MT. NANSEN GOLD PROJECT

MT. NANSEN PROJECT

Tailings Storage Study

FEASIBILITY DESIGN

PB 5314 03

SEPTEMBER 1994

Klohn-Crippen

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1. INTRODUCTION

BYG Natural Resources Inc. (BYG) intends to develop an open pit gold mine on the Mt. Nansen property, near Carmacks, Yukon. Klohn-Crippen has been asked by BYG to prepare a feasibility design for a tailings facility for the proposed mine, considering alternatives to the site upon which a preliminary design (Klohn Leonoff 1990) was based. This report presents the results of field investigations carried out at the site during July 1994, and subsequent design work for a tailings facility. The site work was carried out at a tailings dam site on Dome Creek not previously considered, shown as Site #4 on Drawing D-3003.

1.1 Project Description

The project site is accessed from Carmacks via gravel road and is about 60 km west of Carmacks. The Mt. Nansen Road was used to develop the underground mine on the property which operated for two brief periods in the 1960s and 1970s. The road is also used by a number of prospectors and placer mining operators in the area. Old underground workings, mill buildings, two small tailings ponds, a small water reclaim pond and many bulldozer trenches are still present on the Mt. Nansen property (see Drawing D-3002).

The proposed project will refurbish and utilize the existing mill. The ore to be mined is oxide rather than sulphide ore, and is not expected to be acid-generating. Tailings generated from the oxide orebody will total about 300 000 tonnes, or about 240 000 m^3, assuming a dry unit weight of settled tailings of 1.25 tonnes/m^3. The tailings facility design must accommodate this volume of tailings. Cyanide will be used in the gold recovery process. Cyanide destruction will be used to remove most of the cyanide from the tailings before delivery to the tailings pond.

It is understood that about 600 000 tonnes of waste rock will be mined from the open pit to liberate the ore, and that this waste rock will not be acid-generating. This waste rock is a potential source of construction material for the tailings dam.

1.2 Previous Work

Mr. T. Harper of Klohn Leonoff, inspected the site in September 1985 and submitted a letter-report to Chevron Canada Resources Ltd. on November 7, 1985. This inspection consisted of a preliminary investigation for tailings disposal and for proposed leach pad sites. The report concluded that a tailing storage facility should be located on Dome Creek at a site just below the mill (Site #2, Drawing D-3002).

In 1990, a report was prepared by Klohn Leonoff presenting a preliminary design of a tailings facility located uphill of the mill area (Site #1).

2. SITE CONDITIONS

The minesite is located within the physiographic region known as the Yukon Plateau. The area has typically rounded mountain tops with broad valleys and gentle topographic features. Side slopes of the valleys in the vicinity of the mine vary from 2H:1V to as flat as 6H:1V. Drainage from the minesite and tailings dam locations flows into Dome Creek, a tributary of Victoria Creek, which is part of the Nisling River system. The Nisling River ultimately flows into the Yukon River. The mine elevation is about 1250 m (about 4,100 ft).

Elevations have been determined from an orthophoto provided by BYG Natural Resources Inc. The orthophoto, which is undated, has a contour interval of 10 m and covers the entire property. For preliminary design purposes, a cross section of the valley topography was created using a tape and clinometer (see Drawing D-3003).

2.1 Surficial Geology

Surficial soils in the Dome Creek valley area consist mainly of colluvial, residual and granular glacial outwash soils overlying bedrock. The soil cover is thin on the steeper valley sides, increasing in the valley bottom to about 20 m deep. Upper slopes are covered in a thin veneer of colluvial soils.

Four glacial advances have been defined across the central Yukon Territory. These are, from oldest to youngest, the Nansen, Klaza, Reid and McConnell advances. However, the area was not glaciated during the most recent (Pleistocene) ice age. The Mt. Nansen minesite is situated within the Nansen drift. At least 2,000 years ago, volcanic ash fell on this area up to 30 cm in depth. Remnants of this ash are visible at many locations on the property. The ash occurs at surface or just below the organic soils, and typically has a depth of less than 10 cm. Some glacial till has been noted at depth in the main valley bottom.

The soils vary from a sandy gravel to a fine sandy silt. The material is generally medium dense with some pockets of loose material.

2.2 Bedrock Geology

The bedrock at the site appears to consist of igneous rocks of the Mt. Nansen Group which have intruded into the Pelly Formation metamorphic rocks. The metamorphic rocks have been mapped as undifferentiated schists, gneisses, quartzites and marbles. The bedrock is highly shattered and broken at the ground surface as observed in exploration trenches and test pits. We understand that the degree of shattering does decrease with depth, but the rock is shattered near surface within the area of the tailings pond. The bedrock is a purplish to brown colour. Bedrock is exposed on the ridge tops where there is very little tree or vegetation cover.

2.3 Permafrost

The site lies within the discontinuous permafrost zone, close to the southern boundary of widespread areas of permafrost islands. Because of the high elevation of the site, permafrost is more widespread than is generally true in this region. The -4°C mean annual air isotherm passes through Carmacks. Taking into account the fact that the elevation of the site is between 600 m and 700 m higher than Carmacks, the mean annual air temperature for the site is expected to be at least 2°C colder than that in Carmacks, or at most -6°C, and possibly -8°C (personal communication with Environment Canada). At the time of the site investigation (mid-July 1994), the soils beneath Site #4 were frozen. Where a thick layer of moss exists, such as over most of the north facing side of the valley, the soils were frozen immediately beneath the moss layer. In the sandy terrace soils where the insulating layer of moss does not exist, the soil was thawed to a depth of about 2 m (active zone), below which the soil was solidly frozen. In the areas of sandy terrace soils, only a thin layer of lichen occurs at ground surface, and in some places, sand is exposed over areas of up to tens of square metres.

2.4 Seismicity

The Mt. Nansen minesite lies within a seismically active area of the Canadian north in Seismic Zone 2, as defined by the National Building Code of Canada, 1990. The site lies within the Northern British Columbia (NBC) source zone between the McKenzie (MKZ) zone and the Denali Shakwak (DSK) zone.

A probabilistic assessment of the seismic risk at the site has been undertaken by the Pacific Geoscience Centre for the Mt. Nansen site (October 1988). The results are enclosed in Appendix I. A peak horizontal ground acceleration of approximately 10% g is expected with probability of exceedance no greater than 0.0021, or one in 475 years, while a peak horizontal acceleration of 12% g is expected with a return period of .001, or one in 1,000 years.

The tailings dam will be founded on medium dense granular soils overlying bedrock. Extensive deposits of loose soils, if they exist, will be removed from the foundation to minimize any potential for liquefaction under earthquake loading.

2.5 Climate

The mean annual precipitation for the project site is about 270 mm. Snow begins falling in October or November and usually remains on the ground until May. The typical snowpack is about 1 m. Approximately 40% of the precipitation falls as snow. Some rainfall occurs as early as April, but the majority of rainfall occurs from June to August. The most intense rainfall occurs in July.

3. TAILINGS DAM SITE SELECTION

3.1 General

Three potential dam sites (Site #1, Site #2 and Site #3 - see Drawing D-3002) have been considered in the past. Those three sites are all located on relatively steep slopes and offer relatively low storage volumes in proportion to the size of the dams required. Because of the lack of permafrost in the foundations, Site #1 was chosen as the best of the three. Sites #1 to #3 are described in detail in previous reports (see Klohn Leonoff, 1988 and 1990).

3.2 Site #4

Part of the scope of the current study was to investigate the entire property for additional potential tailings dam sites. A new location, named Site #4 (see Drawing D-3002 and Drawing D-3003) was identified on Dome Creek, downstream of the previously identified sites. Although the site does have frozen foundations, it is superior to the other sites (1, 2 and 3) in the following respects:

- Because of a broadening of the valley bottom and a relatively flat meadow upstream of the proposed dam site, the potential storage volume is good, as compared to other sites.
- A relatively low dam is required to impound the necessary tonnage of tailings.
- Because of a natural restriction of the valley at Site #4, the volume of the dam is relatively low.

In addition to the above benefits, there is a source of granular soils in the area which would make good construction materials. There is also potential to locate a spillway on the left abutment at Site #4 with its crest excavated in bedrock. Consequently, Site #4 was chosen for assessment by test pitting and drilling during the 1994 site investigation.

3.2.1 Site 4 Conditions

Site #4 is located in the Dome Creek valley at about elevation 1130 m. Topographically, Site #4 appears to be the best available site on the property. The south side of the valley (right abutment) is quite steep (slopes of about 3:1 on the abutment and 2:1 higher on the slope). On the north side of the stream, there is a sand terrace, with its top elevation about 12 m above the creek level (see Drawing D-3003).

Three boreholes were drilled and 14 test pits were dug in the area of Site #4 during the July, 1994 site investigation. The locations of the test pits and boreholes are shown in plan and section on Drawing D-3003. Test pit locations in Drawing D-3003 are estimated, and borehole locations are surveyed. The boreholes were drilled with a Nodwell mounted CME-750 rig using solid stem augers. Sampling was carried out using a CRREL (Cold Regions Research Engineering Laboratory, US Department of the Army, Hanover, NH) tube sampler which produced cores of 7.6 cm (3 inch) diameter. Because all of the holes drilled were in frozen ground, no SPT tests were carried out. Drawing D-3003 gives a sectional interpretation of the foundation geology along the proposed dam centreline. Test pit logs and borehole logs are included in Appendix II. No test pits were dug south of the creek because it was considered too risky to attempt access across the creek with the backhoe.

In natural outcrops and where exposed in test pits and trenches, bedrock is highly fractured. This is a result of freeze thaw action and is accentuated in this area of the Yukon which was not glaciated in Pleistocene times.

A layer of apparent glacial till exists over bedrock in the deepest part of the valley. The till is typically a silty fine sand with numerous angular to subrounded pebbles and cobbles.

Overlying the glacial till is a grey silty fine to medium sandy material up to about 15 m thick. The fines content of the silty grey sand varies between about 10% and 40%. Within this silty sand, layers of varying organic content were observed. More organic-rich soils were noted on the right abutment than on the left abutment or in the valley centre. The more highly organic layers contain higher percentages of fines, a higher ice content, and exhibit a distinctive organic odour when thawed. The grey sand exists immediately below surface in most of the area and, where present at surface, it is generally covered by a thick layer (about 20 cm to 30 cm) of moss. The active layer in this unit is very shallow. In mid-July 1994, the soil immediately below the moss layer was frozen.

Terraces of clean, well rounded fine to medium sand occur along the sides of the valley in some areas. The left (north) abutment of Site #4 is formed on one of these terraces. The local sand terrace deposits are apparently remnants of more extensive deposits which once filled the valley bottom. They consist of fine to medium sand with about 5% to 10% fines. Cross bedding, indicating that the sand was originally deposited in water, is evident in test pits and drill core samples. The terrace sands are well drained and, although frozen, contain no visible ice. The active layer in the terrace sands is deeper than in the finer-grained soils. In mid-July 1994, this soil horizon was thawed to a depth of about 1.5 m to 2.0 m.

Minor thicknesses of organic soils (usually less than about 15 cm) occur at surface in most areas. Along the creek in the valley centre, peat of up to about 0.9 m was encountered. Moss covers the ground surface throughout the Site #4 area, except on the terrace sand deposits where aspen trees and lichens indicate the better drainage provided by the sandy soil.

4. TAILINGS DAM DESIGN

4.1 General

A tailings facility capable of storing 300 000 tonnes of tailings is required. Based on the best topographic map available (10 m contours), a storage-elevation curve was drawn for Site #4 to determine the probable height of dam required. It appears that a dam approximately 12 m high will be required to store the 300 000 tonnes. In addition, freeboard of about 2 m was assumed for preliminary design purposes, resulting in a total dam height of about 14 m. These values are preliminary, subject to a more detailed topographic survey of the impoundment area.

The dam would be constructed primarily of the silty fine to medium sand available on site. Although compaction of this material may be more difficult than some other soil types, this sand is the best material available for dam construction for several reasons. It is available in abundant quantities on site. Because of its well drained nature, it is a material well suited for excavation. Test pits excavated in July indicated that it was thawed to a depth of approximately 2 m below surface. Other soils were frozen just below the moss layer at that time. Borrow pits in this material would be relatively easy to reclaim following construction.

Several different dam design concepts have been considered. Because of uncertainties regarding the thermal conditions and permafrost in the dam and dam foundations, it was necessary to assess dams for frozen and unfrozen states.

