APPENDIX III.1

NORTH PILE DEVELOPMENT PLAN

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1.0 INTRODUCTION

This document is a summary of the north pile development plan for the Snap Lake Diamond Project. A detailed plan will be prepared following detailed engineering, scheduled in 2002.

The north pile is the surface containment facility for processed kimberlite (PK) and potentially acid generating (PAG) waste rock. However, a landfill, a landfarm, and three granite quarries will also be located within the north pile.

A total of approximately 22.8 million tonnes (t) of PK will be produced over the mine life. The diamond recovery process will result in three size fractions of PK: coarse PK (fine gravel), PK grits (sand), and PK fines (silt). Approximately 50% of PK paste will be pumped underground for use as mine backfill. Cement will be added to the paste pumped underground to achieve the required strength. The PK that is not sent underground will be placed in the north pile.

The PK is geochemically stable and non-potentially acid generating (non-PAG). Combining the coarse PK and PK grit fractions will produce a construction material that will be used to construct the embankments required to contain the remaining PK materials. The bulk of the PK will be sent to the surface facility as a paste, a partially dewatered material that can be pumped. This negates the requirement for a water pond and reduces the risks in the system.

The mined waste rock that will be produced during the pre-production and production periods consists of metavolcanic rock (330,000 t) and granitic rock (1,410,000 t). The presence of sulphides in the metavolcanic rock, as well as a small portion of the granitic rock that is immediately adjacent to metavolcanic rock, results in the potential to acidify. All metavolcanic rock and all granitic rock with visible sulphides will be treated as PAG. Some of the PAG rock produced will be deposited in the base of the north pile. Pure granite that does not have structures containing visible sulphides can be classified as non-PAG and is suitable for construction and capping purposes.

2.0 NORTH PILE DEVELOPMENT PLAN PRINCIPLES

The following principles were used in the design of the north pile:

- minimize PK and waste rock footprints;
- minimize water content of PK to maximize stability;
- limit stockpiles to an elevation lower than the highest point of elevation in the area; and,
- take advantage of cold weather and permafrost conditions, but do not rely upon them for long-term stability.

3.0 SITE DESCRIPTION

3.1 Location and Topography

The topography of the Snap Lake Diamond Project site is gently rolling, with occasional knolls. The overall gradient in the northeast portion of the site is approximately 2%, with local variations up to 10%. The site is generally barren of vegetation, except for some isolated areas of low trees located in topographic depressions and along the shoreline. Dwarf shrubs are also found in isolated patches. Surface drainage in the area does not follow a defined pattern; there are no major watercourses, such as rivers or creeks, within the site area.

3.2 Geology

Bedrock outcrops are common on the project site with a veneer of Quaternary moraine deposits (till) that ranges in thickness. The footprint of the proposed north pile is underlain by the granodiorite/granite assemblage. The till contains cobbles and boulders mixed with a finer-grained matrix of sand and silt. Fields of boulders and frost-shattered rock debris are found in some topographic depressions on the site. Unconsolidated lacustrine (glacial lake) deposits are sporadically located around the lakeshore. Occasional deposits of organic material are also located on the site.

In general, intact bedrock underlies the boulders and the near-surface fractured bedrock layer, although other fractured bedrock zones have been observed at varying depths. Based on the borehole information obtained within the proposed footprint of the north pile, bedrock was encountered within a depth ranging between about 0 metres (m) and 6 m, and typically within about 2 m of existing ground surface.

Published information by the International Permafrost Association (1997) indicates that the project site is situated just within the zone of continuous permafrost. Temperature measurements within boreholes around the site suggest that permafrost is expected to be present to at least a 100-m depth over much of the northwest peninsula of Snap Lake.

The "thaw" or "active" layer beneath the project site has been observed to be up to 8-m thick. The depth of zero annual amplitude is projected to be between 15 m and 20 m, and the ground temperature at this depth is in the range of -1.3 degrees Celsius (°C) to about -2°C.

