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MT. NANSEN MINE
RECLAMATION OPTIONS STUDY

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1 INTRODUCTION

The general objective this report is to present an evaluation of alternatives for reclamation or long-term management of the site. The specific objectives of the work presented here are to:

- carry out a comprehensive evaluation of the technical and practical aspects of the closure options for the site, with an emphasis on management of the tailings,
- prepare a cost estimate of the most technically viable alternatives,
- identify information requirements to address any assumptions or data gaps with the above steps.

2 BACKGROUND

The Mt. Nansen Mine first produced ore in 1968/69. Further limited production occurred in 1975/76. Mining was focused on the Brown-McDade zone and was conducted by underground methods. In 1996, mining resumed under the management of BYG Natural Resources Inc. (BYG). In 1999, BYG abandoned the property after processing about 245,000 tonnes of ore. Many environmental liabilities remain and the infrastructure is in a state of disrepair.

Since that time, the care and maintenance of the property has been carried out under the management of the Water Resources Division of DIAND. This work has included general site security, operation of the water treatment plant, repairs to the seepage return dam and maintaining compliance with the Water Licence.

Seepage water quality and dam stability are the major liabilities at the site. Management of the site could be required for many years due to the ongoing arsenic leaching from the tailings. The tailings dam and spillway do not have adequate stability for abandonment.

3 INFORMATION SOURCES

The following information has been considered in the preparation of this report:

- A site inspection was conducted on October 4, 2001. Beached tailings and conditions in the open pit were assessed with reference to the potential for relocating the tailings to the pit.
- Previous reports dealing acid generation potential of the tailings (Nov. 1998) and potential closure costs (ongoing water treatment and in-pit tailings disposal) as prepared by Brodie Consulting Ltd. in Dec. 1998,
- reports and reviews submitted by BYG and others in the permitting stage of the project (1994/95),
- cost data from DIAND Water Resources regarding site management and seepage dam repair,
- a draft report (Mar. 2002) from Natural Resources Canada (NR Canada) regarding the geochemical properties of the tailings,
- a draft report (Apr. 2002) from EBA Consulting (EBA) regarding the physical stability of the tailings dam and associated water management structures.

4 CURRENT CONDITIONS

4.1 Geochemistry

NR Canada has completed an assessment of geo-chemical conditions. They have concluded that the pore water associated with the tailings has elevated concentrations of arsenic, zinc, copper and ammonia. Cyanide is either absent, or present only at very low concentrations. Although a portion of the tailings are sulphidic, mineralogic factors are such that the tailings are not potentially acid generating. The leaching of arsenic is believed to be the greatest geo-chemical concern. Arsenic leaching is expected to continue essentially indefinitely. It is expected to be more severe under saturated conditions.

The waste rock at the site is believed to be non-acid generating. At this time it does not appear to be a source of metal leaching.

Exposed rock in the pit bottom may be a source of acid generation and/or metal leaching. Some pockets of oxide and sulphide are exposed in the lower pit walls. Accumulated water in the pit has been found to have an elevated concentration of zinc.

NR Canada has concluded that oxidation and acid generation are not expected to be a problem with the tailings. However, the NNP of the tailings ranges between –12 and –52 kg CaCO3/tonne. None of the samples were potentially acid consuming. Two samples collected by DIAND in 1998 were shipped to Brodie Consulting for analysis. These samples, which are believed to represent the most recently deposited tailings had NNP values of – 186 and –72 kg CaCO3/tonne. It is not clear why the results of NR Canada indicate a much lower acid generation potential or why NR Canada does not seem concerned about the potential for increased oxidation in the long-term. In this report a more conservative approach has been taken. It is assumed that measures will be required to mitigate acid generation for at least a portion of the tailings, all of the old tailings, the rock exposed in the pit bottom and in the Pony Creek portal dump.

4.2 Physical Stability

There are several physical stability issues at the site. These include:

- the tailings dam, which is marginally stable due to a high phreatic surface, lack of internal drainage, and construction of and on low density and potentially liquefiable soils,
- the diversion channel and spillway, which require annual or regular maintenance to remove accumulated debris and repair piping failure in the spillway,

An assessment of the tailings dam by EBA Consulting has concluded that the short-term stability could be tolerable if certain measures are taken, and that long-term stability is not acceptable.

4.3 Other Reclamation Issues

There are a number of other reclamation issues at the site. These include:

- an open portal in Pony Creek,
- several old tailings deposits located near to the mill which were associated with the original mining at the site,
- water accumulation in the pit has elevated zinc levels, this water appears to escape to the environment by seepage to groundwater,
- assorted buildings and equipment in disrepair,
- hazardous waste,
- disturbed areas such as the roads, trenches, waste rock pile, and open pit.

5 CLOSURE OBJECTIVES

The following objectives have been considered in the development of the closure options for the Mt. Nansen site:

- meeting Water Licence objectives for release of water, and protection of downstream receiving water quality at CCME water quality guideline levels,
- providing secure long-term physical containment of mine wastes, and
- reducing post-closure maintenance to the minimum economically justifiable level,
- achieving the lowest net present value of closure costs considering both capital and operating costs.

6 CLOSURE OPTIONS

The primary closure issues pertain to the chemical stability of the tailings and the physical stability of the tailings dam and spillway. In addition to the closure options described below, there is a need for general site reclamation. This will include: removal of buildings, equipment and general wastes, removal of hazardous wastes and contaminated soil, stabilization of roads, trenches, ditches and fill slopes, revegetation, closure of the portal, and post-closure monitoring.

The closure options can be considered in three general classes, with sub-sets as listed below:

Option 1 Long-term maintenance in a slightly modified condition, including;

a) improvements to the water treatment system, stabilizing the dam and up-grading the spillway and diversion channel.
b) improvements to the water treatment system, construction of a new dam and spillway immediately downstream of the existing dam.

Option 2 In situ physical and chemical stabilization of the tailings by;

a) establishing and maintaining permanently frozen conditions with a combination of surface and groundwater diversion, thermosiphons and an insulating rock cover, or,
b) dewatering and consolidation of the tailings, buttressing the dam and construction of an durable spillway.

Option ~~2~~ 3 Ex-situ physical and chemical stabilization of the tailings by;

a) relocation of the tailings to the existing open pit along with either washing or chemical stabilization of the tailings to reduce chemical impacts, or
b) relocation of the tailings to a new impoundment within Dome Creek along with either washing or chemical stabilization of the tailings to reduce chemical impacts, or
c) relocation of the tailings to a new impoundment within Victoria Creek along with either washing or chemical stabilization of the tailings to reduce chemical impacts.

In addition to the above, short-term site management is required for options 2 and 3. Prior to implementation of any of these options there would have to be a period of detailed design, permitting, contract tending and construction. The short-term site management should consist of at least the following:

- continued collection and treatment of contaminated water,
- continued maintenance of the diversion ditch and spillway,
- measures to maintain the tailings pond water level at the lowest practical level,
- ongoing monitoring and data collection.

Each of the options is described and evaluated in the following sections. An estimate of the cost to implement the options is presented in Appendix 1. Appendix 2 contains detailed notes on scope, quantities of work, and assumptions in support of the cost estimate. Table 1, presents a summary of the sections and the cost estimate.

6.1 Option 1 – Long-Term Maintenance

This option deals with continued collection and treatment of seepage water. This will be required until acceptable water quality is achieved, in conjunction with improvements to the water treatment plant, measures to stabilize the tailings dam, upgrading the spillway and diversion channel, and, construction of containment facility for treatment sludge. Improvements to the dam and spillway must be included with this option because long-term stability of these structures is not assured in the current configuration.

6.1.1 Option 1A – Water Management and Stabilizing the Existing Dam

Water Management

A methodology for water management is currently in effect at the site. This methodology is a minimally modified system from that used by BYG. It has not been optimized since the time when cyanide destruction was no longer required. Modifications to improve process control and permit remote operation have not been made. These factors are important in developing a reasonable estimate of the annual cost of long-term maintenance. The annual cost can be looked at historically, by comparison to other sites, and in a re-design scenario.

Over the past three years (1999 – 2001), site maintenance, water treatment and repairs to the seepage return dam have cost $1.12 to $2.43 million dollars. Considering the condition of the dam, diversion channel and spillway, degraded infrastructure and the possibility of wet years, it seems reasonable and conservative to expect some years to be relatively costly. In addition, it would be necessary to conduct ongoing maintenance of the spillway and diversion channel, and it may be necessary to construct a lined pond for treatment sludge. In determining a historical-based cost for long-term site maintenance,

TABLE 1
MT. NANSEN MINE – COMPARISON OF RECLAMATION OPTIONS

OPTION	TAILINGS STABILIZATION	MERITS	CONCERNS	COST[1]
1A	Long-term water management & dam stabilization	• most demonstrable solution for protection of downstream water quality	• risk of release to environment due to system failure (pumps/treatment) • uncertain duration for site management	$15,666,807[2]
1B	Long-term water management & new dam immediately downstream of existing dam	• same as 1A	• same as 1A • difficult to construct better dam	much more than 1A
2A	Insitu stabilization with permafrost	• good physical and chemical stability	• may be difficult to freeze entire tailings mass and dam • creek flow over tailings may cause thawing	$22,853,514[3]
2B	Insitu stabilization with dewatering &consolidation	• good physical stability	• removal of contaminated pore water and reduction in permeability may not meet chemical objectives	$7,273,967[4]
3A	Relocate to open pit	• very good physical stability	• removal of contaminated pore water may not meet chemical objectives • uncontrolled discharge to groundwater may result	$8,386,114[5]
3B	Relocate to new impoundment in Dome Creek	• may achieve good physical stability	• removal of contaminated pore water may not meet chemical objectives • difficult to construct better dam	much more than 3A
3C		• may achieve good physical stability	• removal of contaminated pore water may not meet chemical objectives • difficult to construct better dam	much more than 3A

1 Cost includes general site reclamation cost ($972,623) + interim care and maintenance cost ($2,280,675) = $3,253,298.
2 Cost assumes treatment required for 50 years in new treatment plant.
3 Based in part on quote from Arctic Foundations Inc., supplier of thermosiphons.
4 Based in part on review with Nilex Corp., supplier of wick drains.
5 Based in part on hydraulic mining and processing of tailings by SNC-Lavalin Inc.

the average cost of the past three years may be appropriate. This gives an average annual cost of $1.56 million.

