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E/06/0903
06-1413-021

July 7, 2006

Cumberland Resources Ltd.
Suite 950, One Bentall Centre
505 Burrard Street
Vancouver, BC
V7X 1M4

Attention: Mr. Raj Anand

RE: DESIGN RECOMMENDATIONS FOR THE PROPOSED TEHEK LAKE ACCESS ROAD

Dear Mr. Anand

1.0 INTRODUCTION

Golder Associates Ltd. has prepared geotechnical design recommendations for the proposed Tehek Lake Access Road, extending from Baker Lake in Nunavut to Cumberland Meadowbank Gold Project located about 70 km north of the community (see Figure 1).

The following letter report presents recommendations on the following topics:

- Preliminary vertical and horizontal alignment for the proposed road: this is based on an air photo interpretation and based on a preliminary field investigation of the route corridor. The design of the road is based on general geometric design parameters and project specific design criteria provided by Cumberland for the proposed 'private' mine access road;

- Typical road cross-sections: these have been specified for both thaw-susceptible subgrade soils and thaw-stable subgrade soils based on a thermal and deformation analysis of the road embankment and the anticipated near-surface soils based on previous studies;

- The source and gradation of road construction materials: this includes the location of potential quarry sites and a preliminary blast design (separate document). The work is based on the geologic materials available along the route and the equipment available on site;

- Culvert and bridge abutment designs: the design includes both stability and thermal assessments; and,

- Estimation of required fill and geotextile quantities: these volumes are based on the current available information.

We have not provided design recommendations for the proposed bridge structures. These will be developed this summer after completion of further field investigations we have not provided design layouts for the rock quarries. These will be developed as the project progresses by the contractor selected to build the road with Cumberland.

2.0 BACKGROUND INFORMATION

2.1 Proposed Access Road

We understand that in the preliminary design stage, three design options were considered to connect the Meadowbank mine site to the Hamlet of Baker Lake. The options considered were as follow:

- Ice road that would follow the lakes and rivers to the site and thus would be predominantly an ‘ice road’,
- Seasonal winter road over land with limited ice bridges at creeks and small lakes; and,
- An all season gravel road with bridges.

The ‘all season gravel road’ option of some 115 km length was selected as the preferred alternative. It is understood that the all season gravel road would reduce the freight cost of fuel and materials.

2.2 Previous Investigations

As part of the project a series of preliminary site investigations have been carried out previously for the proposed Tehek Lake access road. These include an air photo interpretation, ground proofed by a geomorphologic mapping and a soil and rock sampling program combined with geochemical analysis of potential borrow quarries / pits. The results of these surveys were presented in the following reports:

- Golder Associates 2005a, Report on Air Photo Interpretation, Site Reconnaissance, Mapping and Sampling. Tehek Lake Access Road, Meadowbank Gold Project, Nunavut. September 13, 2005.

- Golder Associates 2005b,, Technical Memorandum on Geochemical Assessment of Potential Quarry Rock along the proposed Mine Access Road, Meadowbank Gold Project, Nunavut. October 6, 2005.

2.3 Terrain Conditions and Geomorphology

The proposed road alignment crosses an area of low relief, with gently to moderately sloping terrain and in isolated areas there are short, steep slopes occurring locally on bedrock surfaces. The terrain is dominated by undulating and irregular bedrock surfaces, veneers and blankets of till and/or weathered (frost-shattered) bedrock (felsenmeer), and discontinuous zones of thin organic soils. Occasional marine (beach) deposits and very small glaciofluvial deposits are present locally. Periglacial processes present in the area are typical of areas underlain by continuous permafrost, although their surface expression is subdued due to the relatively thin cover of overburden and locally well-drained site conditions. Based on data from work at the mine site, it is anticipated that the depth of annual thaw would be on the order of 1.5 m to 2 m in the soils along the road alignment.

2.4 Site Climate

Based on the “Meadowbank Gold Project Baseline Hydrology Report” (Amec, 2003), the annual average air temperature measured at the site climate station during the period from 1997 to 2003 was –11ºC.

Table 1 presents a summary of the mean monthly temperature, relative humidity, wind speed and soil temperature data available from the Meadowbank site climate station over the period of September 1997 to August 2003.

Table 1: Meadowbank Site Climate Station Mean Monthly Data

Month	Mean Monthly					
	Maximum Air Temperature (°C)	Minimum Air Temperature (°C)	Minimum Relative Humidity (%)	Maximum Relative Humidity (%)	Wind Speed (km/hr)	Soil Temperature (°C)
January	-28.2	-34.9	67.8	76.8	17.1	-24.7
February	-27.9	-35.2	66.6	76.3	16.1	-28.2
March	-21.7	-29.7	69.3	81.9	16.9	-24.4
April	-12.7	-22.1	71.4	90.3	17.1	-17.6
May	-2.3	-9.3	75.7	97.4	19.0	-7.4
June	7.8	0.0	61.7	96.8	16.3	1.9
July	17.2	7.6	47.2	94.0	14.9	11.0
August	13.6	6.7	58.5	97.7	18.3	9.6
September	5.8	1.1	69.6	98.3	18.7	3.7
October	-4.8	-10.6	82.4	97.0	21.1	-2.9
November	-14.5	-21.5	80.8	90.9	17.4	-12.1
December	-22.3	-28.9	74.0	83.4	18.1	-19.2

Note 1. Mean soil temperature is reported by Amec to be measured at a depth between 0.2m and 0.3m below ground surface, but should be confirmed. Installation details such as slope aspect, surficial cover, site drainage, and annual snow cover are not available.

Figure 2 presents an annual summary of the mean monthly maximum and minimum air and soil temperatures. Table 2 presents the calculated annual freezing and thawing indices for the mean monthly air and soil temperature data.

Table 2: Annual Freezing and Thawing Indices

Temperature Data	Annual Freezing Index (°C – Days)	Annual Thawing Index (°C - Days)
Air	4900	850
Soil	4100	775

Based on the site climate station measured mean monthly air temperature, the thaw season begins about day 150 of the year (May 30) and ends about day 270 of the year (September 27). This is shown on Figure 2.

3.0 ROAD DESIGN

3.1 General Route Selection

Based on the results of the terrain assessment (Golder 2005a) combined with limited available topographic data, the route was selected using an optimization of the following criteria:

- Regions of high ground relief (higher elevations) were sought to provide generally better drainage conditions, and to minimize the potential for snow drifting and to avoid organic depressions and / or other poor ground conditions which are more abundant in low lying areas (see below);

- Fine-grained, poorly-drained, ice-rich, frost susceptible soil conditions as noted by the geomorphologic mapping were avoided where possible due to the thaw susceptibility of the soils and related issues; and,

- The number of stream and river crossing were minimized.

3.2 Road Alignment

Upon selection of the general route based on the air photographs, the horizontal and vertical road alignments were further refined using design standards established by the Road and Transportation Association of Canada for the geometric design of secondary gravel surfaced roads. Further, as this is to be a private road to service the mine, criteria established by the United States Department of the Interior Bureau of Mines for the design of surface mine haulage roads. This information was combined with project-specific design requirements provided by Cumberland Resources Ltd. A summary of the design criteria used in the geometric layout of the road is presented in Table 3.

Table 3: Tehek Road Design Criteria for Alignment

Design Element	Criteria	Source
Maximum Design Speed	50 km/h	Cumberland
Maximum Traffic Loads	Super-B Fuel Trucks	Cumberland
Road Alignment at River Crossings	Orthogonal to River	Golder
Cuts and Fills	Fill No Cut	Golder
Minimum Stopping Distance	65 m	RATC[1]
Superelevation	None Planned	Cumberland
Minimum Radius of Curvature	100 m	Cumberland
Maximum Slope Gradient	8 %	Cumberland
Minimum Sag "K" Value	11 m	RATC[1]
Minimum Crest "K" Value	10 m	RATC[1]
Turnout Frequency	Minimum two per kilometre Must be inter-visible	Cumberland
Turnout Length	30 m	Cumberland
Turnout Width	15m (including 10m road width) For low fill section	Cumberland
	To be determined in the field For high fill section	Golder

1. RATC refers to the reference document "Geometric Design Standards for Canadian Road and Streets," published by The Road and Transportation Association of Canada.