A talik exists beneath Snap Lake, with permafrost becoming thicker with distance from the lake; in addition, taliks may be present adjacent to other waterbodies within the mine footprint. Ice lenses occur within the pockets of fine-grained soils. Ice is not common within the moraine deposits or fractured bedrock.

3.3 Climate

Climatic data have been gathered on-site for the Snap Lake Diamond Project since March 1998. These data are summarized in the hydrology baseline (Section 9.3.1.3).

3.4 Seismic Considerations

Based on a seismic hazard assessment provided by Pacific Geoscience Centre for this site-specific location, the proposed development is considered to be located within seismic zone 0 of the current *National Building Code*, which is the negligible seismic risk category in Canada. The 475-year return period earthquake has a peak ground acceleration (PGA) of 0.013 gravity (g) and the 1,000-year return period earthquake has a PGA of 0.016 g.

4.0 DESIGN CRITERIA

4.1 Processed Kimberlite

The process plant will produce three streams of PK material: coarse PK, PK grits, and PK fines. Approximately one-half of the PK will be placed in the north pile. The size distribution of the PK streams and the total quantity of PK and water that will be directed to the north pile over the 22-year mine life are summarized in Table III.1-1. Some day-to-day variation in the proportion of the PK streams will occur.

Table III.1-1
Processed Kimberlite Size Distribution and Quantity

Processed Kimberlite Fraction	Particle Sizes (mm)	Proportion of Processed Kimberlite %	% Solids by Weight	Total Tonnage of Solids to North Pile (million t)	Total Quantity of Porewater to North Pile (million m^3)
coarse PK (sand and gravel)	1.5 to 6.0	36	90	4.4	0.49
PK grits (sand)	0.125 to <1.5	35	78	4.2	1.2
PK fines (silt and clay)	<0.125	29	55	3.5	2.9
Total (Full Mix)		**100**	**72.7**	**12.1**	**4.6**

Note: PK = processed kimberlite; m^3 = cubic metre; t = tonne.

The three streams will be combined and pumped to the north pile for general disposal. The coarse PK stream or combined coarse PK and PK grits can be combined and trucked to the north pile for use as shell construction material. At these times, the PK fines would be pumped as a high-density slurry to the north pile.

4.2 Waste Rock

The majority of the metavolcanic rock will be encountered during the initial phase of underground development. Pre-production development of the underground working will generate approximately 175,000 t of PAG rock. This includes 100,000 t of mined waste rock extracted during the advanced exploration program. Space has been allocated within the north pile for disposal of PAG rock. All PAG rock produced will be deposited in the base of the north pile or used in underground concrete/paste backfill.

During pre-production and operations, approximately 1,410,000 t of non-PAG granite waste rock will be produced. Essentially all of this rock will be used in high-strength concrete pillars underground. A small amount may be used for site general construction or deposited in the north pile. About the eighteenth year of operation, the requirement for high-strength concrete pillars will exceed the volume of waste rock produced from continuing underground development.

4.3 North Pile

The following design criteria were considered for the north pile:

- mine life of 22 years from 2005 to 2026;
- facility to accept 12.1 mega tonnes (Mt) of PK;
- minimum setback from the shoreline of Snap Lake of 50 m;
- the minimum factors-of-safety against instability of 1.3 for static condition and 1.0 for pseudo-static condition;
- peak horizontal ground acceleration of 0.013 g;
- Arctic environment (*e.g.*, cold and dry climate, day length extremes);
- facility able to accept the range of PK mixes that may be produced up to the design capacity of 3,000 tonnes per day (tpd) from the process plant;
- facility able to accept water for flushing the pipelines to the facility;
- surface runoff and collected seepage directed to collection ponds and pumped to the treatment plant; and,
- facility able to accept more than the estimated tonnage within the proposed footprint.

Geometric criteria that have been developed for the containment structures are as follows:

- maximum upstream (inside) and downstream (outside) side slopes for perimeter containment structures of 2 horizontal to 1 vertical (2H:1V) and 3H:1V, respectively;
- maximum upstream and downstream side slopes for interior containment structures of 1.5H:1V and 2H:1V, respectively; and,
- minimum crest or bench widths of 10 m.

