Indian and Northern Affairs Canada

GEOTECHNICAL INVESTIGATION PLANS
SUBSURFACE EVALUTION OF QUARRY RESOURCES
INUVIK, NT

EBA File: 1200209

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1.0 INTRODUCTION

Under INAC Contract No. A7133-06-0017, EBA Engineering Consultants Ltd. (EBA) was retained by R.J. Gowan, Manager, Land Programs, Land and Water Management Directorate, Northern Affairs Program, Indian and Northern Affairs Canada, to carry out a study of quarry resources on Crown Land near the community of Inuvik, NT. The objective of the study was to prepare geotechnical site investigation plans to evaluate areas of potential expansion adjacent to two existing quarries on Crown Land near Inuvik. The plans were to include proposed locations of subsurface evaluation targets, suitable access routes for winter exploration, and recommendations on subsurface investigation methods, cost and logistics. The project is motivated by foreseen increased demands for granular material in an area where existing developed sources are limited.

Recommendations and conclusions are based on air photo interpretation, aerial reconnaissance, reviews of previous reports and subsurface data, and experience in geological mapping and evaluation of granular sources in the study area.

This report incorporates and is subject to the attached General Conditions.

2.0 BACKGROUND

Increasing demands from growing industrial development and transportation infrastructure has a potential to impact the supply of granular resources near Mackenzie Valley communities. This study was initiated by DIAND to follow its strategy for the continuous development of programs to effectively manage granular resources and ensure adequate future supply for communities.

Given present and future projected demands for granular construction material in the Inuvik area, particularly in light of the proposed Mackenzie Gas Pipeline project, definition of existing and potential granular resources near the communities is fundamental.

Remaining sources of unconsolidated granular material near Inuvik are typically small, of poor quality and have been heavily exploited. The community will likely have to rely more heavily on quarried sources for future requirements of good quality granular material. Suitable lithology south of Inuvik hosts three active quarries: one at the airport and two others at km 251 and km 235 of the Dempster Highway.

The focus of this study was to plan a subsurface evaluation program at two study areas of dolomitic limestone for potential expansion of the existing rock quarry site (km 251) and phased development of multiple quarries in the vicinity of the existing quarry (km 235). These sites are located along the Dempster Highway south of Inuvik.

3.0 METHODOLOGY

The two study sites were first evaluated during a desk-top study that focused on air photograph interpretation and a review of previous reports and mapping (EBA, March 2006). On September 16, 2006 EBA completed an aerial reconnaissance to aid in the preparation of geotechnical site investigation plans. To develop a work plan and estimated costs for geotechnical sub-surface investigation programs, the following tasks were undertaken:

- The results of three previous geotechnical evaluation reports were reviewed;
- Preliminary recommendations from previous reports and the aerial reconnaissance survey were reviewed with the Departmental Representative;
- Recommendations for future subsurface geotechnical investigations were developed, including equipment and personnel requirements, general specifications for drilling, sampling and testing, anticipated costs and logistical considerations;
- Revised boundaries and expansion limits of potential quarries were established based on the results of the aerial reconnaissance;
- Proposed access trail alignments located during the desk-top study were confirmed and located on plan drawings;
- Proposed test sites located during reconnaissance were revised or confirmed;
- Figures were prepared to illustrate potential development boundaries, access trail alignments, test site locations, geological boundaries and other pertinent information; and,
- Recommendations were developed on methodology for the subsurface geotechnical evaluation program, including equipment and personnel requirements, general specifications for drilling, sampling and testing, anticipated costs and logistical considerations.

4.0 LIMESTONE QUARRY RESOURCES, KM 251 AND KM 235, DEMPSTER HWY

The Inuvik area is located within the Anderson Plain Physiographic Region at the eastern margin of the Mackenzie Delta and at the base of the Caribou Hills. The Interior Plains are underlain by flat-lying to gently-dipping Paleozoic, Mesozoic and Tertiary sedimentary strata. The terrain is mostly flat lowland, low relief rolling landscape. In the Campbell Lake area south of Inuvik, moderate relief is provided by bluffs of mostly limestone and dolomite, which are the focus of this study.

Bedrock in the Rocky Hills area contains the only durable rock presently exposed in the Inuvik area. Composed of marine sediments ranging in age from Lower Cretaceous (100my) to Proterozoic (>2500my), the feature is formed from the Campbell Uplift and forms relief up to about 100 m above the surrounding terrain of Quaternary fluviatile fan, fan apron and lacustrine deglaciation deposits. Present quarries exploit two windows of Silurian and Devonian (about 410 my bp) limestone that are crossed by the Dempster Highway (km 251 and km 235 to km 232). Occurrences of the limestone unit are also mapped south of Campbell Lake about 8 km west of km 221 of the Dempster Highway. Due to their more remote location and inaccessibility by ground, these areas were not included for potential geotechnical evaluation.

4.1 FIELD RECONNAISSANCE

Aerial reconnaissance was recommended to aid in the planning of suitable geotechnical test sites and access routes to the areas identified as having potential for quarry expansion in the two target areas (km 251 and km 235) (EBA, March 2006). Under INAC Contract No. 20-06-0136, EBA Engineering Consultants Ltd. (EBA) was retained to carry out the field reconnaissance. As the areas identified for potential quarry expansion are not accessible by road and cover a considerable area, ground assessment was an inefficient method of reconnaissance and was not feasible within the scope of the project.

The aerial reconnaissance accomplished the following objectives:

- field-checking of previously mapped terrain;
- confirmation and definition of previously identified limestone quarry resources on Crown Land;
- location of potential targets for subsurface evaluation;
- location and assessment of potential access routes for winter exploration; and,
- consideration of project logistics in light of the proposed future subsurface geotechnical investigation methods.

Reconnaissance of the areas was completed by helicopter on September 16, 2006. The study areas for potential quarry expansion near km 251 and km 235 were viewed and photographed from various elevations. Observations were recorded on site maps prepared for the reconnaissance. The reconnaissance flight was also used to check terrain and identify prominent terrain features or barriers to access.

Results of the field reconnaissance confirmed the approximate limits for practical development expansion of the km 251 quarry to the north and west. The terrain is irregular and outcrops of dolomitic limestone are extensive. Routes were selected to provide access to potential subsurface test sites within areas proposed for quarry development expansion.

Results of the field reconnaissance also confirmed the approximate limits for practical development expansion of the km 235 quarry in three phases to the north and a fourth phase to the south. The reconnaissance revealed that some areas proposed for potential development in the previous report (EBA, March 2006) may be overlain by thick overburden. This emphasizes the need to determine depth to bedrock throughout the areas proposed for phased expansion. Extensive areas of gentle terrain will allow favourable access to all phases from the existing quarry.