The frozen dam condition is one where, following construction, the permafrost moves up into the dam and causes the main body of the dam to become permanently frozen. Ideally, the dam should be constructed so that the top of the permafrost (the bottom of the active zone), is above the maximum pond elevation. In this case, seepage is effectively eliminated, and the structural strength of the dam is high. Development of frozen dams has been successfully carried out at some arctic mines, and generally requires a very broad-crested dam to avoid three-dimensional conditions imposed by heating of the dam faces during the summer months. Two well-documented case histories of frozen earthfill dams are the Crescent Lake Dam near Thule Air Base, Greenland (Fulwider, 1973) and the tailings dams at the Lupin Mine located in the Northwest Territories (Geocon, 1990). These dams consist of low, earthfill dam structures which are constructed in continuous permafrost zones.

The unfrozen case assumes a semi-permeable dam. Appropriate placement and compaction of the dam fill material would ensure adequate strength of the structure itself. Stability of the foundations may be related to the degree of thawing of the permafrost underlying the dam. If the dam foundations thaw, zones of loose sand may result which could be susceptible to liquefaction under seismic conditions. To ensure adequate stability of the dam under these conditions, a dam with gentle side-slopes is required to avoid excessive deformation in the unlikely event of liquefaction of the foundation material. A situation may result where initial seepage causes shallow thawing of foundations, which would later re-freeze as seepage diminishes.

A one-dimensional thermal analysis has been carried out to assess the thermal conditions following dam construction. Stability analyses have been carried out for the above cases (frozen and unfrozen). The thermal and stability analyses, and the required dam cross sections are discussed in the following sections.

4.2 Thermal Analysis

A one-dimensional thermal analysis was carried out for the dam using the computer program THERM1 (Nixon, 1990). The program uses the finite difference method to solve one-dimensional heat transfer problems in soils with freezing or thawing. A wide-crested tailings dam can be considered as a one-dimensional problem. The program produces data which has been plotted (see Appendix III) to illustrate the variation of temperature with depth over the course of the year. The primary intent of the modelling is to determine the depth of the active layer in the dam and/or foundations. The active layer is determined as the soil which, at some time of the year, reaches a temperature at or above the freezing point. The active layer freezes each winter and below the active layer, the soil is assumed to remain permanently frozen.

The modelling program requires input data including mean monthly air temperatures throughout the year. Detailed temperature data are available for Carmacks, 700 m lower than the site. Based on discussions with Environment Canada personnel in their Vancouver weather office, adjustments were made to the Carmacks data to account for the higher elevation of the site. Initially, average values of 4°C less than the Carmacks data were used. However, Carmacks data less 3°C produced results more closely matching those observed on site. Consequently, 3°C less than the Carmacks data was adopted for subsequent modelling.

To calibrate the model, input values including soil parameters and temperature data were adjusted until results agreed with observed field conditions. For the clean terrace sand, which is the preferred construction material, an active layer of about 2 m to 3 m is expected to develop, as seen in the in situ deposits. Where the silty grey sand exists at surface, the modelling shows an active layer of less than about 0.5 m, as observed on the right abutment.

Based on the above results, it is concluded that the active layer in the dam may penetrate to about 3 m below the crest elevation. Where the dam height lessens on the abutments, there is potential for the active layer to penetrate into the foundations. On the left abutment, where the foundations are formed in clean terrace sand, or rocky colluvium, this will not be a problem. However, on the right abutment and valley bottom, and part of the left abutment beneath the low section of the dam, some fine-grained, ice-rich soils exist in the foundations. To avoid thawing of fine-grained, potentially ice-rich soils, raising of the crest will be required in these areas. By providing a minimum fill thickness of 4.0 m in all areas of fine grained soils where the foundation surface is at or below the design maximum pond elevation, thawing of these critical zones can be avoided.

4.3 Stability Analysis

Unfrozen Dam Condition

Stability analyses were carried out to determine the cross sectional geometry required to ensure adequate stability of the dam under static and seismic conditions, for the worst case (unlikely) where both the dam and the foundations are thawed.

For the chosen cross sectional geometry, the minimum factor of safety against failure under static conditions is about 2.2.

A stability analysis has been carried out to assess the possibility of failure for a case where foundation soils thaw. This could result in loose sands which may be subject to liquefaction under seismic conditions. Details of the analysis are given in Appendix IV. The results indicate that, to achieve a factor of safety of 1.1, considered reasonable for this case, requires a dam with a base width of at least 80 m. The dam configuration given in Drawing D-3003 meets the necessary criteria, with a base width of about 90 m.

Frozen Dam Condition

A relatively broad-crested dam is required to avoid three-dimensional heating effects and allow freezing of the dam. It is generally accepted in the literature that a dam width to height ratio of about 3:1 is acceptable. The width is taken as the horizontal distance between upstream and downstream faces of the dam at the elevation of the pond water level. In a situation where a tailings beach exists against the dam, the horizontal thickness of the tailings can be included in the calculation. If we assume that the tailings beach is developed to within 1.0 m of the dam crest elevation, and the freeboard above the pond level is 2.0 m, then, the horizontal tailings thickness will be about 100 m. Adding his 100 m to the horizontal dam width at this elevation provides an adequate effective dam width. Consequently, a conventional dam crest width of about 6 m would be acceptable. These calculations are conservative, because the pond level would normally be kept much lower than 2 m below the dam crest.

4.4 Dam Cross Section

Two stability analyses were carried out, as described above, to determine geometric design parameters for a frozen dam and an unfrozen dam. The results indicate that the cross sectional geometry required to ensure stability for the two conditions are very similar. Consequently, for this level of design, the following basic cross sectional geometry has been chosen:

▸ Crest Width	6 m
▸ Upstream Slope Angle	2.5H:1V
▸ Downstream Slope Angle	3.5H:1V
▸ Minimum fill thickness over fine grained soils	4.0 m

In addition, a minimum fill depth of 4.0 m should be maintained in all areas where the foundation surface is at or below the design dam crest elevation, except where the foundation is formed of the clean terrace sands.

This geometry results in a dam which meets stability requirements for both frozen and unfrozen states. Drawing D-3004 illustrates the proposed dam cross sectional geometry of the dam.

The dam is a homogeneous earthfill structure constructed from the fine to medium grained yellow-brown sand located as a terrace deposit at the site. Grain size tests indicate that this sand contains up to about 10% silt. The siltier grey sand located beneath the terrace deposit is also suitable for construction, but, because of poorer drainage, contains more ice and therefore may be more difficult to excavate. Test pits indicated that in July, the terrace sands were thawed to a depth of about 2 m and that the grey silty sands (insulated with moss) were thawed to a depth of only about 0.5 m or less.

Alternatively, the downstream portion of the dam could be constructed from mine waste rock. If this option is pursued, a suitable filter would be required between the sand fill and the rock fill portions of the dam.

The dam foundations should be excavated to below the active zone, or about 1.5 m to 2.0 m. Below this depth, no significant ice lenses were noted in drill holes, except on the right abutment. Within the active zone, significant ice was noted in drill cuttings and test pits.

Erosion protection will be required on the downstream face of the dam, on the crest, and on the upstream face above the tailings beach. Waste rock from the open pit will be suitable for this purpose. A layer of rock about 0.5 m thick will be sufficient.

4.5 Spillway and Water Diversions

The tailings facility will require an emergency spillway during mine operation to avoid any potential for overtopping of the dam during extreme storm events. The emergency spillway would be upgraded to a permanent spillway following closure of the mine. At that time, because water discharge from the system would be acceptable (following degradation of any remaining cyanide), Dome Creek would be allowed to flow through the pond and over the spillway.

It appears that the best location for the spillway is on the left (north) abutment. Overburden depths are relatively shallow in that area, probably allowing the spillway crest to be developed in bedrock. Overburden in the area consists of terrace sands and rocky colluvium. Development of the spillway trench in these soil types will avoid problems associated with open excavations in permafrost-rich fine grained soils. Portions of the spillway, such as the outlet channel, to be excavated in sandy soils would require riprap available from the open pit waste. A preliminary alignment and typical cross section for the spillway are shown on Drawing D-3003.

Alternatively, the spillway may be developed in the right abutment. Because of the steep slopes, neither the drill or the backhoe could access this area during the 1994 site investigation. However, if soil conditions permit, a spillway on the right abutment may require a smaller excavation than on the left abutment. Further site investigation will be required to determine overburden depths and the soil types in the area south of the dam (right abutment) to confirm feasibility of this option.

Hydrology aspects of the spillway are discussed in Section 5.

4.6 Seepage Control

It is understood that, during mine operation, cyanide destruction will take place in the mill prior to tailings discharge to the tailings pond. However, some cyanide may remain in the tailings and it will be desirable to maintain a zero discharge system. For this reason seepage should be minimized through the dam. The dam, being built from fine to medium sand with a low percentage of fines, will be a semi-pervious structure. However, we understand that the tailings to be stored in the impoundment will be quite fine due to the grind in the mill and the high proportion of clay minerals in the ore. By developing a tailings beach on the upstream face of the dam, a very low-permeability structure can be realized and seepage will be greatly reduced.

A seepage analysis was carried for an unfrozen dam condition out using the two-dimensional finite element computer program SEEP/W. The results of the seepage analysis (see Appendix V) indicate that the dam will be well drained with all seepage occurring in the lowermost 1 m of the dam. Total seepage through the dam is estimated to be less than 1 ℓ/sec. This is dependant on development of a tailings beach on the upstream face of the dam. Hydraulic conductivities of the various materials used in the analysis are given in Table 4.1.

Table 4.1 Summary of Hydraulic Parameters Used in Seepage Analysis

MATERIAL DESCRIPTION	HYDRAULIC CONDUCTIVITY
Deep foundation soils - will remain frozen and essentially impermeable	1 x 10^{-9} m/s
Shallow foundation soils - assumed to be thawed to a depth of about 5 m - consist of fine to medium sands with varying silt content	1 x 10^{-5} m/s
Dam - compacted clean fine to medium sand with up to about 10% fines	1 x 10^{-4} m/s
Tailings - high fines content - permeability may be as low as 1 x 10^{-7} m/s	1 x 10^{-6} m/s

In the most probable event that the permafrost front moves up into the dam to a height higher than the pond level, seepage will be reduced to near zero.

5. HYDROLOGY AND WATER MANAGEMENT

5.1 Climate and Extreme Events

Feasibility level hydrological studies were carried out by Klohn Leonoff (Klohn Leonoff 1988 and 1990). The following information was extracted from these studies unless otherwise noted.

Climatological data has been obtained from the nearest Environment Canada meteorological station, No. 2100300, which is located 60 km east of the site at Carmacks. The weather station is at an elevation of 524 m, 776 m below the minesite elevation of 1300 m. Precipitation data from this station were used for the water balance studies. Evaporation data was obtained from Fort Selkirk, Environment Canada Station No. 2100600, located approximately 80 km northwest of the minesite at elevation 454 m.

Precipitation at Mt. Nansen falls in the form of both rain and snow. Snow begins falling in November and remains on the ground until May. We understand that typically, a snowpack of 1 m occurs. Approximately 40% of the annual precipitation falls as snow. Some rainfall occurs as early as April, but the majority of rainfall occurs from June to August. The most intense rainfall occurs in July. Mean annual precipitation values on a monthly basis are summarized in Table 5.1 along with a 200-year return period wet year and a 10-year return period dry year.

The evaporation data for Fort Selkirk is presented in Table 5.1. The highest evaporation rate occurs in June. Water losses due to evaporation drop off significantly in the winter as temperature drops. During the summer months of May through August, evaporation is nearly five times the value of the average precipitation.

Table 5.2 One-Hour 200-Year Return Period Storm

TIME (minutes)	INTENSITY (mm/hr)
5	5.2
10	5.2
15	5.2
20	5.2
25	5.6
30	30.6
35	121.2
40	30.6
45	5.6
50	5.6
55	5.2
60	5.2

For the purposes of preliminary sizing of a closure spillway a statistical Probable Maximum Precipitation (PMP) was estimated using data from Carmacks. This methodology (National Research Council of Canada) uses the mean and standard deviation of the annual extreme precipitation values. The resulting 1 hour, 6 hour and 24 hour PMP rainfall depths were 63 mm, 76 mm, and 108 mm. These estimates are adequate for this feasibility level study. For final design a detailed site specific PMP and Probable Maximum Flood (PMF) study may be required, including an assessment of seasonal variation and maximized snowpack conditions.