4.4 Water Management

The water management system includes the following components:

- perimeter ditches and sumps to divert upstream runoff away from the north pile;
- internal temporary ponds to collect runoff from the north pile as it is being developed. These ponds will provide primary sediment control and storage for the runoff from the spring freshet;
- external ponds and sumps to collect water decanted from the internal ponds. These ponds also provide sediment control capability and additional storage capacity;

- perimeter ditches and sumps to intercept seepage and runoff from the outside slopes of the north pile;
- pumps and pipelines to carry water to the water treatment plant; and,
- water treatment plant to treat mine water, plant site runoff and water from the north pile to meet water quality standards prior to discharge to Snap Lake.

The ditches are sized to handle the flow resulting from a 1-in-100 year, 24-hour storm event. The water collection ponds, sumps, and pumps are sized to handle the maximum volume of the 100, year 24-hour storm event or the 1-in-100 wet year, snowmelt. The 1-in-100 wet year, snowmelt typically governs pond size and the 1-in-100 year, 24-hour storm governs pump size. Ditches on the north side of the north pile will have approximately 1 m of freeboard; ditches on the south side, which are only about 0.5-m deep, will have at least 0.2 m of freeboard.

4.5 Other Developments Within the North Pile

Quarry rock will be required for mine development and operation. A total of three quarry locations have been identified within the north pile footprint (shown in Figure III.5-2 in the Quarry Management Plan, Appendix III.5). Developing the quarries within the footprint of the north pile reduces the area disturbed by the project and provides additional storage capacity within the north pile footprint. These quarries will be used at various times during the mine life, depending on the area of PK deposition. More information on the quarries is provided in the Quarry Management Plan (Appendix III.5).

The north pile will also be used for waste management. The landfill for solid inert non-combustible waste and the landfarm for the bioremediation of contaminated soils resulting from spills (*e.g.,* oil spills) will both be located in the north pile. The landfill materials will be covered by PK paste. More information is available in the Waste Management Plan (Appendix III.3).

5.0 DEVELOPMENT PLAN

5.1 Development Sequence

The north pile will be sequentially developed using three containment cells (Figures III.1-1 to III.1-4). For start-up, the starter cell will be constructed in the southern portion of the footprint, some 300 m from the shore of Snap Lake (Figures III.1-5 and III.1-6). The starter cell will have the capacity to store two years production of PK. The starter cell containment berm will be constructed of mine development rock from underground operations and rock excavated during construction of the processing plant and camp. The preproduction metavolcanic rock will be used to build the north side of the starter cell berm. All the PAG rock will be put in this location. The bottom of the berm will be made wider than required (on the downstream side) to accommodate the rock. The volume of PAG rock in place will be about 90,000 cubic metres (m^3), which is slightly less than half the requirement for the starter cell. The PAG rock will have a cover of at least 4 m of PK over it.

A temporary pond will be constructed inside the cell, a ditch will collect seepage and runoff along the outside toe of the cell, and the construction quarry located in the east cell footprint will be used as a water collection pond. Water from the starter cell will either flow in the ditch to the water management pond (WMP) or be pumped to the treatment plant.

During the first year of operation, construction tests will be carried out within the starter cell to determine if the full mix PK can be used as a construction material for the shell of the north pile, and how this construction can most efficiently be carried out. Drainage, compaction, and possibly cement addition tests will be performed.

While deposition is occurring in the starter cell, the outer shell of the east cell and the perimeter seepage and runoff collection ditch will be constructed. Construction of the outer shell will be started with rockfill and then advanced using combined coarse PK and PK grits, trucked from the process plant, and compacted in place. This method of construction of the outer shell will continue until the viability of construction using the pumped full mix PK is confirmed by the construction tests in the starter cell.

The starter cell will be operated for about two years; then the east cell will be operated for an additional 10 years. The perimeter ditch for the west cell will be constructed in about year 10 of operation and the outer shell for the west cell will be constructed in year 11.