4.2 LIMESTONE BEDROCK QUARRY - KM 251 DEMPSTER HIGHWAY

4.2.1 Overview

The km 251 quarry is located 18 km south of Inuvik at km 251 on the Dempster Highway (Figure 1). This site is locally known as the Town Quarry and in previous reports as Source I403 (EBA, 1987) and Site 2.52 (Hardy 1986). It is located in an area of irregular relief with limestone outcrops and shallow overburden on ridges adjacent to the Dempster Highway. Bedrock consists of flat-lying to gently southeast-dipping, finely crystallized limestone. Bedding is thin to massive. Several steeply-dipping prominent joint sets are present – notably N60°E and N30°W. (EBA, 1976 and J. Dennett, 2002).

4.2.2 Proposed Subsurface Evaluation Program

Further development of the km 251 quarry is proposed in two areas. Phase 1 includes the remaining exploitable volume on the ridge adjacent to the Dempster highway, in which the present quarry pit is developed. Expansion would include a fringe area at the west end of the present pit and the ridge extension to the north (Figure 2). Phase 1 is about 13 ha in area. Provided the results of a geotechnical evaluation program are favourable, it has a probable volume of about 3,300,000 m^3 at a pit depth of 25 m. Table 4-1 shows probable volume estimates for selected pit depths.

The Phase 2 area is located to the southwest of the present quarry. Phase 2 and Phase 1 are separated by a northwest-southeast oriented linear depression / structural fault. There is no surface stream channel visible in the depression. Phase 2 is about 10.3 ha in area. Provided the results of a geotechnical evaluation program are favourable, it has a probable volume of about 1,000,000 m^3 at a pit depth of 10 m. (Photo 1 shows the approximate area limits of the two phases).

Four 20 m deep exploratory boreholes are recommended in the Phase 1 area and four 10 m boreholes are recommended in the Phase 2 area for a total of 120 m in eight boreholes. To minimize trail development and disturbance to the ground surface, a track-mounted diamond drill is recommended for the sub-surface evaluation. Rock core produced from diamond drilling will allow structural evaluation, more accurate geological logging and more options for geotechnical testing.

A second option is to advance the testing program with an air rotary drill. Air rotary drilling is generally more efficient and is typically faster with reduced drilling costs. However, this method is not as desirable because rock chips produced by air rotary drilling are limited in value for geotechnical assessment and testing. Core recovery is required for structural logging of the bedrock.

About 800 m of trails are proposed to access the test sites. The area is forested with open spruce forest and some limited hand clearing may be necessary to prepare some access trails. Phase 1 may be accessed via an old cut trail that was advanced from about km 250 on the Dempster Highway. Access to the Phase 2 area may be advanced from the winter road alignment that leaves the Dempster Highway about 250 m south of the km 251 quarry (Figure 2). Ground-truthing these routes is recommended, with the drilling contractor, prior to proceeding with the testing program.

The program should be advanced during the winter to ensure minimum impact. Prior to drill mobilization, access routes should be flagged and a slashing crew should be retained to clear any vegetation if required. The recommended locations for the test sites and access trails are shown on Figure 2.

Previous studies have suggested a proven volume of greater than 2,000,000 m^3 (EBA, 1987). This estimate was based on development in the Phase 1 area (Figure 2). Future expansion to develop the Phase 2 area could produce a probable volume of an additional 1,000,000 m^3. This estimate is based on a floor elevation of 82 m asl and an average natural surface elevation of 92 m. Volume estimates are summarized on Table 4-1.

TABLE 4-1 POTENTIAL VOLUMES FOR EXPANSION OF km 251 QUARRY

	AVERAGE SURFACE ELEVATION*	PIT FLOOR ELEVATION*	PIT DEPTH (m)	AREA (ha)	VOLUME (m^3)
PHASE 1	94	69	25	13.1	3,275,000
PHASE 2	92	82	10	10.3	1,030,000
Cumulative Area – Phase 1 and Phase 2				23.4	
Cumulative Volume – Phase 1 and Phase 2					4,305,000

4.2.3 Cost Estimate

Table 4-2 shows a preliminary cost breakdown and estimate for the drill program. Cost estimates assume that a suitable drill would be mobilized from Inuvik.

TABLE 4-2 DRILL PROGRAM COST ESTIMATE

DRILLING				
Mobilize and demobilize from Inuvik			$1500	
Drilling (includes support)	$7500/day	5 days	$37,500	
Expendables	$20/m	200 m	$4,000	
Fuel	200 L/day	5 days	$1300	
Accommodation and meals	2 crew	6 days	$4000	
				$48,300
TRAIL CLEARING				
Slashing crew	$1200/day	2 days	$2400	$2400
GEOTECH				
Test site and access road layout		1 day	$1500	
Drill supervision and core logging		5 days	$7500	
Mob and demob			$2400	
Truck rental	$200/day	6 days	$1200	
Accommodation and meals		7 days	$2100	
Travel			$1000	
Reporting		32 hrs	$4800	
				$20,500
SAMPLE TESTING			$1200	$1200
SUB-TOTAL				$72,400
Suggested contingency (15%)				$10,860
TOTAL				$83,260

The costs in Table 4.2 are estimates prepared for preliminary budgeting purposes and are based in part on past experience. As costs will vary depending on timing, availability of equipment, and non-fixed expenses, direct quotes should be sought from contractors prior to establishing a final budget.

4.2.4 Summary

Potential expansion of the km 251 limestone quarry is recommended in two phases. Phase 1 is a 13.1 ha area to the north and Phase 2 is a 10.3 ha area to the west. For preliminary geotechnical evaluation of both phases, a total of eight boreholes are recommended to an average depth of 15 m. About 800 m of trails are required to access the sites. The program should be advanced during the winter to ensure minimum impact. The cost of the drill program, including sample testing and reporting, is estimated at about $83,000 including a contingency of 15%.

Volume and quarry dimensions are estimates and a topographic survey will be required to produce site drawings at an appropriate scale for pit development planning.

4.3 LIMESTONE BEDROCK QUARRY - KM 235 DEMPSTER HIGHWAY

4.3.1 Overview

The km 235 quarry is located 34 km south of Inuvik where the Dempster Highway follows a prominent series of fault escarpments that form west-facing cliffs with relief of up to 60 m (Figure 1 and Photograph 3). The present access road to this quarry leaves the Dempster Highway at about km 235. Bedrock consists of thin to thickly-bedded, flat-lying to gently southeast-dipping, finely crystallized limestone. Some shaly beds are reported and closely-spaced joint sets are evident, particularly near fault zones. Pyrite sulphides are evident in the bedrock in varying amounts, but this mineral is not expected to exist in sufficient quantities to be problematic. It is estimated that about 535,000 m^3 have been quarried from the existing pit, which is located behind the high face of the escarpment and is out of sight of the highway. (EBA, 1976 and J. Dennett site reconnaissance, 2002). A detailed topographic survey and Quarry Development and Reclamation Plan must be completed prior to development in order to determine that quarry works would not result in an unacceptable impact to view quality.

