2. PROJECT ALTERNATIVES AND OPPORTUNITIES

2.1 INTRODUCTION

2.1.1 Terms of Reference

This section meets the Terms of Reference pertaining to alternatives

The Project Alternatives and Opportunities section of the environmental assessment (EA) for the De Beers Canada Mining Inc. (De Beers) Snap Lake Diamond Project has been prepared to meet the Terms of Reference established by the Mackenzie Valley Environmental Impact Review Board (MVEIRB). The section specifically addresses the Terms of Reference shown in Table 2.1-1 with the exception of the mine development schedule and mine production rates. Although the schedule has evolved over time, there was no time when alternative schedules were compared and one was rejected in favour of the schedule shown in the Project Description (Section 3.2). The mine production rate of 3,000 tonnes per day (t/d) has not changed and no alternatives were considered.

Table 2.1-1 Terms of Reference for Project Alternatives and Opportunities

TOR Section	Environmental Assessment or Topic
2.5.1	**Alternatives to Carrying out the Development** Include a description of the main development/production/technical alternatives, in particular, those associated with the following: I. mining methods; II. waste rock and tailings management; III. mine water management; IV. energy production (*i.e.*, diesel generation); V. decommissioning and reclamation; VI. mine production rates; VII. employee work schedules; VIII. mine development scheduling; and IX. Employee/worker living conditions *e.g.* living quarters, leisure facilities, food, visitors, access to outdoors, etc. Where alternatives that would mitigate impacts on the environment and, or, enhance the socio-economic performance of the proposed mine are deemed not economically feasible, the economic analysis to determine feasibility should also be summarized and made available to the public. The Review Board may request that De Beers provide, in confidence, all supporting documentation in support of its conclusions... De Beers shall discuss alternative water treatment options considered, that can from an engineering standpoint, be used at the Snap Lake project for any mine water, waste rock seepage, or process water that will be discharged into Snap Lake.

Table 2.1-1 Terms of Reference for Project Alternatives and Opportunities (continued)

TOR Section	Environmental Assessment or Topic
2.5.5	**Environmental Optimization** The EAR should report the comparative present day Canadian dollar costs of proposed development alternatives and the corresponding environmental benefits. Any assumptions or uncertainty surrounding implementation of mitigation measures, such as untested technology, will be reported. The reporting of development impacts should provide readers with an easy to understand summary of present-day Canadian value costs of alternatives and their corresponding future environmental benefits.

Source: Terms of Reference and Work Plan for the Environmental Assessment of the De Beers Canada Mining Inc. Snap Lake Diamond Project, September 20, 2001 Issued by: Mackenzie Valley Environmental Impact Review Board (MVEIRB).

2.1.2 Component Description and Organization

Alternatives were accepted or rejected based on practicality, availability, environmental effects, cost, and community concerns

As the Snap Lake Diamond Project developed from the conceptual to the present stage, many design alternatives and opportunities were considered. This section provides the rationale by which alternatives and opportunities were evaluated and accepted or rejected. The following factors were considered by De Beers in the decision to accept or reject alternatives:

- practicality (*e.g.*, Will the alternative work in the north? Can it be transported and built at a remote mine site? If waste is produced, can the volume and type of waste be managed?);
- availability (*e.g.*, Is the alternative commercially available and is it available in the north?);
- environmental effects (*e.g.*, Are there identifiable benefits or negative impacts to the environment?);
- cost (*e.g.*, Are capital and/or operating costs acceptable?); and,
- community interest or recommendations.

The impact has been reduced by changes made during project development

Some of the most substantial reductions in environmental impacts are a result of the decisions made early in the project, such as the decision to limit the area occupied by the project footprint, and the choice of mining and waste rock management methods. De Beers has also looked for opportunities to apply emerging technologies, reduce power consumption, and review transportation alternatives. Summaries of the opportunities and tradeoff studies relevant to the EA are provided in Appendix II.1. These opportunities will continue to be evaluated as more detailed design information becomes available. Alternatives that were accepted are described in more detail in the Project Description (Section 3).

Mitigation required to address specific impacts described elsewhere

In some cases, additional mitigation is necessary to prevent or reduce environmental impacts. Specific mitigation to reduce an impact identified in the impact assessments is included in those sections (*i.e.*, Sections 5 to 13). All of these mitigation measures are also summarized in the Corporate Commitments (Section 14).

2.2 SITE AND FOOTPRINT

De Beers decided to keep the project footprint as small as possible

The decision to limit the size of the mine footprint was made at an early stage in the development of the Snap Lake Diamond Project. This decision was made entirely for environmental reasons, specifically to keep the area of disturbance to a minimum and, therefore, keep the potential effects of disturbance to terrestrial and aquatic resources to a minimum.

Open pit mining in Snap Lake was considered and rejected

The kimberlite dyke extends under Snap Lake. Mining this part of the resource by open pits, with associated dykes and drainage located in the lake, was considered but rejected at the initial concept stage because of the potential impact to the aquatic environment. Concerns related to open pit mining were expressed during community consultations.

Expansion on the north shore of Snap Lake was rejected

Development activities were concentrated on the northwest peninsula. Disturbance on the north shore of Snap Lake will be limited to mine ventilation requirements, although other options were considered and rejected, including laydown areas on the north shore and all-weather roads to vent raises. Helicopters will be used to provide access to the vent raises for maintenance.

The footprint on the northwest peninsula remained unchanged wi th one minor expansion

The configuration of the facility on the northwest peninsula changed over time, but the location of the site and the size of the footprint remained relatively constant. A minor expansion to the west of the mine site to meet safety separation requirements for the manufacture and storage of explosives was the only increase in the footprint since the submission of the scoping document in February (De Beers 2001).