It should be noted that the final road alignment will be a field-fitted based on actual conditions encountered during construction. Thus, the final road alignment will deviate from the planned alignment and accurate survey will be required to confirm the 'as-built' road alignment. Furthermore, as requested the road has been designed and is to be built as a haul road and is not intended to meet the same geometric standards as public roads. As such, transition spirals, superelevation and similar design elements were not considered for the road.

3.3 Horizontal Alignment

The proposed horizontal road alignment is shown on drawings (Appendix I). As indicated above, a minimum radius of curvature of 100 m was specified by Cumberland. However, greater radii are preferred in the design of similar roads and thus the minimum radius was avoided wherever possible. In addition to the minimum curvature, the layout of the horizontal alignment incorporated general road design principles and guidelines for improved safety and drivability: short tangents between two curves were avoided; sharp curves located at the ends of long tangents were minimized; and where possible, small deflection angles were provided for long curves. Stopping sight distances were not considered a potential hazard with respect to horizontal curves.

3.4 Vertical Alignment

The proposed vertical road alignment is also shown in on drawings (Appendix I). A maximum gradient of 8 % was specified by Cumberland but, again, flatter gradients were desirable wherever possible. The lengths of vertical curves were generally maximized with a specified minimum of 50 m (unless vehicle speeds were expected to be traveling at below 50 km/h due to hilly terrain, in which case the specified minimum could be reduced).

In order to provide adequate stopping sight distance in accordance with The Road and Transportation Association of Canada, crest curves were generally specified a minimum K-Value (ratio of length of vertical curve to difference in percent grades) of 10 m while sag curves were generally specified a minimum K-Value of 11 m. However, due to the costs associated with obtaining granular construction materials, grade fills in excess of those required for the specified road structure were minimized where feasible, and as such, the above K-Values were considered impractical where it would result in fill depths in excess of 4 m.

As for the horizontal alignment, general road design principles and guidelines for improved safety and drivability were also applied to the vertical road alignment: smooth grades with gradual changes were sought and two vertical curves in the same direction separated by a short tangent were avoided.

4.0 TYPICAL STRUCTURAL ROAD SECTION

The subgrade conditions along the proposed road alignment are expected to be highly variable. Based on the air photo terrain assessment, subgrade conditions were classified into two major terrain types: thaw susceptible soil (poorly-drained, ice-rich, organic or bog material) and thaw stable soil (well drained soil, ice poor to frost shattered bedrock material). In order to avoid disturbing the fragile subgrade soils along the alignment, road fill material will be placed directly over the existent overburden layer without cut, stripping or grubbing. It is only proposed that thick drifted snow would be removed before the road fills are placed. Furthermore, as a result of the large decrease in bearing capacity and severe settlements that will occur upon thawing of the subgrade, it is recommended that the road foundation be kept in a frozen state. Thermal modeling and stress analyses were carried out to determine the minimum fill thickness required to preserve the overburden in frozen condition and to assess the creep of the frozen overburden.

4.1 Thermal Modeling

The thermal model was prepared using TEMP/W, a two-dimensional (2-D) finite element based thermal modeling package produced by Geoslope International Ltd. The model was prepared by:

- developing a simplified geologic cross-section at a typical site;
- estimating thermal properties for the bedrock, native till materials and quarry rock fill; and,
- inputting boundary conditions.

A range of surface temperature functions were developed previously by Golder for a 2004 evaluation of the proposed Meadowbank tailings deposit. Two of these temperature functions were used in this thermal analysis to predict temperature profiles.

- TS-4: Climate data measured mean monthly soil temperature (°C).
- TS-2: Mean monthly calculated surface temperature, considering 10% of snow pack.

These predicted profiles were then compared to the measured temperature profiles for calibration. Following this, the road fill was added to the model to determine the minimum fill thickness required to keep the overburden layer in frozen condition. The potential for climate change was not considered in the analysis as the road design life is less than 20 years.

The thermal model finite element mesh is presented on Figure 3. The mesh represents a typical cross-section through the proposed roadway extending to a depth of 50 m. To simplify the model, the native materials considered in the profile were generalized into one of three discreet units: bedrock, till soil or rock fill. As noted above, the till soil was further classified as either thaw susceptible (poorly-drained, ice-rich, organic or bog material) or thaw stable soil (well drained soil, ice poor to frost shattered bedrock material). The ground was also assumed to be symmetric about the centreline of the road allowing the finite element mesh to be represented by half the width of the road.

Each soil type was characterized based on field data and a review of available information for the project. The geotechnical properties of the till and bedrock materials were established based on previous work by Golder (2004) and by BGC Engineering Inc on the preliminary geothermal and slope stability of rock storage facilities (2004).

Thermal properties for the quarry rock fill materials were estimated based on the rock mineralogy, geotechnical properties and published empirical formulas by Johansen (1975) and Farouki (1981). No laboratory testing has been carried out to date to determine the thermal properties of the blasted quarry material.

Estimates of the unfrozen water content with respect to temperature were made for the bedrock, till soil and the quarry rock fill materials using the relationship presented by Anderson *et al.* (1973) and published parameters for similar materials from Nixon (1991).

The material and thermal properties assigned to each of the four soil types for use in the thermal model are summarized in Table 4.

Table 4: Summary of Material Properties Used in Thermal Model

Properties \ Soil Material		Bedrock	Quarry Rock Fill	Till – ice rich	Till – ice poor
Moisture Content (%)		0.7	2.1	60	14
Dry Density (kg/m^3)		2650	1830	1020	1700
Specific Gravity, Gs (t/m^3)		2.7	2.65	2.6	2.6
Void ratio, e		0.02	0.4	1.55	0.5
Porosity,n (%)		2	30	61	35
Degree of Saturation (%)		95	15	100	70
Volumetric Water Content		0.02	0.04	0.6	0.25
Thermal Conductivity (W/m °C)	**Frozen**	2.39	1.45	2.25	2.7
	Thawed	3.4	0.7	1.2	2
Volumetric Heat Capacity (MJ/m3 °C)	**Frozen**	2.39	1.45	2.25	2.5
	Thawed	2.4	1.45	3.4	3

The ground temperature conditions around the mine site and at Baker Lake between the depths of 1.2 m and 150 m have been characterized by a number of thermistors monitored over the period of 1997 to 2005. A summary of the recorded ground temperatures from the thermistor monitoring was presented in "Permafrost Thermal Regime, Baseline Studies, Meadowbank Project, Nunavut" Golder (2003).

The boundary conditions used in solving the thermal model were as follows:

- A geothermal flux of 0.05 W/m^2 was applied along the lower boundary of the cross-section (based on the estimated geothermal gradient).

- Surface temperature functions*, (TS-4 and TS-2), developed in Golder (2004), were applied to the upper surface boundary of the cross-section.

*The empirical approach to estimating ground surface temperature from the air temperature had also been used to evaluate the ground temperature on the road fill. By applying n-factor value for gravel (probable range for northern conditions) of n_{thaw}=0.93 and n_{frozen}=2 on the mean air temperature from 1997 to 2003, the annual mean soil temperature obtained was -8 °C. This confirms that the surface temperature functions developed in Golder (2004) are consistent with the empirical approach.

The model was run to predict ground temperature profiles for each of the selected road sections, which were compared to the existing temperature profiles obtained from the mine site and Baker Lake thermistor monitoring. The following seven thermistors were selected for comparison since they provide vertical soil temperature profiles and offer a range of soil temperature data that well represent the temperature difference between Baker Lake and the Meadowbank mine site.

Meadowbank mine site	**Baker Lake**
Background Thermistor	TP03-2
PS-2 (Plant site area)	TP03-3
PS-3 (Plant site area)	TP03-12
TF-1 (Fuel Tank area)	

4.2 Results of Thermal Analysis

The thermal modeling confirmed that, given the current ground conditions combined with the road construction material specifications presented in Section 5, a minimum road fill thickness of 1 m is required above thaw stable material to maintain the overburden layer in frozen condition. Similarly, a minimum road fill thickness of at least 1.2 m is required above thaw susceptible soils.

4.3 Ice Creep and Potential Settlement Assessment

The results of the evaluation suggests that a 4H: 1V slope for thaw susceptible soil is recommended to reduce the shear stress applied to the foundation material at the toe of the road fill embankment. Experience has shown that frozen ice-rich soils have a poor shear bearing capacity and ice creep failure would appear if a steeper road embankment side slope is constructed.