Although the deposit covers a large area, the limit of the deposit that may be practically exploited for quarry rock, where bedrock is potentially shallow and relief is suitable, occurs over an area about 2.8 km long by 0.4 km wide.

4.3.2 Proposed Subsurface Evaluation Program

Further development of the km 235 quarry is proposed in four Phases. The areas making up each phase are shown on Figure 3. Surface areas and potential volumes are summarized in Table 4.3. Potential expansion includes three areas progressing northeast from the existing quarry parallel to the fault escarpment. A fourth phase is located south of, and is accessed from, the existing quarry pit.

Key objectives of the proposed geotechnical evaluation program include rock quality confirmation and determination of overburden depth. The aerial reconnaissance of September 16, 2006 indicates that in some areas proposed for phased development bedrock is masked by overburden of unknown thickness.

TABLE 4.3 POTENTIAL VOLUMES FOR EXPANSION OF km 235 QUARRY

	AVERAGE SURFACE ELEVATION*(m)	PIT FLOOR ELEVATION*(m)	PIT DEPTH (m)	AREA (ha)	VOLUME (m^3)
PHASE 1	82	70	12	11.3	1,350,000
PHASE 2	80	68	12	8.8	1,050,000
PHASE 3	104	92	12	25	3,000,000
PHASE 4	100	78	22	19.4	4,268,000
TOTAL				64.5	9,680,813

*Elevations shown are approximate. Assumes 2 m thickness of overburden.

Overburden thickness and suitability of bedrock are the key characteristics that need to be determined prior to progress with further stages of quarry development in the km 235 area. As overburden thickness is critical to evaluating the development potential, the geotechnical investigation program should proceed in two stages: the first is an initial testpitting program to provide data on overburden thickness; and the second is the a drilling program to evaluate bedrock suitability. This approach is recommended for the following reasons:

- Evaluation of overburden thickness by testpitting with an excavator is considerably more cost effective than drilling;
- Access roads for the drilling stage could be established during the testpitting program; and,
- Information on depth to bedrock will be a significant control for the final design and feasibility of the drilling program.
- A supplementary benefit of a test-pitting program is to explore surficial materials for their potential as a borrow resource.

Twenty-two testpits within the four phases are recommended for the initial stage to provide a general indication of overburden thickness. Approximate location of test sites (Figure 3) was determined by stereographic analysis of air photos and the results of the aerial reconnaissance.

Given favourable results of a testpitting program, Stage 2 is recommended to proceed with 18 exploratory boreholes to an average depth of about 12.5 m (225 m total) to evaluate bedrock throughout the four phases of potential quarry expansion (Table 4.4). Diamond drilling is recommended with a minimum "H" core size in order to obtain suitable samples for a complete suite of geotechnical testing. To minimize the effort required for trail development, a track-mounted diamond drill is recommended for the sub-surface evaluation. Rock core produced from diamond drilling will allow structural evaluation, more accurate geological logging and access to a variety of geotechnical testing.

TABLE 4.4 HIGHWAY QUARRY AREA - km 235 DEMPSTER HIGHWAY	RECOMMENDED NO. OF TESTPITS	RECOMMENDED NO. OF BOREHOLES	ACCESS TRAIL LENGTH
Phase 1	5	4	650 m
Phase 2	5	3	850 m
Phase 3	7	5	1600 m
Phase 4	5	6	1000 m
Totals (km 235 quarry area)	22	18	4100 m

A second option for Stage 2 is to advance the testing program with an air rotary drill. Air rotary drilling can be completed at a faster rate than diamond drilling with a subsequent reduction in drilling costs. This method is not preferable, as rock chips produced by air rotary drilling are limited in value for geotechnical assessment and testing. Core recovery is required for structural logging of the bedrock.

About 4 km of trails are proposed to access the test sites (Table 4.4). Open spruce forest dominates the study area and some hand clearing will be necessary to prepare the access trails. The program should be completed during the winter to ensure minimum impact. Prior to drill mobilization, access routes should be flagged and a slashing crew should be retained to clear any vegetation if required. An individual with suitable training and experience in all aspects of resource development should be retained to locate the access trails. Access trail routes should meet the following objectives:

- Sufficient width and grade to accommodate a track-mounted drill
- Minimize environmental impact (tree cutting) by taking advantage of natural openings or sparsely forested areas.
- Minimize the length of access trails
- Where possible, consider an alignment for access trails that could be upgraded to an all-season road for future quarry development.

The recommended locations for the test sites and access trails are shown on Figure 3 (testpits) and Figure 4 (boreholes).

4.3.3 Cost Schedule – Stage 1 Testpit Program

Cost estimates assume that a suitable excavator would be mobilized from Inuvik. Table 4.5 shows a cost breakdown and schedule of the testpit program.

TABLE 4.5 STAGE 1: TESTPIT PROGRAM COST ESTIMATE

TESTPIT EXCAVATION				
Mobilize and demobilize from Inuvik			$750	
Testpitting (includes support)	$1500/day	8 days	$12,000	
Expendables	n/a	n/a	n/a	
Fuel	200 L/day	8 days	$2400	
Accommodation and meals	n/a	n/a	n/a	
				$14,400
TRAIL CLEARING				
Slashing crew	$1200/day	4 days	$4800	**$4800**
GEOTECHNICAL SUPPORT				
Test site and access road layout		1 day	$1200	
Supervision, logging and sampling		8 days	$9600	
Travel			$1000	
Truck rental	$200/day	9 days	$1800	
Accommodation and meals	$220/day	9 days	$1980	
Airfare			$1000	
Reporting and senior review		30 hrs	$4000	
				$17,240
SUB-TOTAL				**$36,440**
Suggested contingency (15%)				**$5,460**
TOTAL				**$41,900**

The costs in Table 4.5 are estimates prepared for preliminary budgeting purposes and are based in part on past experience. As costs will vary depending on timing, availability of equipment, and non-fixed expenses, direct quotes should be sought from contractors prior to establishing a final budget.

4.3.4 Cost Schedule – Stage 2 Drilling Program

Cost estimates assume that a suitable drill would be mobilized from Inuvik. Table 4.6 shows a cost breakdown and final estimate of the drill program.