2.3 MINING METHODS

Three open pit/underground mining alternatives were considered

The economic and environmental costs and benefits of open pit and underground mining were evaluated. All alternatives included underground mining, but varied in the extent of open pit mining. Three mining alternatives were assessed:

- large open pit mine extending across most of the peninsula allowing maximum extraction of the resources located on the northwest peninsula;
- small open pit mine, allowing less than one third of the resource extraction of the first option; and,
- no open pit mine with all of the reserve mined from underground.

Mining method alternatives were considered

In addition to the decisions related to open pit versus underground mining, a number of alternative mining methods were considered for the underground mine.

2.3.1 Large Open Pit

The first option was a large open pit, which was considered for cash flow reasons

The first alternative, a large open pit mine, was considered because it would have improved the cash flow of the project in the first years of operation. Diamonds would have been produced prior to the substantial commitment of money needed for underground development.

The open pit would have covered most of the northwest peninsula

The open pit mine would not have allowed total resource extraction, but it would have facilitated mining of approximately 700,000 tonnes (t) of ore. The remainder would have been extracted by an underground mine. The open pit would have been situated entirely on the northwest peninsula and it would have extended across as much of the peninsula as possible. This alternative would have been environmentally more desirable than constructing dykes in Snap Lake, since impacts to the lake would have been reduced.

Approximately 11 million tonnes of waste rock would have been produced

However, a large quantity of overburden waste rock (*i.e.*, rock that overlies the ore) would have to be removed. Approximately 11 million t of potentially acid generating metavolcanic rock would have been excavated and would have required surface storage in this alternative. Drill cores had shown that only some of the metavolcanic rock had sulphides (and, therefore, would have been potentially acid generating), but it would have been difficult to separate the acid generating rock from the non-acid generating rock. Thus, all of the metavolcanic waste rock would have to be considered potentially acid generating. Containment of the entire quantity would have been required to prevent acidic run-off.

Dust and noise would occur

The large open pit would also have been a source of other environmental impacts related to the surface mining activities, such as dust and noise.

The first alternative was rejected for environmental reasons

The first alternative was rejected due to the size of the waste rock pile at closure, environmental impacts (*e.g.*, acidified run-off and seepage) of the potentially acid generating waste rock, environmental impacts related to the surface activities, and the overall (*i.e.*, longer term) economics of the project. However, the primary reason for rejection was the large quantity of waste rock and associated concerns with acidified run-off and seepage.

2.3.2 Smaller Open Pit

The second option was a smaller open pit , which would have produced less waste rock

A second option, a much smaller open pit mine, was then considered (Figure 2.3-1). Approximately 180,000 t of ore would have been extracted, largely from the portion of the dyke which sub-crops on the northwest peninsula (*i.e.*, the ore with the least depth of overlying rock). The remaining ore would have been mined by underground methods. The environmental impacts associated with the first alternative (large quantity of waste rock, dust, and noise) would still have occurred, but would have been reduced.

The second option was more favourable economically

The smaller open pit mine was economically attractive. Of the three alternatives considered, the smaller open pit was the lowest cost alternative for mining the upper part of the kimberlite deposit. In addition, the option would have allowed the processing and sale of diamonds to begin before development of the underground mine had been completed, improving the initial cash flow.

Approximately 3.5 million t of waste rock would have been produced

Approximately 3.5 million t of potentially acid generating metavolcanic rock, about a third of the waste rock produced in the first alternative, would have been produced in this alternative. Some of this rock would have been temporarily stored on surface and then placed back in the open pit, filling the pit and creating a mound of waste rock above the pit. Although underground disposal would have reduced the quantity of waste rock left on the surface, there would have been two waste rock piles left on the surface at closure: the north and south piles.

The second alternate was also rejected for environmental reasons

Although this alternative provided an economic advantage, it was rejected for environmental reasons. Although the quantity of waste rock would have been reduced, De Beers deemed the remaining quantity of potentially acid generating waste rock to be environmentally unacceptable.

Figure 2.3-1 Alternatives Considered for Mining and Processed Kimberlite Storage on the Northwest Peninsula

2.3.3 No Open Pit

The alternative that was accepted has no open pit and all ore is mined under-ground

The alternative that was accepted, and is described in more detail in Section 3.3, has no open pit. Therefore, dust, noise, and waste rock impacts have been reduced. Approximately half of the waste rock will be returned for disposal underground, thereby reducing long-term impacts on the northwest peninsula. The alternative that was selected did not have the lowest initial cost.

2.3.4 Underground Mining

Many alternative were not flexible enough

Various underground mining methods were considered, including inclined room and pillar, drift and fill, longwall, and longhole. Inclined room and pillar and longhole methods were rejected primarily because of potential difficulties in responding to variable dyke geometry, which would result in poor control of mining dilution and recovery. Longwall was rejected primarily because of the difficulty in using mobile equipment and the need to use labour-intensive jackleg drilling and slasher mucking. Drift and fill was considered as an alternative method to be used if conditions (mainly dyke geometry) precluded the use of the room and pillar method.

The mining method is the room and pillar method

The underground method proposed to mine the ore reserve is a modified room and pillar method with end slicing. This method has the combination of flexibility, geotechnical stability, and cost-effective production rate needed. It is flexible enough to deal with all the dyke complexities that have been observed during the advanced exploration program.

2.4 WASTE ROCK AND PROCESSED KIMBERLITE MANAGEMENT

Waste rock pile locations changed with changing alternatives

The proposed waste rock pile locations have been moved within the project footprint with the different mining alternatives, due largely to changes in the quantity of waste generated.

