# Kiggavik Project

# Environmental Impact Statement

Tier 3 Technical Appendix 2G

# Kiggavik to Sissons Access Road

December 2011

CREATING AND DELIVERING BETTER SOLUTIONS

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**KIGGAVIK PROJECT**
**KIGGAVIK – SISSONS ACCESS ROAD REPORT**

**V33101016**

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## APPENDICES

# 1.0 INTRODUCTION

This Report is one of a group of studies performed by EBA of various aspects related to access and infrastructure for the proposed Kiggavik Mine Project. The other studies include:

- Northern and Southern All Season Road Report
- Physical Environment Within the DEIS Report
- Andrew Lake Dyke Report
- Port Facility Report
- Mine Site airstrip Report
- Winter Road Report
- Mine Site Building Foundations Report

Figure 1.0-1 below shows the general location of the Kiggavik Project.

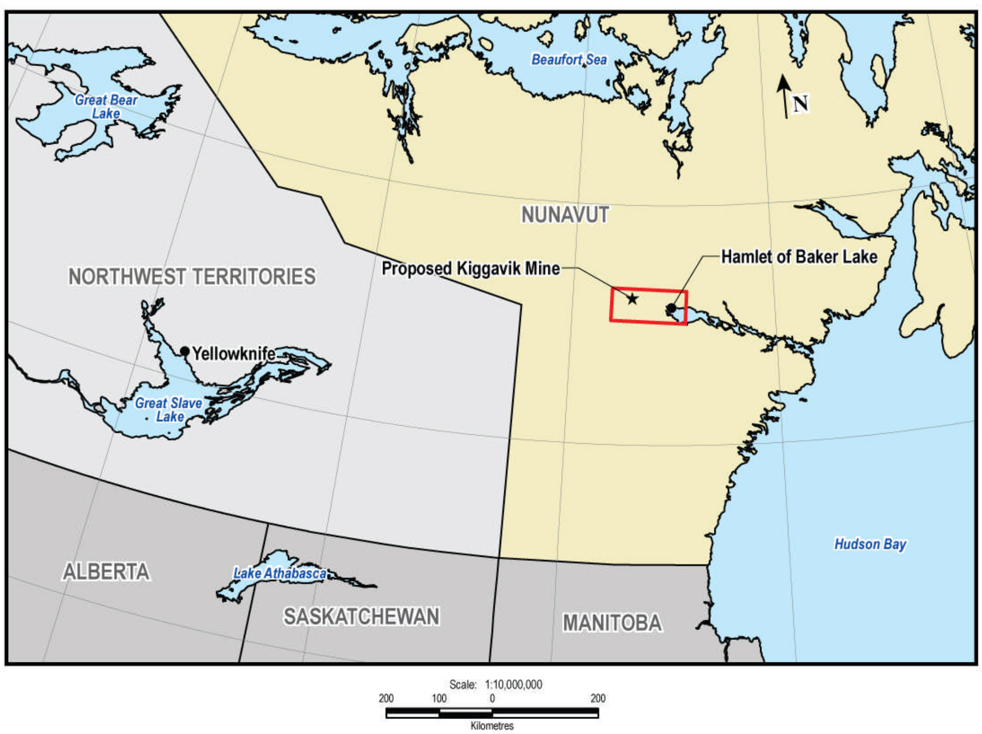



**Figure 1.0-1 Key Plan**

Figure 1.0-2 on the following page shows the various project elements discussed within this Report and the other Reports listed above.

# 2.0 KIGGAVIK TO SISSONS ACCESS ROAD

## 2.1 GENERAL

A 19.6 km long road is required to connect mining operations at the End Grid and Andrew Lake area (Sissons) to the main mine/mill site (Kiggavik). Andrew Lake is located approximately 17.5 km southwest of Kiggavik. The general alignment of the road is shown in Figure 2.1-1 below (Figure has been extracted from the 2008 Project Proposal Report).