5.2 Diversion Channel Design

To divert the flow of Dome Creek around the tailings pond, a diversion channel could be constructed on the left abutment of the dam, as shown on Drawing D-3003. A catchment area of approximately 2.26 km^2 contributes flow to the diversion channel. Based on the 200-year return period 1 hour storm, the peak discharge in the channel was estimated to be 9.1 m^3/s. A trapezoidal channel 3 m wide at the base, 2 m deep with 2H:1V side slopes and a longitudinal slope of 0.1% is adequate to convey the peak level of study. Further studies would be required for detailed design of the closure spillway. To carry this discharge, a closure spillway 10 m wide would have a depth of flow of 1.6 m.

As shown on Drawing D-3003, the spillway has been located on the left abutment. This is subject to the field confirmation of bedrock location on this abutment. The location of the spillway should be reevaluated if, based on additional field investigation, bedrock and soil conditions are more favourable on the right abutment. Based on the studies presented, we recommend that an operational spillway 5 m wide be constructed. The invert of this spillway should be set a minimum of 1.7 m below the crest of the dam, thus providing approximately 0.5 m of freeboard during a 200-year return period flood. Upon mine closure, this spillway could be widened or deepened to provide discharge capacity for the PMF. Alternatively, the dam could be raised approximately 1.5 m to provide sufficient discharge capacity to pass the PMF with the 5 m wide spillway.

A waste rock lined spillway discharge channel is required to carry the spillway flow down the slope and into Dome Creek. The diversion channel could tie into the spillway discharge channel downstream of the spillway crest.

5.4 Water Balance

A preliminary water balance was carried out to determine if a diversion ditch was required to minimize discharge from the pond. Using annual water volumes it was determined that a small surplus of water would result if a diversion ditch was constructed. Based on this analysis, a monthly water balance analysis, including a diversion ditch, was carried out and is presented in Appendix VI. For final design purposes, refinements to the monthly water balance including detailed mill water requirements should be carried out to determine the variation in pond level to ensure sufficient freeboard during operation and to minimize discharge. The water balance assumes a water reclaim system would be used continuously, to recycle water to the mill, so there is no net addition of water from the mill. Domestic and sewage water, which would be discharged with the tailings, have not been accounted for. However, their volumes would be small compared to the other factors and would not have a significant effect on this level of water balance calculation.

The annual precipitation values of 271 mm, 370 mm and 200 mm, corresponding to mean year, 200-year wet year, and 10-year dry year, were used. A catchment runoff coefficient of 0.6 was used for the mean and dry years while a value of 0.8 was used for the wet year. The natural pond catchment area was estimated to be 0.46 km^2, with the Dome Creek diversion channel in place. Without the diversion channel in place, the natural pond catchment area would increase to 2.72 km^2. The pond area was estimated to be 0.04 km^2 for this preliminary monthly analysis. An annual evaporation of 452.9 mm was used. Seepage losses were assumed to be zero for this level of study. Since information was not available on tailings transport water nor reclaim requirements, these were not accounted for in the water balance. These must be accounted for at the next level of design. The loss of water to voids was estimated to be approximately 44 000 m^3/year based on a daily deposition rate of 300 tonnes/day, in-place dry density of 1.25 tonnes/m^3 and a specific gravity of 2.75. A volume of tailings of 40 000 m^3/yr was assumed to enter the tailings pond raising the pond water level.

The results of the monthly water balance are shown in Appendix VI. Results indicate that, with a stream diversion in place, there may be an annual net gain of water in the pond of about 20 000 m^3 to 30 000 m^3, in an average year. The pond level rises from a starting level of El. 1137 m in August of Year 1 to El. 1146.2 m at the end of July in Year 3. In the winter months the monthly water balance indicates a water deficit. Once tailings transport water and reclaim requirements are known, the pond level water level in the fall must be estimated to ensure that sufficient water is available to supply the reclaim requirements over winter.

During a wet year, a surplus of about 90 000 m^3 may result. This translates into a pond rise, above average levels, of 1 m to 2 m assuming no spillage of water from the pond. In a dry year, close to zero excess water would result along with pond levels 1 m to 0.5 m below average levels. Based on the water balance analysis, if a diversion channel is not constructed, then under average conditions an excess of approximately 400 000 m^3 could result.

To minimize excess water, we recommend construction of the Dome Creek diversion channel. During a dry year water could be spilled from the diversion channel into the pond to add water, if required. It is recommended that, for final design, refinements to the monthly water balance be carried to include slurry transport water and reclaim water.

Excess water would be discharged to Dome Creek, and may require treatment to meet water quality guidelines. Assessment of water chemistry and treatment is beyond the scope of this report. We understand that these questions are being addressed by others.

5.5 Seepage Collection

There may be some seepage through the dam, particularly in the early part of the operation, prior to freezing of the dam. If the quality of seepage water is unacceptable, a small seepage recovery pond may be required to catch any seepage and allow it to be pumped back into the pond.

A preliminary design for the seepage collection dam has been prepared and is presented in Drawing D-3003. The dam would be built of compacted sand, from the same borrow as the main dam. The dam would be about 2 m high above original topography, and would be founded in an excavation about 1.5 m deep.

Both the impoundment and the dam would be lined with an impermeable geosynthetic membrane to eliminate seepage. The membrane would be anchored in a trench extending below the active zone into permanently frozen ground to provide a positive cutoff.

A sump is provided at the upstream toe of the dam. Water would be pumped from the sump back to the main tailings impoundment.

The seepage recovery impoundment would be required to be able to store the runoff from a design storm. To minimize this requirement, diversion ditches would be provided to divert slope runoff from adjacent valley sides. Only seepage and runoff from the immediate area and main dam would be collected. Calculations indicate that a dam 2 m above original ground would provide adequate storage. This conceptual design will be refined as part of final design.

6. POND OPERATION

To avoid seepage through the thawed portion of the dam (active zone) the pond level should be kept at least 3 m below the dam crest elevation. This value (3 m) may be adjusted based on monitoring of the active zone as the permafrost develops in the dam. However, the tailings beach can be developed above pond level, essentially up to dam crest elevation, to reduce seepage.

Summer Operation

To reduce the permeability of the dam and to increase the effective horizontal width of the dam, it will be necessary to develop a tailings beach against the dam. This must be accomplished during the first summer of operation. The beach will be created by spigotting tailings from the crest of the dam. Tailings discharged at the dam is expected to slope away from the dam at approximately 1%. During operation, tailings should be spigotted from the dam during summer months each year. This will likely be possible from about May to September.

Water separated from the tailings slurry will form a pond where it can be reclaimed for use at the mill. A minimum water depth of 2.0 m should be maintained in the pond to allow enough depth to allow the fines to settle prior to the water being reclaimed and pumped back to the mill.

Winter Operation

During winter operations, ice lens formation or glaciation could interfere with the tailings discharge. This could lead to a reduction in the reclaim water as ice freezes into the beach causing a decrease in the in situ density of the tailings deposit. Possibly of even greater importance, significant volumes can be taken up by ice, reducing the available storage for tailings. To avoid this problem, single-point, subaqueous deposition of the tailings through the ice-covered pond will be required during the winter months.

Sufficient excess water should be stored in the pond at the end of summer to ensure sufficient reclaim water over winter.

Placement of the tailings subaqueously in the water will reduce the average in situ density of the tails. The solids will tend to build up a flat cone in the pond area, reducing the depth of reclaimable water and reducing the beach areas. Controlled spigotting in the summer will be necessary to re-create the beaches for the following year.

7. CONCLUSIONS AND RECOMMENDATIONS

The following summary and conclusions have been drawn from the study:

- Of the four sites studied to date, Site #4 is the most attractive site for development of a tailings storage dam.
- It is both technically feasible and practical to build a tailings dam at Site #4 to impound 300 000 tonnes of tailings.
- The valley topography at Site #4 is well suited to a possible later dam raise. This would increase storage capacity to accommodate the discovery of additional ore reserves. In this regard, Site #4 is much more attractive than the other three sites previously considered.
- The foundations at Site #4 consist of sandy soils with varying amounts of fines. Occasional gravelly layers exist within the sandy soils. Some organic rich horizons are present, especially on the right abutment.
- If the foundation materials thaw, only very minor settlement will occur in the sandy soils. The organic-rich soils will consolidate significantly if melted, but because of their limited thickness, total settlement in the dam will not be large.
- Significant ice occurs in about the upper 1.5 m of the overburden at Site #4.
- The estimated annual precipitation values for a mean year, 200-year wet year, and 10-year dry year are 271 mm, 370 mm and 200 mm respectively. The statistically estimated 1 hour, 6 hour and 24 hour Probable Maximum Precipitation(PMP) depths are 63 mm, 76 mm, and 108 mm. The estimated annual evaporation is 452.9 mm.
- A diversion channel should be constructed to divert Dome Creek around the tailings pond. During a dry year, water could be spilled from the diversion channel into the pond to make up possible water deficits.
- An operational emergency spillway 5 m wide should be constructed. Initial siting is on the left abutment but it may be located on the right abutment, based on subsequent investigations. The invert of this spillway should be in rock and set a minimum of 1.7 m below the crest of the dam. A riprap lined discharge channel should be provided.
- A closure spillway approximately 10 m wide with an invert in rock and set 2.0 m below the dam crest should be built.

- The water balance indicates that, with the diversion in place and, under somewhat drier than normal conditions, discharge may be avoided. However, to allow for less than perfect diversion efficiency, higher than average rainfall, or other water balance upsets, provision should be made to allow discharge from the pond.

This study has proven the feasibility of developing a tailings storage facility at Site #4, and that Site #4 is the most attractive location available. For detailed design, some refinements will be required, as listed below:

- A detailed site-specific PMP and Probable Maximum Flood (PMF) study, should be carried out including an assessment of PMF seasonal variation and maximized snowpack conditions.
- Sizing and locating of the closure spillway should be carried out.
- The water balance should be refined by including details of slurry transport water and reclaim water.
- Collection of climatic data for the site should be commenced as soon as staff are on site on a regular basis to maintain equipment.
- Test pits or other methods should be employed to investigate soil depth and condition on both abutments, and particularly the right (south) abutment.

KLOHN-CRIPPEN CONSULTANTS LTD.

Blair Trenholme BST

Blair S. Trenholme, P.Eng.
Project Manager

for Peter C. Lighthall, P.Eng.
Technical Reviewer

Richard F. Rodman, P.Eng.
Senior Hydrologist

RICHARD F. RODMAN

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APPENDIX I

Seismic Evaluation

ENERGY, MINES AND
RESOURCES CANADA
GEOLOGICAL SURVEY OF CANADA

ENERGIE, MINES ET
RESSOURCES CANADA
COMMISSION GEOLOGIQUE DU CANADA

SEISMIC RISK CALCULATION *

CALCUL DE RISQUE SEISMIQUE *

REQUESTED BY/ DEMANDE PAR IAN BRUCE / KLOHN LEONOFF CONSULTANTS MJC

SITE MT. NANSEN, YUKON

LOCATED AT/ SITUE AU 62.05 NORTH/NORD 137.17 WEST/OUEST

PROBABILITY OF EXCEEDENCE PER ANNUM/ PROBABILITE DE DEPASSEMENT PAR ANNEE	0.010	0.005	0.0021	0.001
PROBABILITY OF EXCEEDENCE IN 50 YEARS/ PROBABILITE DE DEPASSEMENT EN 50 ANS	40 %	22 %	10 %	5 %
PEAK HORIZONTAL GROUND ACCELERATION (G) ACCELERATION HORIZONTALE MAXIMALE DU SOL (G)	0.057	0.074	0.095	0.117
PEAK HORIZONTAL GROUND VELOCITY (M/SEC) VITESSE HORIZONTALE MAXIMALE DU SOL (M/SEC)	0.126	0.163	0.217	0.262

* REFERENCES

1. NEW PROBABILISTIC STRONG SEISMIC GROUND MOTION MAPS OF CANADA: A COMPILATION OF EARTHQUAKE SOURCE ZONES, METHODS AND RESULTS.
P.W. BASHAM, D.H. WEICHERT, F.M. ANGLIN, AND M.J. BERRY
EARTH PHYSICS BRANCH OPEN FILE NUMBER 82-33, OTTAWA, CANADA 1982.

2. ENGINEERING APPLICATIONS OF NEW PROBABILISTIC SEISMIC GROUND-MOTION MAPS OF CANADA
A.C. HEIDEBRECHT, P.W. BASHAM, J.H. RAINER, AND M.J. BERRY
CANADIAN JOURNAL OF CIVIL ENGINEERING, VOL. 10, NO. 4, P. 670-680, 1983.