Moreover, in the toe areas of the embankment slope, thaw penetration will increase over time, resulting in a deeper permafrost active layer directly beneath the toe areas, and this may result in a deep zone of thaw and potential soil consolidation. The thaw susceptible soils are expected to have high water contents; consequently, high pore water pressures will contribute to strength loss in the soils, and could result in local destabilization of the embankment slope. This will result in the formation of tension cracks and small grabens inside the shoulder area. For these reasons, the 4H: 1V slope should be use to keep the thaw susceptible foundation material beneath the shoulder area in frozen state. The side slope of the road embankment in regions of thaw stable soil are not susceptible to bearing capacity failure and may therefore be developed as steep as 2H: 1V.

Settlements will occur throughout the life time of the road. It is understood that Cumberland will maintain the access road and, in particular, ensure that the minimum road structure thickness is maintained to preserve the subgrade soil in a frozen state.

Furthermore, in regions of thaw-susceptible subgrade conditions, it is recommended that a geotextile fabric be installed over the subgrade before placement of the road fill. This would minimize the intrusion of the granular road material into the soft foundation material; prevent pumping of fines up into the granular material and bridge minor localized differences in subgrade compressibility.

The structural recommendations for the road section are summarized in Table 5 below and shown in the typical road sections presented in Figure 4.

Table 5: Recommended Structural Road Sections

Foundation Conditions	Structural Cross Section[1]	Minimum Fill Thickness[1]	Side Slopes	Geotextile between Road Fill and Ground Surface
Thaw Susceptible Soil **(poorly drained, ice-rich, organic or bog over bedrock)**	**Section 1**	**1.2 m**	**4H:1V**	**Yes**
Thaw Stable Soil **(well drained soil over bedrock)**	**Section 2**	**1.0 m**	**2H:1V**	**No**

1. See Section 5 for road fill material specifications.

5.0 FILL MATERIAL

Sources of granular aggregate for the road construction are relatively small in spatial extent, and are scarce along the proposed road alignment (Golder, 2005a). It is understood, that rock quarries will be developed along the road to provide a source of material for the required road material aggregates.

Graded aggregate for use as general road embankment fill will be generated directly from in-situ rock using a specified blast pattern. Finer graded road surfacing fill will be obtained by further processing the coarse aggregate using a 250 ton per hour portable crusher plant.

Two structural fill types are proposed to be used to construct the access road as follow:

- Type 1 Fill: Minus 75 mm well graded crushed ‘Granular Base’; and,
- Type 2 Fill: Minus 300 mm well graded general ‘Rock Fill’.

The potential quarry sites sampled and identified (Golder 2005a) are composed from different rock species including granite, granite-granodiorite, quartzite, granite gneiss, felsite, metawacke, andesite and mafic volcanics. The locations of quarry sites are presented on drawings (Appendix I).

5.1 Type 1 Fill: Minus 75 mm Crushed Granular Base

Type 1 Fill shall consist of crushed gravel particles of hard, durable rock and shall meet the gradation specification in Table 6 and shown on Figure 5.

Table 6: Type 1 Fill Gradation Specification

Sieve Designation	Per cent by Weight Passing
75 mm	100%
50 mm	70-100%
25 mm	50-100%
4.75 mm	25-100%
2.00 mm	10-80%
0.075 mm	0-5%

5.2 Type 2 Fill - Minus 300 mm Rock Fill

Type 2 Fill shall consist of select native granular mineral soil, imported granular borrow and /or quarried rock fill materials excavated from cut areas or local borrow areas. The maximum particle diameter shall be 300 mm, and meet the gradation specification in Table 7 and on Figure 6.

Table 7: Type 2 Fill Gradation Specification

Sieve Designation	Per cent by Weight Passing
300 mm	100 %
150 mm	75-100%
80 mm	58-100%
4.75	25-60%
0.85	10-30%
0.075	0-10%

6.0 CULVERT AND BRIDGE DESIGN

6.1 General Stream Crossing Conditions

The construction of the Meadowbank all-weather road will include a number of channel crossings. In 2005, some 22 channel crossings were identified along the proposed road alignment. Based on the preliminary observations in 2005 of the channel characteristics at each location, these crossings were proposed to consist of 10 bridges and 12 culverts.

This section summarizes the hydraulic analyses completed in the design of the channel crossings.

6.1.1 Peak flow calculations

The sizing of the culvert and bridge crossings was determined based on an estimated peak flow at each crossing. Due to a lack of site specific and regional meteorologic and hydrometric data for the study area, the peak flow estimates were obtained based on reported peak unit discharge rate (Q_u = 0.47 $m^3/s/km^2$) for the Akkutuak Creek basin (AMEC 2003). The Akkutuak Creek basin, located near Baker Lake was selected for the analysis since its drainage area (15 km^2) is comparable to those of the channel crossings shown on Figure 7A and 7B.

This peak unit discharge rate was then applied to the drainage area at each channel crossing to compute the corresponding maximum flow rate (Table 8).

The reported peak unit discharge rate was also used to compute an equivalent average event "intensity" *I* for each drainage area using the Rationale formula ($Q_u = C*I$) and assuming an average run-off coefficient *C* of 0.62 for the Akkutuak Creek basin (Amec, 2003). Using this approach, the computed *I* (2.61 mm/hr) incorporates the event precipitation rate, snow melt and flow routing effects. It is worth noting that the extreme daily rainfall of record at Baker Lake is 52.1 mm (ref. MSC web site), which corresponds to an average rainfall intensity of 2.17 mm/hr. Therefore, the computed peak flow estimates are considered to be a best approximation at this time given the lack of site specific data. It is strongly recommended however that peak flow estimates be re-evaluated as site specific stream monitoring data becomes available.

6.2 Culvert Design

A total of 12 stream crossing locations identified at the Meadowbank all-season road would consist of culvert crossings. These locations are categorized as having no potential for fish habitat. (Azimuth, 2005)

Multiple full-rounded corrugated steel pipe culverts would be used with nominal sizes of 0.7 m or 1.2 m (internal diameter) to pass the design flow. A minimum of two culverts placed in an "offset stacked" configuration would be used at the various culvert locations to enable flow conveyance before complete ice break-up within the channel. For design purposes, the capacity of the top culvert was assumed to be 20% of the estimated peak flow, while the bottom culvert(s) was sized to convey the remaining 80%.

The sizing of the culverts is based on the estimated peak flow at each channel crossing. Each culvert was sized assuming 80% pipe full depth to maintain non-backwater conditions upstream of the culvert at the design discharge (Table 8).

The minimum cover thickness for the culvert installations is 0.3 m, as specified in the Handbook of Steel Drainage and Highway Construction Products (Corrugated Steel Pipe Institute, 2002). The distance between the two stacked rounded culverts, from edge to edge, should be at least half the diameter of the larger culvert.

Table 8: Meadwobank All-Season Road - Culvert Crossing Details

River Crossing	Drainage Area (ha)	Peak Flow (m^3/s)	80% Peak Flow (m^3/s)	20% Peak Flow (m^3/s)	Potential Migration	Nominal Rounded Culvert Diameter (pass 80% flow) (m)	Nominal Rounded Culvert Diameter (pass 20% flow) (m)
R03	16	0.074	0.059	0.015	No	0.70	0.70
R04	192	0.90	0.72	0.18	No	1.20	0.70
R05 A	124	0.59	0.47	0.12	No	1.20	0.70
R07	130	0.61	0.49	0.12	No	1.20	0.70
R14	558	2.62	2.10	0.52	No	1.20 x 3	1.20
R17	161	0.76	0.60	0.15	No	1.20	0.70
R18A	469	2.20	1.76	0.44	No	1.20 x 3	1.20
R20	75	0.35	0.28	0.07	No	1.20	0.70
R21	279	1.31	1.05	0.26	No	1.20 x 2	1.20
R23	125	0.59	0.47	0.12	No	1.20	0.70
R24	242	1.14	0.91	0.23	No	1.20 x 2	0.70
R25	41	0.19	0.15	0.04	No	0.70	0.70

6.3 Bridge Design

A total of 10 stream crossing locations identified at the Meadowbank all-season road would consist of bridge crossings. These locations are categorized as having potential fish habitat (Azimuth, 2005).

The bridges would have a span length of 12 m or 30 m. Detail structural design for the bridges will be carried out by Associated Engineering.

