al. (2004) passively monitored SO_2 levels in Inuvik from August 2001 to September 2002. During that time, the annual average of SO_2 was 0.1 ppb or 0.41 μg/m³.

Nitrogen Oxides (NOx)

The focus of NOx monitoring is on the NO_2 portion in determining air quality, although NO is of interest for other reasons (e.g. assessment of secondary pollutant formation).

The Inuvik NOx analyzer suffered a serious breakdown in October of 2008 and was not fully operational again until November of 2009. This resulted in the inability to record NO_2 data for 2009. The following information is based on data recorded during the nine months when the analyzer was operational in 2008.

The 2008 Inuvik data show that there were no exceedances of the 1-hour and 24-hour national and territorial standards for NO_2 (GNWT ENR 2008a). The maximum 1-hour average was 48 μg/m³ and the annual average was 2 μg/m³. Figure 3.1.3-3 shows the 2008 monthly averages and highest hourly concentrations.



Source: Figure 13, 2008 NWT Air Quality Report (GNWT ENR 2008a)

Figure 3.1.3-3: Nitrogen Dioxide (NO_2)at Inuvik, 2008

Figure 3.1.3-3 shows both the highest monthly averages and the highest hourly concentrations of NO_2 occurred during the winter months. Meteorological data collected over the last four winters has shown that Inuvik is prone to winter inversions and experiences more inversion days than the other three regions. It is not uncommon in the middle of winter to see consecutive days of extremely cold temperatures accompanied with very low wind speeds (calms), reducing dispersal of pollutants.

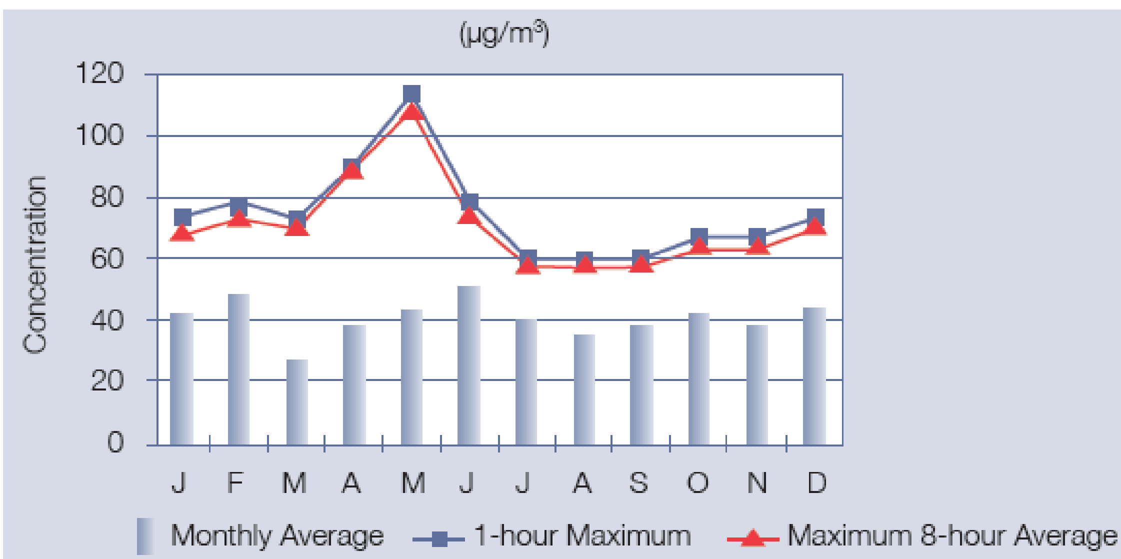
In comparison, nitrogen dioxide was passively monitored from August 2001 to September 2002 in the Inuvik region. The annual average concentration was 0.4 ppb or 0.8 μg/m^3 (IOL et al. 2004).

Ground Level Ozone (O_3)

The maximum 1-hour average was 112 μg/m^3, while the maximum 8-hour average was 106 μg/m^3. Neither the 1-hour national standard (160 μg/m^3) nor the 8-hour NWT standard (130 μg/m^3) for ground level ozone was exceeded in 2009. The annual average was 40 μg/m^3, which is typical of background levels.

The typical elevated readings in the spring-time were observed, which is consistent with historical data.

Figure 3.1.3-4 shows the maximum hourly and maximum 8-hour average per month as well as the monthly averages for ground level ozone recorded in 2009.