TABLE 4.6 STAGE 2: DRILL PROGRAM COST ESTIMATE

DRILLING				
Mobilize and demobilize from Inuvik			$1500	
Drilling (includes support)	$7500/day	9 days	$67,500	
Expendables	$20/m	225 m	$4,500	
Fuel	200 L/day	9 days	$1800	
Truck	$200/day	9 days	$1800	
Accommodation and meals	2 crew	10 days	$4400	
				$81,500
GEOTECHNICAL SUPPORT				
Drill supervision and core logging		10 days	$12,000	
Travel			$1000	
Truck rental	$200/day	10 days	$2000	
Accommodation and meals		10 days	$2200	
Airfare			$1000	
Reporting		32 hrs	$4800	
Sample Testing			$1500	
				$24,500
SAMPLE TESTING			$3000	**$3000**
SUB-TOTAL				**$109,000**
Suggested contingency (15%)				**$16,350**
TOTAL				**$125,350**

The costs in Table 4.6 are estimates prepared for preliminary budgeting purposes and are based in part on past experience. As costs will vary depending on timing, availability of equipment, and non-fixed expenses, direct quotes should be sought from contractors prior to establishing a final budget.

4.3.5 Summary

Potential development of the km 235 limestone quarry is recommended in four phases. The four phases have a combined area of about 64.5 ha with a potential cumulative volume of 9.5 million m^3. A total of 22 testpits (Stage 1) and 18 boreholes (Stage 2) are recommended. Borehole depths are estimated to average about 12.5 m for about 225 m of drilling. About 4 km of trails are required to access the sites. The program should be advanced during the winter to ensure minimum environmental impact. The cost of the combined testpit excavation and drill program, including sample testing and reporting, is estimated at about $125,350 including a contingency of 15%..

4.4 RECOMMENDATIONS FOR SAMPLING AND TESTING SPECIFICATIONS

EBA recommends the following tests on representative samples of bedrock recovered from the testing programs:

1. RQD (core only)
2. Durability – resistance to breakdown from weathering due to exposure that results in, e.g., freeze-thaw and wet-dry conditions
3. Abrasion Resistance
4. Hardness
5. Crushability – the rock should be readily crushable into equi-dimensional fragments and produce a minimum of fines
6. Geochemical testing to determine sulphide content

Representative samples will be selected for testing once drilling is complete and the results of core logging can be consulted. Testing frequency and density will be determined following assessment of the degree of consistency of bedrock quality, structure and mineralogy.

5.0 CONCLUSIONS AND RECOMMENDATIONS - INUVIK QUARRY RESOURCES

The two active Dempster Highway quarries at km 251 and km 235 provide a durable and crushable product suitable for use in a variety of applications where a high quality, uniform granular material is required. Work to date indicates that the Silurian/Devonian limestone deposits at both locations are extensive enough to allow considerable future expansion of the existing quarries. Carbonates are typically very favourable for drilling and blasting. Access to the sites is excellent and overburden thickness at the km 251 quarry is not a deterrent to development. Topography is favourable for gravity drainage management.

Limestone and dolomite have a hardness range from 3 to 4, which is the minimum required to prevent crushing and breakdown in use. Although there have been no references found to indicate that the rock processed to date contains significant deleterious substances, iron pyrite inclusions were observed in parts of the km 235 quarry.

At both km 251 and km 235 study areas, test drilling and analysis for geotechnical properties of the bedrock and consistency of lithology in the areas beyond the present quarry development should be completed to assess the quality and development potential of the deposits. At the km 235 study area, the drill program should be preceded by an excavator-supported testpitting program.

Testing for durability, abrasion resistance, hardness, crushability and sulphide content is recommended. There is potential for variation in the hardness and sulphide mineralization within carbonates.

Drilling is recommended at both sites to determine resource quality and quantity, depth of overburden and bedrock structure. Observations to assess drainage conditions, potential access routes, potential waste storage sites, environmental considerations and other issues that may aid in future stages of development should be documented during drilling or testpitting.

A detailed survey and Quarry Development Plan should be completed in order to determine that post-development view quality objectives are not compromised and to provide topographic detail for future planning. Falcon habitat is reported in the vicinity and an assessment of these environmental values should be undertaken to evaluate habitat potential and to develop guidelines, if warranted, to avoid or minimize impact from development.

5.1.1 Limestone Bedrock Quarry - km 251 Dempster Highway

Probable deposit limits, potential development boundaries and land tenure are shown on Figures 1 and 2. Most of the Phase 1 extension is located on crown land (Figure 2). Four boreholes to a depth of about 25 m are recommended in this area for a preliminary exploration program to ascertain continuity of bedrock quality and quantity. Some efficiencies may be achieved with air rotary drilling; however, if this method is chosen geotechnical testing for rock quality would be limited to hardness and geochemistry. A prospective cumulative volume estimate for Phase 1 and Phase 2 is 4.3 million m^3.

The limits of the deposit on the northeast side of the highway, where bedrock is mostly covered by a veneer to blanket of overburden, occurs over an area about 2 km long by 1.2 km to 0.5 km wide. Outcrops near the highway and the results of a test pit about 300 m inland (EBA, 2002) indicate that the limestone is similar to that in the Town Quarry. Further assessment of this area is outside the scope of this study but it remains an option for future exploration of quarry resources.

Wilderness values have been identified in the area of km 251 on the east side of the Dempster Highway and environmental values (falcon habitat) recognized along the west shore of Campbell Lake.

5.1.2 Limestone Bedrock Quarry - km 235 Dempster Highway

The limestone deposit at km 235 is truncated by a fault line scarp on its southeast margin. The present quarry was developed by the GNWT Transportation Department for highway construction. The department reports that no pre-development exploration drilling was completed at this site (G. Jagpal, pers. comm.).

Previous assessment of the quarry potential at this deposit indicated phased development that would process about 4.45 million m^3 of rock (EBA, 1976). This estimate included the areas of the present quarry at km 235 and Phases 1, 2 and 3 (Figure 3). The proposed development has good access and quarry sites would be developed on the east flank of the limestone scarp to maintain the natural viewscape along the highway.

Probable deposit limits and additional quarry sites for phased development are shown on Figures 3 and 4. Twenty-two testpits (Stage 1) and 18 boreholes (Stage 2) are recommended to ascertain overburden thickness and continuity of bedrock quality and quantity in the 4 phases. Diamond drilling is recommended with a minimum "H" core size in order to obtain suitable samples for a complete suite of geotechnical testing.

A cumulative prospective volume of rock available for processing within the 4-phase development is about 9.5 million m^3.