Figure III.1-1 Snap Lake Diamond Project North Pile Sequencing Plan – Year 1

Figure III.1-2 Snap Lake Diamond Project North Pile Sequencing Plan – Year 6

Figure III.1-3 Snap Lake Diamond Project North Pile Sequencing Plan – Year 17

Figure III.1-4 Snap Lake Diamond Project North Pile Sequencing Plan – Year 22

Figure III.1-5 Snap Lake Diamond Project North Pile Year 1 Deposition Plan June to November

Figure III.1-6 Snap Lake Diamond Project North Pile Year 1 Deposition Plan December to May

Large-scale testing has not been performed to determine the beach slope angles that will be achieved by the pumped full mix PK during the summer or winter periods. However, laboratory observations suggest that beach angles in the range of 6% to 10% may be achieved under thawed conditions. This beach angle is much steeper than the angle that develops with low-density PK slurry deposition. It will require that more discharge points and more pipe moves be made relative to a low-density slurry system. Repositioning of discharge pipes and spigots to achieve relatively flat surface slopes on the north pile crest will be required. The beach slope may be considerably steeper during winter deposition. For preliminary design, a beach slope of 15% has been assumed for the winter months.

It will be necessary to minimize the frequency of pipe movements to achieve efficient PK deposition. In particular, the PK distribution pipes will be very difficult to move during the winter months. A possible distribution sequence has been developed for year 1 of production to demonstrate that PK deposition throughout winter should be possible without continually moving distribution piping in freezing conditions. After PK is deposited in an area, several months are left for the PK to either drain and consolidate or freeze before more PK is deposited in this area.

A possible sequence of PK deposition within the starter cell during year 1 is presented on a monthly basis in Figures III.1-5 and III.1-6. These figures identify when berm construction will be carried out and when the distribution pipes will be moved onto the previously deposited PK. The north pile sequence plans, which include north pile drainage and PK distribution system details, are shown in Figures III.1-1 to III.1-4.

5.2 Shell Design

The shell design adopted for general construction will depend on the characteristics of the full mix. At present, the rate at which full mix materials will gain strength by draining and consolidating and, hence, become suitable for embankment construction has not been accurately determined. Field tests will be performed as part of the construction and operation of the starter cell to determine if construction of the north pile shell using pumped full mix PK is feasible and to optimize the design. If it is found that the pumped full mix PK is not a viable construction material for the north pile shell, construction of the north pile would continue with a shell constructed of combined coarse PK and PK grits using conventional earthmoving techniques.

The containment shells for the starter, east, and west cells will be founded on an initial embankment constructed from compacted quarry rockfill, PK materials, or approved general fills using conventional earthmoving equipment.

Foundation preparation for the initial embankment of the starter cell will consist of the removal and disposal of all ice, snow, organic material, and soft mineral soils from the embankment footprint. Competent mineral soils to remain in place will be proof-rolled prior to embankment placement. The embankment material will be trucked to the site, placed in lifts, and compacted. Depending on the nature of the embankment material, a transition layer may be required for placement against the upstream slope of the initial embankment to filter and retain the full mix PK.

Foundation preparation for the initial embankment along the outside of the north pile will entail removing soft soil or other unsuitable materials from the footprint of the shell. Faults or other permeable zones will be identified in the ditch excavation and treated as required to minimize seepage escaping from the north pile.

The embankments will be raised progressively. It is envisaged that the method of embankment raising will be refined during construction of the starter cell, when the performance and variability of the full mix PK material can be confirmed. Current planning is based on a shell constructed from the combined coarse PK and PK grits using conventional earthmoving techniques.

5.3 Erosion Protection

The PK materials are considered susceptible to wind and water erosion. During PK placement in the short term, it will be possible to minimize dust generation by watering to maintain the upper surface of the PK in a damp condition. When an area of the north pile is raised to final elevation, a layer of non-acid generating granite rock will be placed on the surface to prevent both wind and water erosion.