Source: Figure 13, 2009 NWT Air Quality Report (GNWT ENR 2009e)

Figure 3.1.3-4: Ground Level Ozone (O_3) at Inuvik, 2009

Historic, short-term monitoring in the region conducted in 1972 and 1973 indicated that ozone levels were low, i.e., below the method detection limits (F.F. Slaney and Co. Ltd. 1973b, 1973c). Additional passive field monitoring was completed near Inuvik from August 2001 to September 2002 to determine background ozone levels. Consistently elevated ground level ozone concentrations were identified (i.e., annual average concentration of 23.7 ppb or 46.5 μg/m^3), that likely result from the intrusion of stratospheric ozone from weather systems passing through the region (IOL et al. 2004). The stratosphere (i.e., the region of the atmosphere containing the ozone layer) is closer to the ground at high latitudes than farther south (IOL et al. 2004).

Carbon Monoxide (CO)

Carbon monoxide is not actively monitored at the Inuvik station. Carbon monoxide in the environment typically results from partial or incomplete combustion, usually from vehicle exhaust. Given the absence of anthropogenic sources, such as vehicles, near the proposed route (other than intermittent snowmachines and aircraft), background CO levels were assumed to be zero for the air quality assessment.

However, the Northwest Territories Power Plant for Inuvik reports 70 tonnes of carbon monoxide emitted in 2009 (Environment Canada 2008).

Greenhouse Gas Emissions

Greenhouse gas emission data are collected at the territorial level. Currently the NWT is producing around 2300 Kt of CO2e /year. GHG emissions in the NWT are increasing steadily. The increase is being caused primarily by resource development activities. The mining sector currently dominates as the major GHG emitter but the Mackenzie Gas Project, if developed, would place the oil and gas sector on top as the major GHG producer (GNWT ENR 2009a). By 2020 it is projected that the NWT will be emitting around 3800 Kt of CO2e/year, a 65% increase in emissions from current levels (GNWT ENR 2009a).

3.1.3.6 Climate and Meteorological Conditions Relating to Air Quality

Climate and meteorology conditions relating to air quality are described in Section 3.1.2.

3.1.4 Noise

Although noise is sometimes considered to be any sound it is more correctly defined as loud, unwanted, unpleasant or unexpected sound. Noise is considered during an EIS because it has the potential to affect both humans and wildlife. Typically, noise considerations relate to occupational noise impacts. However, environmental noise effects are also important.

Noise effects assessments compare expected future noise levels to existing noise levels. This baseline section characterizes the current sound environment (i.e., noise level) in the vicinity of the proposed Highway. Baseline conditions are based primarily on work conducted during the Mackenzie Gas Project (IOL et al. 2004) and on broad guidelines established by various agencies.

The descriptor used to measure environmental sound is the energy equivalent sound level (L_{eq}). The L_{eq} value, expressed in decibels (dBA), is the energy-averaged, A-weighted sound level for the complete measurement interval. It is the steady, continuous sound level over a given period that has the same acoustic energy as the actual varying sound levels occurring over the same period in the measured environment.

3.1.4.1 Noise Spatial Boundaries

The spatial boundary for noise is represented by the area in which effects are likely to occur. The local study area is considered to be within 0.5 km of the Highway center-line while the regional study area is defined the area within 15 km of the Highway center-line.

3.1.4.2 Relevant Standards and Guidelines

Federal, provincial and municipal levels of government have different roles and responsibilities with respect to noise-related issues. Standards related to noise levels are primarily directed at occupational exposure limits. Guidelines for environmental noise levels are less developed and have been produced primarily in the United States.

Construction noise has traditionally been excluded from impact assessments because, although it can have great magnitude, it is usually temporary in nature.

Occupational

Federal

The federal government is responsible for establishing and ensuring compliance with standards for noise emission labelling and maximum noise emission for consumer products, equipment, and vehicles. As well, the federal government also establishes guidelines for noise control over interprovincial transportation systems including aircraft, trains and navigable waterways. Health Canada is legally required to provide expert advice on the health effects of environmental noise to environmental assessments involving other federal departments.

Federal noise exposure regulations are found in the *Canada Labour Code* (Part II) and the *Canada Occupational Health and Safety Regulations* (Section 7). Section 7.4 states that "no employee shall, in any 24 hour period, be exposed to a noise exposure level (L_{ex} 8) that exceeds 87 dBA."

Provincial/Territorial

Provincial and territorial governments establish guidelines for noise control in land use planning. They authorize and assist municipalities in creating and implementing municipal plans and noise control by-laws to abate individual sources of noise. Provincial and territorial governments are also responsible for controlling the operational noise levels of many consumer products, equipment and vehicles.