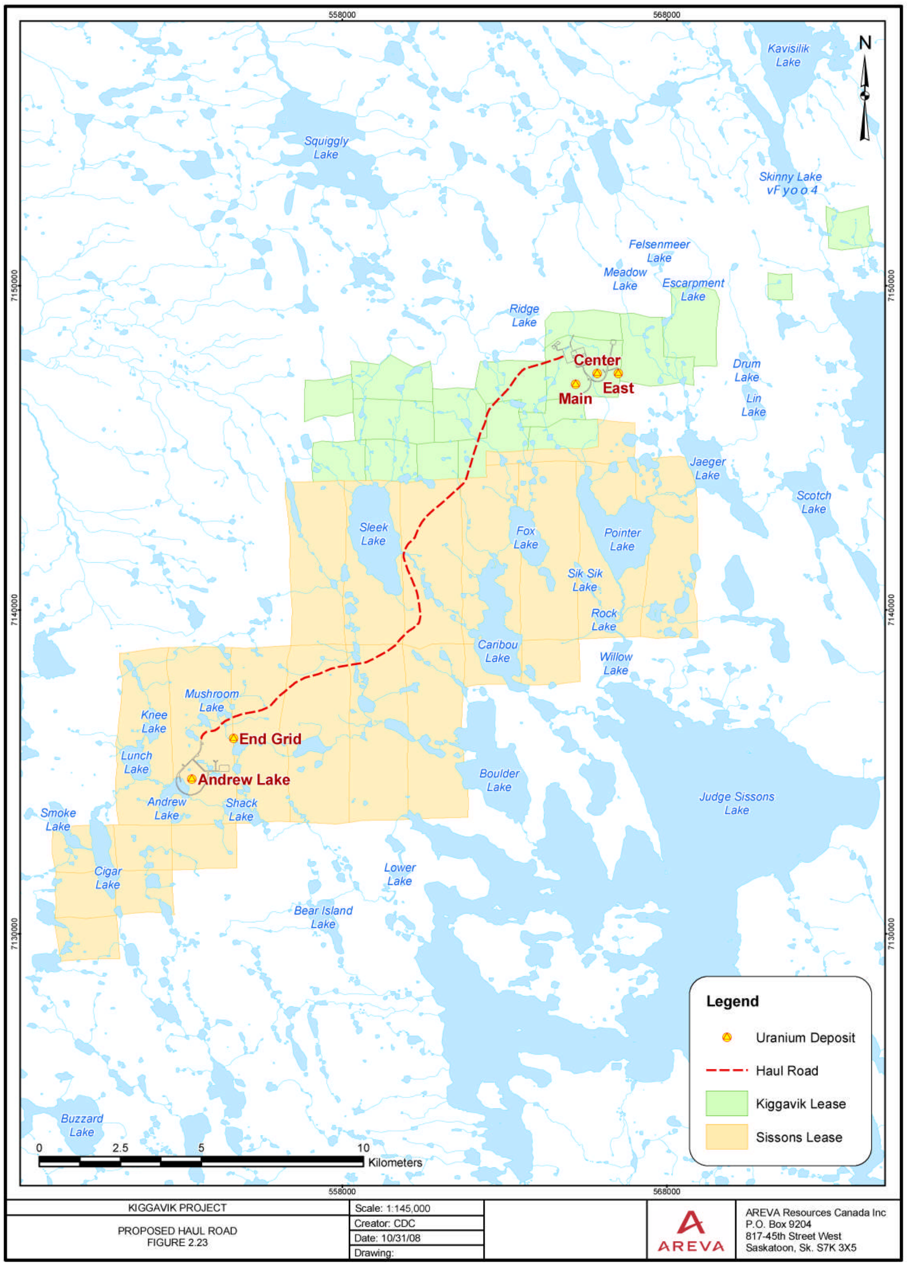



**Figure 2.1-1 Access Road General Alignment**

Two bridges (less than 50 meters in length) will be required along the route.

The road will be a 10 meter wide road, built with run-of-quarry embankment material, with safety berms where required. There will be no earth cuts along the alignment, and the only cut sections will be through rock.

Material for the rock embankment and road surfacing will be derived from rock quarries developed adjacent to the road or waste rock material obtained from open pit mine operations.

### 2.1.1 Design Principles & Criteria

The design principles developed for this project are based on:

- Producing a design that is cost-effective with respect to construction costs;
- A design that produces good operating characteristics for the design vehicles;
- Minimal maintenance requirements, both on an annual and life-cycle basis;
- Respecting the environmental and archaeological constraints.