5.4 Pile Stability

The stability of the north pile will depend on the strengths of the shell construction materials and the PK, the porewater pressure (phreatic surface) within the north pile, and the load conditions (static or dynamic). Stability analyses were carried out for the expected values of strength and pore pressure as well as for a wide range of strength values and phreatic surface levels to determine the impact of variation of these parameters on the stability of the north pile.

The analyses demonstrated that the north pile will have acceptable stability. For a pile with a containment shell constructed of compacted coarse PK and PK grits and full mix PK pumped behind the shell, the calculated factor-of-safety is greater than 1.6 for static conditions, and greater than 1.5 for pseudo-static conditions, based on the expected strengths from laboratory testing. Raising the phreatic surface within the north pile causes a small reduction in the factor-of-safety.

The foundation conditions for the north pile are good. Weak soils will be removed from the foundation of the containment berm to expose either the fractured bedrock surface or competent mineral soils. The factor-of-safety for slip surfaces extending into the foundation was calculated to be greater than 3.0.

Movement of the face of the north pile will occur as the PK consolidates, as water frozen during the winter thaws and drains, and as ice within the north pile creeps under the applied shear stress. These movements will cause some local flattening of the north pile face, and may cause surface runoff to concentrate and erode the north pile face. These areas will be repaired as the north pile is developed.

The stability analyses were carried out using thawed strength parameters for the PK. As such, should global warming cause the north pile and foundation to completely thaw, the north pile would be stable. Due to the probable irregular nature of the ice within the north pile, melting of the ice would cause irregular settlement of the surface and could disrupt the surface drainage patterns.

5.5 Pile Freezing and Seepage

Both seepage and thermal analyses were carried out for the north pile. The analyses were not coupled. The thermal analyses indicate that frozen and unfrozen layers will occur in the north pile during development. About two years after an area is completed, the north pile will be completely frozen, except for the annual development of an active layer.

Seepage analyses were carried out for thawed conditions within the north pile. They show that the north pile would drain and a phreatic surface would not develop more than 1-m to 2-m above the foundation even under unrealistically high levels of infiltration. Seepage from frozen sections of the north pile will be significantly reduced to non-existent.

The seepage analyses were carried out using thawed parameters for the PK and foundation. They demonstrate that, should global warming cause the north pile and foundation to thaw, most of the annual precipitation would run off, a phreatic surface would not develop high in the north pile and most of the north pile would be unsaturated.

6.0 NORTH PILE WATER MANAGEMENT

The water management plan for the Snap Lake Diamond Project is simple. Water will be collected from the disturbed areas (north pile, process plant, and camp site), treated along with the mine water, and discharged. The inventory of water on the site at any time will be minimized. A 10,000 m^3 per day water treatment plant will be constructed for start-up. The plant size will be increased periodically to match the increasing mine water flow that is predicted as the underground workings are developed.

Surface water from the north pile has been grouped into two categories: contact and non-contact water. Contact water is defined as any water that may have been physically or geochemically impacted and includes the following:

- bleed or transport water from PK materials;
- water generated from consolidation of PK materials;
- flush water from PK distribution pipelines;
- drainage water from potentially acid generating metavolcanic materials;
- water from dust control on the north pile;
- surface runoff from the north pile; and,
- seepage from the north pile.

All contact water will be directed to water collection ponds or sumps prior to being pumped to the water treatment plant. On an annual basis, the quantity of contact water from the surface areas will be about 5% of the mine water flow.

Non-contact water is limited to precipitation on catchments outside the north pile footprint or associated mine site facilities that does not come into contact with developed areas. Non-contact water will be directed away from the north pile using natural or man-made drainage courses and allowed to flow into Snap Lake without treatment.

6.1 Water Ponds

Sedimentation ponds, water collection ponds, and sumps will be developed in existing water basins impacted by the north pile development, rock quarry excavations, and within the containment shell (Figure III.1-3). Contact water from these ponds will be pumped to the water treatment plant. During the spring melt, the water treatment plant may not be able to treat the daily flow, and the excess water will be temporarily stored in the WMP. The dams creating the WMP will be raised in about year 2 of the operation.