3. NEW PROBABILISTIC STRONG GROUND MOTION MAPS OF CANADA.
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4A. SUPPLEMENT TO THE NATIONAL BUILDING CODE OF CANADA 1985, NRCC NO. 23178.
CHAPTER 1: CLIMATIC INFORMATION FOR BUILDING DESIGN IN CANADA.
CHAPTER 4: COMMENTARY J: EFFECTS OF EARTHQUAKES.

4B. SUPPLEMENT DU CODE NATIONAL DU BATIMENT DU CANADA 1985, CNRC NO 23178F.
CHAPITRE 1: DONNEES CLIMATIQUES POUR LE CALCUL DES BATIMENTS AU CANADA.
CHAPITRE 4: COMMENTAIRE J: EFFETS DES SEISMES.

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```
SITE                                                   MT.   ANSEN,   YUKON

     ZONING FOR ABOVE SITE/ ZONAGE DU SITE CI-DESSUS

     1985 NBCC/CNBC:   ZA = 2,   ZV = 4,   V = 0.20 M/S

 ACCELERATION ZONE/ ZONE D'ACCELERATION     ZA=2
 ZONAL ACCELERATION/ ACCELERATION ZONALE   0.10 G

 VELOCITY ZONE/ ZONE DE VITESSE             ZV=4
 ZONAL VELOCITY/ VITESSE ZONALE            0.20 M/S


              1985 NBCC/CNBC **
  SEISMIC ZONING MAPS/ CARTES DU ZONAGE SEISMIQUE

        PROBABILITY LEVEL:  10% IN 50 YEARS
     NIVEAU DE PROBABILITE:  10% EN 50 ANNEES

       -----------------------------------
        G OR M/S    ZONE      ZONAL VALUE/
                             VALEUR ZONALE
       -----------------------------------
         0.00
                     0         0.00
         0.04
                     1         0.05
         0.08
                     2         0.10
         0.11
                     3         0.15
         0.16
                     4         0.20
         0.23
                     5         0.30
         0.32
                     6*        0.40
       -----------------------------------

  * ZONE 6:  NOMINAL VALUE/ VALEUR NOMINALE  0.40;
     SITE-SPECIFIC STUDIES SUGGESTED FOR IMPORTANT PROJECTS/
     ETUDES COMPLEMENTAIRES SUGGEREES POUR DES PROJETS D'IMPORTANCE.


 ** FOR NBCC APPLICATIONS, CALCULATED ZONE VALUES AT A SITE SHOULD BE
     REPLACED BY EFFECTIVE ZONE VALUES [ZA(EFF) OR ZV(EFF)] AS SHOWN BELOW/
    POUR APPLICATIONS SELON LE CNBC, ON DOIT REMPLACER LES VALEURS ZONALES
     CALCULEES POUR UN SITE PAR LES VALEURS EFFECTIVES [ZA(EFF) OU ZV(EFF)]
     COMME MONTRE CI-DESSOUS:

      1.   IF/SI  (ZA - ZV) > 1,        ===>  ZA(EFF) = ZV + 1.
 OR/OU
      2.   IF/SI  (ZA - ZV) < 1,        ===>  ZA(EFF) = ZV - 1.
 OR/OU
      3.   IF/SI   ZV=0 AND/ET ZA > 0,  ===>  ZV(EFF) = 1.

        (SEE REFERENCE 2 CITED ABOVE, PAGE 677)
        (VOIR PAGE 677 DE LA REFERENCE 2 CI-DESSUS)
                                                    19-OCT-88   18.57:40
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APPENDIX II

Test Pit Logs and Borehole Logs

TEST HOLE LOG

STARTED: 94/07/16 **FINISHED:** 94/07/16
DRILLING METHOD: SOLID STEM AUGER
GROUND ELEV(m):
COORDINATES(m):

DEPTH(m)	SPT BLOWS PER 0.15m	OTHER TESTS	SAMPLE TYPE AND NUMBER	SYMBOL	DESCRIPTION OF MATERIALS	PIEZOMETER DETAILS
					Silty SAND (SM); silty fine to medium sand, top 0.25 m is moss.	
0.8					Silty SAND (SM); sand medium to coarse, trace to little silt, frozen hard, salt and pepper, ice crystals, no visible ice lenses.	
1.2					Gravelly beginning at 1.2 m. Changed to Carrel Tube and solid stem.	
1.8					SAND (SW); fine to medium sand with layers of coarse sand and pebbles, frozen, no visible ice.	
2.1					SAND (SW); medium sand, medium brown, trace silt, some coarse sand, little rounded pebbles.	
2.6					SAND (SW); fine to medium sand, light brown (blond), little coarse sand.	
3.1					SAND (SW); clean fine to medium sand, trace silt, frozen, no visible ice, cross bedded, light brown.	
					SAND (SW); fine to medium clean sand, well rounded gravelly layer 5 to 7.5 cm thick at 3.7 m.	
4.1			CT 1		SAND (SW); fine to medium clean sand with trace coarse sand and silt, frozen, no visible ice, cross bedding visible in sand, well rounded.	
6			CT 2		Sand becoming coarser at 6.1 m.	
8					Gravelly layer at about 8.4 m.	
8.5			CT 3		SAND (SW); clean medium sand, well rounded, light brown, no visible ice, at 9.1 m gravel angular to sub-rounded, cross bedded, teperature reading = 0.0 degrees celsius, Photo 1 at 9.0 m.	
10					...Cont'd	

Su - kPa
20 60 100 140 180

VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMOLD	◇	□	△ P.PEN/2

● SPT N

W_P% W% W_L%
× ---------- ○ ---------- ×
10 30 50 70 90

PROJECT NO.: PB5314 03
PROJECT: MT. NANSEN
LOCATION: SITE #4
LOGGED BY: BST **CHECKED BY:**
SHEET 1 **OF** 3 **HOLE NO.:** DH94-01

FORM: SI01-3

TEST HOLE LOG

Su - kPa
20 60 100 140 180

VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMOLD	◇	□	△ P.PEN/2

● SPT N

W_P% W% W_L%
× ········ ○ ········ ×
10 30 50 70 90

STARTED: 94/07/16 **FINISHED:** 94/07/16
DRILLING METHOD: SOLID STEM AUGER
GROUND ELEV(m):
COORDINATES(m):

DEPTH(m)	SPT BLOWS PER 0.15m	OTHER TESTS	SAMPLE TYPE AND NUMBER	SYMBOL	DESCRIPTION OF MATERIALS	PIEZOMETER DETAILS
					SAND (SW); (continued)	
					Gravelly layer at 10.7 m. Gravelly layer at 10.8 m. Gravelly layer at 11.3 m.	
11						
					11.3	
					SAND (SW); medium grey fine sand, trace silt, no visible ice.	
					11.6	
					SAND (SW); medium grey fine to medium sand, trace to little silt, no undisturbed sample recovered in tube (fell out).	
12					12.2	
					SAND (SW); grey fine to medium sand with trace silt and little coarse sand and gravel, organics, no visible ice.	
13					13.1	
			CT 4		SAND (SW); very fine sand with little to some silt, frozen hard, no visible ice, some organic layers and organic smell.	
					13.7	
					Sample taken at 13.4 m.	
14					SAND (SW); medium grey fine to medium sand with trace to little silt, organics, organic smell, no visible ice.	
15						
16						
			CT 5			
17						
18			CT 6			
19					19.1	
					GRAVEL (GRAVEL)	
					Very rocky at 19.8 m.	
20					...Cont'd	

PROJECT NO.: PB5314 03
PROJECT: MT. NANSEN
LOCATION: SITE #4
LOGGED BY: BST **CHECKED BY:**
SHEET 2 **OF** 3 **HOLE NO.:** DH94-01

FORM: SI01-3
Klohn-Crippen

TEST HOLE LOG

STARTED: 94/07/16 **FINISHED:** 94/07/16

DRILLING METHOD: SOLID STEM AUGER

GROUND ELEV(m):

COORDINATES(m):

Su - kPa
20 60 100 140 180

VANE FIELD LAB
PEAK ◆ ■
REMOLD ◇ □
▲ UC/2
△ P.PEN/
● SPT N

W_P% W% W_L%
× ······ ○ ······ ×
10 30 50 70 90

DEPTH(m)	SPT BLOWS PER 0.15m	OTHER TESTS	SAMPLE TYPE AND NUMBER	SYMBOL	DESCRIPTION OF MATERIALS	PIEZOMETER DETAILS
20.1					Refusal at 20.1 m.	
					END OF TEST HOLE AT 20.1 m.	
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

PROJECT NO.: PB5314 03

PROJECT: MT. NANSEN

LOCATION: SITE #4

LOGGED BY: BST **CHECKED BY:**

SHEET 3 **OF** 3 **HOLE NO.:** DH94-01

FORM SI01-3

TEST HOLE LOG

STARTED: 94/07/17 **FINISHED:** 94/07/17
DRILLING METHOD: SOLID STEM AUGER
GROUND ELEV(m):
COORDINATES(m):

Su - kPa: 20 60 100 140 180
VANE / FIELD / LAB
PEAK ◆ ■
REMOLD ◇ □
▲ UC/2
△ P.PEN/2
● SPT N
W_P% × W% ○ W_L% ×
10 30 50 70 90

DEPTH(m)	SPT BLOWS PER 0.15m	OTHER TESTS	SAMPLE TYPE AND NUMBER	SYMBOL	DESCRIPTION OF MATERIALS	PIEZOMETER DETAILS
					MOSS (ORGANICS); 0.3 m cover over frozen soil. 0.3	
					SAND (SW); organic rich fine to medium sand with some small pebbles. 0.9	
1 2			CT 1		SAND (SW); organic rich at top, grading to little organics by 1.2 m, fine to medium sand with trace to little silt, 5 ice lenses each 1 mm thick in silty or organic-rich layer at 1.2 m depth, otherwise sand shows no visible ice, sand is medium brown, well rounded. 2.3 Ice cuttings at 1.8 to 2.1 m.	
			CT 2		2.4 SAND (SW); dark brown, fine to med., trace silt & organics, no vis. ice.	
3					SAND (SW); light brown fine to medium sand becoming coarser with depth, trace silt, some pebbles, no visible ice, 40% angular rock below 2.9 m. Sample taken at 2.4 m. 3.7	
4					SAND (SW); fine to medium sand, trace silt, trace to little pebbles, no visible ice. 4.3	
5					Silty SAND (SM); organic, rich brown, silty to sandy, ice rich with many 0.5-1.0 mm ice lenses in organics. Sample taken at 4.4 m. High ice content in cuttings (4.6 to 5.3 m). 5.3	
6			CT 3		Silty SAND (SM); silty fine to medium sand with organics and roots, numerous ice crystals to 3 mm in size, ice rich layers of frozen peat. 6.1 Sample taken at 5.8 m.	
					Silty SAND (SM); silty fine sand with organics, strong organic odour, numerous roots, some visible ice crystals. 6.7	
7					Silty SAND (SM); highly organic silty sand, brown. 7.0	
			CT 4		SAND (SW); light grey fine to medium sand, trace to little silt, bedding visible in sand, no visible ice, angular pebbles at 7.6 m, organics melt to very soft consistency. 7.6	
8					Silty SAND (SM); silty fine to medium sand, frozen, sand well rounded, trace to some silt. 8.2	
9				?	Attempted Carrel sample but sample fell from tube - no recovery. 9.2	
10					Silty SAND (SM); (same as from 7.6 to 8.2 m) Refusal (on bedrock?) at 10.0 m. ...Cont'd	

PROJECT NO.: PB5314 03
PROJECT: MT. NANSEN
LOCATION: SITE #4 RIGHT ABUTMENT
LOGGED BY: BST **CHECKED BY:**
SHEET 1 **OF** 2 **HOLE NO.:** DH94-02

FORM: SI01-3
Klohn-Crippen

TEST HOLE LOG

STARTED: 94/07/17 FINISHED: 94/07/17
DRILLING METHOD: SOLID STEM AUGER
GROUND ELEV(m):
COORDINATES(m):

DEPTH(m)	SPT BLOWS PER 0.15m	OTHER TESTS	SAMPLE TYPE AND NUMBER	SYMBOL	DESCRIPTION OF MATERIALS	PIEZOMETER DETAILS
10.0					END OF TEST HOLE AT 10.0 m.	
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Su - kPa
20 60 100 140 180