### 2.1.2 Geometric Design Criteria

The primary vehicles that will be using the road are:

- Trailers that can be transported using tractors (highway trucks). The proposed unit would consist of a hi-drive tractor with two custom designed B-train trailers. The 12-axle unit would be capable of hauling a payload of 120 tonnes;
- Bus, emergency vehicles and pick-ups. Occasionally, for maintenance or repair purposes, mine haul trucks will also use the road.

The road design criteria have been determined using the Mine Health and Safety Act, Northwest Territories and Nunavut. The act indicates that the minimum haul road width be three times the maximum width of the largest haul truck and safety berms of at least three-quarters the height of the haul truck tire are required if the embankment is greater than 3 m high.

If this access road and its associated design vehicle are considered respectively a haul road and haul vehicle, the following design criteria would apply:

- Design maximum haul truck operating speed: 60 km/h
- Minimum width of travelling surface: 10 m (3 times the maximum width of the largest haul truck)
- Minimum safety berm height if embankment is over 3 m high: 2.2 m
- Maximum grade: 5%
- Minimum horizontal curve radius: 500 m

### 2.1.3 Geotechnical Design Cross Sections for Varying Subsurface Conditions

A typical design cross-section for the road is shown in Figure 2.1-2. With the exception of the width of the travelling surface and the requirement for safety berms when the embankment thickness exceeds 3.0 m, the road is configured identically to the Northern All-Season Road.

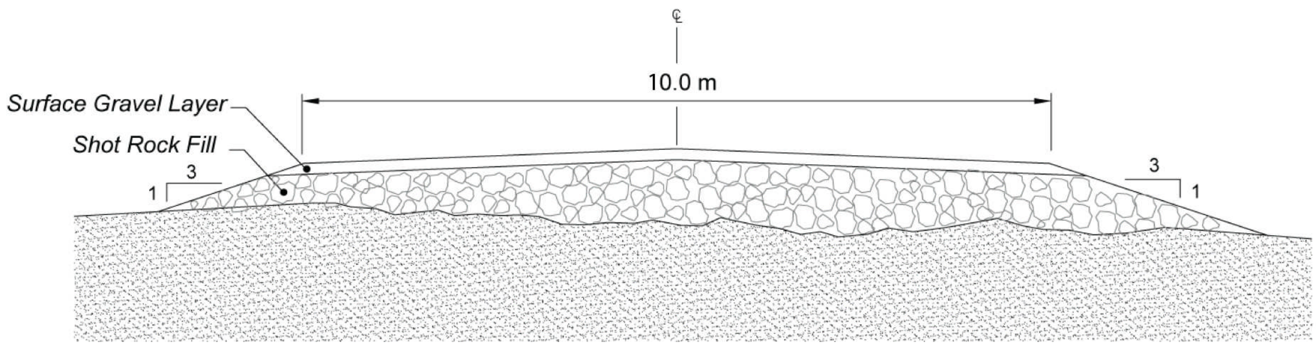



**Figure 2.1-2 Road Design Cross Section**

In non-permafrost areas, it is common for road designs to incorporate both cuts and fills to establish the final grade along the alignment. However, in permafrost areas, disturbing sensitive overburden soils and surface vegetation can result in thaw degradation and the creation of unstable ground. Consequently, the design for this project calls for fill-construction only, wherever the road passes over overburden soils. Minimum depth of embankment fill is specified for various "terrain types", and is designed to be sufficient to construct a stable road embankment and to protect the underlying permafrost. In this design, cuts have only been incorporated in bedrock.

The following generalized "terrain types" have been considered in the design of the road:

**Terrain Type 1:**

Terrain Type 1 is relatively dry, stable, till and outwash deposits, on level terrain overlain by a thin organic cover. There is little surface expression of ice-rich permafrost conditions. Figure 2.1-3 shows the typical road cross-section associated with traversing this type of terrain.