To provide for fish passage, it is proposed that the maximum channel flow velocities through the bridge openings should not exceed 0.7 m/s (Azimuth, pers. comm.). Where the computed maximum flow velocities exceed this value, baffles or large substrate materials would be placed within the crossing to dissipate energy, diversify flow conditions and provide potential resting zones for migrating fish.

Hydraulic analyses were completed to determine the capacity, flow depth and water velocity at each bridge crossing at the design peak flow, and to compute stable riprap diameters for protection of bridge abutments. The corresponding bridge crossing details, including span lengths, maximum flow velocities, the need for flow diversification, and required rip rap sizes, are summarized in Table 9 below.

6.4 Bridge Design

Table 9: Locations of Stream Crossing with Bridges

River Crossing	Drainage Area (ha)	Peak Flow (m³/s)	Potential Migration	Bridge Span (m)	Final Base Width (m)	Final Top of Water Width (m)	Bridge Height with 1m Freeboard (m)	Velocity (m/s)
R01	244	1.15	Yes	12 m Bridge	7.9	9.0	1.4	0.38
R02	20,576	96.71	Yes	30 m Bridge	17.5	26.8	4.1	1.41
R05	5,075	23.85	Yes	30 m Bridge	23.3	26.8	2.2	0.82
R06	5,723	26.90	Yes	30 m Bridge	23.0	26.8	2.3	0.86
R09	1,973	9.27	Yes	12 m Bridge	3.9	9.0	2.7	0.84
R13	540	2.54	Yes	12 m Bridge	7.2	9.0	1.6	0.52
R15	4,877	22.92	Yes	30 m Bridge	23.4	26.8	2.1	0.81
R16	1,241	5.83	Yes	12 m Bridge	5.6	9.0	2.1	0.71
R18	1,126	5.29	Yes	12 m Bridge	5.9	9.0	2.0	0.68
R19	2,026	9.52	Yes	12 m Bridge	3.7	9.0	2.8	0.85

7.0 ESTIMATION OF FILL AND GEOTEXTILE

7.1 Fill Volume Estimation

The estimated fill volume required for the construction of the access road was based on the vertical alignment, shown on drawings (Appendix I), base mapping to 10 m contours and the road sections shown on Figure 4. About 1,800,000 m^3 of quarried rock and about 200,000 m^3 of crushed rock will be necessary for the road embankment construction, including the turnouts and finer material at river crossings.

7.2 Geotextile Quantity Estimation

As recommended in Section 5, geotextile fabric should be installed in regions of thaw-susceptible subgrade conditions. It is understood that the road will be built during the winter. Therefore, geotextile placement may be omitted during the winter construction phase. However, Cumberland should have on site a reasonable quantity if the construction carries on in thaw season. Bridge and culvert construction will require some 10,000 m2 of geotextile. A Propex Non-woven Geotextile 4550 or its equivalent is recommended.

8.0 CLOSURE

We trust this meets your requirements at this time. Should you have any questions regarding the contents of this report, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

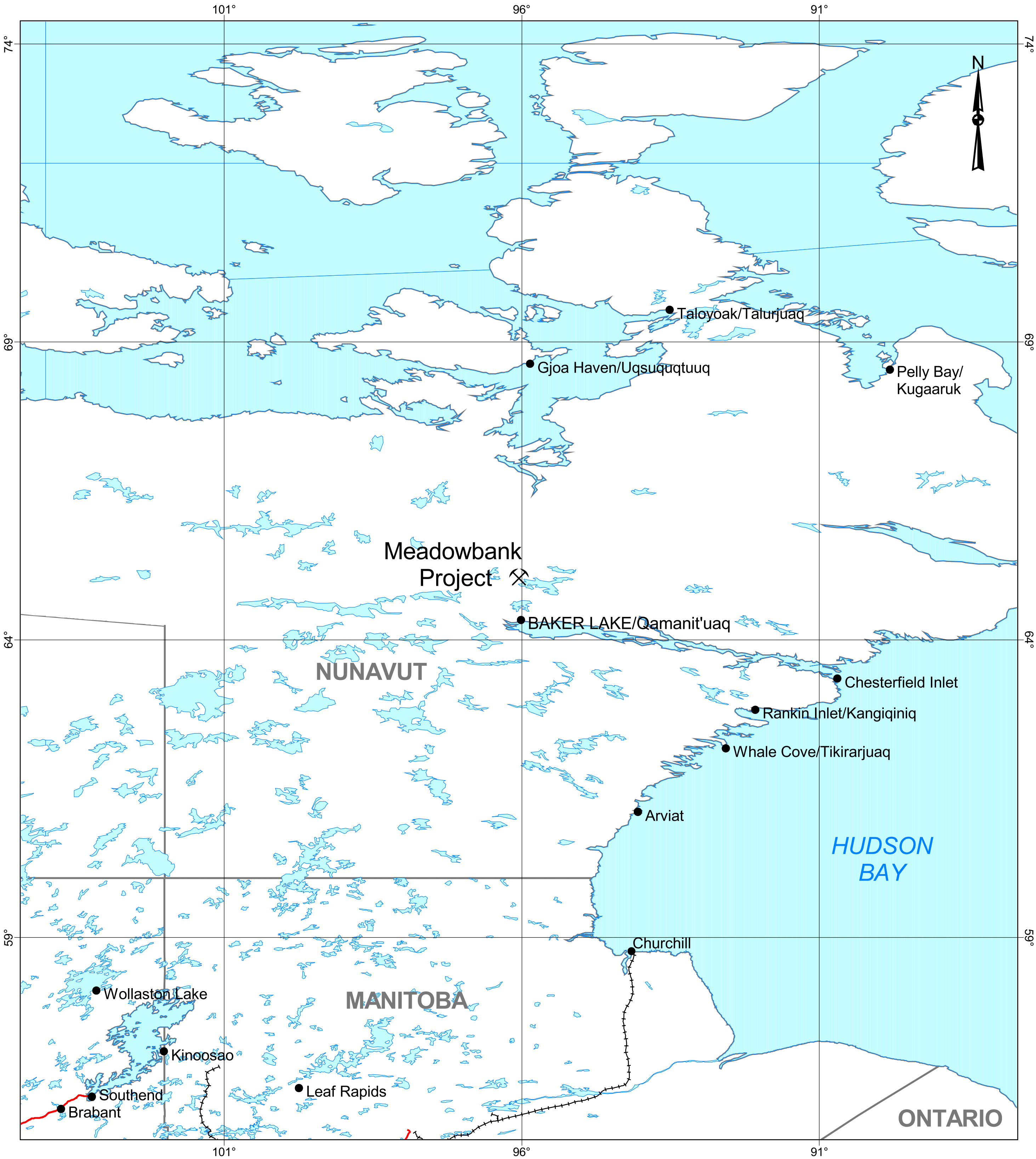
Karine Doucet, EIT
Geotechnical Engineer

Reviewed by

Christopher Williams
Geotechnical Engineer

John A Hull, P. Eng.
Principal

KD/CW/JAH/cm
Attachments
N:\FINAL\2006\1413\06-1413-021\RPT-0707_06 CUMBERLAND-TEHEK LAKE ACCESS.DOC



LEGEND

- Meadowbank Project
- Town/Village
- Provincial Border
- Water
- Primary Highway
- Railroad

REFERENCE

Base digital data obtained from ESRI Inc.,
DATUM: WGS84 PROJECTION: Geographic

PROJECT

CUMBERLAND
RESOURCES LTD.