VANE	FIELD	LAB	
PEAK	◆	■	▲ UC/2
REMOLD	◇	□	△ P.PEN/2

● SPT N

W_P% W% W_L%
× ○ ×
10 30 50 70 90

PROJECT NO.: PB5314 03
PROJECT: MT. NANSEN
LOCATION: SITE #4 RIGHT ABUTMENT
LOGGED BY: BST CHECKED BY:
SHEET 2 OF 2 HOLE NO.: DH94-02

FORM: SI01-3

TEST HOLE LOG

STARTED: 94/07/18 **FINISHED:** 94/07/18

DRILLING METHOD: SOLID STEM AUGER

GROUND ELEV(m):

COORDINATES(m):

Su - kPa: 20 60 100 140 180

VANE: PEAK FIELD ◆ LAB ■; REMOLD FIELD ◇ LAB □

▲ UC/2 △ P.PEN/2

● SPT N

W_P% × ······ W% ○ ······ W_L% ×

10 30 50 70 90

DEPTH(m)	SPT BLOWS PER 0.15m	OTHER TESTS	SAMPLE TYPE AND NUMBER	SYMBOL	DESCRIPTION OF MATERIALS	PIEZOMETER DETAILS
					SAND (SW); (continued)	
10.4					SAND AND Coarse GRAVEL (SG); very dense, dark grey-brown, trace silt, possibly glacial till.	
11						
11.4			CT 6			
11.6					11.4 to 11.6 m: Silty SAND AND GRAVEL (SG); some silt, gravel angular to sub-rounded (possibly glacial till), no visible ice, dense. Sample bagged at 11.6 m.	
12						
13					Silty SAND (SM); grey brown silty to sandy (possibly glacial till) with numerous rocky layers, rocks angular to sub-rounded, very hard drilling, dense, rocky.	
14						
15						
16					Refusal at 16.2 m. Assumed bedrock.	
16.2					END OF TEST HOLE AT 16.2 m.	
17						
18						
19						
20						

PROJECT NO.: PB5314 03

PROJECT: MT. NANSEN

LOCATION: SITE #4 VALLEY CENTRE

LOGGED BY: BST **CHECKED BY:**

SHEET 2 **OF** 2 **HOLE NO.:** DH94-03

FORM: SI01-3

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9405 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ___ .M. ___ 19__
LOCATION: LATITUDE ___ DEPTH 2.0 m FINISHED ___ .M. ___ 19__
DEPARTURE ___ WIDTH ___ ELEVATIONS: DATUM ___
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ___ GROUND SURFACE ___
METHOD OF EXCAVATION BACK HOE WATER LEVELS ___

LOG LEGEND
▥ SILT ▨ SAND
▧ CLAY ⁘ GRAVEL

* SAMPLE CONDITION
▩ GOOD ☒ DISTURBED
▤ FAIR ■ LOST

** SAMPLING METHOD
B - THIN WALL TUBE
C - PISTON SAMPLER
E - AUGER
G - SHOVEL
H - CARVED BLOCK

** SHIPPING CONTAINER
O - TUBE
P - WATER CONTENT TIN
Q - GLASS JAR
R - CLOTH BAG
S - PLIOFILM BAG
T - METAL CAN
U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	** TYPE	NO.	SIZE	RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
ORGANIC SOIL									10 cm organic soil
med. brown SAND			0.2						10 cm - 20 cm med brown fine to medium SAND
			0.4						
light brown SAND			0.6						20 cm - 2.0 M light brown fine to medium clean SAND, little pebbles, cross bedded, pebbles angular to sub-rounded no visible ice
			0.8						
			1.0						
			1.2						
			1.4						
			1.6						
			1.8						
			2.0						
frozen solidly ↓			2.2						

KLOHN-CRIPPEN

JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. 9405 INSPECTOR BBT
APPROVED BBT DATE 16 JULY 94

Klohn-Crippen

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9406 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ______ 19__
LOCATION: LATITUDE ______ DEPTH 2.5m FINISHED ____ .M. ______ 19__
DEPARTURE ______ WIDTH ______ ELEVATIONS: DATUM ______
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ______ GROUND SURFACE ______
METHOD OF EXCAVATION BACK HOE WATER LEVELS ______

LOG LEGEND
- ▥ SILT
- ░ SAND
- ▨ CLAY
- ⁘ GRAVEL

*** SAMPLE CONDITION**
- ▩ GOOD
- ☒ DISTURBED
- ▤ FAIR
- ■ LOST

**** SAMPLING METHOD**
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- E - AUGER
- G - SHOVEL
- H - CARVED BLOCK

**** SHIPPING CONTAINER**
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR
- R - CLOTH BAG
- S - PLIOFILM BAG
- T - METAL CAN
- U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE	SAMPLE RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
organic soil									0-5cm organic soil
med. brown SAND									5cm-20cm medium brown
			0.2						fine SAND, some roots,
light brown SAND			0.4						Volcanic ash mixed in top
									5cm
			0.6						
									20cm - 2.5m fine to
			0.8						medium clean SAND, cross
									bedded, medium dense
			1.0						no visible ice, light brown
			1.2						Refusal on solidly frozen
									ground at 2.5m
			1.4						
			1.6						
			1.8						
			2.0						
			2.2						
			2.4						
solidly frozen									

KLOHN-CRIPPEN

JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. 9406 INSPECTOR BBT
APPROVED BBT DATE 16 JULY 94

Klohn-Crippen

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9407 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ______ 19__
LOCATION: LATITUDE ______ DEPTH 0.5m FINISHED ____ .M. ______ 19__
DEPARTURE ______ WIDTH ______ ELEVATIONS: DATUM ______
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ______ GROUND SURFACE ______
METHOD OF EXCAVATION BACK HOE WATER LEVELS ______

LOG LEGEND
- ▥ SILT
- ▒ SAND
- ▨ CLAY
- ⁘ GRAVEL

*** SAMPLE CONDITION**
- ▒ GOOD
- ☒ DISTURBED
- ☰ FAIR
- ■ LOST

**** SAMPLING METHOD**
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- E - AUGER
- S - SHOVEL
- H - CARVED BLOCK

**** SHIPPING CONTAINER**
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR
- R - CLOTH BAG
- S - PLIOFILM BAG
- T - METAL CAN
- U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE					DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAS, ODOUR, ETC.
				*	** TYPE	NO.	SIZE	RET'D.	
Moss & peat									0-20cm Moss & Peat
			0.2						
SAND			0.4						20cm-50cm Medium SAND clean, no visible ice salt & pepper texture
REFUSAL FROZEN SOLID			0.6						Refusal at 50cm in solidly frozen SAND, as above

KLOHN-CRIPPEN

JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. 9407 INSPECTOR BBT
APPROVED BBT DATE 16 JULY 94

Klohn-Crippen

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314/03 PIT No. 9408 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ____ 19__
LOCATION: LATITUDE ____ DEPTH 0.5 m FINISHED ____ .M. ____ 19__
DEPARTURE ____ WIDTH ____ ELEVATIONS: DATUM ____
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ____ GROUND SURFACE ____
METHOD OF EXCAVATION BACK HOE WATER LEVELS ____

LOG LEGEND
▥ SILT ░ SAND
▨ CLAY ● GRAVEL

*** SAMPLE CONDITION**
▩ GOOD ☒ DISTURBED
☰ FAIR ■ LOST

**** SAMPLING METHOD**
B - THIN WALL TUBE
C - PISTON SAMPLER
E - AUGER
G - SHOVEL
H - CARVED BLOCK

**** SHIPPING CONTAINER**
O - TUBE
P - WATER CONTENT TIN
Q - GLASS JAR
R - CLOTH BAG
S - PLIOFILM BAG
T - METAL CAN
U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE					DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
				*	** TYPE	NO.	SIZE	RET'D.	
ORGANIC SOIL & ROOTS			0.2						0-30 cm organic soil and roots
SAND			0.4						30 cm - 50 cm fine to medium SAND, little silt (source of silt may be ash?) salt & pepper no visible ice
FROZEN SAND ↓			0.6						
			0.8						
			1.0						Refusal on solidly frozen sand, as above, at 50 cm

KLOHN-CRIPPEN

JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. 9408 INSPECTOR BBT
APPROVED BBT DATE 16 JULY 94

Klohn-Crippen

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9409 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ________ 19__
LOCATION: LATITUDE ________ DEPTH 1.0 M FINISHED ____ .M. ________ 19__
DEPARTURE ________ WIDTH ________ ELEVATIONS: DATUM ________
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ________ GROUND SURFACE ________
METHOD OF EXCAVATION BACK HOE WATER LEVELS ________

LOG LEGEND		* SAMPLE CONDITION		** SAMPLING METHOD		** SHIPPING CONTAINER	
▥ SILT	▨ SAND	▩ GOOD	☒ DISTURBED	B - THIN WALL TUBE	G - SHOVEL	O - TUBE	S - PLIOFILM BAG
▨ CLAY	▨ GRAVEL	▤ FAIR	■ LOST	C - PISTON SAMPLER	H - CARVED BLOCK	P - WATER CONTENT TIN	T - METAL CAN
				E - AUGER		Q - GLASS JAR	U - WOODEN BOX
						R - CLOTH BAG	

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE	SAMPLE RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
organic soil & roots ASH			0.2						0-10cm organic soil & roots
SAND			0.4						10cm-12cm volcanic ash mixed with underlying sand & overlying organics
			0.6						
			0.8						12 cm - 1.0m medium brown fine to medium clean SAND trace silt, no visible ice
frozen SAND ↓			1.0						
			1.2						Refusal at 1.0m on solidly frozen SAND, as above

KLOHN-CRIPPEN

JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. 9409 INSPECTOR BBT
APPROVED BBT DATE 16 JULY 94

Klohn-Crippen

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9410 SHEET No. 1 of 1

PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME

SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ____ 19__

LOCATION: LATITUDE ____ DEPTH 0.5 m FINISHED ____ .M. ____ 19__

DEPARTURE ____ WIDTH ____ ELEVATIONS: DATUM ____

CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ____ GROUND SURFACE ____

METHOD OF EXCAVATION BACK HOE WATER LEVELS ____

LOG LEGEND
- ▥ SILT
- ▒ SAND
- ▨ CLAY
- ⁘ GRAVEL

*** SAMPLE CONDITION**
- ▩ GOOD
- ☒ DISTURBED
- ☰ FAIR
- ▓ LOST

**** SAMPLING METHOD**
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- E - AUGER
- G - SHOVEL
- H - CARVED BLOCK

**** SHIPPING CONTAINER**
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR
- R - CLOTH BAG
- S - PLIOFILM BAG
- T - METAL CAN
- U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH (m)	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE	SAMPLE RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
organic soil & roots									0-10 cm organic soil & roots
SAND			0.2						
			0.4						10cm-50cm grey-brown fine to coarse SAND, trace silt, some pebbles sand rounded, pebbles angular to sub-rounded, larger fragments more angular. No visible ice
frozen SAND ↓			0.6						
			0.8						
									Refusal on frozen SAND as above at 50 cm

KLOHN-CRIPPEN

JOB No. PB5314 03 LOGGED BY BBT

PROJECT MT. NANSEN

LOCATION MT NANSEN MINE

HOLE No. 9410 INSPECTOR BBT

APPROVED BBT DATE 16 JULY 94

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314/03 PIT No. 9411 SHEET No. 1 of 1

PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME

SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ___ .M. ___ 19___

LOCATION, LATITUDE ___ DEPTH 1.2 m FINISHED ___ .M. ___ 19___

DEPARTURE ___ WIDTH ___ ELEVATIONS, DATUM ___

CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ___ GROUND SURFACE ___

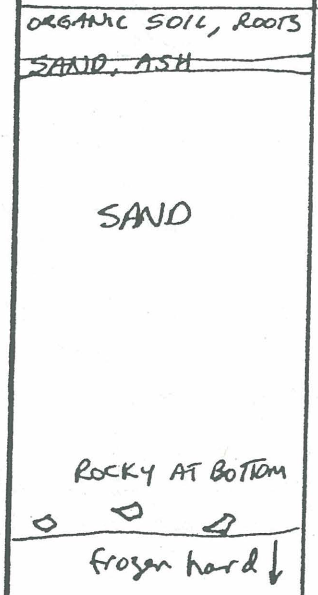
METHOD OF EXCAVATION BACK HOE WATER LEVELS ___

LOG LEGEND
- ▥ SILT
- ░ SAND
- ▨ CLAY
- ⁘ GRAVEL

*** SAMPLE CONDITION**
- ▩ GOOD
- ☒ DISTURBED
- ☰ FAIR
- ▓ LOST

**** SAMPLING METHOD**
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- E - AUGER
- G - SHOVEL
- H - CARVED, BLOCK

**** SHIPPING CONTAINER**
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR
- R - CLOTH BAG
- S - PLIOFILM BAG
- T - METAL CAN
- U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE	SAMPLE RET'D.	DESCRIPTION AND FIELD NOTES, COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
			0.2						0-10cm organic soil & roots
			0.4						10cm-12cm mixed sand and volcanic ash
			0.6						
			0.8						12cm-1.2m medium brown SAND trace silt sand well rounded, no visible ice. loose
			1.0						
			1.2						Refusal on frozen SAND, as above at 1.2 m
			1.4						Some angular rock frags at base of pit - may be close to bedrock?