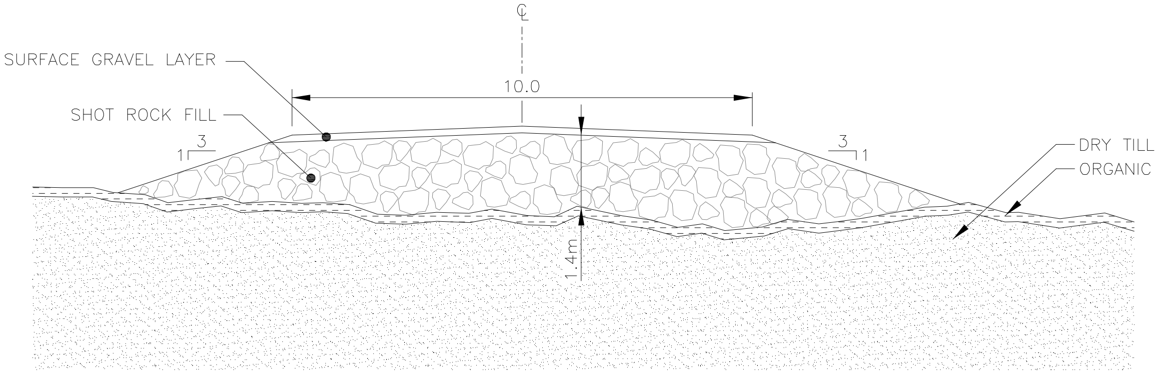



**Figure2.1-3: Typical Road Cross Section on Relatively Dry, Stable, Till (Terrain Type 1)**

### Terrain Type 2:

Terrain Type 2 includes wet till and till with ice-rich permafrost features indicative of thermally sensitive terrain. The terrain is relatively wet, with some expression of ice-rich permafrost conditions, overlain by a thin to moderate organic cover Figure 2.1-4 shows the typical road cross section associated with crossing this type of terrain.

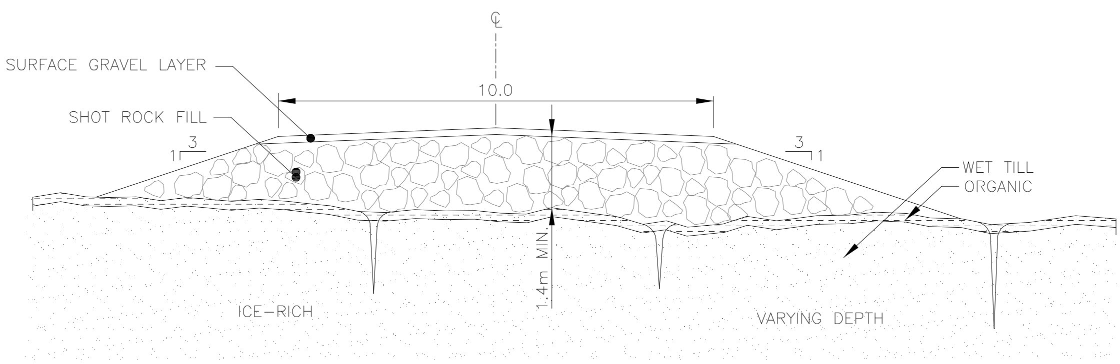



**Figure 2.1-4: Typical Road Cross Section on Wet Till or Till with Ice-Rich Patterned Ground (Terrain Type 2)**

### Terrain Type 3:

Terrain Type 3 includes alluvial silts & sands and/or organic peatlands & ice-rich permafrost. This generalized terrain usually consists of thick organics and poorly drained, fine grained, deposits with moderate to thick organic cover and distinct expressions of ice-rich permafrost conditions. In general, this terrain is unfavourable and was avoided wherever possible. Figure 2.1-5 shows the typical road cross section associated with traversing this type of terrain.