North and south piles of waste rock were initially proposed

In both of the rejected options, there would have been two waste rock piles: the north and south piles. In these alternatives, the south pile would have been filled with waste rock, capped with processed kimberlite, and then covered with clean rock. The north pile would have been formed by a starter berm of rock, with paste tailings placed behind the berm and, at closure, it would have been capped in the same manner as the south pile. A slurry tailings area was never considered.

The water management pond is now proposed for the location first proposed for the south pile

Two alternative locations of the south pile were considered for the smaller open pit. In the first alternative, the south pile would have been located south of the processed kimberlite containment (PKC) area (now the water management pond) (Figure 2.3-1). Thus, the south pile would have covered the area currently used for collection of site water. With the elimination of the south pile, the existing water retention pond between Dams #1 and #2 can be used and expanded as required. This water management pond now plays a major role in the control of site water in the revised plans.

The second alternative location was also rejected

In the second alternative, an area south of the airstrip, including the location of the 1998-1999 exploration camp, was considered for waste rock storage during full-scale mining (Figure 2.4-1). This alternative was ruled out due to the large area covered by the pile and the extensive containment required.

Approximately half of the waste rock and processed kimberlite will go underground

In the alternative that has been chosen, waste rock and processed kimberlite would be returned for disposal underground, thereby reducing long-term impacts on the northwest peninsula. The intention has always been to place as much waste rock as possible underground with estimates varying slightly around 50%. All alternatives included the north pile. In the alternative that was accepted, the north pile was the only surface location for waste rock storage.

2.5 WATER MANAGEMENT

The north pile sedimentation pond has been deleted

Water management plans have changed with the mining plans. Water generated in the open pit was going to report to either one of the two sedimentation ponds. The south pond was eliminated with the elimination of the south pile. The north pond has since been reduced in size to a collection pond and sump. The decision to build a water treatment plant meant that sediment could be removed more effectively by the plant, rather than in a larger sedimentation pond.

A discharge to the north arm of Snap Lake was considered and then rejected

The earlier plan proposed a discharge to the north arm of Snap Lake that was rejected because water quality modelling showed that water from the north arm did not mix with the much larger volume of water in the main body of Snap Lake. Over time, the concentrations of some water constituents in the north arm could have increased. Also, there was a potential for the discharge to impact the water supply for the project, which is drawn from the north arm. Now, all treated water discharge will be to the main body of Snap Lake.

Figure 2.4-1 Alternative Considered for Processed Kimberlite Storage South of the Northwest Peninsula

The location of the south pile sedimentation pond is now the water management pond

The south pile sedimentation pond was going to be a small pond located at the south end of the processed kimberlite containment (PKC) area. With the removal of the south pile, the PKC area is now available for use as a water management pond. Water from a number of sources (see Section 3.6.2 for further details) will now report to this pond for temporary storage during unusual high runoff or upset conditions. Normally, all water will be directed to the water treatment plant for treatment and discharge to Snap Lake.

Sedimentation in the water management pond was the only treatment proposed initially

When the scoping document (De Beers 2001) was prepared, studies and monitoring to assess the potential effect of water releases on water quality in Snap Lake were ongoing. Since groundwater will dominate the volume of water released to Snap Lake, investigations of the characteristics of the groundwater inflow to the mine were continuing. At that time, the results of two preliminary water samples indicated that a residence time in the water management pond would result in acceptable quality of water, allowing the water from the sedimentation pond to be discharged to Snap Lake without further treatment. In the spring of 2001 during their traditional knowledge work at the minesite, the Lutsel K'e elders expressed concern that the water management pond would not be sufficient to hold the volumes of water needed and to settle sediments and recommended that a treatment plant be installed (Lutsel K'e Dene First Nation 2001). Based on both traditional knowledge and further scientific analysis (*e.g.*, water quality data, modelling, and pilot plant studies) indicating that further treatment was needed to achieve an acceptable water quality, the Project Description (Section 3.6.6) now includes a commitment to build a water treatment plant.

The water treatment plant will use proven treatment technology

The water treatment system currently planned for full-scale operation will use conventional treatment technology, which will consist of a thickener and final effluent filter. This treatment will remove suspended solids, and metals associated with the suspended solids, to low levels. The selection of this type of treatment system was based on achieving the best practical discharge limits that would in turn comply with specific ambient water quality objectives set for Snap Lake as discussed in Section 9.4.2.1. During the early years of operation, when minewater flows are relatively small, solids removal from the minewater will be carried out by filtration.

A thickener and filter combination was selected

Although many proven treatment alternatives were evaluated, the use of the thickener and filter system was selected as the best practical alternative to achieve the objectives based on the laboratory and pilot plant studies. Currently, the water treatment plant will be constructed in stages with an initial capacity of 10,000 m^3/day to be expanded to approximately 20,000 m^3/day. Options such as a settling pond only, which would be less costly than the proposed scheme, were eliminated due to their inability to meet the discharge requirements.

Ion exchange and reverse osmosis alternatives were rejected

Secondary treatment alternatives, such as ion exchange or reverse osmosis, aimed at providing further metal reduction, and ammonia and chloride removal were rejected for practical reasons. These alternatives would have resulted in substantial reject streams (up to 10% of the inflow) that would prove environmentally and economically difficult to manage. The high minewater flow expected and the poor water quality of the reject streams would result in a large impoundment containing wastewater that could not be discharged. These alternatives were also rejected due to the cost. For example, a reverse osmosis plant or ion exchange plant would cost between $60 million and $80 million to construct and approximately $10 million per year to operate. This is not economically feasible for the Snap Lake Diamond Project.