Water management at the Mt. Nansen site involves collection and treatment of about 100,000 m3 of water per year and uses about 5 tonnes of reagents. It is about two hours drive from the nearest community. By comparison, the Equity Silver mine in northern B.C. processes about 1,000,000 m3 of acid drainage per year. It is about 1 hour drive from the nearest community. Annual operating costs at Equity Silver are in the order of $800,000 per year, about one half of which is reagents. These costs are covered by the owner and could be higher if a contractor was used for this work. This comparison suggests that the site maintenance costs at Mt. Nansen are disproportionally high for assessment of long-term costs and that modifications should be considered to reduce the net present value of site maintenance. The annual cost at Mt. Nansen should be less than that at Equity Silver.

A previous estimate of long-term site maintenance costs (Brodie Consulting, 1998), suggested that the annual cost would be in the order of $160,000. This assumed site presence was required for only half the year as opposed the full year which has been found to be necessary given the existing site infrastructure and conditions. This estimate is based on the assumption of construction of a new water treatment plant which is optimized for the influent chemistry and includes process automation in the plant and seepage collection system to permit operation with a part-time operator. The capital cost is assumed to be $500,000 and the annual operating cost is estimated to be $474,000, as described in Appendix 1 and Appendix 2.

Collection and treatment may not be required indefinitely. Once the contaminants are flushed out of the tailings pore water the rate of contaminant release should drop to levels which can be released to the environment. If it is conservatively assumed that water treatment is required for up to 50 years, then the net present value of the future annual cost is about $12.4 million, based on a real rate of return of 3% per year. If required in perpetuity, then this cost would be about 4% higher.

It is assumed that the precipitates from the water treatment process are stable and exhibit low leaching rates, such that long-term disposal of these precipitates into the tailings pond can be continued. Construction of lined pond for treatment sludge could be required, but is not included in the estimate for this scenario.

The costs included in this scenario do not include the internal costs of DIAND Water Resources Division for management of the work, which could be in the order of $50,000 per year. Other costs such as road maintenance to the site (which are covered by others) are not considered in this assessment.

Dam Stabilization

The primary problem with the perpetual maintenance approach is that the dam is not sufficiently stable. A major capital improvement would is required. A stabilizing buttress could be constructed over the downstream face of the dam and critical areas of the abutments. This buttress would have to be designed to reduce the risk of piping failure and improve the seismic stability.

For the purpose of reducing the risk of piping failure it would be necessary to prevent the migration of fine material out of the dam. A filter, which grades from finest at the bottom to coarsest at the top, could achieve this objective. For permanent stabilization, it is recommended that the filter be composed of earthen materials instead of a geotextile. The latter would be less costly but subject to future degradation. The waste rock on site could be screened to provide the coarse filter material. The fine portion, such as the 6 inch minus fraction, could be placed first on the dam and abutments with the coarse fraction placed over top. The fine filter layer should be in the order of 0.5 m thick.

Further assessment is required to assess the grain size distribution of the waste rock, the resulting distribution from screening, and the mass balance of fines and coarse fraction after screening.

In addition to placing the filter, stabilization of the dam will require increased resistance to failure under seismic conditions. This could be achieved by placing a substantial toe buttress over the toe region of the dam and extending it to the crest so that the additional load consolidates the potentially liquefiable layers. Installation of wick drains or other means to remove water from the loose layers may also be required. Further assessment is required to assess the consolidation and stabilizing effects of such a layer of rock.

It would be necessary to provide a route for runoff from the catchment of the dam over the stabilizing layer. In a perpetual maintenance scenario, removal of any debris from the diversion channel could be conducted. However, the flow would still have to be routed past the dam. A channel over the cover and construction of improvements to the spillway would be required.

A cost break-down for the option of perpetual treatment in conjunction with stabilization of the existing dam is presented in Appendix 1.

6.1.2 Option 1B – Water Management & Construction of New Dam and Spillway

This option would involve the same water management requirement as discussed in Option 1A.

An alternative to stabilization of the existing dam would be the construction of a new dam immediately downstream of the existing dam. Due to similar foundation conditions, such a dam would likely suffer the same construction problems as were encountered in the existing tailings dam and seepage collection dam. A different design and construction method would likely be needed in order to yield a satisfactory product. A new dam would be much larger, possibly up to 30 m high (1123 m up to 1152 m elevation), not including the sub-surface extension of the seepage cut-off. Unless the tailings were moved against the upstream face of the new dam to aid in control of seepage, the new dam would have to be designed as a water retaining dam. This would require elaborate seepage control measures. A dam at this location could involve at least 50% more material than the current dam, or about 150,000 m3 of material.

A new structure would require significant modification to the diversion channel and establishment of a new spillway. The existing channel and spillway have performed poorly. The channel requires regular removal of sediment, and the spillway has failed once. There is no bedrock in either abutment. The fine silty sand in the abutments is readily eroded. This location is not well suited to construction of a spillway with long-term durability. Annual maintenance of the diversion and spillway, even after improvements, would likely be required because of the generally unsuitable soil conditions at the present location.

Considering the potential difficulties with a new dam and spillway being similar to or even greater than those of the existing or stabilized structure, the additional cost of construction makes the option of a new dam un-attractive. Consequently, it is recommended that option be considered further.

6.1.3 Option 1 Summary

Long-term collection and treatment, as a stand alone option does not satisfy the closure objectives, for long-term physical containment of the wastes. Modifications to the water management system should be considered to reduce long-term costs. Physical stabilization of the dam at the current location appears to be possible. Long-term water treatment coupled with dam stabilization measures has an estimated net present value cost of $12.8 million, including a 25% contingency.

6.2 Option 2 – In Situ Stabilization

Two methods of insitu stabilization have been considered:

Option 2A; establishing and maintaining permanently frozen conditions and construction of a durable spillway, and ,

Option 2B; dewatering and consolidation of the tailings, along with buttressing the dam and construction of a durable spillway.

6.2.1 Option 2A - Permafrost

It may be possible to achieve long-term physical and chemical stability by establishing permanently frozen conditions in the tailings and the dam. The Mt. Nansen site is located within the zone of discontinuous permafrost. Some, but not all, of the lower layers in the tailings impoundment are currently frozen, based on the drilling results of NR Canada. The assessment by EBA suggests that further thawing of the valley bottom and south abutment is not likely, and that further thawing of the north abutment could be significant.

Global warming may further reduce the extent of natural permafrost at the site. Consequently, a solution which relies upon permafrost must be robust. Establishing permafrost may be difficult because it is very difficult to freeze flowing water. Currently, seepage enters the impoundment as direct precipitation, seepage loss from the diversion ditch and groundwater flow which passes under the diversion ditch.

Freezing could be achieved by either active or passive means. Active freezing would involve some form of heat removal using a mechanical refrigeration plant and circulation of coolant through pipes installed in the tailings. Active freezing, such as through the use of a brine-based refrigeration plant, could be used to accelerate the initial freezing, but is not a suitable long-term option. Passive freezing could involve either a cold air trap of waste rock (which would serve as an insulating layer in the summer) or heat removal using thermosiphons, such as have been used to create the seepage cut-off in the new seepage return dam.

The cold air trap would be effective at initiating and maintaining frozen conditions in the uppermost tailings. However, it would be very slow to freeze the lower tailings as the zero degree isotherm would advance at a decreasing rate with depth into the tailings. The continued migration of seepage through the tailings from upstream sources may limit the depth to which permafrost penetrates. Installation of well points for removal of groundwater upstream of the tailings may be necessary. Seepage collection and treatment would be required for many years if the cold air trap was the only means for establishing frozen conditions.

It is possible that the concave upwards geometry of the tailings surface would result in pooling of water. It may be necessary to fill the tailings surface up to level or slightly convex upwards in order to ensure that frozen conditions would remain.

Thermosiphons would be more effective at freezing the lower portion of the tailings deposit than a cold air trap. However, the surface of the tailings would thaw every year unless an insulating layer is present. Used alone, neither method would be suitable for stabilization of the tailings. Used together, they may provide a solution to both physical and chemical stability issues associated with the tailings impoundment.

A combined approach involving filling the tailings surface, upstream groundwater removal, placement of a insulating layer and installation of thermosiphons could be effective. The thermosiphons would be required over the tailings surface, and all of the crest and downstream slope of the tailings dam. Based upon a review with the manufacturer of thermosiphons, Arctic Foundations Inc. they would required on approximately 6 m centers. Complete freezing is estimated to take 3 to 5 years.