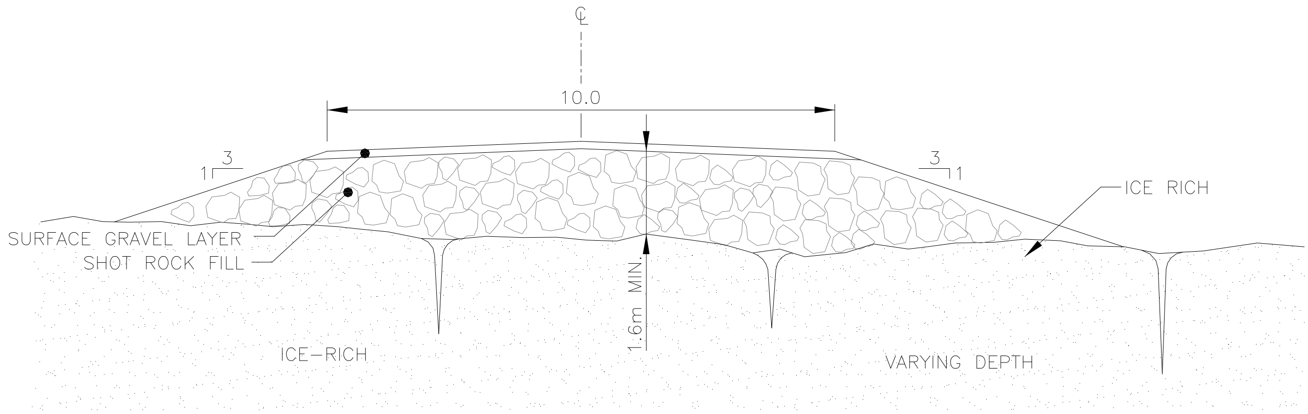



**Figure 2.1-5 Typical Road Section on Organic and Wet Fine Grained Deposits (Terrain Type 3)**

### Terrain Type 4:

Terrain Type 4 comprises frost shattered and boulder covered terrain. The terrain has rugged micro-relief and sometimes depressions are infilled with sediment and/or organics. The fill height required on this terrain is controlled by the micro-relief and geometric constraints to provide a reliable road surface.

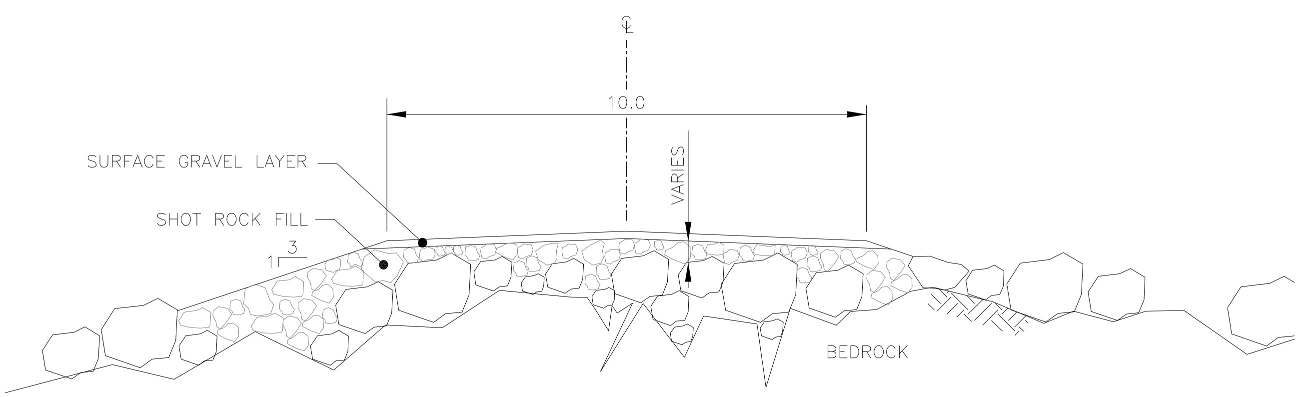



**Figure 2.1-6 Typical Road Section on Frost Shattered and Boulder Covered Terrain (Terrain Type 4)**

### Terrain Type 5:

Terrain Type 5 comprises all bedrock terrain, including exposed/shallow undulating bedrock. This terrain unit is typically irregular and non or sparsely vegetated. This terrain unit is present at the quarry sites and at other areas where exposed bedrock was found. Figure 2.1-7 shows the typical road cross section associated with traversing this type of terrain.