Noise exposure limits in Northwest Territories workplaces are found in the *General Safety Regulations* under the territorial *Safety Act* (Section 30 and 31, Schedule A, Table 1). Table 3.1.4-1 summarizes these limits:

TABLE 3.1.4-1: NWT *SAFETY ACT* – OCCUPATIONAL NOISE EXPOSURE LIMITS	
Continuous Noise	
Sound Level (dBA)	**Maximum Exposure (hours per day)**
80	16
85	8
90	4
95	2
100	1
105	0.5
110	0.25
115	0.125
>115	0
Impulse Noise	
Peak Sound Pressure Level (dBA)	**Maximum Permitted (impulses per 8 hours)**
120	10,000
130	1,000
140	100
>140	0

An employer must ensure that an employee is not working with noise levels above the limits set in the regulation. The limit is 85 decibels for 8 hours within a 24 hour period. If the employee works with noise levels higher than 85 decibels for 8 hours, then the employer must decrease the number of hours the employee works at that noise level, according to precise noise levels and work hours set in the regulation. If the noise level is higher than the legal limit, the employer must provide the employee special hearing protection equipment. Prior to providing the hearing protection equipment, the employer is legally obliged to try to decrease the noise level and separate the employee from the source of the noise.

Municipal

Most noise control legislation has been enacted at the municipal level. Municipalities exercise environmental noise control through municipal noise control by-laws, municipal land use plans and zoning, traffic management and road noise barrier retrofit programs.

The Highway is located outside of municipal boundaries; therefore, municipal noise by-laws are not applicable. However, typical municipal regulations limit construction activities to "normal working hours" to minimize disturbance. Normal working hours are often defined as 07:00 to 19:00, Monday to Friday, with work outside these times requiring a municipal variance.

3.1.4.3 Environmental

The NWT has no acceptability criteria for noise levels associated with construction activities or road activities. Little information is available for acceptable limits of environmental noise.

3.1.4.4 Existing Noise Conditions

The proposed Highway is located in a remote, generally uninhabited area of NWT. Existing noise conditions are dominated by natural environment contributions such as wind and rain (IOL et al. 2004). Anthropogenic contributions are associated with annual winter traffic on the existing winter road, local off-road ATV and snowmachine traffic, helicopter and aircraft overflights, and associated hunting that occur seasonally in the area.

Typical noise level of quiet outdoors is 35 dBA; intermittent sources, such as winter traffic, measure in the 75 to 85 dBA range (Alberta EUB 2007). Elevated noise levels, from traffic, aircraft, all-terrain vehicles, and snowmachines are infrequent, of short duration, and transient in nature. Therefore, current noise conditions along the proposed route are expected to mostly be at 35 dBA with occasional peaks of 75 to 85 dBA when off-road vehicles or aircraft pass through the area.

3.1.4.5 Previous Noise Monitoring

Baseline sound levels have been recorded at the proposed Mackenzie Gas Project's Inuvik Area Facility which was considered representative of ambient sound levels along most of the pipeline corridor. Measurements were recorded in December 2002 (winter) and July 2003 (summer) to account for seasonal variations that may affect sound levels. Table 3.1.4-2 summarizes the measurement results.

TABLE 3.1.4-2: BASELINE SOUND LEVELS AT INUVIK AREA FACILITY

Survey Period	Sound Level				
	Daytime L_{eq} Day (dBA)	Night-time L_{eq} Night (dBA)	Daily L_{eq} (dBA)	Minimum Hourly L_{eq} (dBA)	Maximum Hourly L_{eq} (dBA)
Dec. 3-4, 2002	21	19	20	17	24
July 5-6, 2003	33	25	31	21	39

Source: IOL et al. (2004)

Sound levels at the survey sites were low and were consistent with remote environments. During periods when the winds were light, the sound of the wind dominated and raised sound levels to between 20 and 30 dBA; short periods of wind and rain caused the sound level to rise to between 30 and 40 dBA. There is currently no industrial presence within audible distance of the monitoring site. The only audible sounds were from wind and occasional air traffic at the Inuvik Airport.

The daily sound level after validation for the Inuvik Area Facility were between 20 dBA (winter) and 31 dBA L_{eq} (summer).

The Inuvik Area Facility is approximately 20 km east of Inuvik and the proposed Highway alignment. These data are considered representative of noise conditions in the study area. It is reasonable to assume that background noise levels along the proposed Highway corridor will have a similar range to those found during the Mackenzie Gas Project and be approximately 35 dBA.