The results and recommendations of this report are based on small scale contour maps and air photograph interpretation. A detailed topographic survey is required to determine pit development plans and to confirm potential pit floor elevations, drainage management and volume estimates.

6.0 CLOSURE

The information and analyses contained in this report and maps are based on the results of previous reports, air photograph interpretation, current understanding of regional terrain and geology, and on limited observations of land-surface conditions. In most of the study area, subsurface conditions (e.g., characteristics of subsurface materials and subsurface hydrologic conditions) are interpreted from surface observations or air photo interpretation with only reconnaissance scale field checking. The terrain and soil conditions indicated are intended as a useful guide for regional planning purposes and should not be used to guide specific development until local material textures have been evaluated by sub-surface investigation.

For further information regarding the use of this report, please refer to the attached general conditions that form a part of the report.

EBA Engineering Consultants Ltd.

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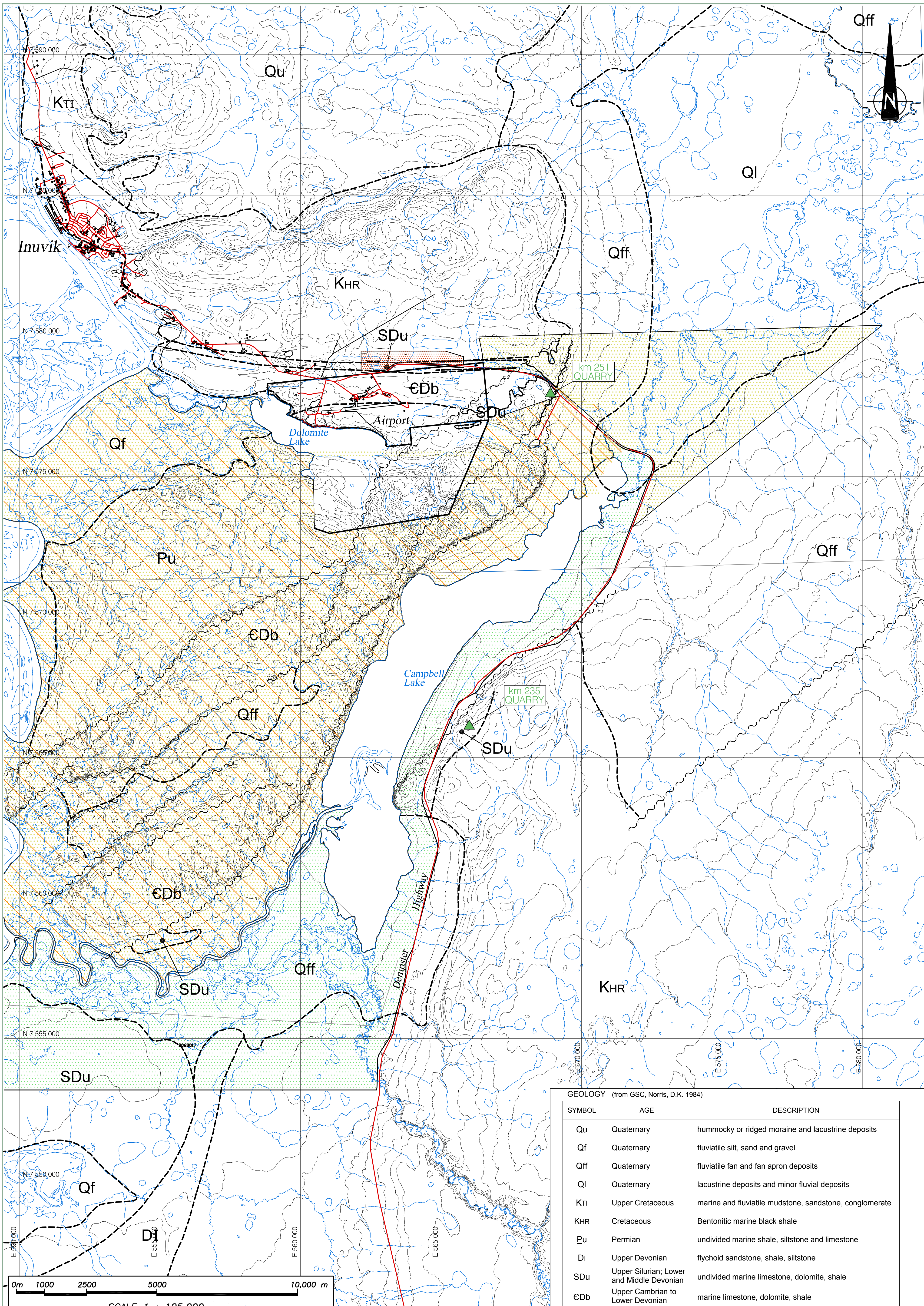
FIGURES



GEOLOGY (from GSC, Norris, D.K. 1984)

SYMBOL	AGE	DESCRIPTION
Qu	Quaternary	hummocky or ridged moraine and lacustrine deposits
Qf	Quaternary	fluviatile silt, sand and gravel
Qff	Quaternary	fluviatile fan and fan apron deposits
Ql	Quaternary	lacustrine deposits and minor fluvial deposits
KTI	Upper Cretaceous	marine and fluviatile mudstone, sandstone, conglomerate
KHR	Cretaceous	Bentonitic marine black shale
Pu	Permian	undivided marine shale, siltstone and limestone
DI	Upper Devonian	flychoid sandstone, shale, siltstone
SDu	Upper Silurian; Lower and Middle Devonian	undivided marine limestone, dolomite, shale
ЄDb	Upper Cambrian to Lower Devonian	marine limestone, dolomite, shale

s s s geological fault — — — — geological contact

NOTES:
1. TERRAIN SYMBOLS ARE DEFINED ON "LEGEND FOR SURFICIAL MATERIALS" ON SEPARATE SHEET.
2. THIS DRAWING HAS BEEN PRODUCED IN COLOR, ANY REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL.

LEGEND:
- GWICH'IN PRIVATE LAND - SURFACE
- GWICH'IN PRIVATE LAND - SURFACE/SUBSURFACE
- GWICH'IN MUNICIPAL LANDS
- GWICH'IN TERRITORIAL PARK

EBA Engineering Consultants Ltd.