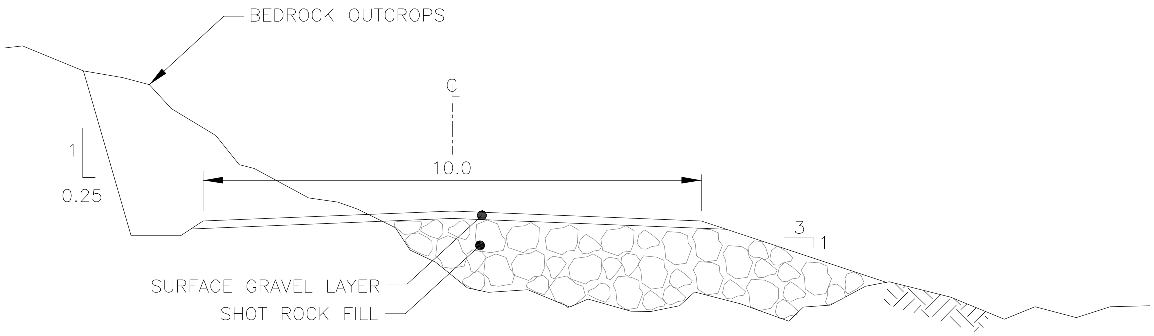



**Figure 2.1-7: Typical Road Cross Section on Bedrock (Terrain Type 5)**

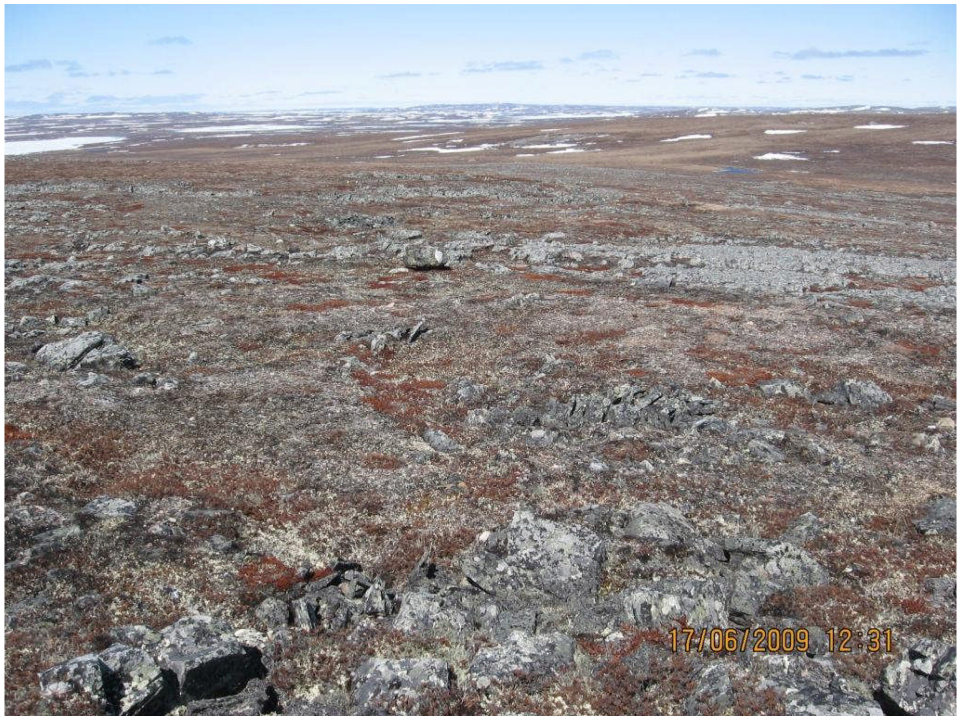
Table 2.1-1 provides the design parameters for minimum depth of embankment fill by Terrain Type.

**TABLE 2.1-1: DESIGN PARAMETERS FOR MINIMUM DEPTH OF EMBANKMENT FILL**

| Terrain Type | Terrain Description | Depth of Embankment Fill |
|---|---|---|
| 1 | Dry (Ice-poor) Till<br>(relatively dry, stable, upland till and outwash deposits, on level terrain overlain by a thin organic cover) | 1.4 m |
| 2 | Wet (Ice-medium to Ice-rich) Till<br>(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 | Alluvial Silts & Sands (Ice-rich) or Thick Organic Peatlands & Ice-Rich Permafrost<br>(wet, fine grained, deposits with distinct expressions of ice-rich permafrost conditions, moderate organic cover) | 1.6 m - 1.8 m |
| 4 | Frost shattered and boulder covered terrain - rugged micro-relief, with depressions infilled with sediment and/or thin organics) | 0.5 m to 1.0 m - Varies based on size of rock (smooth over) |
| 5 | Exposed Bedrock - rock (irregular to relatively smooth outcrops, rock cuts) | <0.5m |

As indicated in Table 2.1-1, a minimum depth of quarried rock embankment of about 1.4 m is recommended over glacial till terrain for construction, operational and maintenance considerations. Construction with less fill often results in greater maintenance effort and cost, and ultimately additional fill materials will be required. Increased depths of embankment will be required across low-lying, wet areas and areas of ice-rich ground that cannot be avoided, as shown in the photo below, and will most likely be 1.8 m thick or greater.