There is a geosynthetic clay liner (GCL) on the upstream side of the dam. Careful assessment of the effects of puncturing the GCL during thermosiphon installation is required before this option could be fully supported. Puncturing the liner could temporarily increase seepage to the toe of the dam where the phreatic surface is already very high. This approach is not recommended. Angled drill holes under the liner from the crest of the dam could be used but it may be difficult to ensure that all areas of the dam and foundation become frozen.

It would be necessary to provide for infrequent long-term monitoring and maintenance of the thermosiphons.

The consideration of permafrost as a permanent solution implies no ongoing maintenance. Therefore, continued operation of the diversion channel is not expected. It should be assumed that the flow of Dome Creek will enter the upstream edge of the tailings impoundment. It would be necessary to route this flow over the tailings without allowing thawing to occur. The bed of the channel would have to be thick enough that the active zone beneath it does not extend into the tailings.

Finally, this option would require establishment of a spillway with good long-term stability. This may be best achieved by an overflow structure which allows the water to travel in and on the insulating cover on the dam or in a constructed alignment on the north abutment.

Establishment of frozen conditions could take several years from the time of construction. Ongoing seepage collection and treatment would be required during this period. It would be necessary to modify the seepage return during dewatering. Storage of the water elsewhere is a problem. The volume could be up to 70,000 m3 (3 lps over 9 months). Construction of a dedicated pond about one fifth the size of the existing pond does not seem justified. Other options could be to make an ice pile to store the seepage or fill the pit after sealing the portal. Further evaluation of these options is required.

A cost estimate for the establishment of permanently frozen conditions is presented in Appendix 1 and supporting details are presented in Appendix 2. It is estimated that it will cost $19.6 million to freeze the tailings and dam.

6.2.2 Option 2B - Dewatering and Consolidation of the tailings

Much of the problem with the Mt. Nansen tailings facility relates to the quantity and/or quality of the pore water in the dam, it's foundation and the tailings. It may be possible to address both of these factors by removal of excess pore water. Removal of the excess pore water would have several benefits, including:

- reducing the contaminant load in the tailings,

- consolidation of the tailings would occur and the permeability of the tailings would decrease which in turn would reduce future flushing of the tailings
- removal of excess pore water from the dam and foundation would allow consolidation of the potentially liquefiable soils and thus increase the static and seismic stability of the dam. If this is done in conjunction with consolidation measures which also provide a buttress effect, then stability would be further enhanced.

The concept of dewatering and consolidation is relatively well known in the field of geotechnical engineering for improving the physical properties of a soil structure. However, it is not clear that this method would be effective in reducing the future flushing of contaminants to a level which would permit cessation of water treatment.

In order to achieve dewatering and consolidation it is necessary to provide both a driving force and conduit to permit the water to escape. The driving force would be most easily provided by a surcharge of waste rock. Dewatering could be provided by vertical wick drains, which are manufactured and installed by Nilex Corp. These are a rigid plastic channel surrounded by a geotextile cloth. They are about 10 cm wide by 0.5 cm thick and installed as a vertical ribbon.

The spacing of the wick drains depends upon soil properties, the vertical surcharge force and the desired dewatering time. Appropriate soil parameters are not available at this time. Based upon discussion with Nilex Corporation of Denver Colorado the supplier of wick drains, they suggest that, the wick drain spacing would be in the order of 4 m centres which would give a consolidation period in the order of one year.

Installation of the wick drains would be easiest in late winter. It would be necessary to minimize the pond area so that freezing conditions could create the largest possible working area. As with the permafrost option, storage of the tailings pond and seepage return water elsewhere is a problem. A temporary storage pond would be required.

After the drains are installed, placement of the consolidation layer could commence. The thickness of the consolidation layer will affect the rate of consolidation in both the tailings and the dam/foundation area. More data is required to estimate the appropriate thickness of the consolidation layer on these areas. For the purpose of this assessment, the consolidation layer is assumed to be 1.5 m on the tailings. Approximately 94,000 m3 of rock would be required to cover the dam and tailings areas. A dewatering sump would have to be installed in the cover over the tailings at the current low point of the tailings surface. Discharge from the wick drains would flow through the rock cover and be collected for treatment along with any seepage from the toe of the dam.

A cost estimate for the stabilization by dewatering and consolidation is presented in Appendix 1 and supporting details are presented in Appendix 2. It is estimated that it will cost $4.02 million to dewater and consolidate the tailings and dam.

6.3 Option 3 – Ex-Situ Stabilization

Three methods of ex-situ stabilization are considered, as described below. Each option would require some washing or geochemical stabilization of the tailings to reduce the release of contaminants. The options considered are:

Option 3A; relocate the tailings into the open pit using either truck and shovel or slurry methods,
Option 3B; relocate the tailings into a new impoundment in Dome Creek, and,
Option 3C; relocate the tailings into a new impoundment in Victoria Creek.

There are approximately 284,000 m3 of tailings. All relocation options are likely to over-excavate some of the foundation soil. It is assumed uniform depth of 1 m of excavation of the original soil in the tailings deposition area will be required. This would yield an additional 65,000 m3 of material. Allowance should also be made to store a portion of the dam due to over-excavation and/or removal of arsenic contaminated material. Provision for 30% of the dam volume yields a further 30,000 m3. The total volume to be stored could be up to 380,000 m3.

There are two options for relocating the tailings; conventional truck and shovel or hydraulic mining and transport as a slurry. In general, the tailings are too soft and wet for truck and shovel excavation, although this method could be used around the perimeter of the pond. Hydraulic mining works best on cohesionless soil. Not only are the tailings composed entirely of cohesive silt and clay particles, but there are frozen layers within the tailings. Hydraulic mining offers the best opportunity to wash or stabilize the tailings to reduce geochemical concerns. This approach could be made to work, but it may be slow and energy intensive. Excavation assistance with a dozer would likely be required.

Unless the tailings are relocated to a "near-zero" seepage and discharge facility, it will be necessary to mitigate the geochemical concerns. Otherwise, relocation would only address the physical stability objective. It is believed that such a facility is not viable at the Mt. Nansen site. Even the open pit which is continuously filled by seepage entering at the north end does not fill up to the level of the adit.

Further work is needed to determine the effectiveness and cost associated with a chemical mitigation program for the tailings. Based on the geochemical assessment by NR Canada and discussion with the author suggests that:

- unsaturated containment is best in terms of aiding future cyanide destruction and reducing the rate of arsenic leaching, (this will not address the concern for acid generation as identified in the geochemical section above),
- washing the tailings to reduce the existing contaminant levels will be difficult due to the fine grain size of the tailings,
- even if washing were conducted, it is likely that the dissolved arsenic concentration in the pore water would eventually rise back to the current level of several parts per million,

- slurry processing of the tailings coupled with addition of ferric sulphate to precipitate any dissolved arsenic or addition of cement to reduce the flushing rate could reduce the geochemical hazard associated with the tailings.

6.3.1 Tailing Treatment with existing mill equipment

The solid liquid separation/thickening equipment available in the existing mill plant will not be adequate for dewatering the tailings, however the leach tanks and agitators may be used for the required water treatment. The design criteria, for the water treatment process was not available at the time of this review.

The hydraulically mining the existing tailings will be undertaken using high pressure water monitors and pumping the resulting slurry to the existing mill for dewatering from approximately 20% solids to 40% solids and chemical treatment for destruction of any residual cyanide compounds. The thickened, treated slurry would then be pumped to the abandoned Brown-McDade open pit. The ultimate settled density of the tailings is projected to be approximately 75% solids. The supernatant solution will return to the tailings pond by gravity and will again provide feed water for the hydraulic mining operation.

The design criteria for the proposed reclamation plan are summarized as follows:

Tailings flow rate	m^3/h	360
Tailings density	% solids	20
Tailings flow rate	t/hr	518
SG Solids	t/m^3	2.7
SG slurry	t/m^3	1.44
Thickener underflow density	% solids	40
Tailings flow rate to open pit	m^3/h	155
Tailings solids flow rate	t/hr	104
Tailings solids flow rate	t/day	2,500

The existing mill was designed to process approximately 300 tonnes of ore per day, which corresponds to an average feed rate of approximately 12.5 tonnes of ore per hour. The design feed rate to the existing 12m (40 ft) diameter thickener was 12.5 tonnes per hour of ore, with a feed slurry density of 25 percent solids, which corresponds to a slurry flow rate of 42 m3/h. The thickener underflow slurry density was designed for 50 percent solids corresponding to a flow rate of 17 m3/h.
In order to provide the dewatering and treatment for the proposed tailings reclaim flow rate, a new thickener would be required to be installed based on current settling test data for the reclaimed tailings. Depending on the condition of the mill equipment, it may be possible to use one or more of the existing cyanide leach tanks for the chemical treatment stage. The reagent storage and delivery systems may, with modifications, be appropriate for use in the treatment process.

Depending on the settling characteristics of the material, it may be possible to bypass the thickening stage altogether and allow solid liquid separation to occur in the open pit. A larger volume of water would have to be decanted and returned. Treatment chemicals could be added either into the pipeline or in mixed tanks at the pit rim.