The ponds will be active at various periods during the development of the north pile. Internal temporary sedimentation ponds (TP1, TP2, and TP3) will be filled with PK materials during the development of the north pile (Figures III.1-1 to III.1-4).

The approximate volumes of the ponds are shown in Table III.1-2.

Table III.1-2
North Pile Ponds

Pond	Description	Approximate Volume (m^3)
water management pond	pond created by dams 1 and 2	130,000
temporary pond #1	internal pond for starter cell	25,000
temporary pond #2	quarry for plant site development	200,000
temporary pond #3	internal pond for west cell	35,000
collection pond #1	natural pond	63,000
collection pond #2	natural pond	40,000
collection pond #3	natural pond	8,000

Note: The natural ponds were investigated and found to contain no fish. More information on small waterbodies may be found in Section 9.5.1.5 of the EA.

6.2 Ditches

The ditches around the perimeter of the north pile are required to collect the following:

- surface runoff from the external faces of the north pile and the immediate area beyond the toe of the north pile;
- seepage emerging from the northern toe of the north pile; and,
- near-surface seepage from below the north pile.

The ditches required to carry the surface runoff and seepage flows are small. Sizes of these ditches will be governed by the construction issues. Minimum ditch base widths of 0.6 m to 1.0 m will suffice.

6.2.1 Northern Seepage and Runoff Collection Ditches

The ditches along the north side of the north pile are designed to intercept near-surface seepage and collect surface runoff. These ditches will extend through the soil profile into the underlying fractured or intact bedrock. Detail survey of the alignment and investigation of the subsurface conditions along the alignment have not been carried out. A trapezoidal ditch with a nominal depth of 2-m below ground surface, a base width of 1 m, sideslopes at 2H:1V, and a minimum gradient of 0.3% is proposed. To achieve the design grade, some rock excavation will be required along sections of the ditch. A liner will be required on the lake side of the ditch. A geosynthetic clay liner would be suitable and easily installed in cold conditions. Approximately 1,100 m of ditching will be required.

6.2.2 Southern Runoff Collection Ditches

Runoff collection ditches are required on the west and south sides of the north pile. The total length requiring containment is about 1,700 m. The minimum ditch size is based on construction issues. A trapezoidal ditch with a base width of 0.6 m, 2H:1V sideslopes, and a nominal depth of 0.5-m below ground surface is proposed. In areas of exposed rock, a 0.5-m high berm would suffice. No ditch lining is required.

7.0 NORTH PILE CLOSURE

Closure of the north pile will consist of contouring the surface to mimic the surrounding landforms and the placement of a capping layer of minus 250 millimetres (mm) quarried, non-PAG granite. The PK distribution system, sump pumps, and associated pipes will be removed from the perimeter of the north pile. The capping layer will minimize the potential for erosion of the north pile by either precipitation or wind. The capping layer will be placed progressively over the north pile as the design elevations are achieved. The final surface will be graded to produce localized mounds consistent with the surrounding topography.

After completion of the cover, a stable surface will develop and the suspended solids content of runoff is expected to decline substantially. The runoff will continue to be directed towards existing small lakes where sedimentation of the remaining suspended solids will occur. The outlets of the lakes will be restored to pre-construction conditions after acceptable water quality is confirmed, such that water can discharge to Snap Lake along existing drainage paths. The concept for closure of the north pile is shown on Figure III.1-7.

Figure III.1-7 Snap Lake Diamond Project North Pile Sequencing Plan - Closure

8.0 REFERENCES

International Permafrost Association. 1997. Circum-Arctic Map of Permafrost and Ground Ice Conditions. U.S. Geological Survey, Map CP-45, 1:10,000,000 scale.

9.0 UNITS AND ACRONYMS

UNITS

g	gravity
m	metre
m^3	cubic metre
mm	millimetre
Mt	mega tonne
^{o}C	degrees Celcius
t	tonne
tpd	tonne per day

Acronyms

H	horizontal
non-PAG	non-potentially acid generating
PAG	potentially acid generating
PGA	peak ground acceleration
PK	processed kimberlite
V	vertical
WMP	water management pond