TITLE

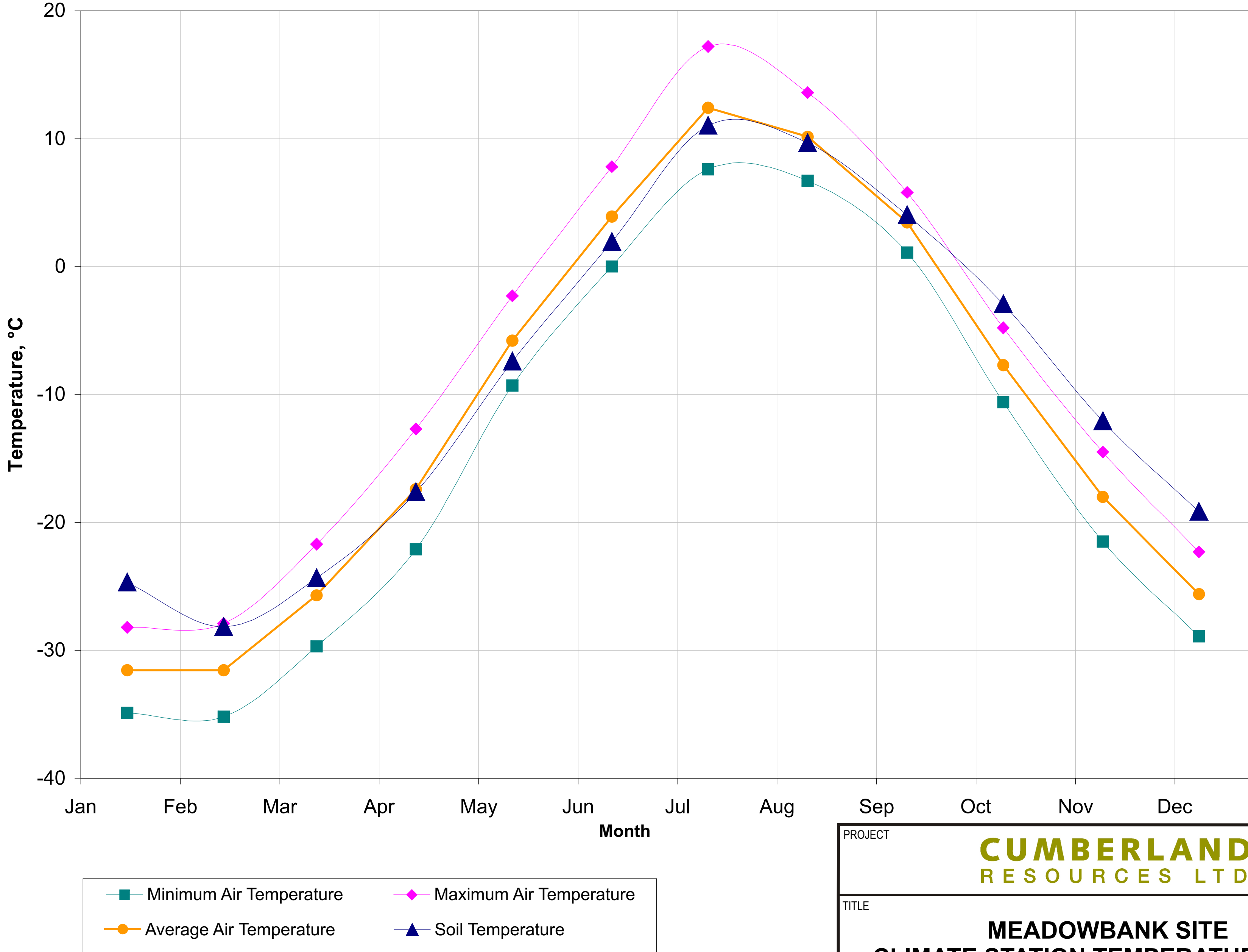
LOCATION PLAN
MEADOWBANK PROJECT

Golder Associates
Burnaby, B.C.

PROJECT No. 05-1413-021			SCALE AS SHOWN	REV. 0
DESIGN	CJC	31 Aug. 2005	FIGURE 1	
GIS	CDB	31 Aug. 2005		
CHECK	CJC	31 Aug. 2005		
REVIEW				

N:\Bur-Graphics\Projects\2005\1413\05-1413-021\GIS\aprs\figure-01_location-plan-meadowbank-project.apr (Layout: 8.5x11 Portrait) August 31, 2005

DRAWING DATE: 01-Jun-06 COREL FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-021\Drafting\corel\Figure 2.cdr



PROJECT

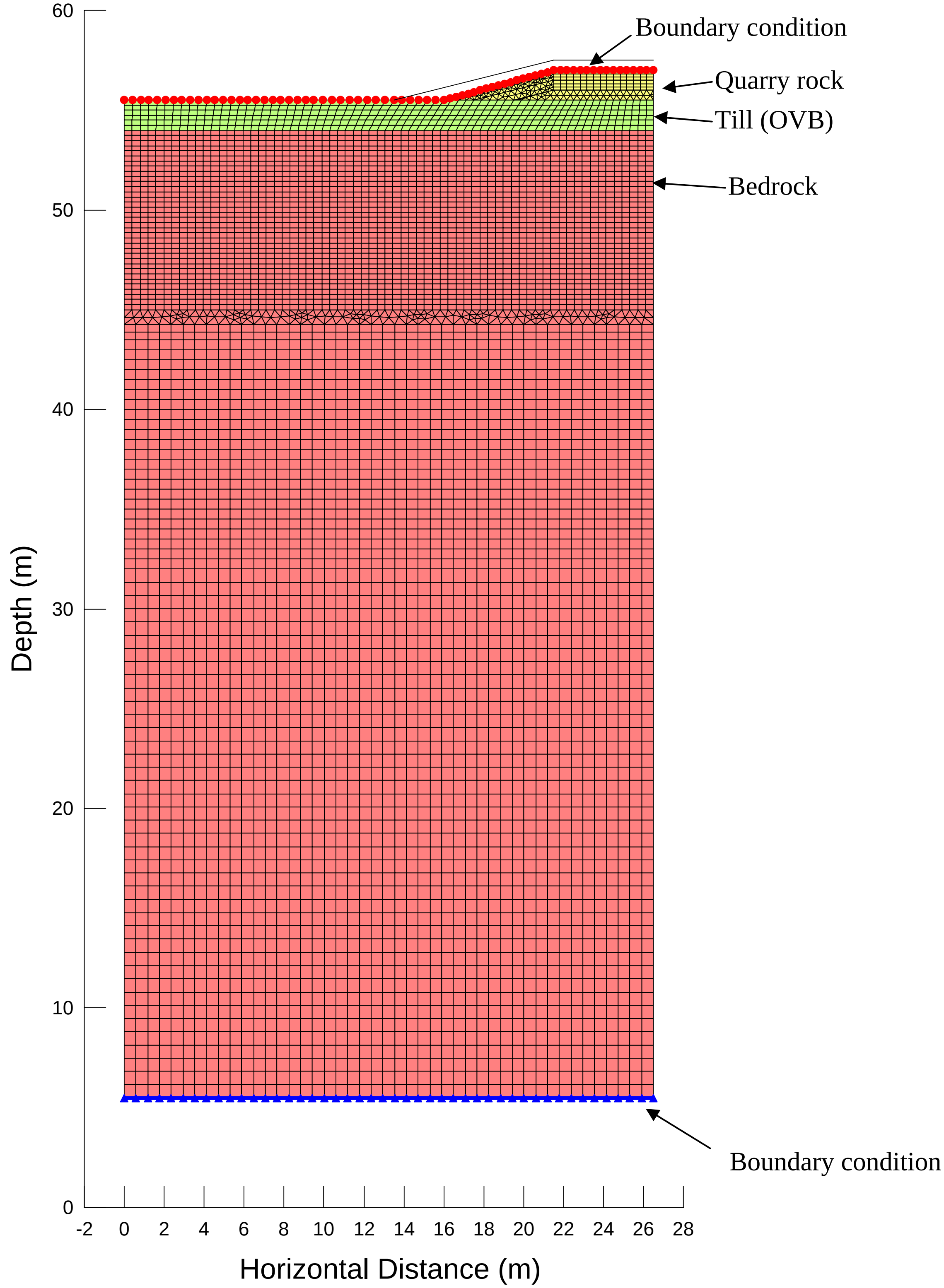
CUMBERLAND RESOURCES LTD.