DWN. JSB CHKD. JTD/JRT

EBA JOB NO. 1200209

CLIENT
DEPARTMENT OF INDIAN AFFAIRS & NORTHERN DEVELOPMENT LAND & WATER MANAGEMENT, NRE

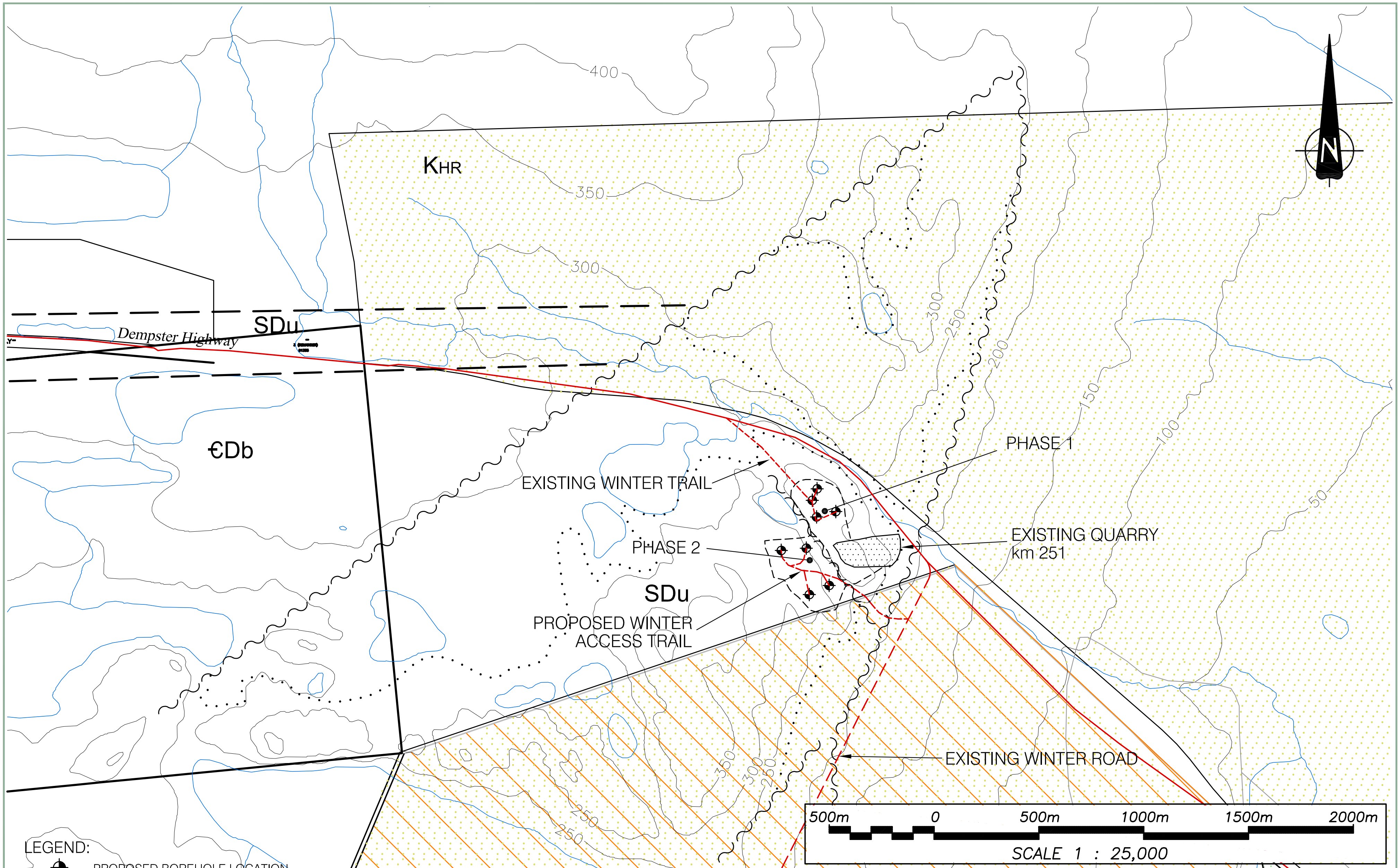
FILE: 1200209 Figure 1.dwg REVISION NO.: 1

PROJECT
GEOTECHNICAL INVESTIGATION PLANS - SUBSURFACE EVALUATION OF QUARRY RESOURCES, INUVIK, NT

TITLE
SITE LOCATION AND GEOLOGY CAMPBELL LAKE, INUVIK, NT

DATE: SEPTEMBER 2007

Figure 1



LEGEND:
- PROPOSED BOREHOLE LOCATION
- LIMIT OF OUTCROP OR SHALLOW BEDROCK
- PRACTICAL LIMIT OF FUTURE DEVELOPMENT
- GWICH'IN PRIVATE LAND
- GWICH'IN PRIVATE LAND - SURFACE/SUBSURFACE

NOTE:
1. THIS DRAWING HAS BEEN PRODUCED IN COLOR, ANY REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL.