Initially, treated sewage was to be discharged to a wetland

The plan for the disposal of treated sewage has been changed. Initially, the effluent was to be piped for disposal to the adjacent wetland as an added effluent treatment measure. However, there was concern regarding the effect of sewage on the wetland vegetation. This concern was specifically expressed during the traditional knowledge work with the Lutsel K'e Dene elders in the spring of 2001 (Lutsel K'e Dene First Nation 2001). The Yellowknives Dene also expressed this concern during their traditional knowledge study of EKATI™ (Weledeh Yellowknives Dene 1997). They recommended that mining companies' wastewater be well filtered and monitored. Thus, the treated sewage will be combined with the discharge from the water treatment plant and discharged directly to Snap Lake.

Settling ponds will be drained and, if necessary, covered

During decommissioning, the ponds will be treated and drained. If necessary, a clean rock cover will be placed over the ponds to prevent any dust from blowing once the pond contents are dry.

2.6 EMPLOYEE WORK SCHEDULE

De Beers did not initially impose an employee work schedule

Factors related to employment were not developed by selecting and then revising a series of alternatives. Rather, De Beers listened to the opinions of potential workers.

The proposed schedule is two weeks in and two weeks out during operations

Through a combination of public consultation and a review of the employee work schedules that were selected or working successfully at other mines, De Beers selected a work schedule of two weeks in and two weeks out.

This combination appears to allow sufficient time for a combination of traditional and wage economy activities. During the construction period, workers will spend three weeks at the site and one week out. De Beers will continue community consultation and review alternative rotation schedules.

2.7 EMPLOYEE LIVING CONDITIONS

Design of the accommodation and recreational facilities requires a balanced approach

Several alternatives are under consideration for the architectural and recreational design of the permanent accommodations complex. De Beers recognizes that these aspects are important in attracting and retaining skilled personnel, but it is also necessary to balance camp quality with project economics.

Alternatives for the facility exterior are being considered based on community surveys, experience in northern climates, and economic requirements

Community surveys conducted by De Beers in early 2001 provided a number of desirable features with respect to architecture and recreation, many of which are under consideration. In addition, concerns about the layout of the camp exterior and its potential for creating wildlife/human interaction were also recorded. These inputs are being combined with extensive experience in designing mining camps in northern climates to evaluate many alternatives for the final camp design. The final design may not include all of the alternatives considered, as the cost of the camp must also satisfy economic requirements.

The exterior design will address noise, views, and wildlife-human interactions

The following alternatives for the exterior design are being considered:

- locating the complex on the site to minimize visual and noise impact from mining and processing operations, while maximizing views of natural scenery;
- minimizing building height (*e.g.*, two to three stories) to reduce visual impact;
- arranging bedroom dorm wings to avoid creation of "dead ends", where wildlife could potentially become cornered in the presence of humans or other wildlife; and,
- providing outdoor deck lounges overlooking the lake for use in summer to provide an opportunity for enjoyment of the natural environment.

Alternatives for the interior design are also being considered

The following alternatives to the interior design are being considered:

- designing bedrooms to ensure maximum quality of life, including considerations of alternative furnishings, room arrangements, and windows;
- considering both private and shared bathrooms (*i.e.*, one bathroom between two adjacent bedrooms);
- maximizing glass area for natural light and openness, but balancing this with heating and air conditioning costs; and,
- providing a balance of recreation and leisure facilities for activities such as exercise, games, reading, crafts, music, and other entertainment.

Food alternatives are being considered

Decisions have not been made on these and other alternatives. For example, De Beers will provide a variety of food including country food (when it can be obtained from approved sources). Alternatives related to food are still under consideration.

Facilities will be linked by corridors

Elders from the Yellowknives Dene are concerned that the planned distances between camps and mining operations should not be too great. They say that if the sites are not close together, workers will face potentially fatal challenges walking between the sites during blizzards (Weledeh Yellowknives Dene 1997). From the outset, De Beers has designed the Snap Lake Diamond Project to limit the footprint of the mine. This includes linking the camp complex, recreation facilities, service complex, and process plant with heated and insulated corridors.

Family visit alternatives are under consideration

During consultation, De Beers was often told of the importance of family to people's well being. This was discussed in the "Traditional Knowledge on Community Health, Community Based Monitoring" (Lutsel K'e Dene First Nation 1999). From the Elder's stories described in this report, the family was identified as the central unit of social organization. Alternatives related to family visits are also still under consideration.

The site will not become a town

The Yellowknives Dene prefer that no public tours of mines and no construction of permanent towns surrounding mine sites be allowed (Weledeh Yellowknives Dene 1997). De Beers will be allowing guided tours for Elders, community consultation, and other visitors. At no time has De Beers considered supporting a town for its workforce at Snap Lake (such as Nanisivik in Nunavut). Snap Lake will be a fly-in-fly-out operation.

2.8 ENERGY SOURCES

2.8.1 Diesel

Diesel power generation is the most reliable option when power from a central grid is not available

Diesel power generation is typically the first, and many times the only, power option considered for remote mining operations where transmission lines from a central grid are not available. The possibility of upgrading the Snare Lake power generation facility and adding transmission lines to a number of mines has been discussed at a preliminary level. Diesel power is a proven technology that is reliable and suitable for a remote mining operation. The direct capital cost of the diesel generating facility for the Snap Lake Diamond Project was estimated at $25 million.

But diesel fuel could cost up to $15 million annually

The operating cost associated with diesel fuel consumption for power generation at the Snap Lake Diamond Project, estimated to be up to $15 million annually, will be substantial. The cost of diesel fuel, which was estimated to be 87% of the operating and maintenance cost of the facility, justified studies to assess alternative means of supplemental power generation.