TITLE

MEADOWBANK SITE
CLIMATE STATION TEMPERATURE DATA

Golder Associates

PROJECT No.	06-1413-021		FILE No.	FIGURE 2
DESIGN	KD	01JUNE06	SCALE NTS	REV.
CADD	SS	01JUNE06	**FIGURE 2**	
CHECK	KD	01JUNE06		
REVIEW				



PROJECT
CUMBERLAND RESSOURCE LDT.
MEADOWBANK GOLD PROJECT
MEADOWBANK, NU

TITLE
TEMP/W Thermal Model
Finite Element Mesh

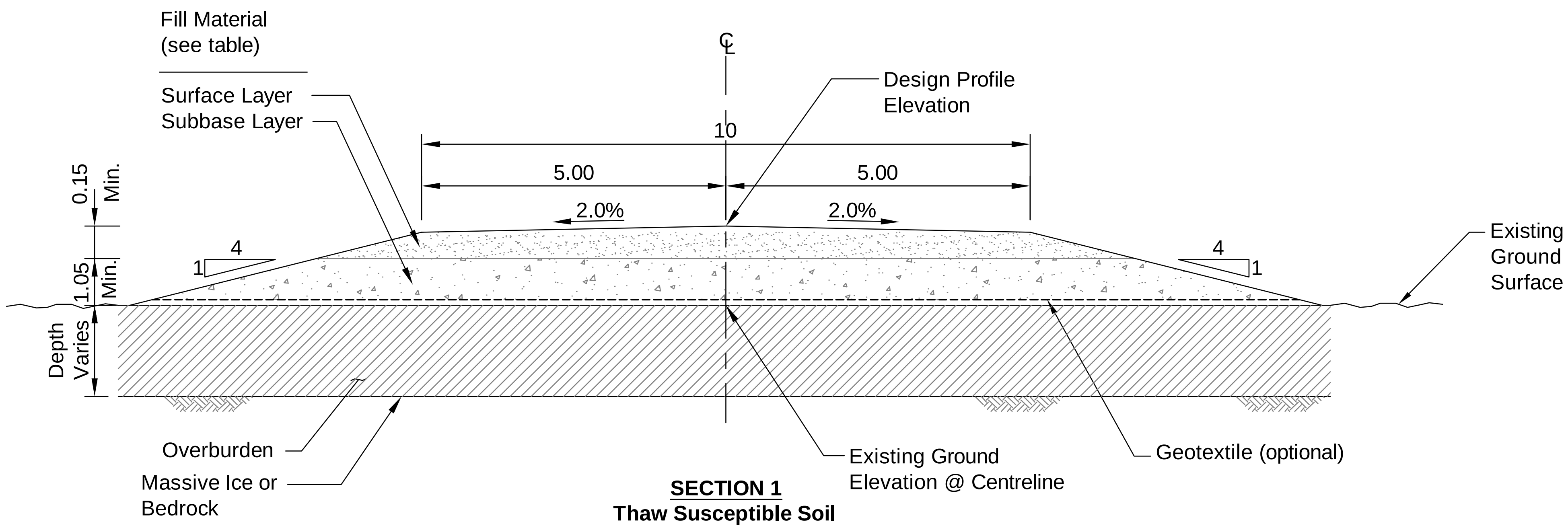
Golder Associates

PROJECT No.	06-1413-021	
DESIGN	KD	01JAN04
CADD	--	01JAN04
CHECK	JAH	01JAN04
REVIEW		

FILE No. ----
SCALE NTS
REV.

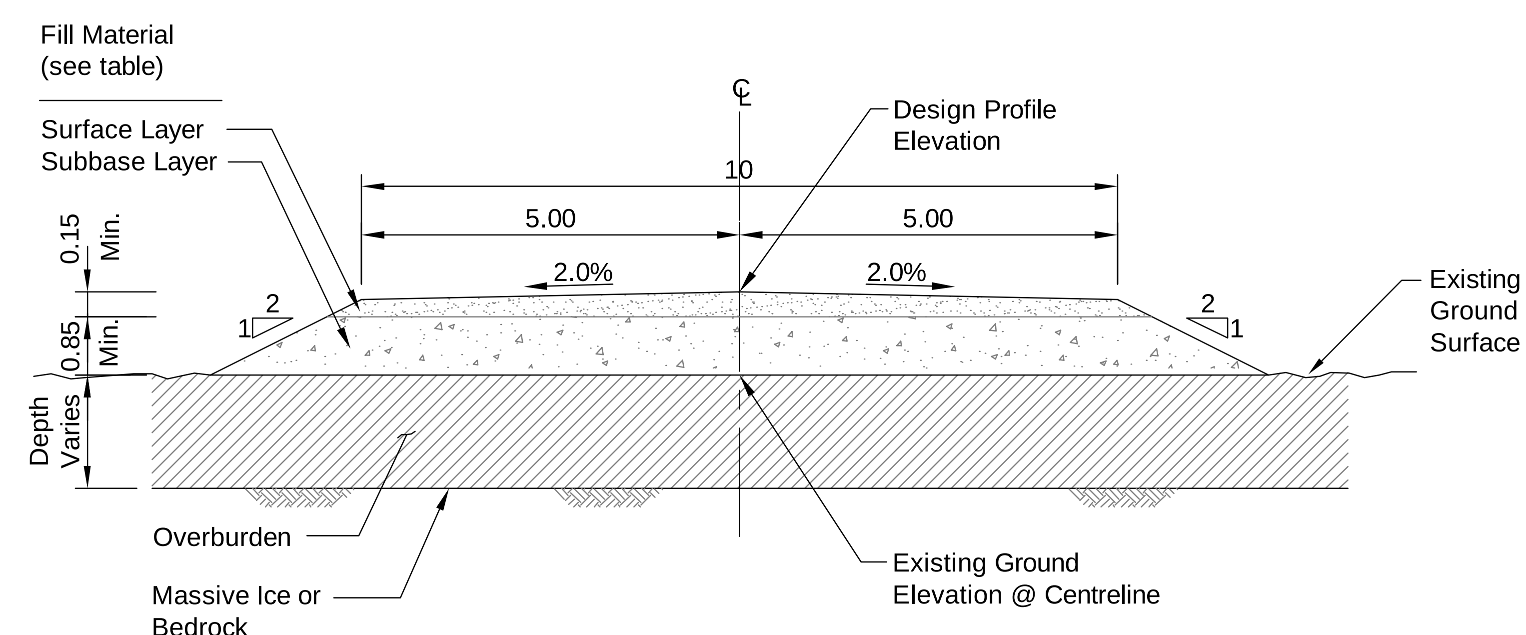
FIGURE 3

REVISION DATE: BY: FILE:



SECTION 1
Thaw Susceptible Soil
(see Note 1)

0 3 6 9 12 15
Scale in Meters



SECTION 2
Thaw Stable Soil
(see Note 2)

0 3 6 9 12 15
Scale in Meters

Layer	Minimum thickness	Material description
Surface	150mm	75mm minus
Subbase	1050mm-on "thaw susceptible" soil 850mm-on "thaw stable" soil	300mm minus

NOTES

1) Thaw susceptible soils comprise those areas where thawing of the near-surface subgrade is expected to result in significant strength loss and exessive settlements.

2) Thaw stable soils comprise those areas where thawing of the near-surface subgrade is expected to result in minimal strength loss and tolerable settlements.

3) All dimensions in metres, unless noted otherwise.

ISSUED FOR CONTRACT

PROJECT
CUMBERLAND RESOURCES LTD.