6.3.2 Option 3A - Relocate to the Open Pit

The open pit appears to be the most suitable alternative containment site. As noted above, the pit appears to allow significant seepage loss to groundwater, which may be an unmitigatable flaw with this approach. Construction of a 10 m high dam at the south end of the pit would give a storage capacity of about 310,000 m3 at an elevation of 1260 m. The invert elevation at the north end of the pit is about 1261 m elevation. The incremental storage capacity of the pit is about 21,000 m3 per meter of elevation at this height. The pit could be filled to store the required volume with a low saddle dam around the north end of the pit and an extension of the south dam. It may be possible to dome the tailings with a high point in the centre of the pit. The final surface could be cemented or stabilized with a cover of waste rock. A vegetative cover may also be possible.

6.3.3 Hydraulic Mining and Transportation

Tailings would be mined using high-pressure water through moveable monitors with tailings being sluiced down to trash type slurry pumps at the tailings pond. The trash pumps would discharge into a rotating trommel trash screen where debris and oversize materials will be washed from the mined tailings. The bottom of the trommel will be a pump box, which will collect the sized tailings for pumping on to the existing mill. The slurry would have a density of approximately 20% solids by weight and would be pumped to the mill by two stage centrifugal slurry pumps in a surface 10" HDPE pipeline routed along existing roadways. Based on the proposed operating season and volume of tailing slurry to move it is estimated that the pumping rate will be 360 m3/hr (1600 usgpm) at an specific gravity of 1.144 t/m3 will be required. The pumping head between the pond and the mill is estimated to be 132 m.

At the existing mill the tailing would enter a thickening/washing circuit to increase the tailings density to a maximum of 40% solids by weight prior to transfer to the Brown-McDade open pit. The treated tailings would be pump by single stage centrifugal slurry pumps via a surface 6" HDPE pipeline to the north end of the Brown-McDade open pit. The slurry pumping rate will be 155 m3/hr (680 usgpm) with a head of 120 m. Thickener overflow water (210 m3/hr – 900 usgpm) will be recycled back to the pond for tailing hydraulic mining in a 8 " HDPE pipeline placed adjacent to the slurry pipeline from the pond.

The tailings discharged into the Brown – McDade open pit is assumed to achieve a settled density of 75% solids by weight due dewatering from to a proposed internal sub-drain filter and natural settling which occur during the winter between the reclamation season. The tailing drainage water will be recycled back to the tailing pond for hydraulic mining. The average drainage water recovery rate is estimated to be 96 m3/hr (425 usgpm) which will flow by gravity back to the pond in a 6 " HDPE pipeline which will be routed along the existing roadways from the south end of the open pit.

Power for all the remote pumping stations will be from diesel generators. It is expected that utilization of much of the existing infrastructure (pipelines, roads, power supply) should be done to reduce costs. The capital cost for the pump, monitor and pipelines is estimated to be $1,250,000. This estimates excludes the cost of a new thickener if required.

For the operations of the tailing recovery system, it is estimated that 6 people will be required (3 men on 2 x 10 hour shifts) once the system is installed with an operating cost per season (150 day) of $165,000 for power and $360,000 for labour (excludes accommodation and travel). Reagents and cement costs will be based on test work to be undertaken and are extra. Maintenance costs will depend on the condition of the existing infrastructure and the amount of refurbished equipment utilized but it is estimated to be $55,000 per operating season.

6.3.4 Option 3B - Relocate In Dome Creek

This option would involve relocating the tailings to a new impoundment in Dome Creek. During the project screening stage in 1995, four sites were considered, all three being further up Dome Creek from the existing impoundment. These sites all have poorer storage ratios than the current site. Therefore, a dam at any of these locations would be higher than the existing dam. Construction costs would also be higher due to the greater amount of earthworks involved. All of these sites would likely have the same geotechnical and seepage water quality issues as the existing location because the foundation conditions are similar.

The presence of permafrost conditions at all three locations would make it very difficult to construct a containment with a low seepage rate. Unless additional measures were undertaken to wash the tailings during the relocation to yield acceptable pore water quality, then long term collection and treatment would be required.

Similar spillway issues to those at the existing dam location would occur at all three alternative sites.

Conceptually, option 3B appears to be very costly; relocation and washing of tailings and construction of a new low storage efficiency dam. It would be inferior to tailings containment in the open pit where dam stability and spillway issues would be very minor. Therefore, it is recommended that this option not be evaluated further because of the apparent weaknesses.

6.3.5 Option 3C - Relocate In Victoria Creek

There may be a potential containment location on a terrace of Victoria Creek about 2 kilometers further downstream of the existing location in Dome Creek. A side hill embankment would be required. This site is believed to be underlain by sand and gravel. It is very unlikely that a water retaining structure could be constructed here. The tailings would be left in a partially or unsaturated condition. It would be appropriate to assume that tailings pore water would be readily flushed into the underlying soil and migrate via groundwater pathways to Victoria Creek. Use of this site would require washing the tailings so that the expected flushing of the tailings would not result in impacts to Victoria Creek. Conceptually, this would require better washing of the tailings than any of the other options.

Conceptually, option 3C appears to be similar to option 3B. It would be very costly with all of the problems outlined in option 3B. It would be inferior to tailings containment in the open pit where dam stability and spillway issues would be very minor. Therefore, it is recommended that this option not be evaluated further because of the apparent weaknesses.

7 FURTHER STUDIES

The following studies are recommended in order to aid in determination of the best reclamation option for the Mt. Nansen tailings:

1. Re-assess the geochemical data and if necessary, conduct additional testing.
2. Thermal assessment to determine the minimum spacing of thermosiphons.
3. Permability and consolidation testing to determine the viability of the dewatering and consolidation option.

4. Determination of the grain size distribution of the waste rock and its suitability for filter material.
5. Options for customizing or improving the performance of the water treatment plant.
6. Assessment of the practicality of hydraulic mining of the tailings and washing of the tailings slurry.

Other tests or studies may be required.

8 SCHEDULE

A rough schedule for reclamation of the Mt. Nansen mine is proposed as follows. The final schedule will depend upon which reclamation option is selected.

Detailed design	
- bench scale &/or pilot plant of washing	spring 2003
- design and reporting	summer/fall 2003
Permitting	fall/winter 2003
Contracting	spring 2004
Construction	summer 2004 & 2005
Commence monitoring	2005 - 2007

9 CONCLUSIONS

Based on the work presented here, the following conclusions are presented for consideration in developing and implementing a solution to the liabilities at the Mt. Nansen mine site.

1. There is uncertainty as to the geochemistry of the tailings. It is not clear at this time whether the best long-term containment for the tailings is submerged (anaerobic) containment or beached (exposed to oxygen) containment. Due to this uncertainty, it is not possible to state that any one option is technically superior, except for insitu

freezing which eliminates all water transport. Further geochemical evaluation is required.

2. Seven options for management of the tailings at Mt. Nansen were identified and 4 were evaluated in detail. These are:
   - long-term maintenance with physical stability upgrades (i.e. perpetual water treatment),
   - insitu containment by establishing permanently frozen conditions
   - insitu containment by dewatering and consolidation,
   - exsitu containment by relocationg to the open pit, with or without treatment.

   The three which were not evaluated in detail, tailings relocation into secure containmnet in another watershed, were considered undesirable due to the creation of impacts beyond the currently affected areas.
3. Each of the four main options will consist of:
   - general site reclamation,
   - interim care and maintenance,
   - option selection and permitting, final design and implementation of measures for physical and chemical stabilization of the tailings and the dam,
   - post-reclamation monitoring.
4. At this stage, there does not appear to be a single good option.
5. All options, except for insitu freezing, will require some ongoing water treatment.
6. The perpetual water treatment option does the least for ensuring long-term physical stability of the tailings.
7. Freezing of the tailings does not eliminate the problem, it merely contains the contaminants. If thawing were to occur, then impacts could result.
8. Dewatering and consolidation will address physical stability and may help with chemical stability. Some improvement in water quality may occur. However, this cannot be estimated at this time.
9. The most promising options, in terms of both physical and chemical stability, appear to be relocate to the pit and insitu freezing.
10. Further study is required for all options.

11. Some optimization of the options which were considered may yield a reduction in the estimated cost or improvement in performance.
12. Water treatment will likely be required for up to 5 more years, depending upon which option is selected.
13. The total reclamation liability for the site ranges between \$7 and \$23 million, depending upon which option is selected.

Please call if you have any questions.

Yours truly,
Brodie Consulting Ltd.