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JOB No. PB5314 03 LOGGED BY BBT

PROJECT MT. NANSEN

LOCATION MT NANSEN MINE

HOLE No. 9411 INSPECTOR BBT

APPROVED BBT DATE

FIELD TEST PIT LOG

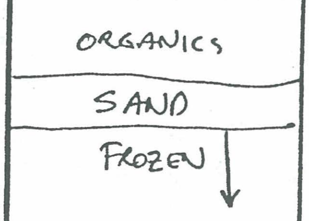
CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9412 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ________ 19__
LOCATION: LATITUDE ____ DEPTH ____ FINISHED ____ .M. ________ 19__
DEPARTURE ____ WIDTH ____ ELEVATIONS: DATUM ____
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ____ GROUND SURFACE ____
METHOD OF EXCAVATION BACK HOE WATER LEVELS ____

LOG LEGEND
- ▥ SILT
- ▨ CLAY
- ░ SAND
- ⁘ GRAVEL

*** SAMPLE CONDITION**
- ▩ GOOD
- ☒ DISTURBED
- ☰ FAIR
- ■ LOST

**** SAMPLING METHOD**
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- E - AUGER
- G - SHOVEL
- H - CARVED BLOCK

**** SHIPPING CONTAINER**
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR
- R - CLOTH BAG
- S - PLIOFILM BAG
- T - METAL CAN
- U - WOODEN BOX



SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE	SAMPLE RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
									0-20cm organics
			0.2						20cm-30cm oxide stained salt & pepper SAND fine to medium
			0.4						Refusal on frozen SAND, as above at 30cm

KLOHN-CRIPPEN

Klohn-Crippen

JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. 9412 INSPECTOR BBT
APPROVED BBT DATE

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9413 SHEET No. 1 of 1

PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME

SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ___ .M. ___ 19__

LOCATION: LATITUDE ___ DEPTH 1.2 m FINISHED ___ .M. ___ 19__

DEPARTURE ___ WIDTH ___ ELEVATIONS: DATUM ___

CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ___ GROUND SURFACE ___

METHOD OF EXCAVATION BACK HOE WATER LEVELS ___

LOG LEGEND
- ▥ SILT
- ▨ CLAY
- ░ SAND
- ⁘ GRAVEL

*** SAMPLE CONDITION**
- ▦ GOOD
- ☰ FAIR
- ☒ DISTURBED
- ■ LOST

**** SAMPLING METHOD**
- B - THIN WALL TUBE
- C - PISTON SAMPLER
- E - AUGER
- G - SHOVEL
- H - CARVED BLOCK

**** SHIPPING CONTAINER**
- O - TUBE
- P - WATER CONTENT TIN
- Q - GLASS JAR
- R - CLOTH BAG
- S - PLIOFILM BAG
- T - METAL CAN
- U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	SAMPLE ** TYPE	SAMPLE NO.	SAMPLE SIZE	SAMPLE RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
ORGANIC SOIL & ROOTS									0-15cm organic soil & roots
			0.2						15cm - 1.2m
SAND			0.4						Clean, fine to medium SAND, med. brown, no visible ice med dense, some angular pebbles - Angular broken rock at base of pit - close to bedrock?
			0.6						
			0.8						
angular rock at base △ ◇ △			1.0						
frozen ↓			1.2						Refusal on frozen SAND as above at 1.2m
			1.4						

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JOB No. PB5314 03 LOGGED BY BBT

PROJECT MT. NANSEN

LOCATION MT NANSEN MINE

HOLE No. 9413 INSPECTOR BBT

APPROVED BBT DATE

FIELD TEST PIT LOG

CLIENT B.Y.G NATURAL RESOURCES JOB No. PB5314 03 PIT No. 9414 SHEET No. 1 of 1
PROJECT MT. NANSEN GOLD MINE WEATHER CLEAR INSPECTOR B.TRENHOLME
SITE SITE #4, MT NANSEN TEMP. 25 °C STARTED ____ .M. ______ 19__
LOCATION: LATITUDE ______ DEPTH 1.5M FINISHED ____ .M. ______ 19__
DEPARTURE ______ WIDTH ______ ELEVATIONS: DATUM ______
CONTRACTOR I CAN DIG IT CONTRACTING LENGTH ______ GROUND SURFACE ______
METHOD OF EXCAVATION BACK HOE WATER LEVELS ______

LOG LEGEND
▥ SILT ▒ SAND
▨ CLAY ⁘ GRAVEL

*** SAMPLE CONDITION**
▦ GOOD ☒ DISTURBED
▤ FAIR ▩ LOST

**** SAMPLING METHOD**
B - THIN WALL TUBE
C - PISTON SAMPLER
E - AUGER
G - SHOVEL
H - CARVED , BLOCK

**** SHIPPING CONTAINER**
O - TUBE
P - WATER CONTENT TIN
Q - GLASS JAR
R - CLOTH BAG
S - PLIOFILM BAG
T - METAL CAN
U - WOODEN BOX

SKETCH	LOG	ELEVATION	DEPTH	SAMPLE *	** TYPE	NO.	SIZE	RET'D.	DESCRIPTION AND FIELD NOTES: COLOUR, CONSISTENCY, DENSITY, TEXTURE, STRUCTURE, SHAPE AND SURFACE CONDITION OF GRAINS, TESTING AND SAMPLING PROCEDURES AND EQUIPMENT, WATER AND GAIN, ODOUR, ETC.
ORGANIC SOIL, roots									0-10cm organic soil & roots
			0.2						10cm-1.5m
									Colluvial soil, SAND,
			0.4						trace to little silt,
									some angular pebbles
			0.6						no visible ice
SANDY COLLUVIUM			0.8						Refusal on fractured
									rock at 1.5m
			1.0						
			1.2						
			1.4						
x' fractured rock ↓			1.6						

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JOB No. PB5314 03 LOGGED BY BBT
PROJECT MT. NANSEN
LOCATION MT NANSEN MINE
HOLE No. INSPECTOR BBT

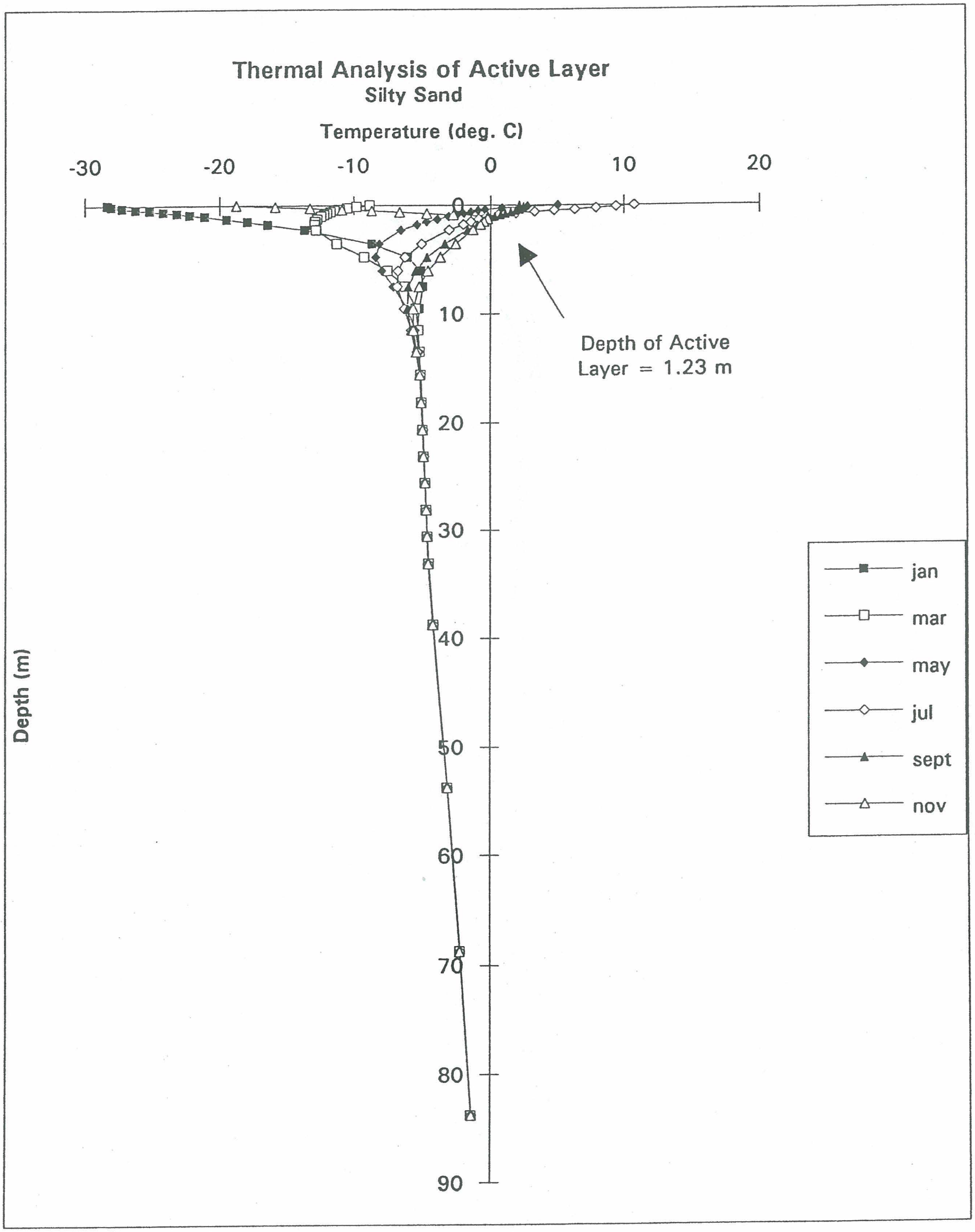
APPENDIX III

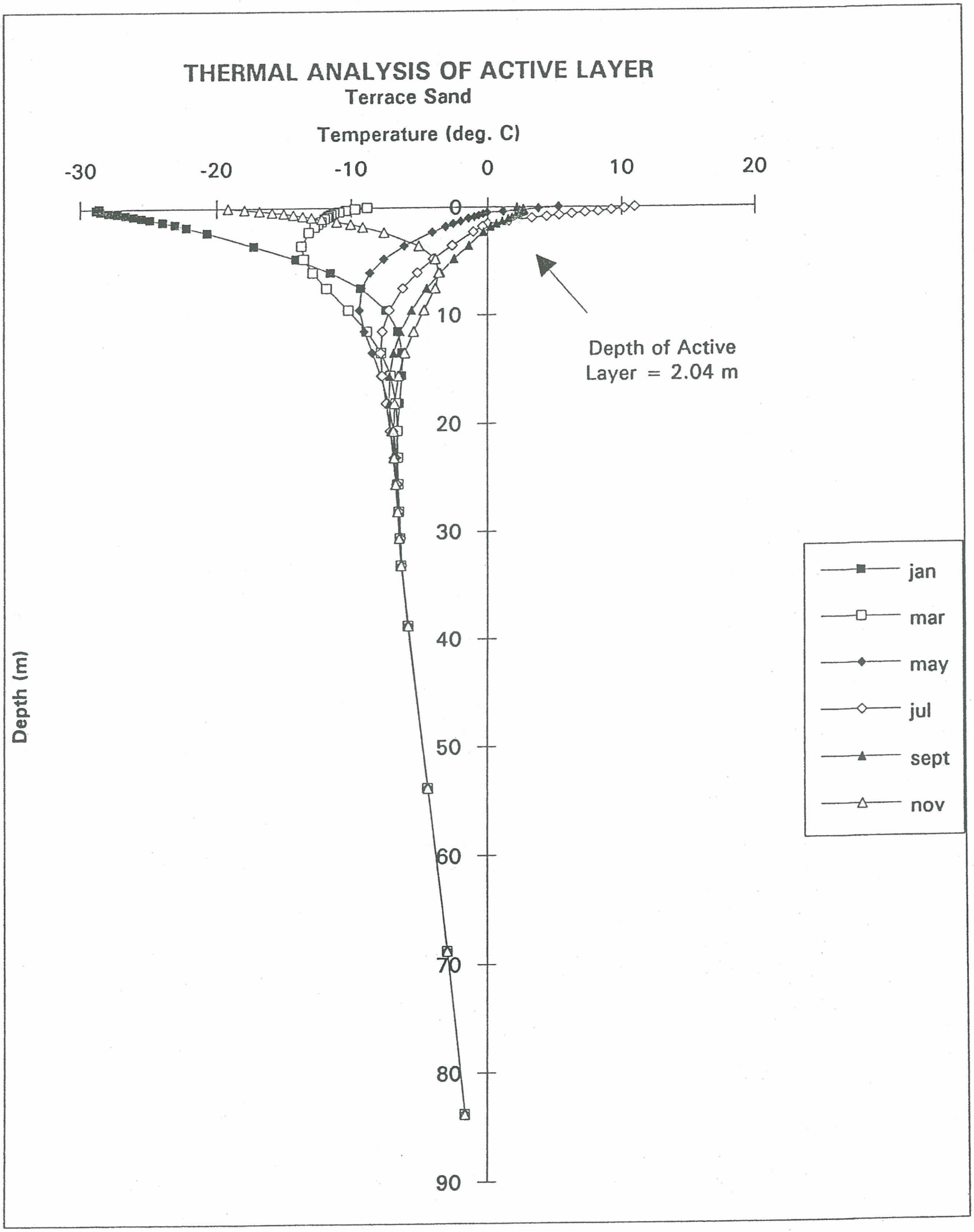
Thermal Analysis

APPENDIX III

THERMAL ANALYSIS

Thermal analyses were carried out to determine the depth of the active layer. Two plots are shown (terrace sand and silty sand) representing the two main soil types on site. The terrace sand will probably be used for low construction.