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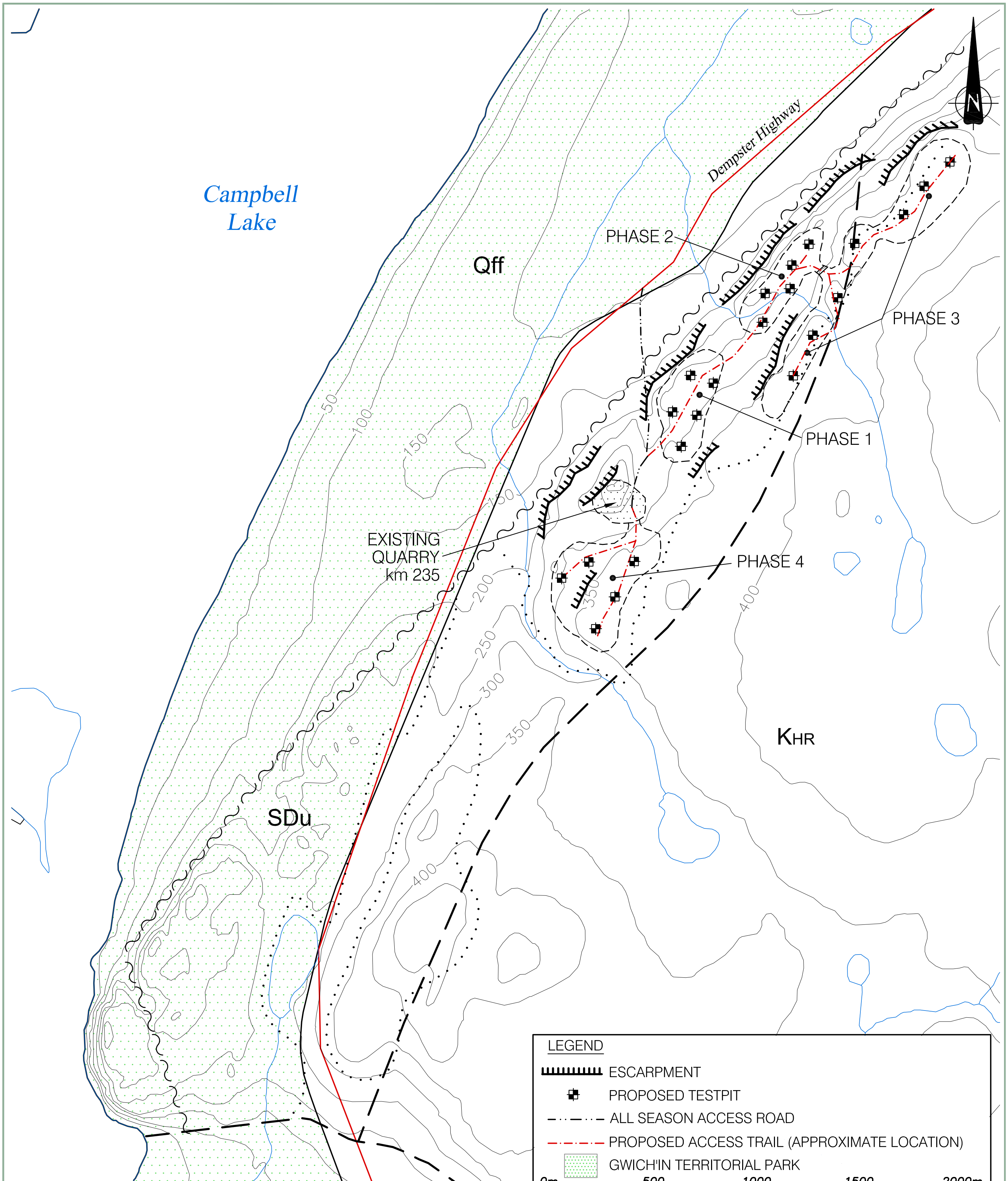
DWN. JSB	CHKD. JTD/JRT		TITLE: SITE MAP - km 251 QUARRY CAMPBELL LAKE AREA, INUVIK, NT
EBA JOB NO. 1200209		FILE: 1200209 Figure 2.dwg / REVISION NO.: 1	DATE: SEPTEMBER 2007 / Figure 2



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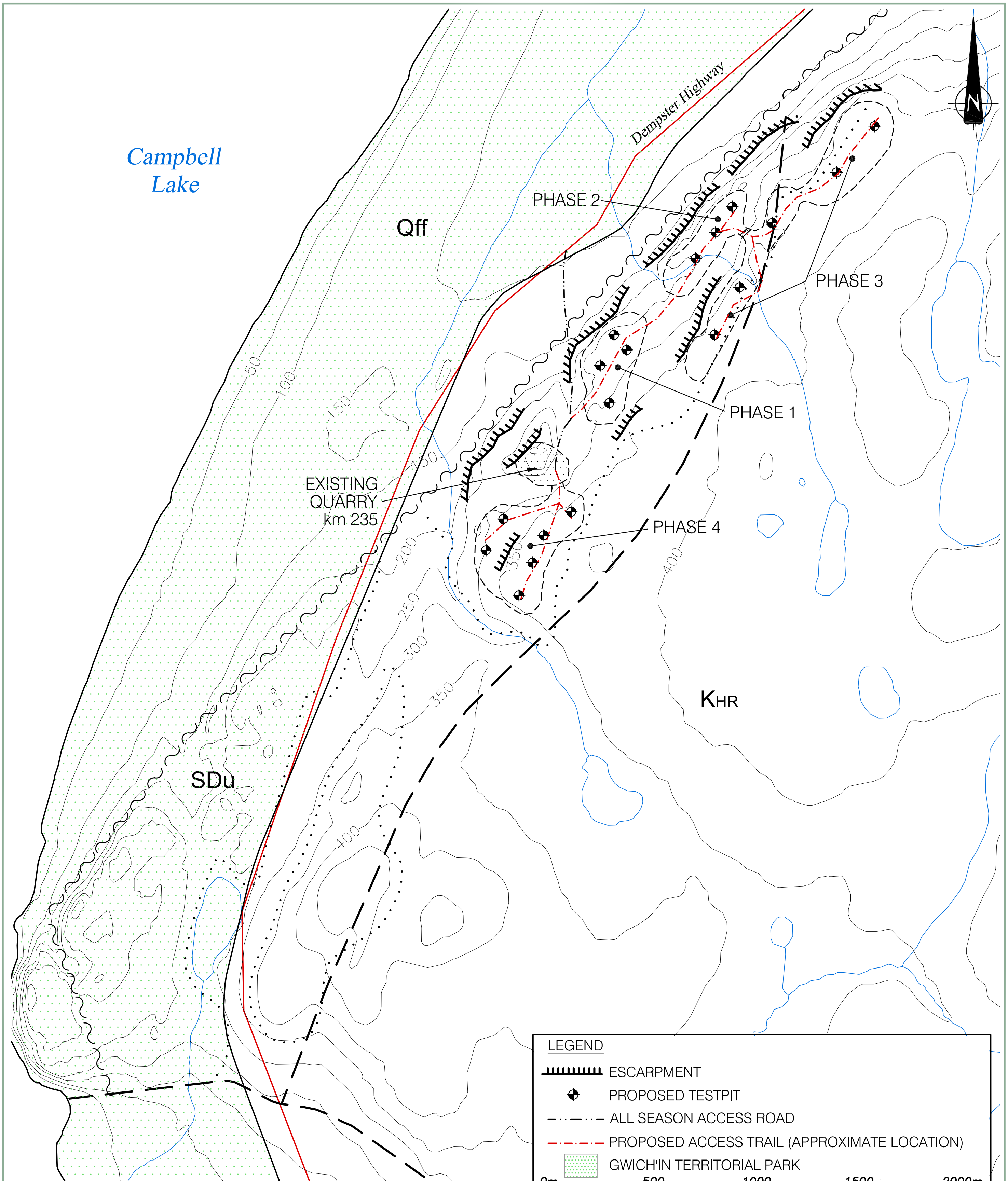
			TITLE: SITE MAP - km 235 QUARRY STAGE 1 - TESTPIT PROGRAM CAMPBELL LAKE AREA, INUVIK, NT
EBA JOB NO. 1200209	FILE: 1200209 Figure 3.dwg	REVISION NO.: 1	DATE: SEPTEMBER 2007

Figure 3



NOTE:
1. THIS DRAWING HAS BEEN PRODUCED IN COLOR, ANY REPRODUCTIONS MAY NOT BE REPRESENTATIVE OF ORIGINAL.