M. J. Brodie, P.Eng. (B.C. and N.W.T.)

APPENDIX 1

Mt. Nansen Mine

Reclamation Cost Estimate

1 General Reclamation Activities — Common to all options

ACTIVITY/MATERIAL	UNITS	QUANTITY	COST CODE	UNIT COST	COST
Hazardous materials audit	each	1	#N/A	5000	$5,000
Hazardous materials, collection & removal	each	1	#N/A	25000	$25,000
HC contam. Soil, remediation cell, const.	each	1	#N/A	5000	$5,000
HC contam. Soil, excavation & remediation	m3	200	csrl	35	$7,000
Building demolition					
bunkhouses, 2	m2	1503	brw1l	19.5	$29,309
kitchen	m2	397	brw1l	19.5	$0
office	m2	231	brw1l	19.5	$4,505
crusher	m2	320	brs1h	48	$15,360
mill, upper	m2	642	brs1l	32	$20,544
mill, lower	m2	3255	brs1l	32	$104,160
generator plant	m2	301	brs1l	32	$9,632
cold storage	m2	387	brs1l	32	$12,384
water treatment	m2	235	brs1l	32	$7,520
Ketza shop	m2	300	brs1l	32	$9,600
general refuse	m3	200	sc3h	10.6	$2,120
remove original tailings to pit	m3	6000	sc3h	10.6	$63,600
supply lime to add to tailings	tonne	24		540	$12,960
add lime to tailings	tonne	24		100	$2,400
clean up Pony Creek portal area	m2	200	brw1l	19.5	$3,900
drift rehab.	each	1		10000	$10,000
bulkhead in adit		1		50000	$50,000
grouting at bulkhead		1		50000	$50,000
remove ARD rock at portal	m3	1500	sc2h	8.76	$13,140
supply & add lime to ARD rock	tonne	15		640	$9,600
cover waste in pit	m3	750	sb2l	3.61	$2,708
berm around north end of pit	m3	3600	sb2l	3.61	$12,996
berm at south pit access	m3	144	sb2l	3.61	$520
contour mill, camp & old tailings	m3	18774	dsl	0.71	$13,330
scarify roads & remove culverts	ha	5	scfyl	3215	$16,075
vegetate roads/mill,camp & old tailings	ha	8.75	vhfl	1450	$12,688
contour & scarify top of rock dump	m3	15080	dsl	0.71	$10,707
mob/demob for general reclamation only					
1 dozer	km	600	mherl	2.55	$1,530
3 dump trucks	km	1800	mherl	2.55	$4,590
2 excavators	km	1200	mherl	2.55	$3,060
pickup trucks, 2	monthly	2500		3	$7,500
misc. supplies, establish office	allowance	1		15000	$15,000
rehab. Camp	allowance	1		25000	$25,000
house workers, 10 men	man-days	900	accml	50	$45,000
Post closure water sampling	annual cost	3	wsh	8000	$24,000
Post closure water sampling	annual cost	7	wsl	4775	$33,425
Post closure geotechnical monitoring	annual cost	3	vih	6400	$19,200
Post closure geotechnical monitoring	annual cost	7	vil	3200	$22,400
Administration & engineering @ 3% each		6%			$44,548
contingency @ 20 %		25%			$185,615
Subtotal					**$972,623**

COMMENTS:

see report for comments and appended notes for details

2 Interim C&M + Final Design — Common to all options

ACTIVITY/MATERIAL	UNITS	QUANTITY	COST CODE	UNIT COST	COST
Water Treatment Upgrades - allowance	each	1	#N/A	50000	$50,000
Water treatment , automation	each	1	#N/A	50000	$50,000
Seepage Return automation	each	1	#N/A	25000	$25,000
			#N/A	0	$0
Geochemistry, further studies	each	1	#N/A	25000	$25,000
Geotechnical, further studies	each	1	#N/A	25000	$25,000
Geotechnical drilling			#N/A	0	$0
Final closure plan, preparation, permitting	each	1	#N/A	50000	$50,000
Sub-total, studies & capital improvements					**$225,000**

SITE MAINTENANCE, annual cost					
site personnel	mandays	180	#N/A	300	$54,000
vehicle	month	12	#N/A	3015	$36,180
water treatment plant, operation	annual	1	#N/A	49000	$49,000
reagents	annual	1	#N/A	64000	$64,000
fuel	estimate	1	#N/A	200000	$200,000
generator, rental	annual	1	#N/A	56000	$56,000
communication	annual	1	#N/A	18000	$18,000
water sampling & analysis	annual	1	#N/A	32000	$32,000
shipping		1	#N/A	14000	$14,000
earthworks, diversion ditch & spillway		1	#N/A	25000	$25,000
contingency @ 25%		25%	#N/A	0	$137,045
Sub-total annual cost			#N/A	0	$685,225
Period for Pre-reclamation activities	years	3			
Sub-total, pre-closure site maintenance					**$2,055,675**

Subtotal	**$2,280,675**

COMMENTS:

see report for comments and appended notes for details

3 Tailings Reclamation Option 1A — Long-term water mgmt & dam stab.

ACTIVITY/MATERIAL	UNITS	QUANTITY	COST CODE	UNIT COST	COST
Const. new water treatment plant	each	1	#N/A	500000	$500,000
Long-term water management					
site personnel	mandays	120	#N/A	300	$36,000
vehicle	month	12	#N/A	3015	$36,180
water treatment plant, operation	annual	1	#N/A	40000	$40,000
reagents	annual	1	#N/A	50000	$50,000
fuel	estimate	1	#N/A	100000	$100,000
generator, rental	annual	1	#N/A	35000	$35,000
communication	annual	1	#N/A	18000	$18,000
water sampling & analysis	annual	1	#N/A	32000	$32,000
shipping		1	#N/A	7000	$7,000
earthworks, diversion ditch & spillway		1	#N/A	25000	$25,000
contingency @ 25%		25%	#N/A	0	$94,795
Sub-total annual cost					$473,975
Period for Pre-reclamation activities	years	50			
Net present value of post closure water management	**interest rate**		**3.00%**		**$12,195,265**
Dam stabilization					
filter material, excavate, haul & place	m3	4930	sb2h	5.43	$26,770
filter material, screening	m3	4930		0.5	$2,465
buttress material	m3	19720	sb2h	5.43	$107,080
mob/demob , add 3 more dump trucks to Gen. Reclam. activities					
mob, 3 dump trucks	km	1680	mherl	2.55	$4,284
house workers, 13 men, 40 days	mandays	520	accml	50	$26,000
Administration & engineering @ 3% each		6%			$9,996
contingency @ 25 %		25%			$41,650
Sub-total, dam stabilization					**$218,244**

Subtotal	**$12,413,509**

COMMENTS:

see report for comments and appended notes for details

4 Tailings Reclamation Option 2A Insitu stabilization with permafrost

ACTIVITY/MATERIAL	UNITS	QUANTITY	COST CODE	UNIT COST	COST
Earthworks & capital equipment					
cost as described in attachment by Arctic Foundations Ltd.		1	#N/A	13000000	$13,000,000
contour tailings surface & notch dam	m3	4090	sc2l	6.32	$25,849
placement of 4 m rock cover over tailings	m3	257000	sb2l	3.61	$927,770
placement of terraces on dam face	m3	4160	sc2l	6.32	$26,291
placement of rock for channel on dam face	m3	1600	sc2l	6.32	$10,112
construct temporary seepage return pond					
dam, waste rock	m3	70784	sb2l	3.61	$255,530
dam, silt bedding on U/S face	m3	3792	sc2l	6.32	$23,965
pond strip area	m2	24000	dsl	0.71	$17,040
PVC liner, supply	m2	23242	gspvcs	8.4	$195,233
PVC liner, installation	m2	23242	gsih	1	$23,242
Sub-total, earthworks & thermosiphons					$14,505,032
contingency @ 25%		25%			$3,626,258
Total earthworks & thermosiphons					**$18,131,291**
Ongoing seepage return					
site personnel	mandays	180	#N/A	300	$54,000
vehicle	month	12	#N/A	3015	$36,180
water treatment plant, operation	annual	1	#N/A	49000	$49,000
reagents	annual	1	#N/A	32000	$32,000
fuel	estimate	1	#N/A	100000	$100,000
generator, rental	annual	1	#N/A	56000	$56,000
communication	annual	1	#N/A	18000	$18,000
water sampling & analysis	annual	1	#N/A	32000	$32,000
shipping		1	#N/A	14000	$14,000
			#N/A		$0
contingency @ 25%		25%	#N/A	0	$97,795
Sub-total annual cost					$488,975
Period for Pre-reclamation activities	years	3			
Sub-total, pre-closure site maintenance					**$1,466,925**
breach existing seepage return dam	m3	200	dss	10	$2,000
Subtotal					**$19,600,216**

COMMENTS:

see report for comments and appended notes for details

5 Tailings Reclamation Option 2B Insitu stabilization with dewatering/consolidation

ACTIVITY/MATERIAL	UNITS	QUANTITY	COST CODE	UNIT COST	COST
supply & install wick drains, tailings & dam	linear m	156162	#N/A	3	$468,486
contour tailings surface & notch dam	m3	4090	sc2l	6.32	$25,849
remove upper most tailings to pit		42600	sb3h	4.83	$205,758
add lime to tailings		443		640	$283,520
placement of 1.5 m rock cover over tailings	m3	93750	sb2l	3.61	$338,438
placement of terraces on dam face	m3	4160	sc2l	6.32	$26,291
placement of rock for channel on dam face	m3	1600	sc2l	6.32	$10,112
construct temporary seepage return pond					
dam, waste rock	m3	70784	sb2l	3.61	$255,530
dam, silt bedding on U/S face	m3	3792	sc2l	6.32	$23,965
pond strip area	m2	24000	dsl	0.71	$17,040
PVC liner, supply	m2	23242	gspvcs	8.4	$195,233
PVC liner, installation	m2	23242	gsih	1	$23,242
Sub-total, earthworks & wick drains					$1,873,464
contingency @ 25%		25%			$468,366
Total earthworks & wick drains					**$2,341,830**