Thermal Analysis of Active Layer
Silty Sand
Temperature (deg. C)
-30
-20
-10
0
10
20
Depth (m)
0
10
20
30
40
50
60
70
80
90
Depth of Active Layer = 1.23 m
jan
mar
may
jul
sept
nov


THERMAL ANALYSIS OF ACTIVE LAYER
Terrace Sand
Temperature (deg. C)
-30
-20
-10
0
10
20
Depth (m)
0
10
20
30
40
50
60
70
80
90
Depth of Active Layer = 2.04 m
jan
mar
may
jul
sept
nov

APPENDIX IV

Stability Analysis for Foundation Liquefaction

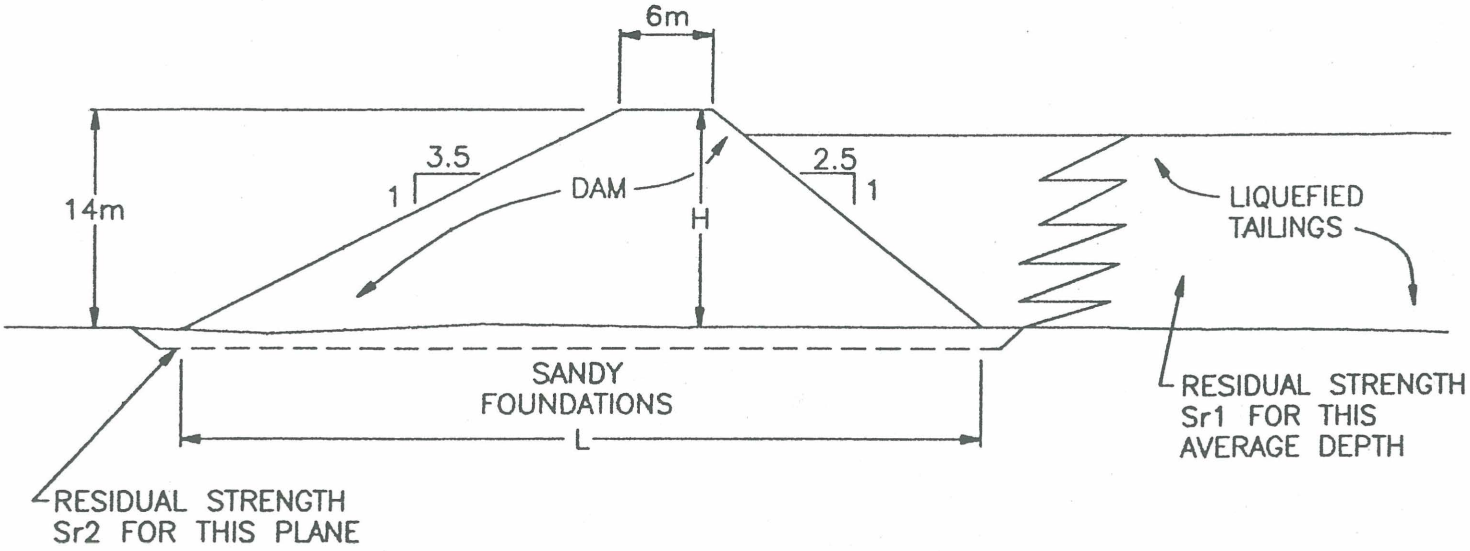
APPENDIX IV

STABILITY ANALYSIS FOR FOUNDATION LIQUEFACTION

There is a small potential for thawing of the foundations, particularly at the beginning of operations. This could result in loose sands which may be subject to liquefaction under seismic conditions. The residual strength of the tailings following liquefaction (S_{r1}) has been assessed using relationships developed from case histories (see Figure IV.1). Using these relationships, the residual strength can be estimated as a fraction of the initial vertical stress (σ_{v0}') related to the $(N_1)_{60}$ value. The $(N_1)_{60}$ value is normally derived from cone penetration tests. However, this is impossible in frozen ground. Based on previous experience, $(N_1)_{60}$ values in the range of 8 to 10 are conservatively assumed for the thawed foundation sands and for the tailings. From the lower bound of the plot of $(N_1)_{60}$ vs. S_r/σ_{v0}' (see Figure IV.1 after Stark and Mesri, 1992), a value of 0.09 is implied for S_r/σ_{v0}'. Consequently, a residual strength for liquefied tailings and foundation sands of 0.09 times the vertical stress is assumed for design.

For the overall stability of the embankment, a simple two-dimensional model is used to calculate a factor of safety (see Figure IV.2). It is assumed that the entire saturated mass of tailings behind the embankment will liquefy. It is also assumed that a layer of saturated sand in the foundations will also liquefy, producing a potential horizontal failure path underneath the dam. The dry density of the tailings is assumed to be about 1.25 tonnes/m^3 (12.26 kN/m^3). The dry density of the compacted sand embankment is assumed to be about 1.75 tonnes/m^3 (17 kN/m^3). The residual strength following liquefaction (S_{r1}) of the tailings is calculated according to the average depth of tailings, or about 6 m:

$$S_{r1} = (0.09)(12.26\ \text{kN/m}^3)(6\ \text{m}) = 6.6\ \text{kPa}$$



Sr1 = RESIDUAL STRENGTH OF LIQUEFIED TAILINGS

Sr2 = RESIDUAL STRENGTH OF LIQUEFIED SANDS ALONG THE HORIZONTAL FAILURE SURFACE.

L = HORIZONTAL WIDTH OF DAM BASE

H = AVERAGE DEPTH OF THE FAILURE SURFACE.

SCALE NOT TO SCALE

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PROJECT
MT. NANSEN GOLD PROJECT

TITLE
LIQUEFACTION FAILURE MODEL

CLIENT:
B.Y.G. NATURAL RESOURCES INC.

DATE OF ISSUE

APPROVED

PROJECT No.
PB531403

DWG. No.
FIG IV–2

REV.

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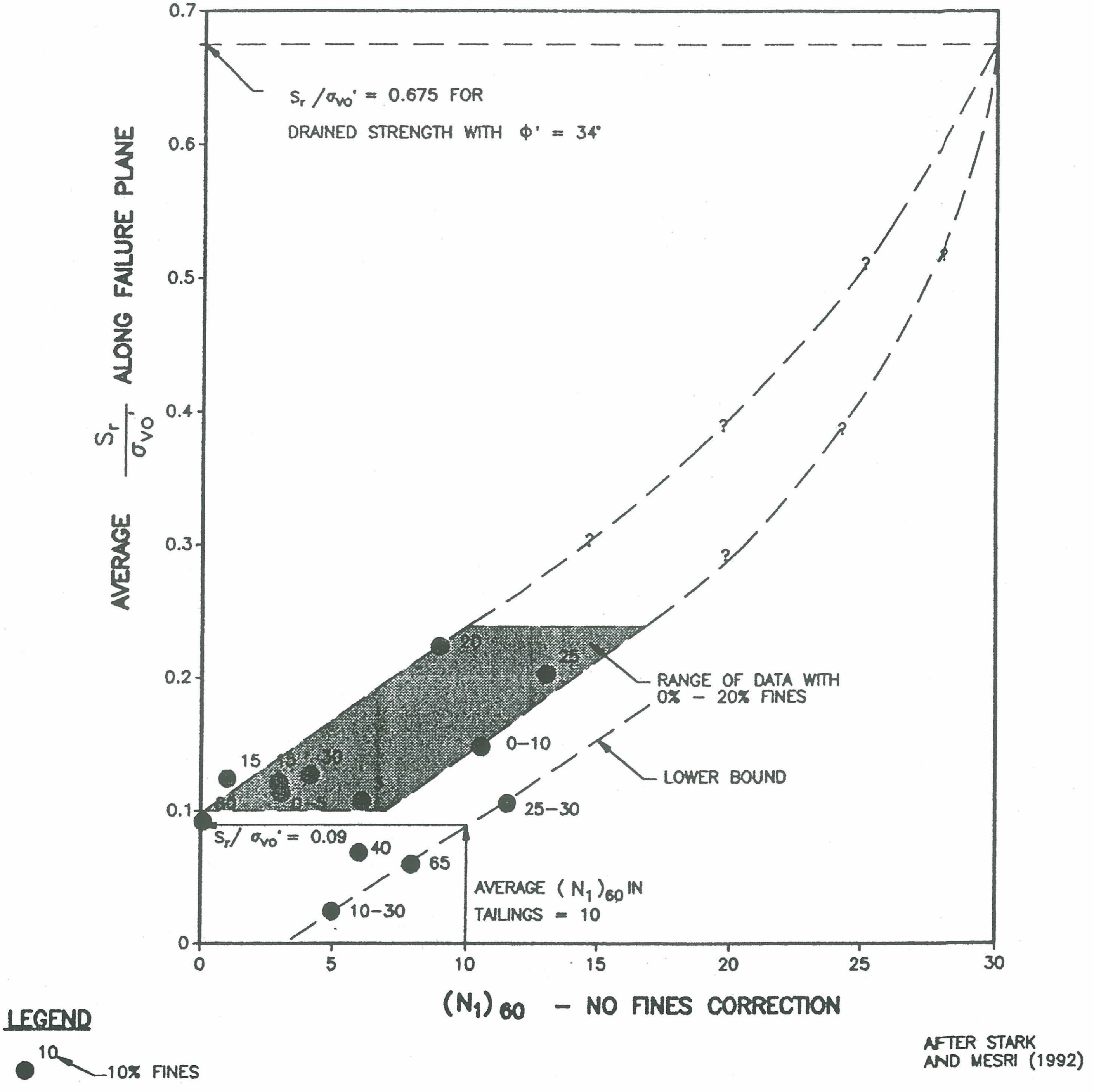


AFTER STARK
AND MESRI (1992)

NOTES:

S_r = AVERAGE RESIDUAL SHEAR STRENGTH BACKCALCULATED ALONG FAILURE PLANE IN LIQUEFIED SOIL MASS USING POST-FAILURE GEOMETRY

σ_{VO}' = AVERAGE INITAIL VERTICAL STRESS IN LIQUEFIED SOIL MASS PRIOR TO FAILURE.

SCALE

KLOHN-CRIPPEN

PROJECT
MT. NANSEN GOLD PROJECT

TITLE
STRESS - NORMALIZED S_r VERSUS $(N_1)_{60}$
FROM CASE HISTORIES

CLIENT:
B.Y.G. NATURAL RESOURCES INC.

DATE OF ISSUE

APPROVED

PROJECT No.
PB531403

DWG. No.
FIG. IV-1

REV.