Burning diesel fuel for power also increases air emissions

In addition, burning 25 million litres of diesel fuel annually causes emissions of carbon monoxide, carbon dioxide, sulphur dioxide, nitrogen oxide, and other compounds that may affect air quality. Therefore, alternative means of producing power to lower both operating costs and emissions were explored. Potential reduction of operating costs was not necessary to justify the implementation of other power sources. De Beers considered alternative technologies to reduce emissions with or without reductions in operating costs.

Wind turbines, solar energy, and hydrogen fuel cells were considered as alternative sources of power

Based on the geographical location, landscape characteristics, climate conditions, and amount of power required, the following sources of alternative power generation were considered worthy of exploration:

- wind turbines;
- solar energy; and,
- hydrogen fuel cells.

Prior experience, suitability, cost, and environmental impact were evaluated

Technologies available, experiences of other similar applications, suitability of local meteorological conditions, environmental effects, and economics of each alternative power source were considered in the evaluation of these alternative power generation opportunities.

2.8.2 Wind Turbines

Wind power was considered as a secondary power source

Since the plant and critical equipment require steady, non-fluctuating, and reliable power, diesel would have to be the primary power source. However, a reduction of diesel consumption could reduce air emissions and operating costs. For example, when power demand is at a maximum, a 10% reduction in diesel consumption would reduce operating costs by over $1 million annually. This is a compelling reason to consider wind turbines. If implemented, wind power would most likely be used for low-voltage power generation for lighting, heat tracing, *etc*.

Wind turbines operate in arctic climates

Wind turbines have been installed in Arctic climates in Alaska and Antarctica, including diesel-wind hybrid power generation. Many current turbine installations in cold climates have been developed and continue to operate as partially publicly funded, test facilities. For example, economic gain has not been demonstrated at Kotzebue, Alaska even though average annual wind speeds (and, therefore, turbine efficiencies) are 40% higher than those at Snap Lake.

Average annual wind speeds above 16 km/h are needed to operate turbines efficiently

Average annual wind speed is more important than instantaneous data in assessing the viability of wind power (National Research Council 2000). National Research Council (NRC) indicates that average annual wind speeds of 22 to 29 km/h are moderate to excellent wind regimes, while speeds of 15 km/h or less are not satisfactory. The American Wind Energy Association suggests that typical turbines are designed to operate at wind speeds between 16 and 80 km/h. For the three installations examined in the opportunity study (a North Wind 100 turbine near the South Pole, 11 Zond Z-40 wind turbines at Searsburg, Vermont, and the Kotzebue installation), the long-term average annual wind speeds ranged from 20 to 30 km/h.

The average wind speed measured at Snap Lake (13.6 km/h) is marginal for wind turbine use

Wind data from various locations in the Northwest Territories (NWT) over several decades indicate a range of wind speeds from 12 to 21 km/h (Table 2.8-1). Although the wind monitoring station at Snap Lake has only been operating since 1998, the average wind speed from February 1998 to January 2001 of about 13.6 km/h was within this range. Other sources of wind data for the region (*e.g.*, Environment Canada wind map, NASA satellite weather data) supported the range shown in Table 2.8-1.

Table 2.8-1 Summary of Average Annual Wind Speeds at Northwest Territories Locations

Location	Latitude	Longitude	Elevation (m)	Average Annual Wind Speed (km/h)
Yellowknife	62° 28N	114° 27W	205	15
Norman Wells	65° 17N	126° 48W	67	12
Baker Lake	64° 18N	96° 05W	18	21
Fort Reliance	62° 43N	109° 10W	164	12

Source: Canadian Meteorological Centre.

Wind turbines do not appear to be a viable power source due to the high cost and low average annual wind speed

Although there are limitations in the wind data (measurements are limited to 10 m above ground and on-site measurements are limited to two years), the available data indicate that the low annual average wind speed at Snap Lake does not appear to support wind turbines as a satisfactory power source. It was estimated that a 1.0-megawatt (MW) wind turbine plant would cost over $3 million to design, install, and commission. It would result in a net savings of only $67,000 per year based on available wind data and known diesel power generation costs. It was therefore determined that wind power was not economically viable from both power source (*i.e.*, wind) and cost perspectives.

Wind monitoring will continue

De Beers will continue to collect and analyze wind data from the monitoring station at the site to build a longer-term database that would be available for future re-evaluation of the use of wind turbines. A literature review of the potential for bird mortality would also be included in a future re-evaluation.

2.8.3 Solar Energy

Solar energy was evaluated as a secondary source of low voltage power and space heating

Energy radiating from the sun can be converted into electrical energy by photovoltaic cells. This radiant energy can also be used directly to produce heat. It is not feasible to implement solar energy as the primary source of power or air heating due to the lack of sufficient solar radiation to provide a non-fluctuating, continuously available, power source. Therefore, two alternative uses of solar energy were explored as a secondary source of power:

- generation of low-voltage electricity via photovoltaic cells to supplement the low voltage power distribution system or power equipment directly; and,
- pre-heating of air for space heating using solar wall panels.

Due to the low solar energy available, photovoltaic cells are not an economically viable option

Using historical solar energy data and an average of 12% efficiency (from a range of 7 to 17% efficiency for current technology reported by the U.S. Department of Energy, Photovoltaics Program), the average daily electrical energy that could be produced at the Snap Lake Diamond Project ranged from 0.01 to 0.70 kilowatt hour per square metre per day (kWh/m^2/day). It is unlikely that photovoltaic cells would be effective for power generation at the Snap Lake Diamond Project based on the low solar energy available annually for this technology. It was estimated that a photovoltaic cell bank of 1,000 square metres (m^2) in area, which would cost well over $1 million to manufacture and install, would save only $16,000 per year in diesel fuel consumption. This small reduction in fuel consumption would also be reflected in a small reduction in air emissions. It was therefore determined that solar power was not economically viable. In the sunniest month of the year, a cell bank of this size would generate less than 30 kilowatts (kW) of power; 30 kW provides sufficient energy for only 60 high pressure sodium (HPS) 500 watt (W) light fixtures or 20 electric baseboard heaters.