Construction across wet, undefined drainage channels containing thick organics will also require a greater depth of embankment fill to bridge-over and protect the underlying terrain and allow for a competent road surface. The required depth of embankment over bedrock-exposed terrain will be controlled by the micro-topography of the area, as shown in the photo below, but in general will be 0.3 m to 0.5 m thick.




## 2.2 DETAILED ROUTE DESCRIPTION

### 2.2.1 Geometrics

The alignment and profile for the proposed road are shown in Appendix B. The road is 19.6 km long. The locations and suggested sizes of culverts for creeks and streams are also shown on the noted drawings.

### 2.2.2 Geotechnical Route Description

The surficial landforms along the road between the Sissons and Kiggavik mine/mill sites comprise glacial till overlying Precambrian intrusive igneous and metamorphic bedrock. The glacial till overburden soils are interrupted by bedrock outcrops, which become more dominant at the Kiggavik site. Widespread areas of thin till veneer are present and bedrock boulder fields frequent the route. More recent alluvial sediments occur as thin deposits of fine-grained sand and silt presenting themselves locally in topographic depressions (low-lying, areas) and along stream channels. The general surficial geology of the project area is well described by the Geologic Survey of Canada, Schultz Lake south, Nunavut, Map 2120A at scale 1:100,000 (McMartin, I., et al., 2008; Aylsworth, J.M., 1990); and Aylsworth, J.M. et al., 1990, 1989, 1985).

Generalized terrain and topographic conditions observed along the proposed road between the Sissons and Kiggavik mine/mill sites, beginning at the proposed Sissons site at the west end of the route (Km 0) and traveling east towards Kiggavik (Km 19.6) are described in Table 2.2-1 below.

Generalized Design cross sections for the varying subsurface conditions (Terrain types referenced in table 2.1-1) are shown in the table. These design cross sections will be revised and refined during the next stages of design as more information becomes available.

**TABLE 2.2-1: GENERALIZED TERRAIN CONDITIONS ALONG THE PROPOSED ACCESS ROAD**

| Kilometres | | Design Terrain Type | Description of Terrain Conditions |
|---|---|---|---|
| 0 | 2.0 | 2 | The proposed route departs the Sissons site in a northeasterly direction along a relatively level till blanket crossing some wet areas with undefined flow that require cross drainage. The wet areas generally support a thicker layer of organics and may be underlain by alluvial sediments. |
| 2.0 | | 4 | The route crosses a wet drainage area with a defined channel that will require a bridge structure. The crossing is mapped as a post-glacial active drainage system with alluvial soils. |
| 2.0 | 6.7 | 2 | After the first significant crossing the route beings to climb from about El 170 m to El 210 m (difference of 40 m) over a distance of 1.5 km and then proceeds to descend over a distance of 2.5 km to the second significant water crossing at Km 6.7 (at a topographic low of about El 150 m). Two potential quarry sites were identified to the south of the alignment at about Km 3. |
| 6.7 | | 4 | Crossing requires a bridge across a defined channel with a broad wetted perimeter along either side of the defined channel with a visually thick organic cover. Surficial mapping on either side of the crossing shows alluvial soils covered by a layer of organics. |
| 6.7 | 11.3 | 4 | The route traverses onto a relatively smooth, rolling till/morainal blanket that varies from dry to wet conditions between the topographic highs and lows, maintaining an average elevation of about 160 ml. |
| 11.3 | | 2 | At Km 11.3, the route encounters a third significant stream crossing at the outflow of Sleek Lake (~El 150 m), which flows into Caribou Lake. The crossing is wide and requires a bridge structure. |
| 11.3 | 17.2 | 4 | After the bridge crossing, the route again climbs onto stable, rolling till veneer terrain with shallow grades varying in elevation between 160 m and 175 m. A few frost shattered bedrock deposits were noted along route denoting the thin till and underlying bedrock conditions. The route crosses wet, low-lying sections at about Km 15.7 and Km 16. 4, and crosses a defined channel between Km 17.1 and 17.2. Surficial mapping denotes rock 500m northwest of the alignment, at about Km 16, which may be an appropriate quarry site, but the area was not visit during the field reconnaissance. A deposit of outwash material was noted during the field program, so rock could be exposed a little further away from the alignment. This area should be investigated if required. |
| 17.2 | 19.6 | 2 | At Km 17.2, the route begins to climb in elevation with patches of frost shattered bedrock, from about El 175 m to El 210 m at the proposed Kiggavik mine/mill site at Km 19.6. Exposed bedrock becomes more prevalent at the proposed Kiggavik site and till veneer becomes predominate with increasing frost shattered rock in the area. |