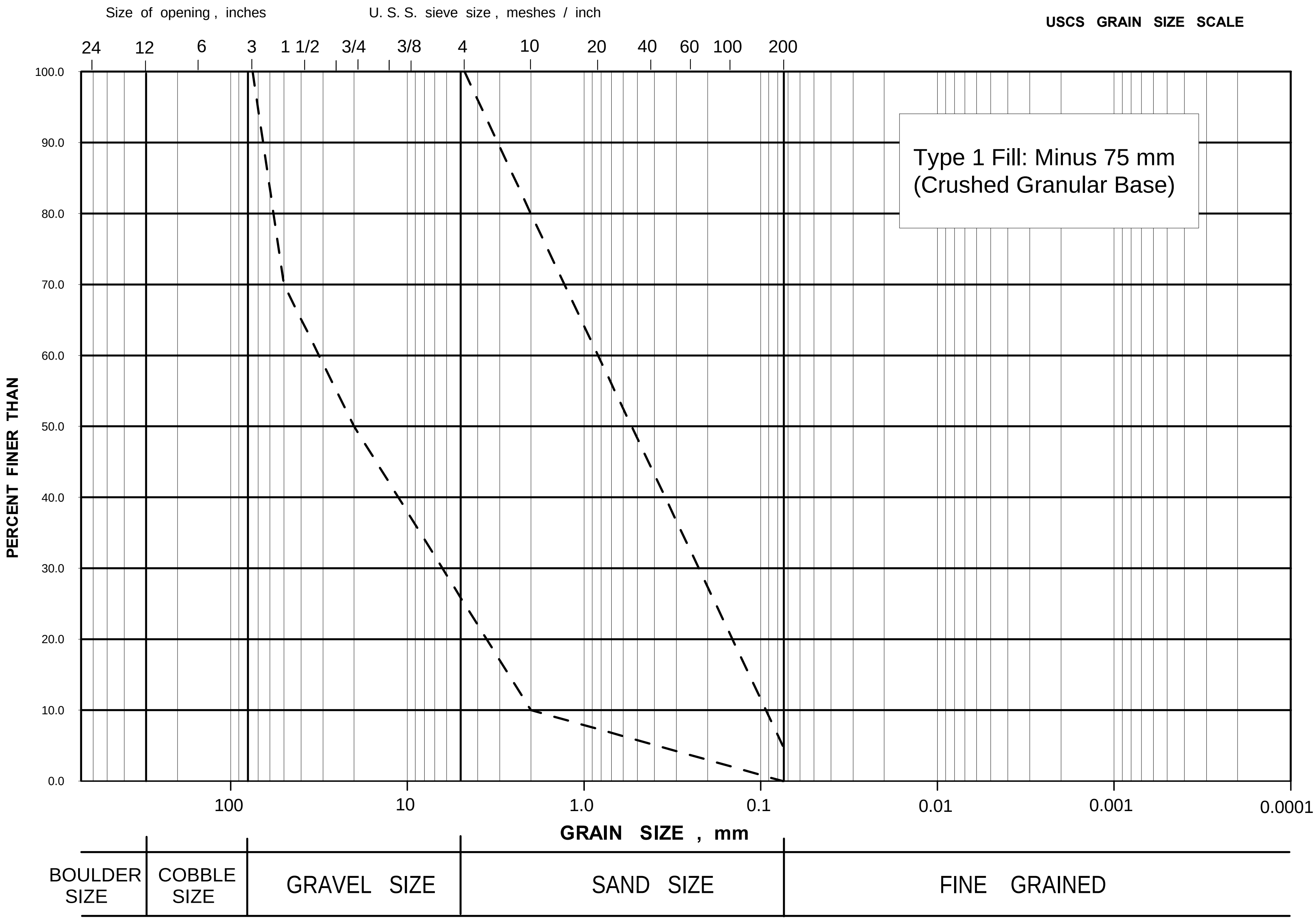
TITLE
TEHEK ACCESS ROAD
TYPICAL CROSS SECTIONS

Golder Associates

PROJECT No.	06-1413-021	FILE No.	061413021-DWG12
DESIGN	KD	23JUNE06	SCALE AS SHOWN REV. –
CADD	JK	23JUNE06	
CHECK	CC	23JUNE06	
REVIEW			

FIGURE 4

REVISION DATE: 06/07/04 10:14AM By: ASalvador CADD FILE: N:\Bur-Graphics\Projects\2006\1413\06-1413-021\Drafting\cad\061413021-DWG12.dwg