Solar air heating offers opportunities that will be considered further at the detailed design stage

Solar heating of building intake air appears to offer some potential, but will require further investigation when detailed building information is available. Solar heating using Solarwall™ or similar technology that uses metal cladding placed on the south facing walls of buildings was evaluated. Solarwall™ has been installed in the NWT and other areas of similar climate. Although the solar energy available in January may be insufficient to produce any appreciable temperature rise, the solar energy available in May, for example, may be sufficient to increase the temperature of intake air passing through a metal panel by about 8°C to 10°C. This reduces the diesel power generation required to heat the air to proper temperature. Buildings using these panels would also need conventional insulated cladding (in addition to the solar panels), as well as fans and controls. The increased capital costs will have to be compared to operating cost savings and environmental benefits to determine the feasibility. This evaluation can be made when detailed engineering design information is available.

2.8.4 Fuel Cell

Fuel cell power generation is almost emission free, but the technology is not available

In a fuel cell, hydrogen fuel (which can be obtained from natural gas, methanol, or petroleum) and oxygen from the air electrochemically combine to produce electricity. Heat and pure water vapour are the only by-products from the fuel cell's electrochemical reaction. Fuel cell power generation is typically viewed as an "emissions free" technology, hence the attractiveness of its application at Snap Lake. Fuel cells would not be considered for primary power generation due to the prohibitive costs and the present status of this technology. Commercially available, cost-effective, fuel cells for use as power plants have yet to be developed. Fuel cell technology is not yet at the point where it can be considered a proven power generation source at remote locations.

Fuel cells are not available for the type of use needed

It was estimated that a 250 kW hydrogen fuel cell power plant would save approximately $180,000 per year in diesel consumption. However, such power plants are still in the experimental stage and cost well over $1 million each. In addition, there is additional cost associated with supply and storage of natural gas on site to provide the necessary hydrogen fuel. Since these fuel cell power plants are currently designed for grid-based power systems, as opposed to independent power systems such as that needed for the Snap Lake Diamond Project, the cost of a suitable fuel cell power plant is unavailable. The opportunity study concluded that fuel cells are not an option, based on availability and the present status of technology development. However, this technology is advancing rapidly and the status of fuel cell technology will be reviewed regularly.

2.8.5 Propane

Earlier studies assumed that propane would be used for mine air heating

Previous studies of the Snap Lake Diamond Project assumed the exclusive use of propane-fired heaters for heating the underground mine ventilation air in the winter, based on the high efficiency and perceived low cost of propane-fired heaters when compared with oil-fired heaters. The pre-feasibility study assumed that a propane-fired heater would be installed at each fan location, together consuming an estimated 8.2 million litres of propane annually. A trade-off study examined propane-fired versus diesel-fired mine air heating.

Propane has lower air emissions (except NO_2) than diesel

Propane was the preferred fuel environmentally due to its lower emissions. The cleaner combustion and the higher combustion efficiency of the mine air heaters using propane would result in lower emissions for all major emission components except for nitrogen dioxide (NO_2).

All aspects of the two fuels were evaluated including cost, emissions, safety, and supply; however, reliability of supply became a critical factor

When the capital costs for the mine air heating, including fuel storage, handling, distribution, and heating system were estimated, the capital cost of propane was approximately twice that of diesel. However, the operating cost was higher for diesel. Both fuels were similar when net present value and relative fuel price stability were compared. Diesel was the preferred fuel for operations (safety, training, etc.); its use also resulted in a smaller footprint, less visual impact and greater reliability of supply. There are suppliers delivering diesel to the other mines in the NWT, but propane deliveries of this size have yet to be proven under winter road conditions. Propane storage infrastructure of this size does not currently exist in the

NWT and none of the suppliers have the trucking and transhipment facility capacity to reliably refuel the site during an annual winter road window. De Beers was not confident that all the propane required annually could be delivered when the winter road was open.

The study concluded that diesel was the preferred fuel

Overall, the trade-off study concluded that diesel is the preferred fuel for mine air heating when all criteria are considered. Although propane use results in lower operating cost and air emissions (except NO_2), diesel is the superior fuel when personnel and overall site safety, capital cost, visual impact, footprint, and logistics are considered. The reliability of supply and safety on the winter road and at the mine site were the determining factors.

2.9 POWER REDUCTION

Various methods of power reduction and energy conservation will be implemented

In addition to evaluating alternatives, De Beers has looked for opportunities, particularly opportunities to reduce power use and, therefore, diesel consumption, air emissions, and costs. The Snap Lake Diamond Project will implement various methods of power reduction and energy conservation. The methods will be selected at the detailed design stage, but the following options will be implemented:

- An automated power plant management system will be used to monitor and manage the power generation plant so that generators are running at optimum efficiency and minimal diesel consumption based on power demand. The system will also monitor and indicate upcoming maintenance requirements to ensure continued optimum performance.
- Waste heat from generators, incinerators, building exhausts and, if practical, mine water and mine exhausts will be extracted via heat exchangers to the greatest practical extent. Waste heat will be used for process and building heating, thereby minimizing diesel consumption.
- High efficiency electric motors will be used to reduce motor losses, which translate to lower power plant load demand and thus lower diesel fuel consumption. Variable frequency drives (VFDs) will be used on large electric motors that are subject to varying demand such as large pumps, crushers, and fans. The VFDs will ensure that the motors are consuming only the power necessary to drive the equipment.
- High efficiency lighting will be used for maximum efficiency. This includes HPS or metal halide lights for exterior and interior plant lighting, T-8 fluorescent lamps for office lighting, light emitting diode (LED) exit lights, and compact fluorescent (instead of incandescent) lights. Lighting controls will also be used to reduce power consumption.