Ongoing seepage return					
site personnel	mandays	180	#N/A	300	$54,000
vehicle	month	12	#N/A	3015	$36,180
water treatment plant, operation	annual	1	#N/A	49000	$49,000
reagents	annual	1	#N/A	32000	$32,000
fuel	estimate	1	#N/A	100000	$100,000
generator, rental	annual	1	#N/A	56000	$56,000
communication	annual	1	#N/A	18000	$18,000
water sampling & analysis	annual	1	#N/A	32000	$32,000
shipping		1	#N/A	14000	$14,000
contingency @ 25%		0.25	#N/A	0	$97,795
Sub-total annual cost					$488,975
Period for Pre-reclamation activities	years	3			
Sub-total, pre-closure site maintenance					**$1,466,925**

Dam stabilization					
filter material, excavate, haul & place	m3	4930	sb2h	5.43	$26,770
filter material, screening	m3	4930		0.5	$2,465
buttress material	m3	19720	sb2h	5.43	$107,080
mob/demob , add 3 more dump trucks to Gen. Reclam. activities					
mob, 3 dump trucks	km	1680	mherl	2.55	$4,284
house workers, 13 men, 40 days	mandays	520	accml	50	$26,000
Administration & engineering @ 3% each		0.06			$9,996
contingency @ 20 %		0.2			$33,320
Sub-total, dam stabilization					**$209,914**
breach existing seepage return dam	m3	200	dss	10	$2,000
Subtotal					**$4,020,669**

COMMENTS:

see report for comments and appended notes for details

6 Tailings Reclamation Option 3A Relocate to open pit

ACTIVITY/MATERIAL	UNITS	QUANTITY	COST CODE	UNIT COST	COST
Capital Equip.supply & install, as per SNC-Lavalin, Apr 2002		1	#N/A	1299600	$1,299,600
slurry and pumping to pit, cost for each of 2 years of operation					
power		1	#N/A	165000	$165,000
crew, 8 men	mandays	900	#N/A	400	$360,000
accom	mandays	1200	accml	50	$60,000
travel	mandays	80		400	$32,000
equipment parts & maintenance		1	#N/A	55000	$55,000
dozer operation, D8,capital & maint. only	allowance, hours	500	#N/A	150	$75,000
excavator, C325, capital & maint. only	allowance, hours	500	#N/A	90	$45,000
dump truck, C771, capital & maint. only	allowance, hours	500	#N/A	110	$55,000
reagents, into tailings slurry 2 double WTP rate		1	#N/A	89000	$89,000
pickup trucks	monthly	5	#N/A	3015	$15,075
Sub-total, tailings relocation, first year	$951,075	Sub-total, tailings relocation, two years			$1,902,150
contingency @ 25%		25%			$475,538
Total tailings slurry/transfer/treatment					**$3,677,288**
continued site operation during relocation to pit					
site personnel	mandays	180	#N/A	500	$90,000
vehicle	month	12	#N/A	3015	$36,180
water treatment plant, operation	annual	1	#N/A	49000	$49,000
reagents	annual	1	#N/A	64000	$64,000
fuel	estimate	1	#N/A	200000	$200,000
generator, rental	annual	1	#N/A	56000	$56,000
communication	annual	1	#N/A	18000	$18,000
water sampling & analysis	annual	1	#N/A	32000	$32,000
shipping	annual	1	#N/A	14000	$14,000
Sub-total, relocation cost for each of 2 years					$559,180
contingency @ 25%		25%			$139,795
Sub-total tailings transfer & treatment costs					**$1,118,360**
pit dam					
foundation cleaning	each	1	#N/A	15000	$15,000
foundation grouting	each	1	#N/A	50000	$50,000
foundation slush grouting	m2	252	#N/A	20	$5,040
core zone, supply bentonite	tonne	72	#N/A	450	$32,400
core zone, mix bentonite in trommel	m3	576	#N/A	0.75	$432
core material, bentonite ammended silt	m3	576	sc4h	17.3	$9,965
filter zone, silt	m3	144	sc4h	17.3	$2,491
filter zone, sand	m3	144	sc4h	17.3	$2,491
U/S & D/S shell, waste rock	m3	3312	sc4h	17.3	$57,298
spillway channel in right abutment	m3	375	rc1h	30	$11,250
reclaim tailings area, dozer	m2	35000	dsl	0.71	$24,850
revegetate tailings area	ha	7	vhfl	1450	$10,150
construct new channel for Dome Creek	m3	9600	sb3h	4.83	$46,368
remove seepage return dam	m3	200	dss	10	$2,000
Sub-total, earthworks					$269,735
contingency @ 25%		25%			$67,434
Sub-total, pit dam & tailings area					$337,169
Subtotal					**$5,132,816**

COMMENTS:

see report for comments and appended notes for details

APPENDIX 2
Mt. Nansen Mine
Detailed Notes For Reclamation Cost Estimate

Notes To RECLAIM Estimate

Part 1 - General Site Reclamation – Common to all options

- hazardous materials audit, assumed done by Conner Pacific Environmental Technologies, Apr. 2000, confirmation and update only
- hazardous material removal, assume no PCB's left on site, minor quantities of oil, lubricants and process chemicals left on site
- hydrocarbon contaminated soil, simple remediation cell consisting of local silty sand over geomembrane liner, area to be 400 m2, 30 mil PVC liner, \$4.20/m2 FOB Edmonton, assume \$8.40/m2 installed and soil cover 0.5 m thick for 200 m3 at \$8.00/m3, total cost approx. \$5000
- hydrocarbon contaminated soil remediation, allow \$35/m3 for excavation (including technician using PetroFlag field testing), transport to and placement on liner, irrigation and monthly harrowing over two summers, removal of soil and on-site disposal of liner,
- building demolition;
  - bunkhouses, kitchen and office all wooden buildings, all others are steel frame/steel clad,
  - demolition based on plan view area of buildings and increased to account for height of building
  - all building demolition waste to open pit
- two deposits of old tailings remain, assumed to acid generating (these came from the adit which intersected the deposit at depth and acid generation potential is assumed to increase with depth), tailings area is about 3000 m2, average depth is assumed to be 2 m, volume is 6000 m3, mass at bulk specific gravity of 1.25 t/m3 is 4800 tonnes, assume some oxidation has occurred and residual NNP is –50 kg/tonne – need to add 0.05 tonnes CaCO3/tonne tailings or 0.005tonnes lime/tonne tailings, 4800 tonnes x 0.005 tonnes lime/tonne gives 24 tonnes lime, assume difficult excavation due to wet tailings, lime added onto exposed tailings during excavation for mixing in excavation and dumping,
- debris and clean-up required at Pony Creek portal for reclamation and to re-gain access to adit
- drift rehabilitation to include removal of rotten timbers at portal, stabilization of portal and check scaling and rock bolting in adit

- bulkhead required in adit to ensure that seepage out of pit remains in Dome Creek drainage and to aid in flooding potentially acid generating material (wall rock, tailings and portal waste rock) in pit bottom, grouting of rock prior to bulkhead construction will be required to reduce seepage losses around bulkhead, grouting may involve drilling, injecting warm water and then injecting cement based grout,
- rock at Pony Creek portal is assumed to contain at least some potentially acid generating rock, the portal rock pile is to be treated as though it is all acid generating, it is to be removed, amended with lime and disposed in the pit bottom, 1500 m3 rock (adit is about 500 m x 1.5m x 2 m = 1500 m3), @ 2 tonnes/m3 and residual NNP is –50 kg/tonne – need to add 0.05 tonnes $CaCO_3$/tonne tailings or 0.005tonnes lime/tonne tailings, 3000 tonnes x 0.005 tonnes lime/tonne gives 15 tonnes lime, lime added onto exposed rock during excavation for mixing in excavation and dumping,
- waste rock is placed over demolition wastes disposed in pit, assume demolished building volume is 25% of existing volume and waste is placed 5 m deep and cover is effectively 2m thick due to losses into voids, cover volume is about 750 m3,
- berms are required at south pit access and around northern end of pit, berm is 3 m high with 1:1 sides and 1 m wide crest, length is 12 m at south pit and 300 m around north end,
- final reclamation will include contouring of mill, camp and old tailings areas, scarifying roads and removal of culverts, and establishment of grass vegetation,
- general reclamation assumed to require 1 D8 dozer, 3 dump trucks, and 2 excavators, contractor will have two pick-up trucks on site
- mobilization distance assumes 180 km Whitehorse to Carmacks and 60 km Carmacks to Mt. Nansen on a gravel road which is charged at twice the pavement mobilization rate,
- reclamation contractor will need to supply an office including communications, rehabilitation of the camp and kitchen is assumed to be required
- general reclamation work is assumed to take 10 men over a 3 month period
- post-closure water sampling and geotechnical inspection is assumed to be comprehensive for first 3 years followed by reduced scope for next 7 years,
- there will be costs associated with administration and design/problem resolution engineering during the general reclamation work, these are each assumed to cost 3% of the total cost

- a contingency of 20% is included to reflect the preliminary nature of this assessment and the potential for changes in scope.