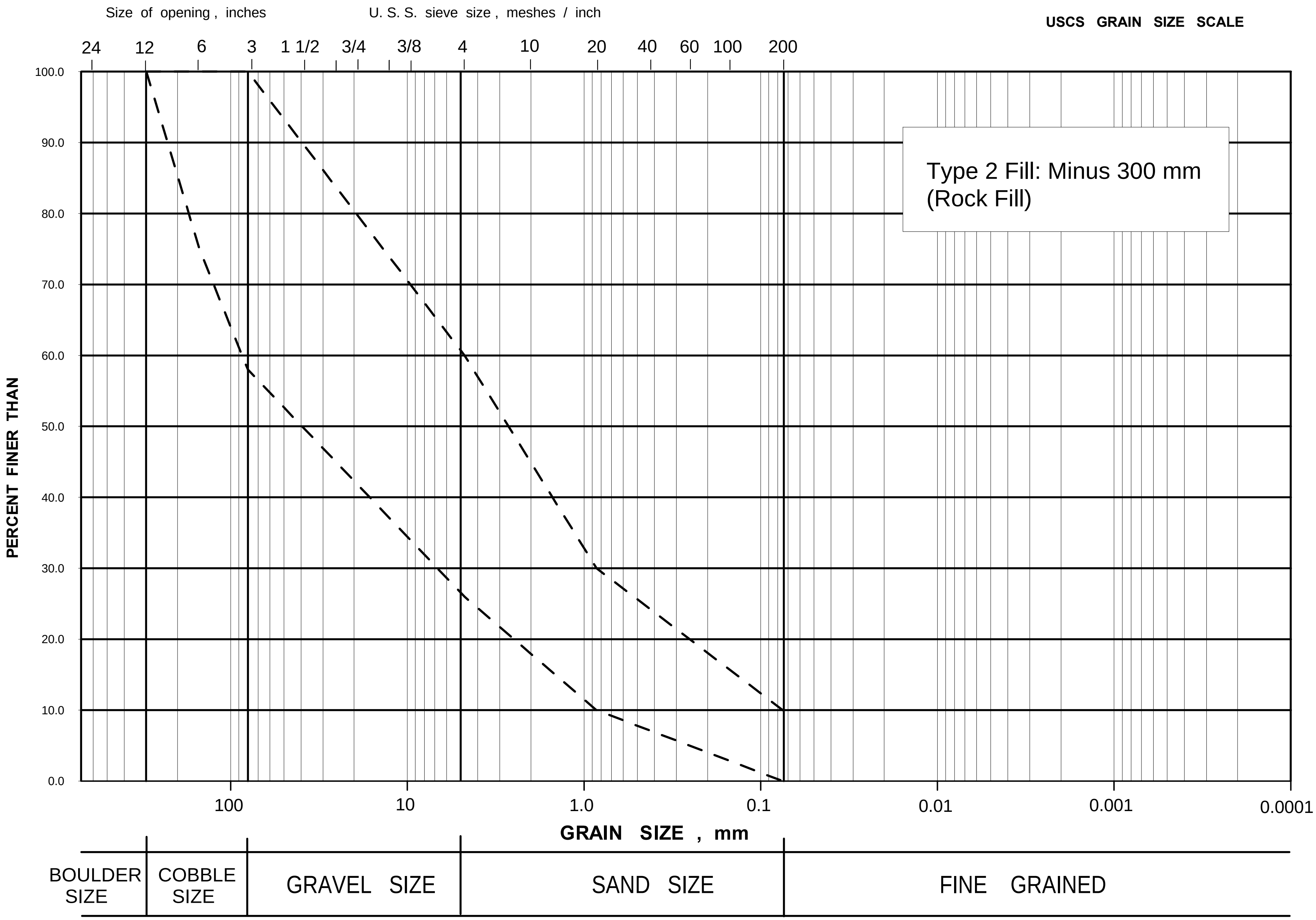


Project No. 06-1413-021
Drawn TM
Reviewed LL
Date 06/26/06

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure 5

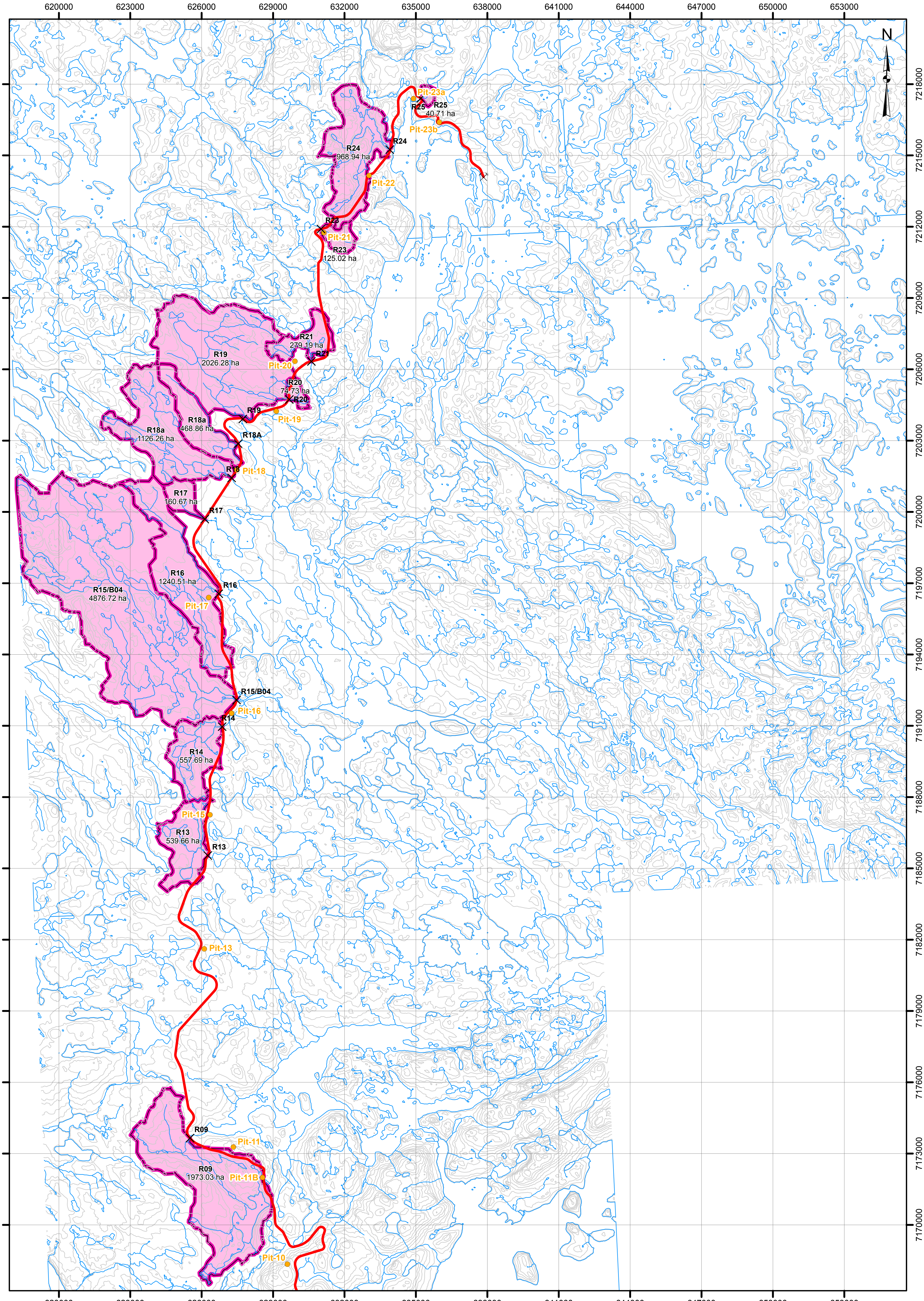


Project No. 06-1413-021
Drawn TM
Reviewed LL
Date 06/26/06

Golder Associates

GRAIN SIZE DISTRIBUTION

Figure 6



LEGEND

- Meadowbank Project
- Stream Crossing
- Approximate Location of Potential Rock Quarry Site
- Proposed Route
- Contour (10 m interval)
- Watercourse
- Waterbody
- Crossing Watershed

3,000 1,500 0 3,000 Metres

Scale - 1:150,000

REFERENCE

Cumberland Resources Ltd. Watersheds delineated by Golder Associates Ltd.
Datum: NAD 83 Projection: UTM Zone 14

N:\Bur-Graphics\Projects\2005\1413\05-1413-021\GIS\aprs\watersheds_north.mxd

PROJECT

CUMBERLAND RESOURCES LTD.

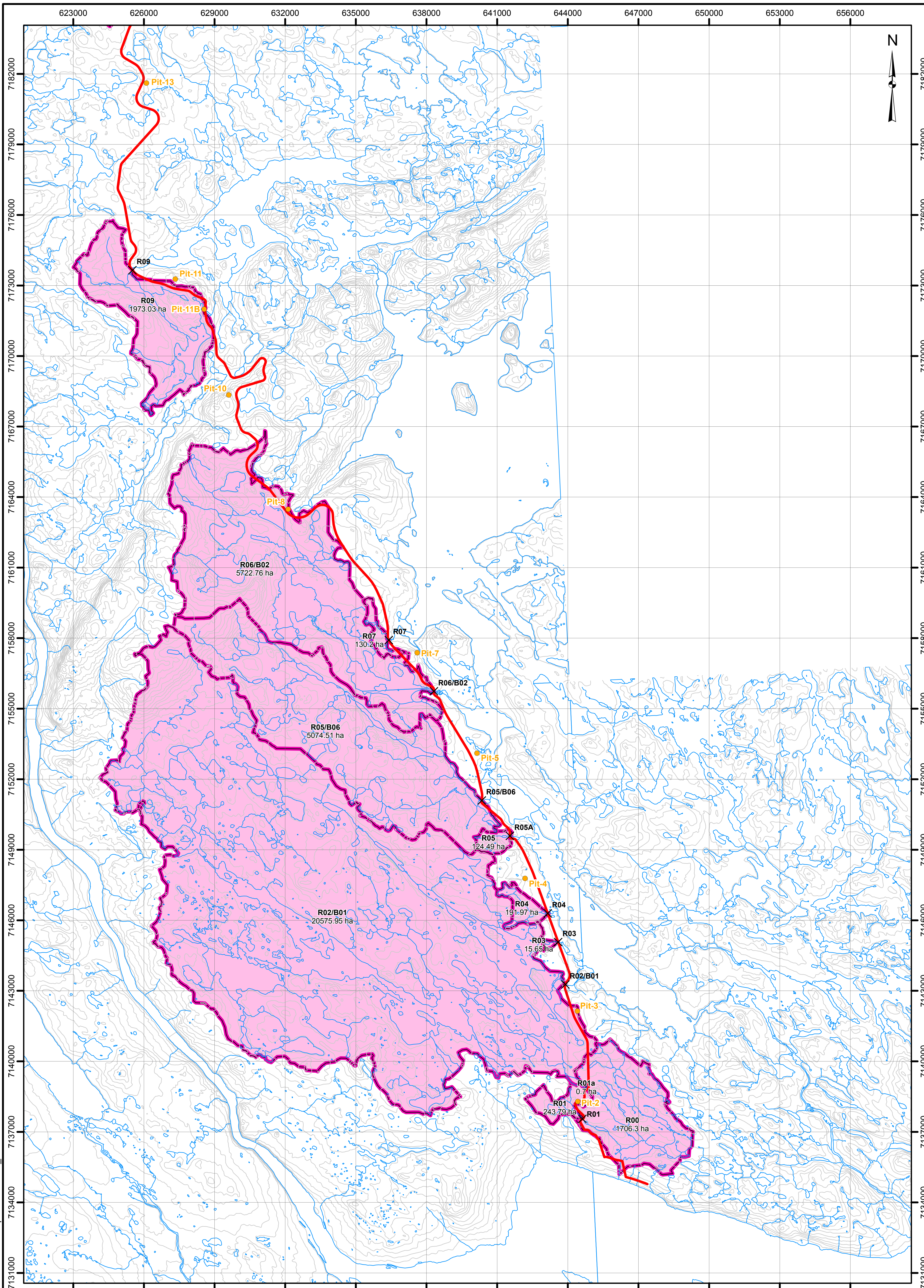
TITLE

ROUTE ALIGNMENT, WATERSHEDS, AND POTENTIAL QUARRY SITES 1:150,000 Mapsheet 1 of 2

PROJECT No. 05-1413-021			SCALE AS SHOWN	REV. 0
DESIGN	KD	11 Apr. 2006		
GIS	KG	27 Jun. 2006		
CHECK	JPM	27 Jun. 2006		
REVIEW				

Golder Associates
Burnaby, B.C.

FIGURE 7A



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LEGEND

- Meadowbank Project
- Stream Crossing
- Approximate Location of Potential Rock Quarry Site
- Proposed Route
- Contour (10 m interval)
- Watercourse
- Waterbody
- Crossing Watershed

3,000 1,500 0 3,000 Metres

Scale - 1:150,000

REFERENCE

Cumberland Resources Ltd. Watersheds delineated by Golder Associates Ltd.
Datum: NAD 83 Projection: UTM Zone 14

PROJECT

CUMBERLAND RESOURCES LTD.

TITLE

ROUTE ALIGNMENT, WATERSHEDS, AND POTENTIAL QUARRY SITES
1:150,000 Mapsheet 2 of 2

Golder Associates
Burnaby, B.C.

PROJECT No. 05-1413-021			SCALE AS SHOWN	REV. 0
DESIGN	KD	11 Apr. 2006		
GIS	KG	01 Jun. 2006		
CHECK	KD	01 Jun. 2006	**FIGURE 7B**	
REVIEW				

APPENDIX I

DRAWINGS IN LARGE ROLL
& SUBMITTED SEPARATELY