- Automated building heating systems will include programmable temperature controls to lower temperatures in areas at times of no occupancy. Solar air heating of fresh intake air may be implemented where practical to lower diesel consumption by reducing the energy required to heat intake air when ambient temperatures are low.

Further reductions will be evaluated at the design stage

Energy conservation will not be limited to the opportunities presented above. As the detailed engineering progresses, further power reduction opportunities will be identified and considered for incorporation in the detailed design.

2.10 TRANSPORTATION

Transportation alternatives were considered for primary cargo

Transportation alternatives for the principal bulk cargoes (*i.e.*, cement and diesel fuel) were evaluated. Mine consumables, equipment, and supplies were not considered since they will represent only a small proportion of the total mine tonnage during operations.

The Tibbitt to Contwoyto winter road has been used by other mines for truck transport

Winter road truck transport has been the principal means of transporting almost all equipment, fuel, and supplies to remote exploration and mine sites in the NWT since the 1960s. A joint venture (BHP Billiton, Echo Bay Mines Ltd., and Diavik Diamond Mines Inc.) establishes and operates the Tibbitt-Contwoyto winter road with a transport season that has historically varied from about 50 to 80 days.

Many alternatives were considered but they would have to be cost competitive with the winter road

An alternative mode of transport would need to be a cost competitive and reliable replacement for some or all of the truck transport on the winter road. A wide range of opportunities including a barge and road combination, heavy-lift airships, specialty all-terrain transport vehicles, and hovercraft were included in the review. Options such as rail, pipeline, and aerial tramway were eliminated from further consideration due to high cost or technical impracticality.

A combined barge plus overland transport was considered

From early May through mid-October, fuel and supplies are currently transported between communities on Great Slave Lake by Northern Transport Company Ltd. A combined barge/overland route along Great Slave Lake (approximately 360 km) to Thompson Landing (abandoned) and then by road to Snap Lake (approximately 80 km) was considered for supply during May through October. A road suitable for non-winter use would result in disturbance of vegetation throughout its length and greater disturbance to wildlife (*e.g.*, habitat fragmentation) compared to the winter road.

However, no alternative to the winter road was found

No alternative to the use of the winter road was found that would have the proven reliability and cost effectiveness. The capability of the winter road to meet increased truck traffic has been assessed and will be presented in Resource Uses (Section 6.6) of the EA.

2.11 DECOMMISSIONING AND RECLAMATION

2.11.1 Underground Mine

Only one alternative was considered for underground mine closure

During the operating life of the project, mined out areas of the underground mine will be sequentially backfilled with a combination of high strength concrete and cemented paste backfill. On cessation of mining activities, all mined out areas of the underground will have been backfilled. Because moving approximately half of the processed kimberlite and most of the waste rock underground substantially reduces the environmental impacts due to surface disturbance, no other alternatives were given serious consideration. Upon final closure of the underground mine, all openings will be sealed to prevent inadvertent access to the mine. Caps for all mine openings including the portal and the ventilation raises will be designed to current standards and regulations.

2.11.2 Mill and Ancillary Facilities

Two alternatives for mill demolition were considered: removal from site and underground disposal

Two alternatives were considered for decommissioning of the mill and related ancillary facilities including the mine shops, administration offices, and camp facility. The following options were evaluated:

- demolition of all buildings and equipment, and removal from site; or,
- demolition of all buildings and equipment, and disposal in the underground workings or in the site landfill.

The preferred alternative will be selected at closure

All buildings and equipment will be demolished or dismantled on cessation of mining activities. Salvage values for all material will be determined upon closure of the mine. A decision will be made at that time as to whether the materials and equipment should be removed from site or disposed of on site.

2.11.3 Roadways and Airstrip

Two alternatives were considered

Two alternatives were considered for reclamation of roadways and the airstrip, as follows:

- "leave as is"; or,
- regrade and contour.

The "leave as is" alternative was rejected

The "leave as is" concept was eliminated as not feasible due to the inclusion of structures such as culverts in these facilities that could degrade and ultimately lead to failures. These structures could have an adverse impact on the surrounding environment as well as posing hazards to wildlife.

The closure concept adopted will reduce impacts

A closure concept of removing all culverts, regrading, and contouring the roads and airstrip to re-establish natural drainage patterns was chosen. In addition, the surface of these facilities will be scarified or loosened to promote re-vegetation. This alternative was chosen for environmental reasons even though the cost of the "leave as is" alternative would be less.

2.11.4 Quarries

Two alternative quarry locations were considered

A number of quarries will be developed over the life of the project. Two alternatives were proposed for siting the quarries:

- within the boundary of the proposed north pile area; or,
- outside of all proposed development.

An alternative that met multiple needs is preferred

The operating mine will have requirements for borrow materials for mine backfill, concrete, or road construction, as well as a requirement for surface disposal of processed kimberlite. Any alternative which could meet both requirements would present a substantial advantage over an alternative which would only meet one requirement.

Excavation of rock from a quarry within the footprint is the preferred alternative

It is anticipated that rock within the foundation of the footprint for the proposed north pile area will be adequate for most of the above noted requirements. Excavation of rock from a quarry within this area will result in extra storage capacity for processed kimberlite within this area. As well, placement of processed kimberlite within a mined-out quarry is a suitable method of decommissioning the quarry.