Part 2 - Interim Care & Maintenance + Final Design

Common to all options

- assumption that upgrades and maintenance to the water treatment plant will be beneficial in improving performance, reducing reagent consumption and increasing process rate, allowance is $25,000,
- assumption that installation of process automation equipment will improve effluent quality and reduce demands on the operator to make continuous adjustments and permit some operation without the operator in attendance,
- assumption that automation of the seepage return system will reduce requirement for operator always on site, reduce to less than daily inspection with access from Carmacks, cost includes installation of second seepage return pump,
- further geochemical work may be required to confirm details of final reclamation plan, allowance is $25,000
- further geotechnical work may be required to confirm details of final reclamation plan, allowance is $25,000
- preparation of a final reclamation plan for regulatory approval will be required, allowance is $50,000,
- site operator reduced to 180 days per year at $300 per day average cost including tradesmen as required
- costs for operation of water treatment plant, generator and vehicle rental, communication, and water sampling as per DIAND costs from last 3 years,
- cost for fuel at ½ of cost for 2001 when new seepage return dam was constructed,
- allowance of $25,000 per year for misc. earthworks and clearing diversion channel and repairs to spillway,

- a contingency of 25% is included in the site maintenance costs in consideration of the age and condition of the equipment, annual climate variability, uncertainty as to the extent that the requirement for site personnel can be reduced,

Option 1A Long-term Water Management & Dam Stabilization

- a new water treatment plant is constructed on the left abutment of the dam, the plant is constructed to be fully automated for continuous operation without an operator in attendance, and to shut down and notify the operator in Carmacks in the event of a problem,
- site personnel is assumed to require 2 inspections per week for nine months of the year (monitoring and maintenance as needed of the seepage return system) and 3 inspections per week during active water treatment season of 3 months plus 12 mandays for start up and shut-down of the water treatment plant,
- operating and reagent costs for the water treatment plant are assumed to be approximately 80% of current costs
- fuel consumption is assumed to 50% of assumed interim period consumption because water is not pumped all the way up the hill for treatment,
- it is assumed that water treatment will be required for at least a 50 year period before the water could be released without treatment (this assumption ignores the potential for long-term water quality problems associated with acid generation in the upper-most tailings),
- dam stabilization is assumed to consist of: 1 m thick filter layer over the lower half of the dam and extending 10 beyond the dam over the abutments and a 4 m thick buttress layer of waste rock over the filter, the filter layer is sourced from the waste rock dump and consists of a screened 6 inch minus material, filter volume is 4930 m3, buttress volume is 19,720 m3,
- an additional 3 dump trucks to than includes in the general reclamation activities is assumed to be required, it is estimated that material could be placed at about 600 m3/day and the work would take a total of about 40 days
- additional camp accommodation costs are based on 13 men for 40 days for the dam stabilization work,

Option 2A Insitu Permafrost Stabilization

- supply and install thermosiphons as described in attached letter from Arctic Foundations, April 2002, higher cost option of installation through waste rock used in this estimate because of concerns for practicality of placing waste rock after thermosiphons have been installed, further information on thermosiphons can be obtained from the Arctic Foundations web site: http://www.arctic-fnd.ca/
- contour tailings and excavate notch in crest of dam (2.6 m deep approx. 30 m north of seepage return line) to create new channel for Dome Creek along the north edge of tailings flowing over waste rock cover, new invert slopes at 3% and is 5 m wide, side slopes of breach sloped at 3:1
- placement of 4 m thick rock cover on surface of tailings, rock cover to be 5 m thick over 20 m wide path along future alignment of Dome Creek, tailings area is approximately 6.25 ha, the volume of rock is 4m x 6.25 ha + 1 m x 20m x 350 m = 257,000 m3,
- placement of waste rock on downstream face of dam to create 7 terraces for installation of thermosiphons, terraces are 5 m wide with 1.5:1 slope, volume is 5.2 m3/m and the total length of the terraces is 800 m for a total volume of 4160 m3,
- placement of rock on downstream face of dam to extend spillway from end of breach down to Dome Creek channel, volume is 4 m depth x 8 m width by 50 long = 1600 m3,
- pooling of seepage water on the tailings would significantly delay the onset of freezing and would not be possible if the dam is partially breached to allow freezing in the final configuration, therefore construction of a temporary seepage holding pond would be required, the volume to be stored is about 3 lps times 9 months or about 70,000 m3, a lined side-hill impoundment somewhere between the tailings pond and the mill could provide the needed storage, based on rectangular side-hill dam with 7 m water depth and 8 m dam height with 3:1 U/S & D/S slopes the PVC liner area is 23,254 m3 and dam volume is 70,000 m3, assumes local silt is used for bedding,
- breach existing seepage return dam once seepage no longer needs to be returned for treatment,
- allow for collection and treatment of seepage for 3 years after installation of permafrost measures, collection and treatment at rate for interim care and maintenance, reagent and fuel

consumption should decrease to zero through this period so costs for these two parameters are reduced by 50% from interim care and maintenance assumed cost

Option 2B Insitu Stabilization – Dewatering & Consolidation

- supply and install wick drains, pre-feasibility level wick drain layout based on personal communication with J. Crammer, Nilex Corporation (1-800-537-4241), based on tailings being 100% finer than 200 sieve size (coarse silt) it is expected that wick drains on 4 m centres will achieve substantial consolidation in 2-3 years, Nilex supplies and installs wick drains, this typically costs $3.50/m including mobilization allowance for total length up to 50,000 m, (decreases to $3.25/m for up to 100,000 m and $3.00/m for more than 150,000m), further information on wick drains can be obtained from the Nilex Corporation web site at www.nilex.com,
- installation of wick drains in tailings and on downstream face of dam will require 156,162 m of wicks
- contour tailings and excavate notch in crest of dam (2.6 m deep approx. 30 m north of seepage return line) to create new channel for Dome Creek along the north edge of tailings flowing over waste rock cover, new invert slopes at 3% and is 5 m wide, side slopes of breach sloped at 3:1
- it is assumed that the upper most tailings are potentially acid generating and cannot be left in an unsaturated condition, allowance is made to remove 15% or the tailings or 42,6000 m3, if this material has an SG of 1.25 it would represent 34,080 tonnes, assuming an NNP of – 129 kg CaCO3/tonne (average of 2 samples from 1998) the ARD potential could be reduced by addition of 443 tonnes of lime, the amended tailings would be disposed in the pit,
- placement of 2 m thick rock cover on surface of tailings, tailings area is approximately 6.25 ha, the volume of rock is 1.5m x 6.25 ha = 93,750 m3,
- placement of waste rock on downstream face of dam to create 7 terraces for installation of thermosiphons, terraces are 5 m wide with 1.5:1 slope, volume is 5.2 m3/m and the total length of the terraces is 800 m for a total volume of 4160 m3,
- placement of rock on downstream face of dam to extend spillway from end of breach down to Dome Creek channel, volume is 4 m depth x 8 m width by 50 long = 1600 m3,

- pooling of seepage water on the tailings would significantly delay the onset of freezing and would not be possible if the dam is partially breached to allow freezing in the final configuration, therefore construction of a temporary seepage holding pond would be required, the volume to be stored is about 3 lps times 9 months or about 70,000 m3, a lined side-hill impoundment somewhere between the tailings pond and the mill could provide the needed storage, based on rectangular side-hill dam with 7 m water depth and 8 m dam height with 3:1 U/S & D/S slopes the PVC liner area is 23,254 m3 and dam volume is 70,000 m3, assumes local silt is used for bedding,
- breach existing seepage return dam once seepage no longer needs to be returned for treatment,
- allow for collection and treatment of seepage for 3 years after installation of permafrost measures, collection and treatment at rate for interim care and maintenance, reagent and fuel consumption should decrease to zero through this period so costs for these two parameters are reduced by 50% from interim care and maintenance assumed cost

Option 3A Relocate Tailings to Open Pit

- supply and install equipment to mobilize, transport, treat and discharge tailings as per letter of Apr. 2002 by SNC-Lavalin, amount adjusted upward by 5% to make contingency 25% for direct comparison with other options,
- details of hydraulic mining and transpiration as outlined in report section *???*,
- tailings relocation to pit is assumed to require 10 months over 2 years, (process is designed for 60 m3/hr x 20 hr/day x 150 day/yr x 90% availability x 2 years = 324,000 m3,)
- fuel for power estimated to be $130,000 per season
- a crew of 8 men (2 crews working 10 hr per day) is required,
- provision for crew change is included,
- upset conditions, buried debris, ice layers, or spills will require additional measures, provision for a dozer, excavator and dump is included,
- tailings pore water may contain pockets of contaminant rich water, provision is made for treating contaminant load in water treatment process at twice the current reagent consumption rate,

- allow for collection and treatment of seepage during tailings relocation project, cost is adapted from site maintenance cost for interim care and maintenance rate, reduced only for no further need to maintain diversion ditch and spillway,
- a dam will be required to contain the tailings, design assumes that water retaining dam will be required, dam is to consist of 12 high by 12 m wide structure with 2:1 U/S and D/S slopes, core zone of bentonite amended local silt 3 – 5 m wide, one silt filter zone and one sand filter zone & each are 1 m wide, shell material is local waste rock, foundation cleaning/grouting/slush grouting proceed fill placement,
- a spillway from the pit to be constructed on south pit rim, channel is 1.5 m deep, 2:1 side slopes and 2 m base width, length is 50 m,
- after removal of the tailings it will be necessary to reclaim the area, revegetate and re-establish a new channel for Dome Creek.

APPENDIX 3
Mt. Nansen Mine
Quote from Arctic Foundations of Canada Inc.

April 16, 2002

John Brodie
Brodie Consulting Ltd.
Fax: (604) 922-9520

John

Re: Mount Nansen Tailings Pond

Attached are drawings showing the proposed layout and thermoprobe section that we have based the following estimates on. In general the layout has thermoprobes on a 4.2m spacing in the row and and the distance between rows at 8.4m. Based on rough soils data, We estimate that freeze back between the thermosyphons on the row would occur in 1 year and that frezeback between the rows would take 2 – 5 years.