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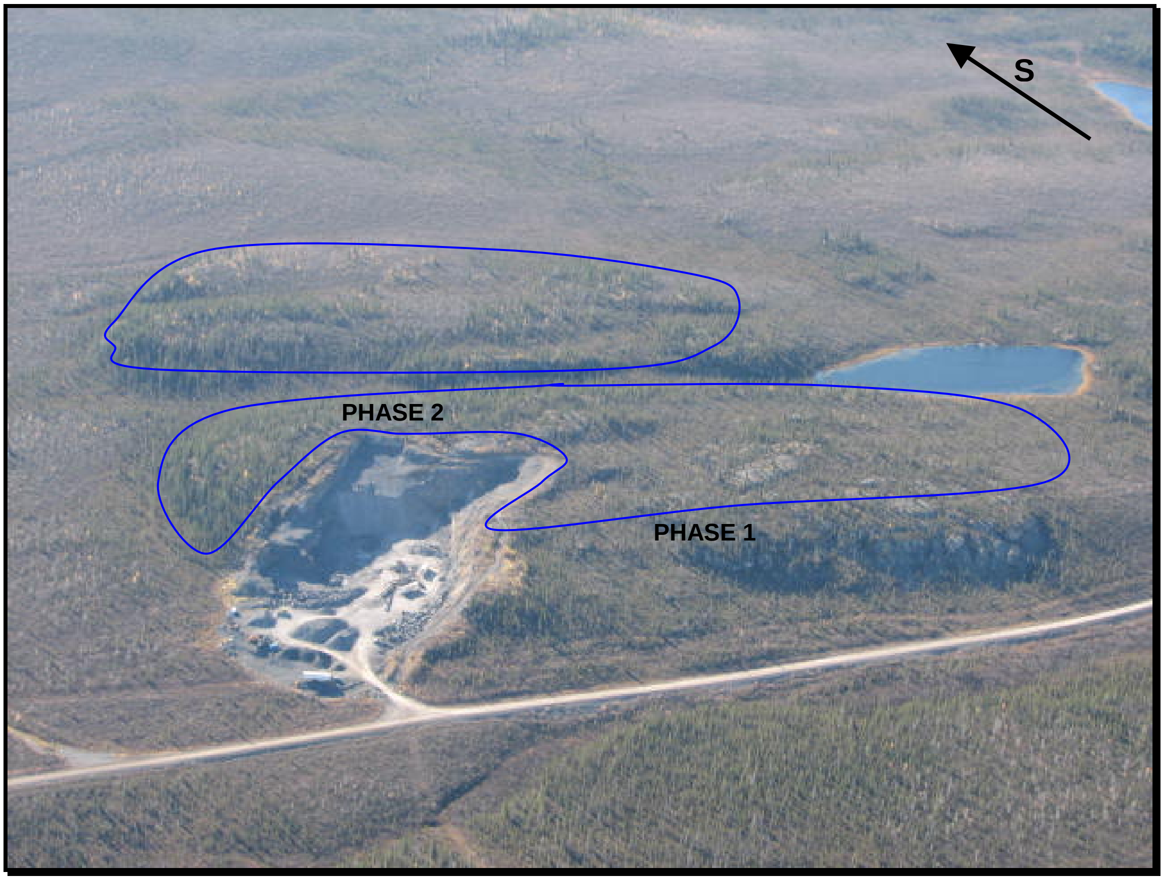
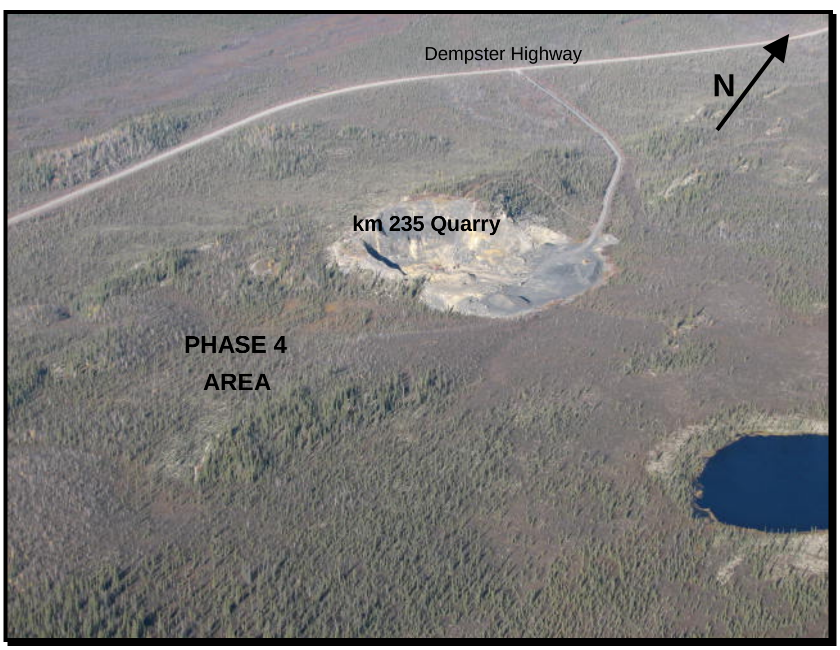
			TITLE: SITE MAP - km 235 QUARRY STAGE 2 - BOREHOLE PROGRAM CAMPBELL LAKE AREA, INUVIK, NT
EBA JOB NO. 1200209	FILE: 1200209 Figure 3.dwg	REVISION NO.: 1	DATE: SEPTEMBER 2007 — Figure 4

PHOTOGRAPHS



Photograph 1. September 16, 2006. Approximate boundaries of potential pit development at km 251 Quarry.



Photograph 2. September 16, 2006. km 235 quarry.

Photograph 3. September 16, 2006. Approximate locations of Phase 1, 2 and 3 at km 251 Quarry study area. Potential boundaries of actual quarry development are not shown.

APPENDIX A

APPENDIX A General Conditions *

GEOTECHNICAL REPORT – GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

3.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

4.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

5.0 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

6.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

7.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

8.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

9.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

10.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

11.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

12.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client's expense upon written request, otherwise samples will be discarded.

13.0 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

14.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

15.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), the Client agrees that only the signed and sealed hard copy versions shall be considered final and legally binding. The hard copy versions submitted by EBA shall be the original documents for record and working purposes, and, in the event of a dispute or discrepancies, the hard copy versions shall govern over the electronic versions. Furthermore, the Client agrees and waives all future right of dispute that the original hard copy signed version archived by EBA shall be deemed to be the overall original for the Project.

The Client agrees that both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. The Client warrants that EBA's instruments of professional service will be used only and exactly as submitted by EBA.

The Client recognizes and agrees that electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.