The driving force (P_d) is generated by the hydrostatic head of the liquefied tailings (behaving as a dense slurry) behind the embankment, less a small strength component calculated from the residual strength (S_{r1}). The driving force is calculated according to the following equation:

$$P_d = 0.5\ \gamma\ h^2 - 2\ S_{r1}$$
$$P_d = (0.5)(12.26)12^2 - (2)(6.6) = 869 \text{ kN/m}$$

If we assume that the average depth of embankment dam above the foundation failure surface is about 8 m, then the residual strength (S_{r2}) along the basal failure plane is:

$$S_{r2} = (0.09)(17 \text{ kN/m}^3)(8 \text{ m}) = 13.8 \text{ kPa}$$

The length (L) of the failure surface times the residual strength (S_{r2}) gives the force resisting failure (P_r). Assuming a foundation length of 100 m, the resisting force is calculated according to the following equation:

$$P_r = L\ S_{r2}$$
$$P_r = (100)(13.8) = 1377 \text{ kN/m}$$

So the factor of safety against failure is equal to the ratio of the resisting force over the driving force:

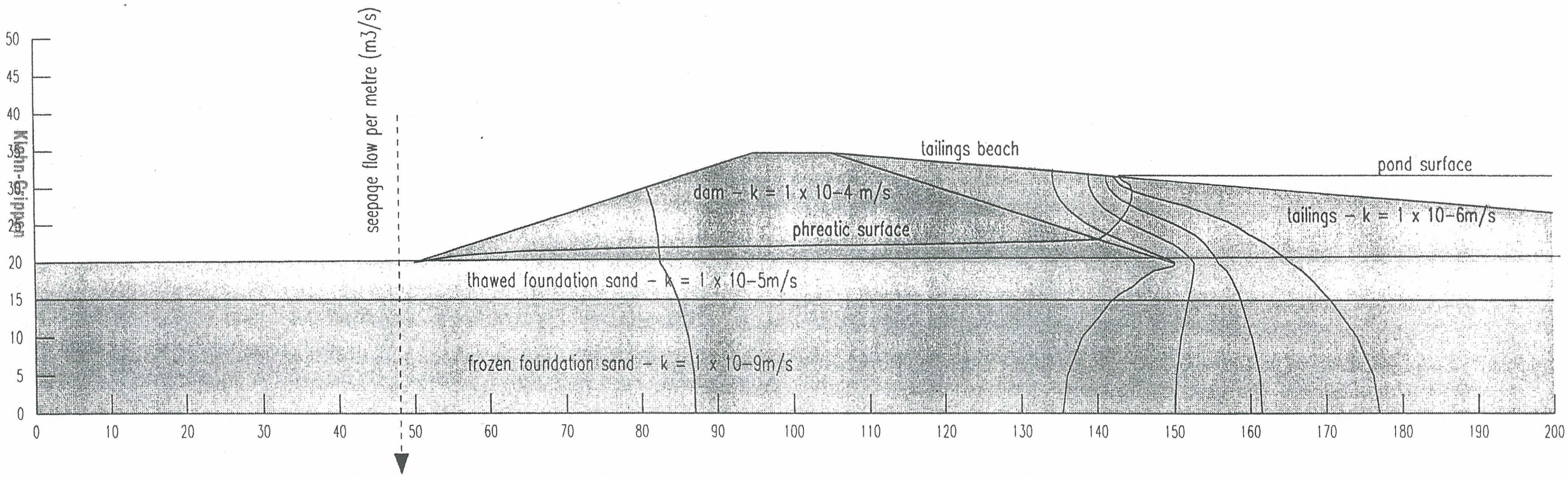
$$F = P_r\ /\ P_d = 1377/869 = 1.6$$

From this it can be seen that the factor of safety is proportional to the length of the failure surface, or the width of the dam. For this situation, a factor of safety of 1.1 is considered appropriate for design. A factor of safety of 1.1 is achieved when the dam base width is about 80 m.

APPENDIX V

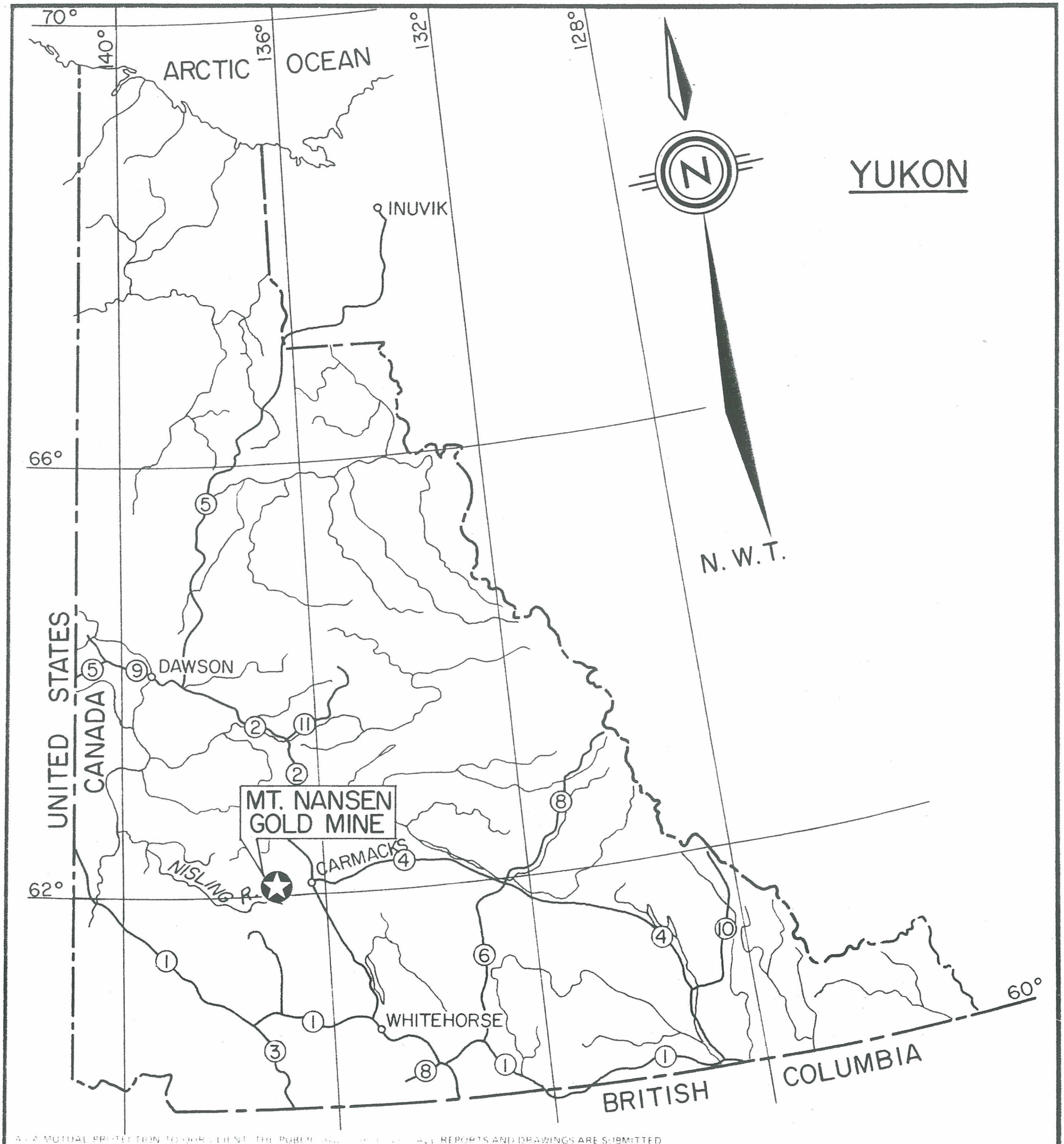
Seepage Analysis

SEEPAGE ANALYSIS RESULTS



DRAWINGS

A-3001	Location Plan
D-3002	General Arrangement Plan
D-3003	Plan, Section and Profile, Site #4



KLOHN-CRIPPEN

PROJECT
MOUNT NANSEN GOLD PROJECT

TITLE
SITE LOCATION

CLIENT:
B.Y.G. NATURAL RESOURCES INC.

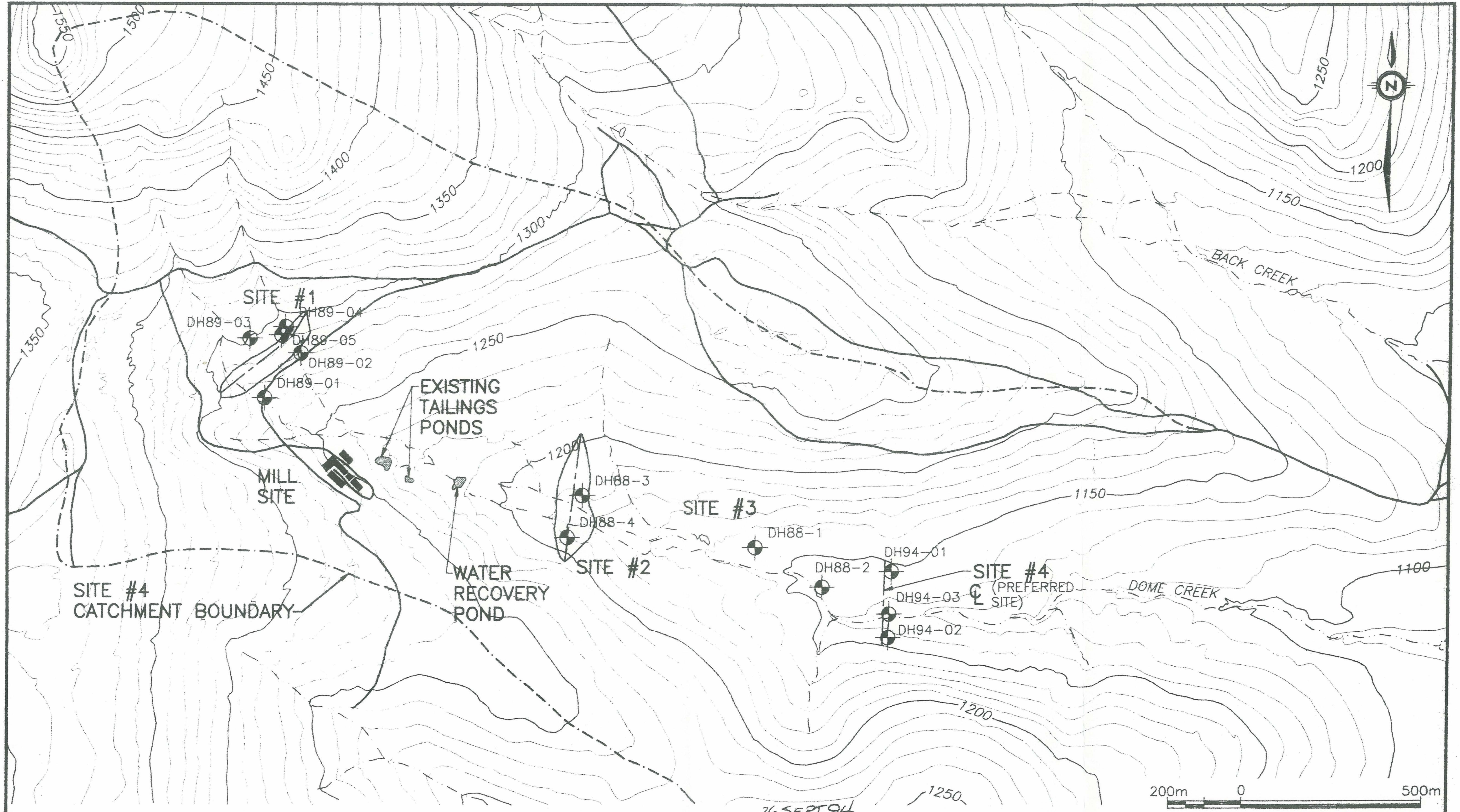
DATE OF ISSUE
26 SEPT 94

APPROVED

PROJECT No.
PB5314 03

DWG. No.
A-3001

REV.



TO BE READ WITH KLOHN-CRIPPEN REPORT DATED 26 SEPT 94

KLOHN-CRIPPEN		DATE
DESIGNED	BGG	
DRAWN		
CHECKED		
RECOMMENDED		
APPROVED	BGG	09/94

KLOHN-CRIPPEN

CLIENT
B.Y.G. NATURAL RESOURCES INC.

PROJECT
MT. NANSEN GOLD PROJECT

TITLE
GENERAL ARRANGEMENT PLAN

DATE OF ISSUE	PROJECT No.	DWG. No.	REV
26 SEPT 94	PB531403	D-3002	

August 23, 1994 9:09:21 a.m.
Drawing: BASE.DWG