### 2.2.3 Water Crossings

Three bridges are required along the route, all less than 50 meters in length. The remainder of the water crossings can be accommodated with culverts. Additional bridges may be required if fisheries issues dictate the need for a bridge rather than a culvert

Hydrology work on the Kiggavik project has been undertaken by Golder Associates (Golder). This information has been used to aid in the initial assessment of the stream crossing requirements for the road design. During detailed design, the hydrology information collected by Golder will be used to help determine the type and size of structures to be used. EBA anticipates the following typical structure types will be used:

- 2 Single-span bridges;
- 5 Culverts;
- 5 Coarse rock fills.

The following table 2.2-2 summarizes the water crossings and proposed crossing methods.

TABLE 2.2-2 WATER CROSSINGS ALONG ROAD

| Crossing # | Plan/Profile Sheet # | Crossing Type | Bridge Length |
|---|---|---|---|
| 0.8 | 001 | rockfill | |
| 1.6 | 001 | rockfill | |
| 2.0 | 002 | bridge | 5 |
| 2.2 | 002 | rockfill | |
| 3.6 | 002 | rockfill | |
| 6.7 | 003 | culvert | |
| 11.3 | 004 | bridge | 25 |
| 14.1 | 005 | culvert | |
| 15.6 | 005 | culvert | |
| 17.2 | 005 | culvert | |
| 18.4 | 006 | rockfill | |
| 19.6 | 006 | culvert | |

### 2.2.4 Borrow Sources and Quarry Locations

Approximate preliminary material quantities were developed using the Lidar information along the road. The quantities were calculated applying the typical sections outlined in Section 2.1.3.and modeling the finished road surface in Civil3D. Results are summarized below and have been extrapolated from representative sections that were carefully designed along the alignment.

- 20 mm minus surfacing material – 125,000 $m^3$.
- 200 mm minus subgrade rock fill – 950,600 $m^3$.

The following table shows estimated volumes based the level of design completed to date.

**TABLE 2.2-3: ROAD QUANTITIES**

| Start Station (km) | End Station (km) | Design Terrain Type | Embankment Fill ($m^3$) | Surfacing Material ($m^3$) |
|---|---|---|---|---|
| 0 | 2 | 2 | 118,000 | 13,000 |
| 2 | 6.7 | 4 | 202,000 | 30,000 |
| 6.7 | 11.3 | 2 | 272,000 | 29,000 |
| 11.3 | 17.2 | 4 | 254,000 | 38,000 |
| 17.2 | 19.6 | 4 | 104,000 | 15,000 |
| | | **Total** | **950,000** | **125,000** |

It is assumed that the materials required to construct the road would either be from quarry sites or waste rock obtained from the open pits.

Quarry sites are limited in number and size along the road. Prospect locations have been identified and are shown on Figure 2.2-1. These locations are not equally spaced along the alignment and will necessitate the need for fairly long quarry hauls to construct the road if they are to be considered the only source of embankment material.

### 2.2.5 ARD and ML Potential

ARD and ML potential were not evaluated for the road.

## 2.3 ALTERNATIVES CONSIDERED

There were no obvious alternatives to consider in the field. The terrain is generally consistent. Routing of the road was developed on choosing the best overall terrain conditions.

Construction staging for the road has not been studied in detail to date. A possible scenario would be to construct the majority of the road after mining has commenced at the Kiggavik site. However, a section of the road from 17.5km to Kiggavik may need to be completed during the construction of the access road to allow for access to the proposed Pointer Lake Airstrip. This short section would most likely be constructed to the same travel lane width as the access road anticipating road widening to access road standard in the future.

## 3.0 CLOSURE

We trust this report meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

Yours truly,

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