On-site quarries within the north pile was the chosen alternative

In their traditional knowledge work for EKATI™, the Yellowknives Dene recommend that mining companies use material from sources other than eskers (Weledeh Yellowknives Dene 1997). As well, development of quarries external to the north pile area will result in substantial cost and effort to decommission the facilities. Therefore, excavation from eskers, all of which are outside the project footprint, was reduced in favour of developing quarries within the footprint of the proposed north pile area.

The esker will be recontoured and plant growth promoted

To meet specific requirements for sand, one quarry was developed in the esker located to the south of the Snap Lake Diamond Project site. This quarry will be re-graded and contoured to match the natural topography to minimize any surface erosion. Re-vegetation of this esker quarry will also be promoted to reclaim the habitat. The alternative of using more than one esker quarry was rejected.

2.11.5 North Pile

Alternatives were considered for closure of the north pile

A number of alternatives were evaluated for decommissioning of the north pile:

- underground disposal of processed kimberlite; and,
- variation of pile footprint.

The shape of the north pile was chosen to conform more closely to the landscape

Although approximately 47% of the processed kimberlite is to be placed back underground in the mined-out workings as paste backfill, the remainder of the processed kimberlite must be disposed of on the surface. Two primary alternatives were considered for the north pile. The first alternative was a relatively high pile, which had a smaller area but greater visual impact. The second alternative included a larger footprint, which would result in a much lower pile. The first option was eliminated in order to minimize any visual impacts of the pile profile on the landscape.

The north pile will be capped to prevent erosion

Lutsel K'e elders have visited other mine sites and are concerned about the wind blowing away the processed kimberlite (Lutsel K'e Dene First Nation 2001). Processed kimberlite and waste rock will be stored in the north pile, which will be capped with non-acid generating granitic rock for erosion protection. Further information can be obtained in Section 3.5.2 of the Project Description.

2.12 REFERENCES

De Beers (De Beers Canada Mining Inc.). 2001. Snap Lake Project Scoping Document in support of De Beers Canada Mining Inc. Class A Land Use and Class A Water Licence Applications. Submitted to the Mackenzie Valley Land and Water Board. February 2001.

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MVEIRB (Mackenzie Valley Environmental Impact Review Board). 2001. Terms of Reference and Work Plan for the Environmental Assessment of the De Beers Canada Mining Inc. Snap Lake Diamond Project.

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2.13 UNITS, ACRONYMS, AND GLOSSARY

UNITS

km	kilometre
km/h	kilometre per hour
kW	kilowatt
kWh/m^2/day	kilowatt hour per square metre per day
m	metre
m^2	square metre
m^3/d	cubic metre per day
MW	megawatt

NO_2	nitrogen dioxide
^oC	degree Celsius
t	tonne
t/d	tonne per day
W	watt

ACRONYMS

De Beers	De Beers Canada Mining Inc.
EA	environmental assessment
EAR	environmental assessment report
HPS	high pressure sodium
LED	light emitting diode
MVEIRB	Mackenzie Valley Environmental Impact Review Board
N	north
NASA	national aeronautics and space administration
NRC	National Research Council
NWT	Northwest Territories
PKC	processed kimberlite containment
VFD	variable frequency drive
W	west

GLOSSARY

backfill	to refill (as an excavation) usually with excavated material
dyke	a tabular igneous intrusion that cuts across the planar structures of the surrounding rock

ion exchange	treatment alternative which removes metals, ammonia and chlorides beyond conventional technology; a reversible interchange of one kind of ion present on an insoluble solid with another of like charge present in a solution surrounding the solid with the reaction being used especially for softening or demineralizing water, the purification of chemicals, or the separation of substances
jackleg drilling	a mining method using a hand-held rock drill that has a compressed air leg the extends behind the drill
kimberlite	an agglomerate biotite-peridotite that occurs in pipes especially in southern Africa and that often contains diamonds
metal cladding	metal coating bonded to a metal core
metavolcanic	consists mainly of well-foliated high-grade amphibolites
non-acid generating (non-PAG)	pure granitic rock that does not have structures containing visible sulphides
opportunity study	a feasibility study in which several options are investigated to determine the most effective strategy
paste tailing	residue separated in the preparation of various products (as ores) of a paste-like consistency
photovoltaic cell	utilizes the generation of a voltage when radiant energy falls on the boundary between dissimilar substances (as two different semiconductors)
portal	portal is the main entrance to the underground mine for personnel and equipment
potentially acid generating (PAG)	metavolcanic rock and granitic rock with visible sulphides
principal bulk cargo	the main transported cargo (i.e., cement, diesel fuel)
project footprint	geographic area over which the direct environmental effects of the project extend
residence time	the amount of time required for a waterbody to be completely replenished with new water by incoming streams and other natural input sources assuming the waterbody is empty of water
reverse osmosis	treatment alternative which removes metals, ammonia and chlorides beyond conventional technology; freshwater is moved through a semipermeable membrane when pressure is applied to a solution on one side of it

slasher mucking	a mining method in which a bucket is scraped over the mine floor by a winch attached to the rock face
slurry	watery mixture of insoluble matter (as mud, lime)
starter berm	contains the north pile; constructed of rock that is non-PAG from a quarry within the north pile footprint and from non-PAG waste development rock
trade-off study	an economic study in which several options are investigated to determine the most effective strategy
variable frequency drive (VFD)	used on large electric motors that are subject to varying demand such as large pumps, crushers, and fans; the VRDs will ensure that the motors are consuming only the power necessary to drive the equipment
ventilation raise	vertical hole from the mine to the surface allowing ventilation