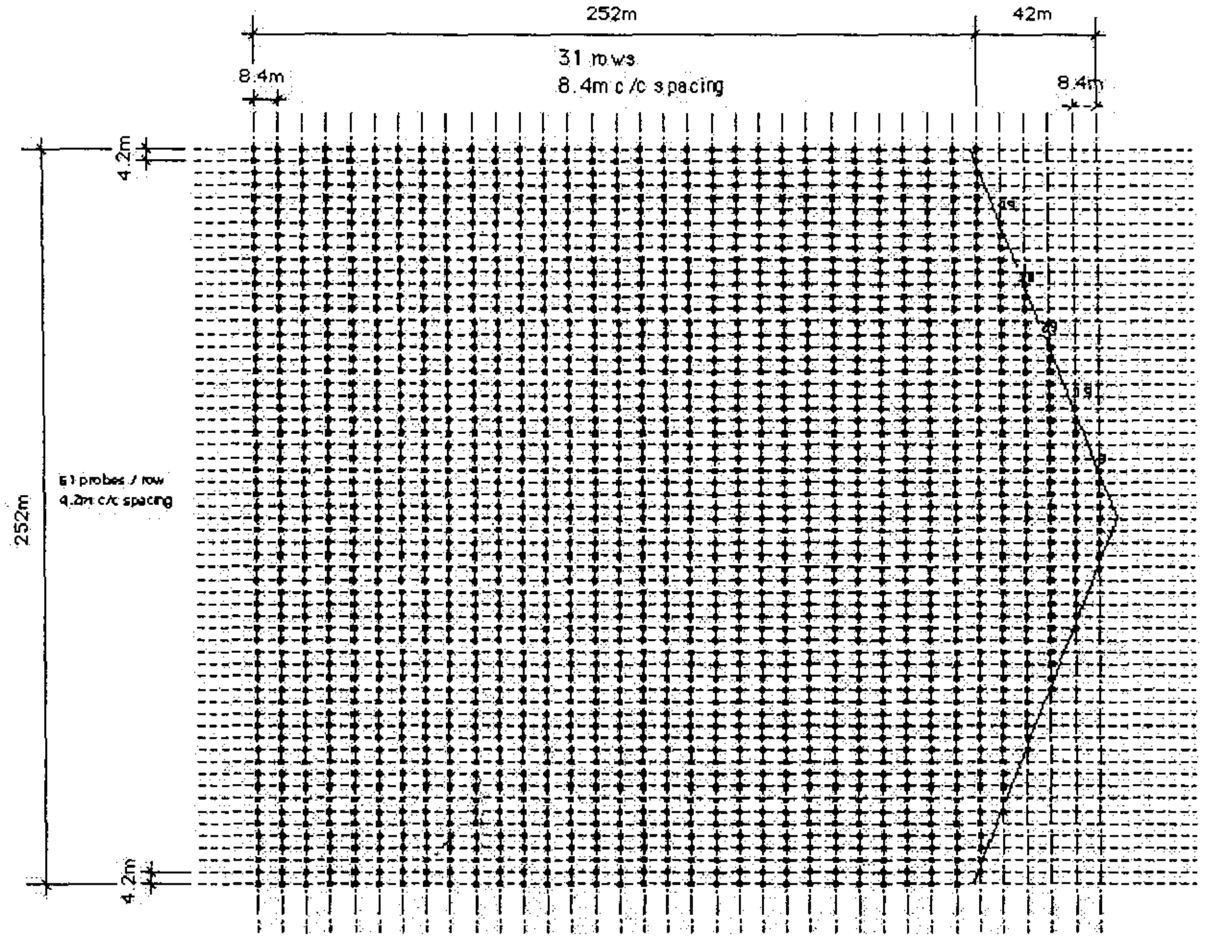
We have considered two installation scenarios.

1) Placing thermoprobes prior to installation of the 3m rock cover. This allows easier drilling but requires that we place a protective sleeve around the portion of the evaporator that goes through the rock fill. There will also be an increased cost of placing the rock. Placing the thermoprobes first may allow more of the winter season for freeze back. The estimated cost to supply and install the 2035 thermoprobes using this method is $11,000,000. This includes the drilling, mobilization, room and board, freight, and an allowance for thermistor cables.
2) Placing the rock cover and then installing the thermoprobes. This requires more time and consumables to drill through the loose rock fill. We will require that the rock surface be sufficiently level to allow equipment to operate on it. The estimated cost to supply and install the 2035 thermoprobes using this method is $13,000,000. This includes the drilling, mobilization, room and board, freight, and an allowance for thermistor cables.

Please give me a call when you have looked at this and we can discuss it further.

Yours truly,
Arctic Foundations of Canada Inc.

John D. Jardine
General Manager



31 Rows X 61 probes = 1891
Dam 49+38+29+19+9 = 144
Total = 2035

ARCTIC FOUNDATIONS
OF CANADA INC.
#15 Elle St. E. Elle, MB. R0H 0H0
Ph. 204-353-2510 Fax. 204-353-2610

CLIENT: Brodie Consulting Ltd.

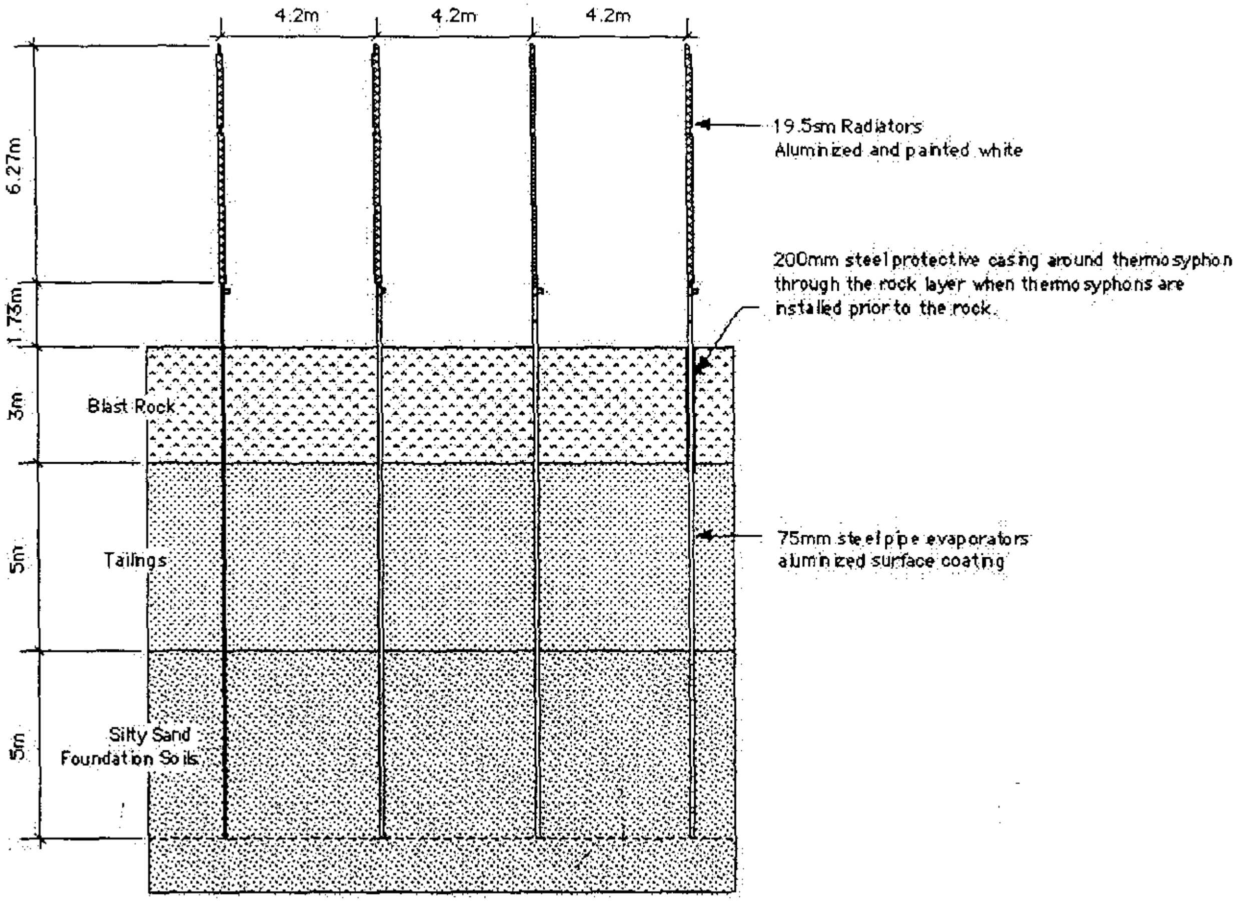
PROJECT: Mount Nansen Tailings

DRAWING TITLE: Preliminary Thermoprobe Layout

SCALE:

DATE: May 2002

DRAWING NO.:



ARCTIC FOUNDATIONS OF CANADA INC. #15 Elie St. E. Elie, MB R0H 0H0 Ph. 204-353-2510 Fax: 204-353-2610	PROJECT: Mount Nansen Tailings
	DRAWING TITLE: Section Along Thermosyphon Row
CLIENT: Brodie Consulting Ltd.	SCALE: 1:150 · DATE: May 2002 · DRAWING NO.: