2. Project Description

Since the 1991 exploration discovery of the initial kimberlite pipes at Point Lake in the Lac de Gras area, the NWT Diamonds Project has been advanced in many areas. Concurrent with exploration and bulk sampling, the Proponent has

- investigated appropriate mining methods and mining equipment
- determined construction and infrastructure requirements
- assessed mineral processing techniques
- developed suitable human resource and occupational, health and safety programs and policies
- established an economically feasible development plan
- pursued regulatory and permitting approval.

The arctic biophysical setting has been a major consideration in project planning and engineering. The transport of equipment and supplies over a short duration winter road and the need for many construction activities to be conducted during the summer months are important factors that are unique to any development planned for this region.

To assure project reliability, the project design and development will be based on state-of-the-art technology that has been proven in arctic conditions. Leading edge technology that is unproven will not be utilized.

Site visits were made to various North American arctic and subarctic open pit mining operations. These open pit mines have been successfully utilizing heavy-duty mining equipment, specially equipped for arctic service, similar to that planned for use at this project. In addition, all of the mines that were visited operate successful tailings disposal systems similar to that proposed for the NWT Diamonds Project. An example is the tailings system at Cominco’s Polaris Mine on Little Cornwallis Island, NWT. Many of the mines visited also operate reliable on-site diesel power plants.

The information presented in the following subsections will provide details of the proposed overall mine development plan for this project.

2.1 Discovery and Exploration Phases

Diamonds are formed deep in the earth’s crust, in the region known as the upper mantle. Kimberlite (and lamproite) is a rare volcanic rock type that originates at similar depths and is able to carry diamonds to the surface during eruptions. Diamond-bearing kimberlites are confined to continental regions that have an old, relatively cool "keel" that is thick enough to extend to the depths of diamond formation. These continental regions are known as "cratons", with diamond-iferous kimberlite pipes often found in the oldest (Archean age) part. The NWT Diamonds Project is located on the Archean Slave craton.

Although isolated diamond finds were made throughout Canada and the United States as early as the mid-1800s, there has only been one diamond mine in North America, at Prairie Creek, Arkansas. The discovery of diamond-bearing kimberlite pipes is difficult because kimberlite is generally a soft, easily erodible rock. In the NWT the preferential erosion of soft crater and diatreme facies kimberlites has left depressions, which have filled with water to become small lakes (Plate 1.4-1). As the presence of lakes and glacial overburden obscures the existence of kimberlite, geological targeting requires the use of both geophysical and geochemical techniques.

Geochemical techniques involve tracking indicator minerals that are known to be formed and/or found with diamonds. Typical indicator minerals are garnets, chromites and chrome diopsides, which are more abundant than diamonds. Prospectors are able to follow trails of these minerals (Plate 2.1-1) in eskers, which are glacial deposits left by water running under the ice sheets, back to their source in kimberlites.

Geologist Charles E. Fipke spent nearly ten years prospecting in the Archean Slave province using this indicator mineral approach. This work evolved from the 1980s discovery of garnets and chromites in the Mackenzie Valley. Fipke followed indicator minerals more than 600 km to the east to the Lac de Gras area, which he believed the source of the mineralization.

The discovery led to a staking rush that has now covered nearly the entire Slave Geological Province. The NWT Diamonds Project consists of five pipes that are economically viable on its claim block of 344,000 ha. Thirty-nine of the 44 kimberlites identified to date on the claim block have been announced as diamond bearing.

In mid-1993, the Proponent announced its intention to bulk sample two of the most promising kimberlite pipes: Koala and Fox. A bulk sampling program submitted (BHP 1993a) to the Regional Environmental Review Committee (RERC), an advisory body to federal government departments, was approved.

This lead to the construction in late 1993 of a small heavy medium separation (HMS) plant, a 200-person camp and supporting infrastructure. Due to the lack of access to the site, an airstrip was constructed for transportation of goods and personnel. The facility is now widely known as Koala Camp.

Plate 2.1-1: *Prospector following a trail of indicator minerals*

The intent of the bulk sampling program was to obtain a large enough volume of ore to determine the economic feasibility of a pipe. Since the grade (i.e., carats per dry metric tonne) can vary considerably from pipe to pipe, or within a pipe, a large bulk sample is a critical component of diamond exploration. Bulk sampling can be undertaken using large diameter drills or underground declines.

The disadvantages of sampling with vertically orientated drill holes are the large number of holes required and the restriction of drilling to the winter months. Since the pipes are all overlain by lakes, drilling must be done only when the ice has reached a safe working thickness, thus leaving a very limited time (January to April) for operations. An advantage of this sampling method is the ability to obtain both vertical and horizontal spatial grade data.

Large samples can also be obtained from underground mining, which can be undertaken year-round. The limitation of this method is that the grade information collected has spatial limitations for modelling purposes. Ideally, a combination of the two methods is utilized to ascertain both the grade and stone quality characteristics of a given pipe. Approximately 7,000 tonnes of kimberlite were sampled from a decline into the Fox pipe from October 1993 to August 1994, and approximately 1,200 tonnes of kimberlite were sampled during the winter of 1994 by rotary drilling of the Koala pipe. Exploration proceeded concurrent with the bulk sample program and succeeded in targeting two more promising pipes, Panda and Misery.

The proximity of the Panda pipe to the Koala pipe required only minor additional road construction for access. Approval was received in April 1994 to sample Panda from underground, and construction of a 460 m long decline through the granite host rocks began. The kimberlite contact was reached at about 90 m below the lake surface. Sampling was concluded by December 1994 after approximately 3,000 tonnes of kimberlite were removed. Underground decline bulk sampling applications are outlined in Addendum Reports (BHP 1994b, 1994c, 1995).

Additional reverse circulation drilling was done on all five development pipes, as well as other exploration targets, during the winter of 1995 to better define reserve characteristics. The results, not yet fully analyzed, are not expected to materially change the project plan and schedule described in the next section.

2.2 Project Plan and Schedule

The schedule outlined in the following sections highlights the interaction of the approval process with development activities as can be reasonably foreseen at this time. These activities have been subdivided into exploration, mine development and mine reclamation. The timing of each, as it relates to the five deposits to be mined, is illustrated in a sequential manner.

2.2.1 Approval and Permitting

Diamond production from the NWT Diamonds Project is planned to begin by the end of 1997. As shown in the master schedule (Figure 2.2-1), project approval in principle, based on EARP recommendations, is anticipated in the second quarter of 1996, along with a corresponding Class A Water Licence and appropriate land leases. Timely approval and permit issuance are integral to meeting projected scheduling dates.

The effect of the arctic climate is a major consideration in project planning. As reflected in the schedule, the summer months provide the only cost-effective and reasonable period for major concrete construction, building erection and lake dewatering. Similarly, the winter period is the only reasonable time to transport equipment, fuel and materials and construct frozen core dams.

Approval, permitting and climate are interwoven factors that can have drastic effects on the project plan and schedule; if there is a delay in obtaining approval or a requisite permit, construction cannot begin during the summer of 1996. Thus a one- or two- month delay can effectively delay the project by up to one year.

2.2.2 Preproduction/Construction Phase

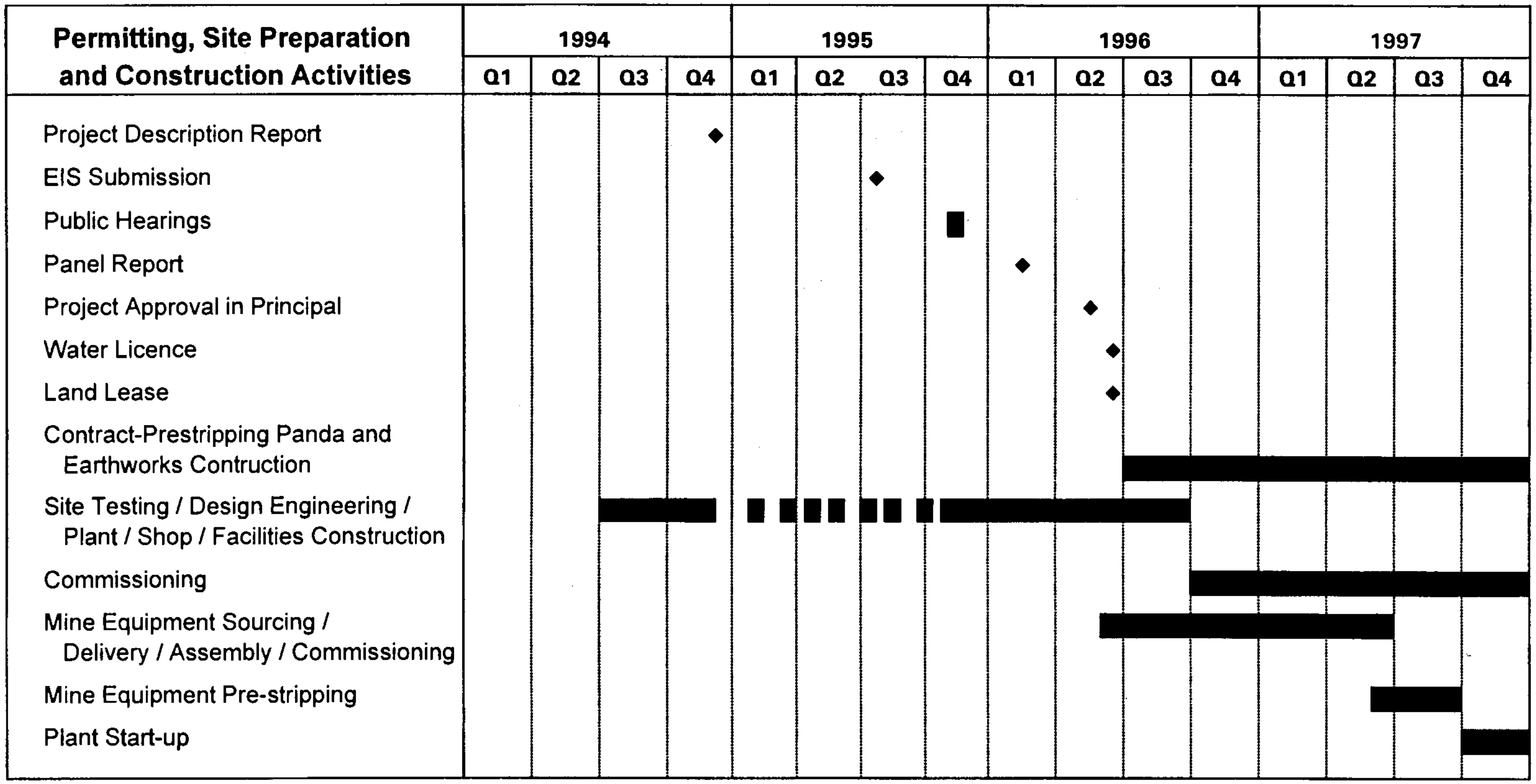
In 1996, a temporary construction camp, offices, temporary power and utilities, and construction equipment and material will be mobilized over the winter road. These temporary facilities will be established in designated locations in accordance with existing permit authorizations. A temporary aggregate crushing plant and concrete batch plant will be constructed at the prepared site, and fuel will be delivered to the capacity of the existing site fuel storage facilities. One additional large fuel tank will be constructed and filled during this winter road season. Personnel involved in the construction of these temporary facilities will be housed in the exploration camp.

2.2.2.1 Facilities Construction

When approval and permits have been received, construction work will commence immediately. The major objective for summer 1996 is to prepare enough concrete foundations and piling work to support the erection of building shells before the onset of winter. At this time, two additional diesel storage tanks will be installed to increase the site fuel storage capacity.

Once building shells have been erected and are providing necessary shelter, interior steelworks and mechanical/electrical installations can proceed throughout the winter of 1996/1997. Steel supply and erection efforts will be supported by an airfreight program. During the winter of 1997 large, heavy processing, mining and power generation equipment will be transported to site. Work in summer

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV



NWT DIAMONDS PROJECT

Figure 2.2-1
Master Schedule

Source: Rescan, 1994

1997 will involve continued electrical/mechanical installation, tailings and water pipelines construction and installation of the coarse ore storage building. By the close of 1997, the process plant will be treating ore.

A more detailed description of the facilities construction schedule is provided in Section 2.8.

2.2.2.2 Mine Preproduction/Bulk Civil Works

Panda pit development and bulk earthworks will be coincident with the construction of facilities. An experienced contractor will be mobilized during the 1996 winter period to establish temporary maintenance facilities, a laydown area and explosives magazine sites. This will allow earthworks to begin once permits have been received.

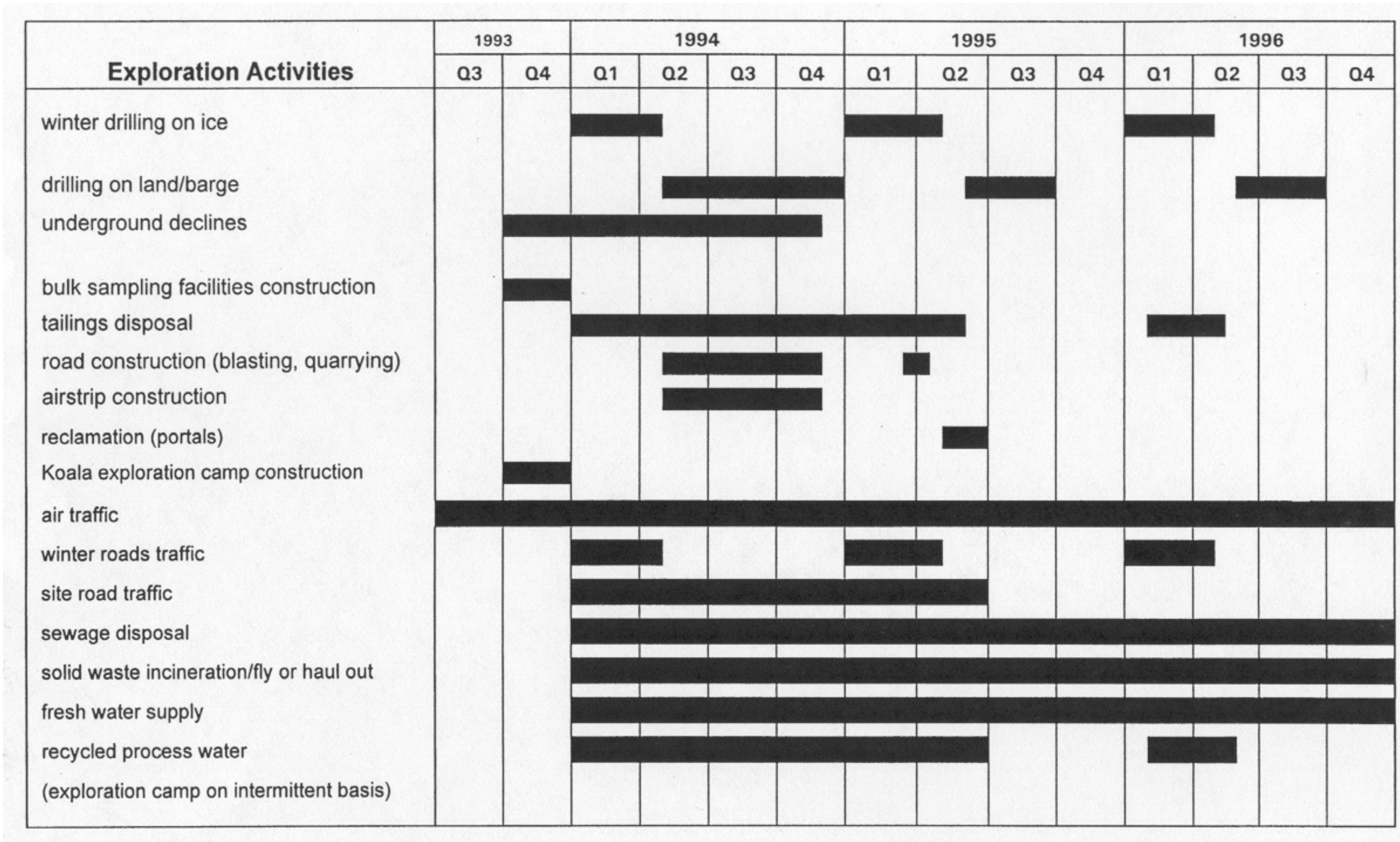
The mine development activities schedule (Figures 2.2-2a, Exploration; 2.2-2b, Operation; 2.2-2c, Reclamation) details the site work, beginning with diversion channel completion and temporary diversion dam construction at Panda. Completion of the diversion dam across the upper reaches of Panda Lake will re-direct water flow to the diversion channel, allowing the southern portion to be significantly dewatered over a period of one and a half months. As dewatering progresses, and while the initial pre-stripping areas at Panda are limited, the earthworks contractor will excavate material from the Airstrip esker quarry for crushing and screening to provide aggregate and sand for ongoing construction use.

Pre-stripping of the Panda Lake surroundings (Panda pit) will start concurrently with the dewatering operation. Waste rock from higher elevations of the dewatered lake shore will be used for plant site area fills and to build haul roads. Access roads joining the plant site and Long Lake will also be built from waste rock to allow dike and dam construction to begin. Lake bottom sediments will be stockpiled in a designated impoundment area for settling and retrieval for future reclamation use.

Using Panda waste rock, road construction to Misery will begin at the northwest end, near Airstrip esker quarry, and advance eastward toward the Paul Lake crossing (Figure 1.1-2). This will continue until conditions are suitable for frozen core dam construction in winter 1997, at which time the construction equipment used for Misery road construction will be reassigned.

Using Airstrip esker material for the core and Panda pit waste for the shell, the east perimeter dam at Long Lake will be constructed in winter 1997. Access road construction to the north end of Long Lake will progress with available waste rock in preparation for dike construction.

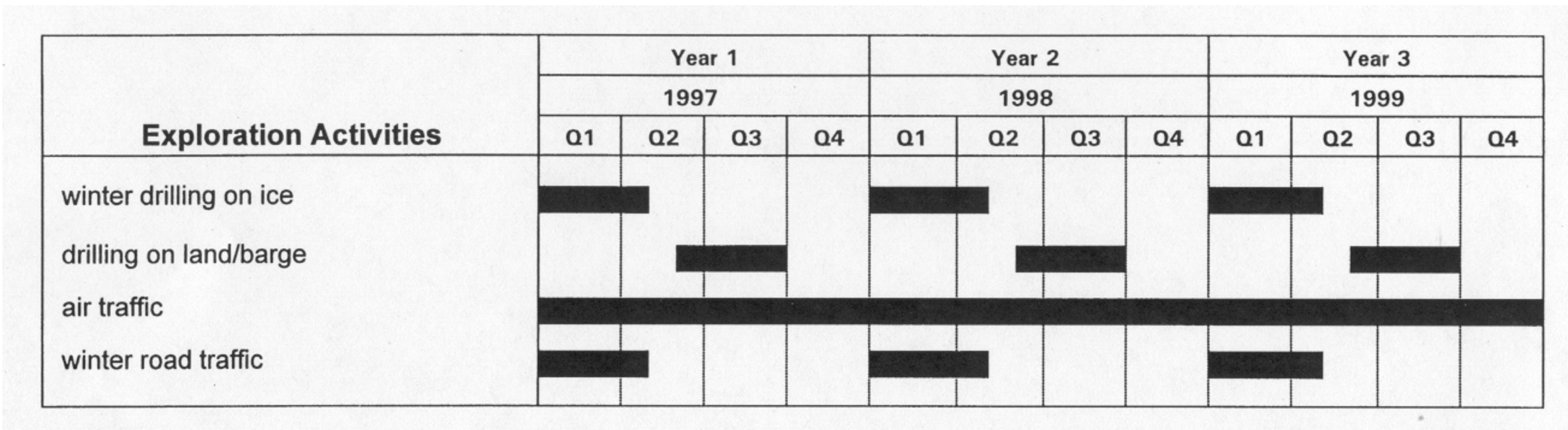
Cad No. a371s　Job No. 455　03/29/1994-05:22pm　Res_AV



NWT DIAMONDS PROJECT

Figure 2.2-2a
Mine Development Schedule (Exploration)

Source: Rescan, 1994

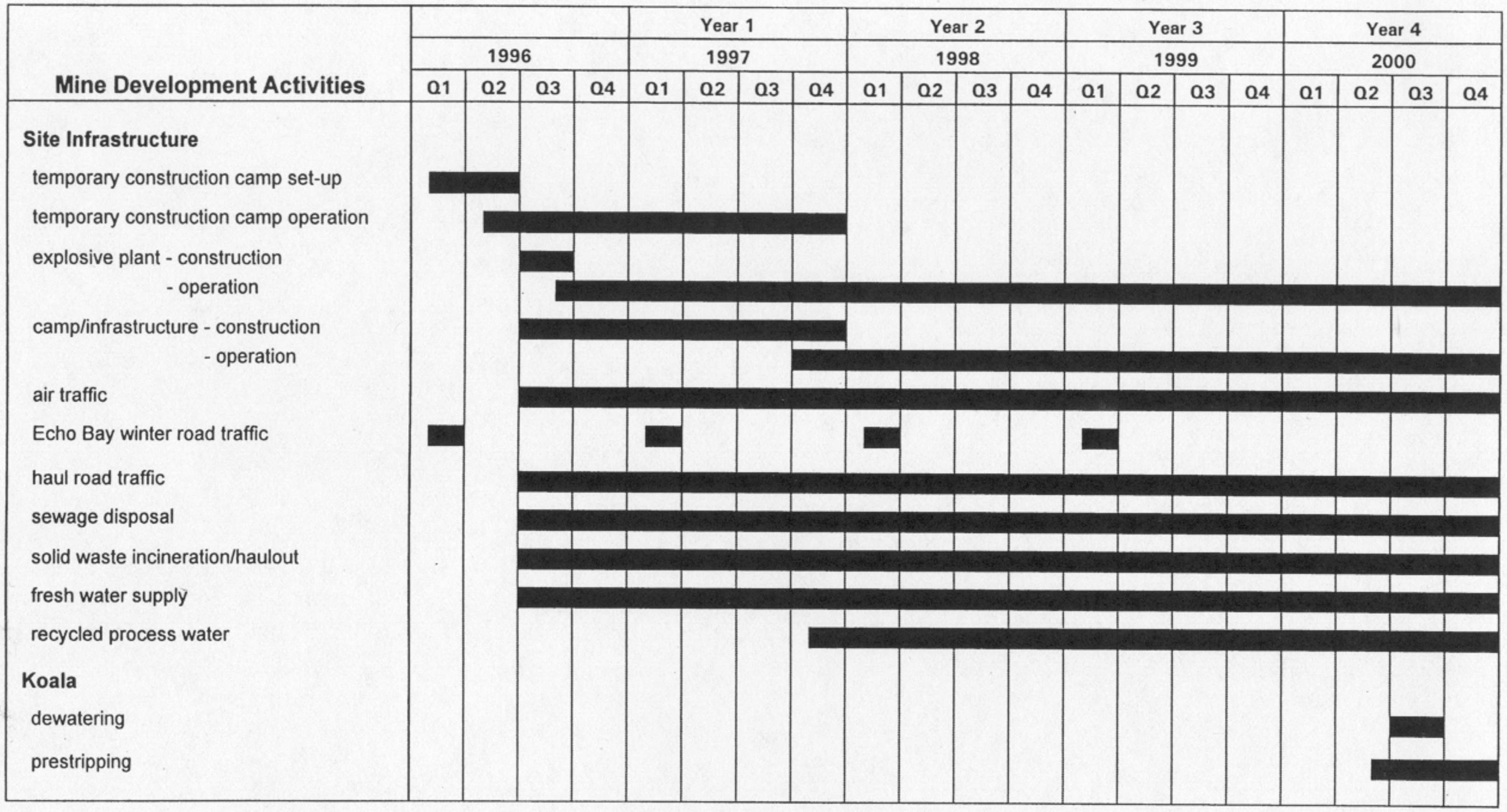


NWT DIAMONDS PROJECT

Figure 2.2-2a
Mine Development Schedule (Exploration) con't

Source: Rescan, 1994

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV

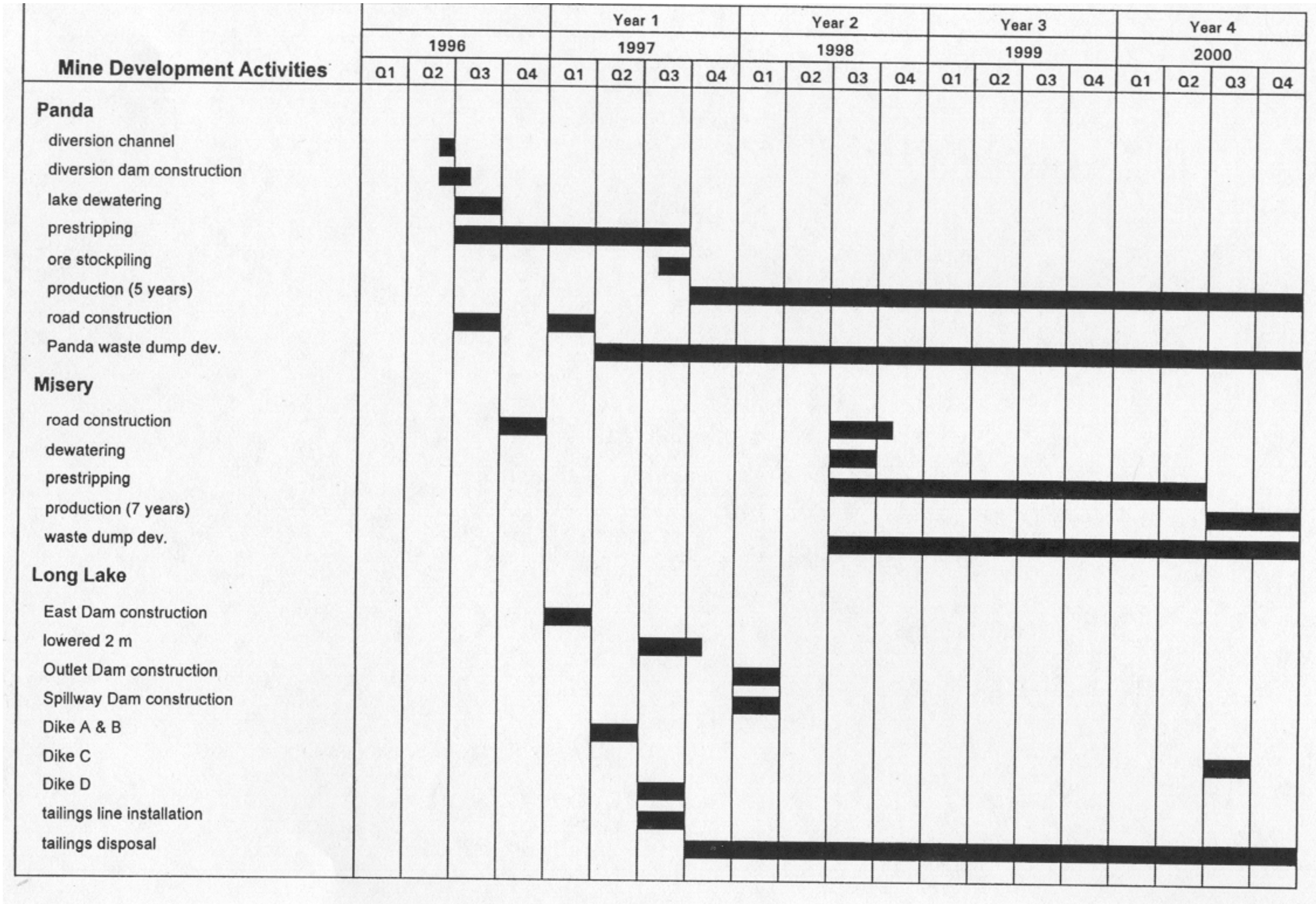


NWT DIAMONDS PROJECT

Figure 2.2-2b
Mine Development Schedule (Operation)

Source: Rescan, 1994

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV

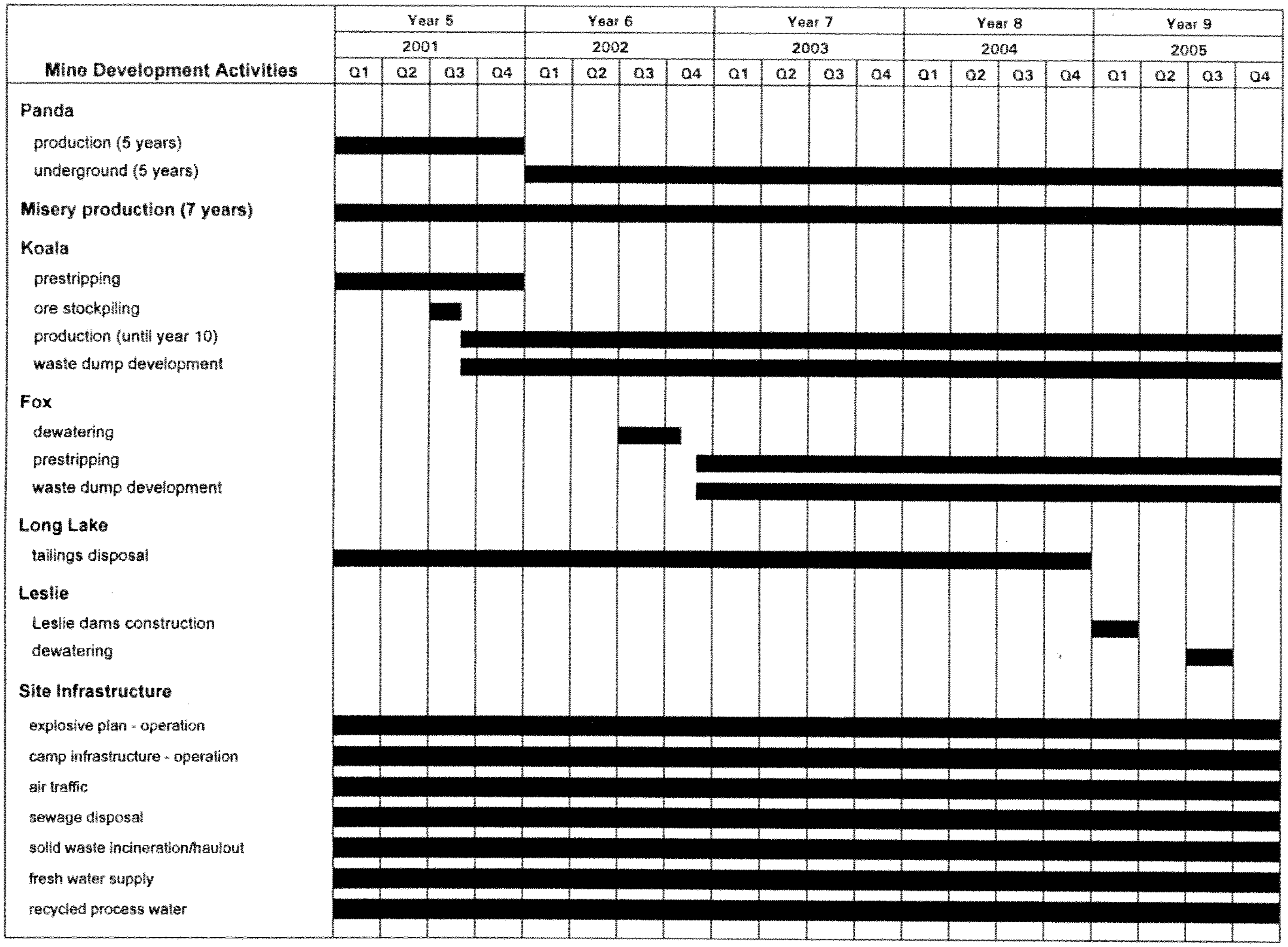


NWT DIAMONDS PROJECT

Figure 2.2-2b
Mine Development Schedule (Operation) con't

Source: Rescan

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV

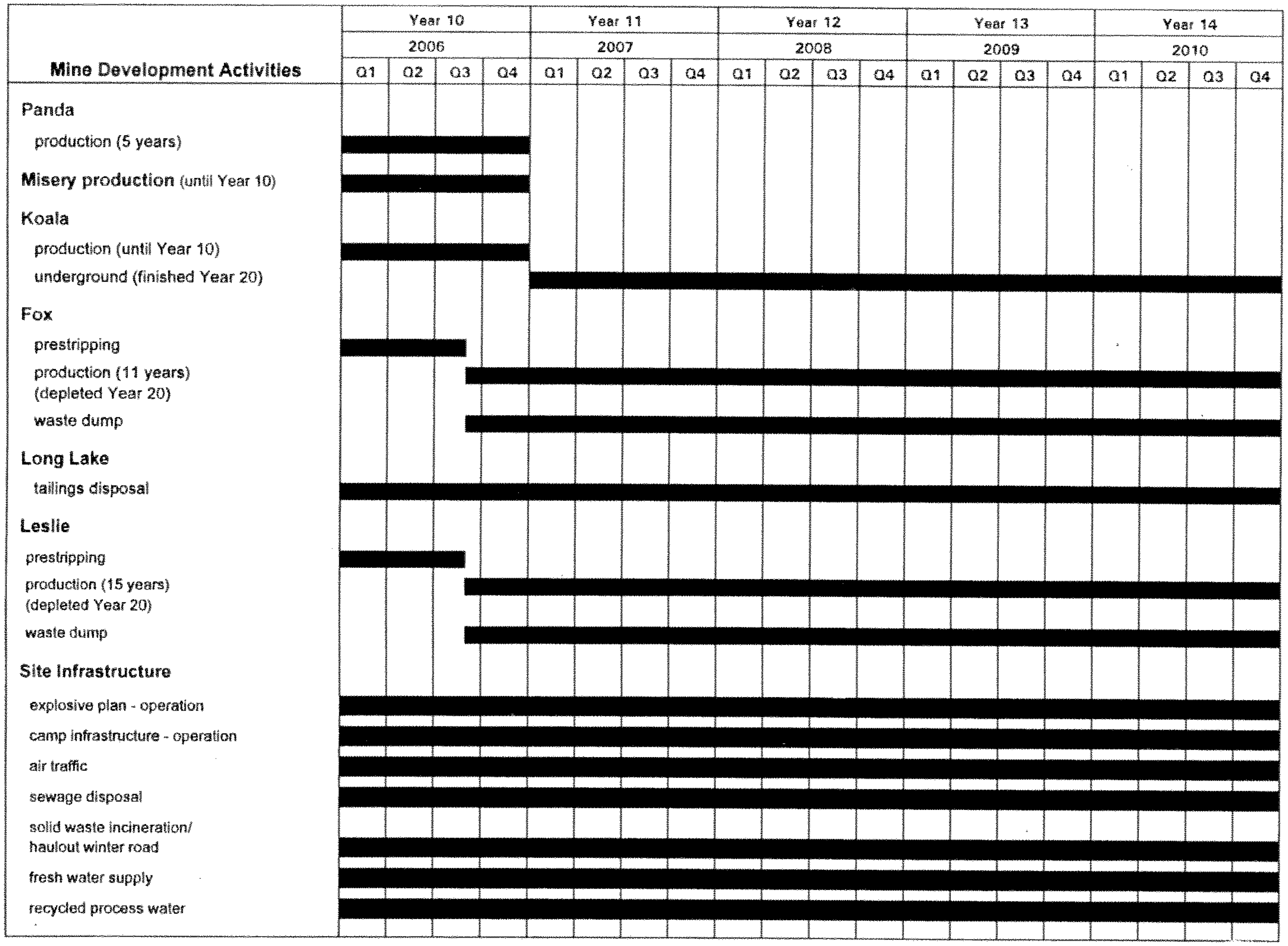


NWT DIAMONDS PROJECT

Figure 2.2-2b
Mine Development Schedule (Operation) con't

Source: Rescan, 1994

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV

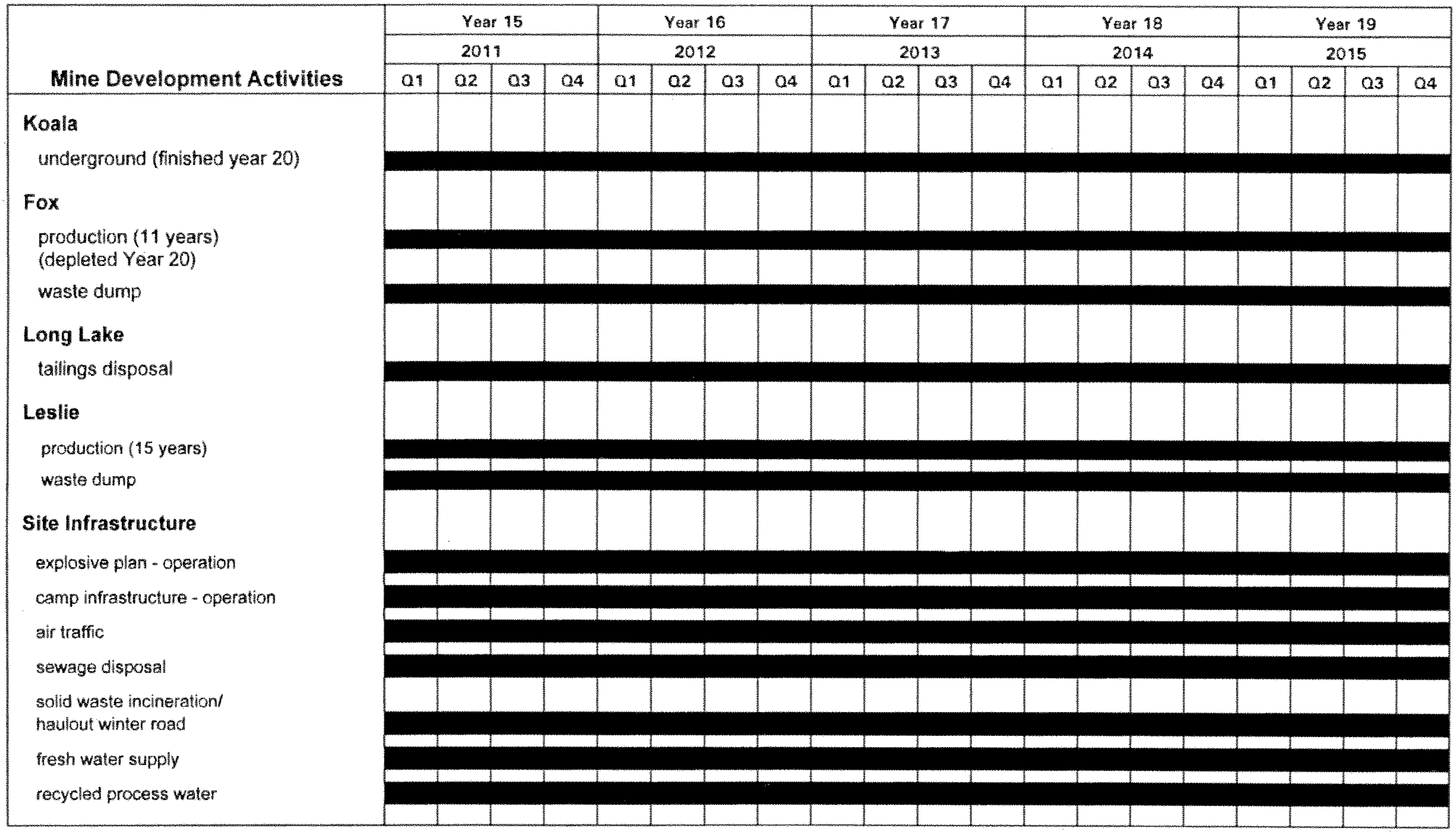


NWT DIAMONDS PROJECT

Figure 2.2-2b
Mine Development Schedule (Operation) con't

Source: Rescan, 1994

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



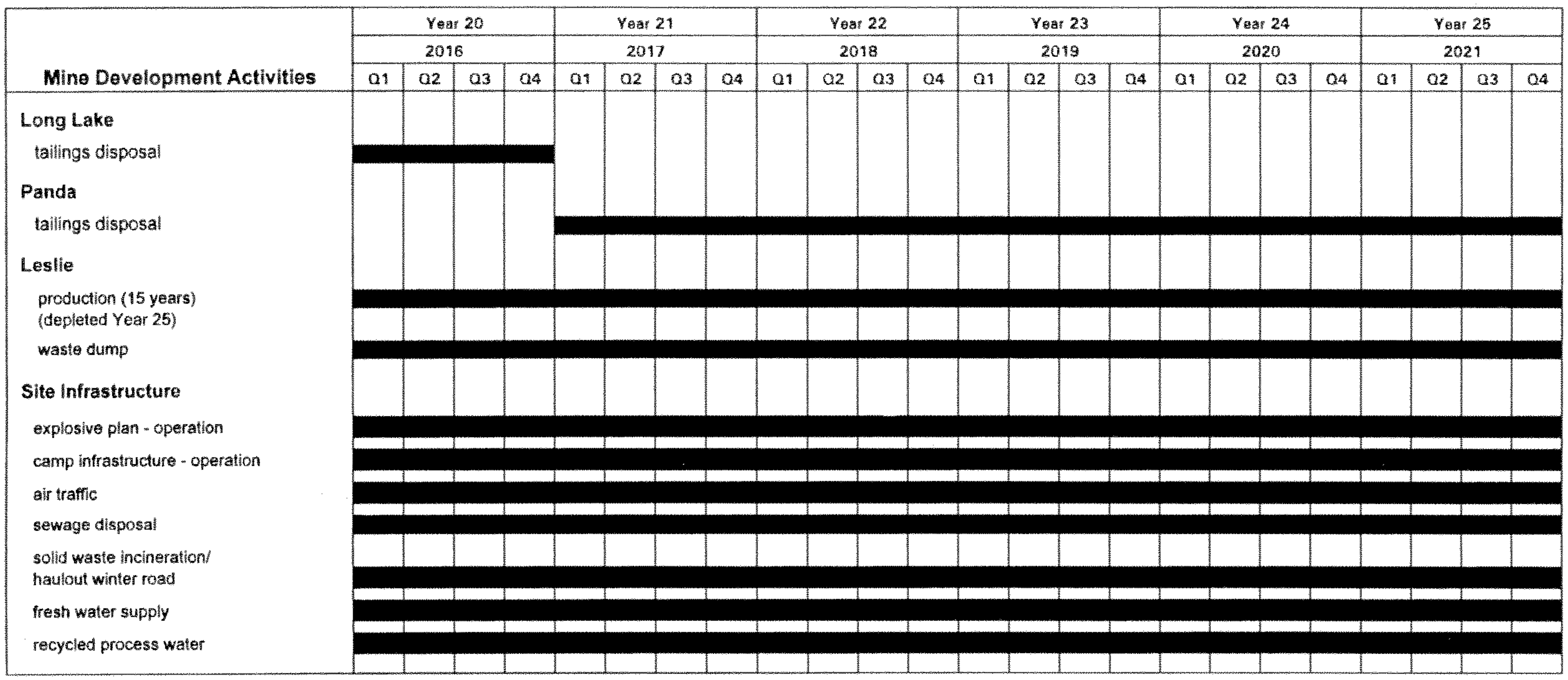
NWT DIAMONDS PROJECT

Figure 2.2-2b
Mine Development Schedule (Operation) con't

Source: Rescan, 1994

Table of Contents

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV

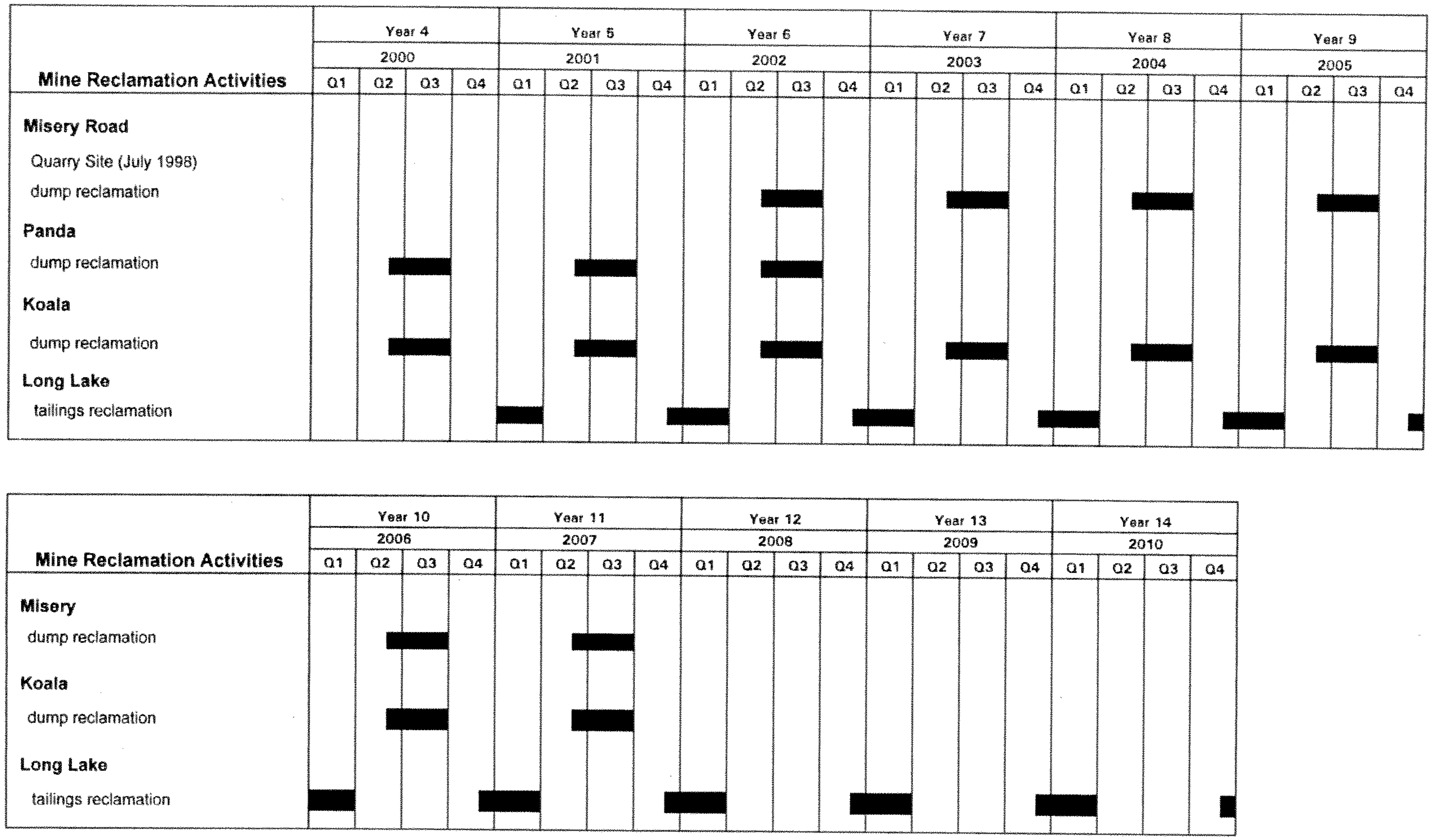


NWT DIAMONDS PROJECT

Figure 2.2-2b
Mine Development Schedule (Operation) con't

Source: Rescan, 1994

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV

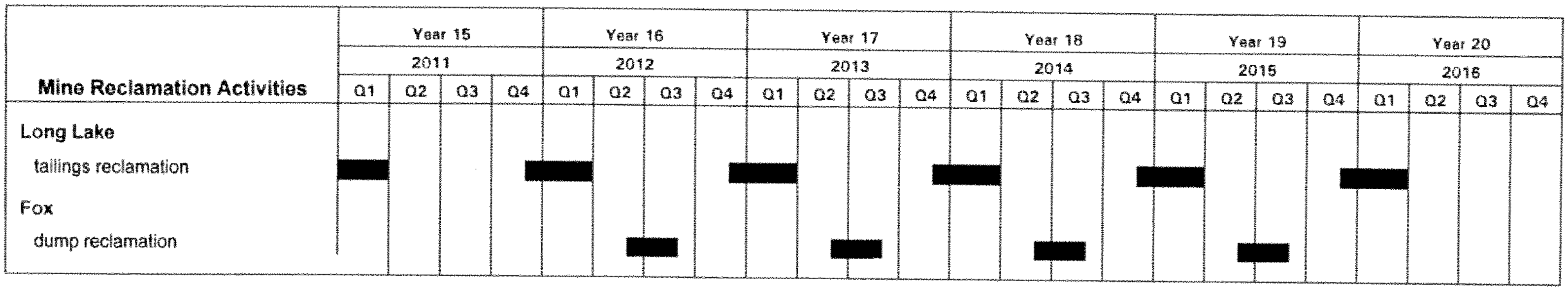


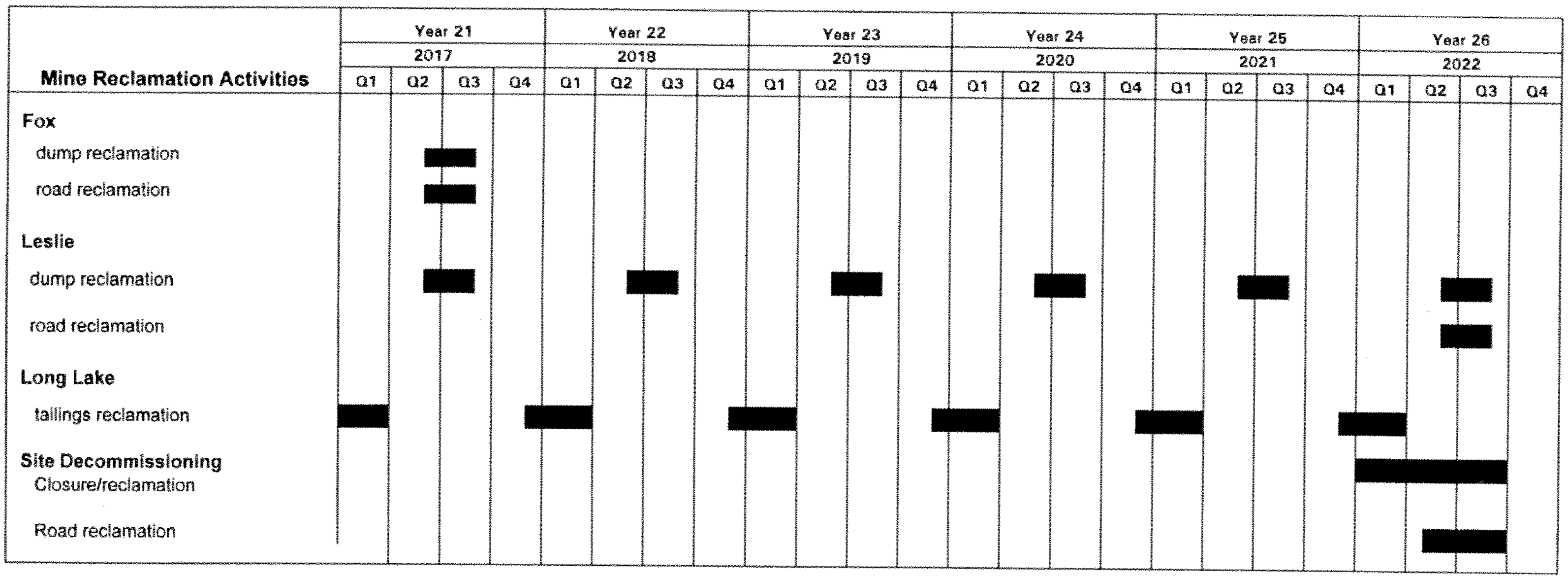
NWT DIAMONDS PROJECT

Figure 2.2-2c
Mine Development Schedule (Reclamation)

Source: Rescan, 1994

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV





NWT DIAMONDS PROJECT

Figure 2.2-2c
Mine Development Schedule (Reclamation) con't

Source: Rescan, 1994

The permanent mine operations fleet will be delivered and assembled during the 1997 winter season. As mine crews are trained, control of Panda pre-stripping operations will be transferred gradually from the contractor to the Proponent's operations.

By the end of winter 1997, the earthworks contractor will complete construction of the Long Lake access roads. The construction of several internal dikes will be completed by summer 1997, using waste rock from Panda. At this time, Long Lake will also be lowered by 2 m and tailings line installations will be completed.

Prior to winter 1998, the contractor will build diversion berms for basin drainage and access roads to the outlet and spillway dams. Throughout the winter, the contractor will construct two final, frozen core perimeter dams, one at the Long Lake outlet and one at the spillway.

When construction of the Long Lake dams has been completed, the fleet and temporary facilities will be transported for use at the Misery Lake operations, beginning in early summer 1998. After dewatering Misery Lake, waste rock from the stripping operation will be used by the contractor to complete the haul road to the permanent camp. This road will join the previously constructed portion at the Paul Lake narrows crossing.

By late 1997, Panda mining operations will be in full production, delivering a steady stream of ore for processing at the plant.

2.2.3 Production Phase

The mine plan involves the development of five diamond-bearing kimberlite pipes: Panda, Misery, Koala, Fox and Leslie. Conventional open pit (truck-and-shovel) mining has been selected for all five pipes, followed by underground development of the Panda and Koala pipes. This methodological sequence is used at other diamond mines throughout the world.

In its first three years of production, the Panda pit will provide 9,000 t/d to the processing plant. Pre-stripping of waste at Misery will continue for two years beginning in the second year of operation. In the fourth year of operation, Koala Lake will be drained, allowing waste stripping to begin. The exposed Misery ore (1,500 t/d) will be blended with Panda (7,500 t/d) to maintain mill throughput at 9,000 t/d. Necessary underground development at Panda will commence.

Reclamation will begin in Year 4 as mining operations at Panda near completion. Waste haulage to the north end of the Panda dump will be reduced as the southern portion begins receiving waste from the Koala pit. Reclamation efforts, consisting of dump resloping, till capping and revegetation, will begin in those areas where mining operations have reached design limits.

By the fifth year of operation, Panda underground development will be completed, making ore production possible in Year 6. With depletion of the Panda pit, stockpiling and haulage of Koala ore can also begin. In mid-Year 6, Fox Lake will be dewatered, allowing waste stripping to commence late in the fourth quarter, and access roads will be upgraded with granite waste rock to permit haul truck traffic.

In Year 5, reclamation activities will begin at the northern portion of the Long Lake tailings impoundment. By this time the first cell will have reached the design capacity of 11.0 million m^3 and will be removed from the tailings system, as deposition is switched to the second cell. Cell reclamation activities will involve draining the surface water, applying an engineered waste rock cover, distributing a layer of coarse tailings and laying a cap of organic material.

To permit dewatering of Leslie Lake by the third quarter of Year 9 as scheduled, the Leslie Lake dams must be constructed by the first quarter of Year 9. Pre-stripping of the Leslie pipe will commence as soon as possible, likely in the first quarter of Year 10. Both Leslie and Fox pre-stripping will be completed late in the third quarter so that ore production can offset the depleted Panda underground and Misery open pit mines. The lower ore grades of the Fox and Leslie pipes will require an increase in the mill throughput from 9,000 t/d to 18,000 t/d to maintain economic viability. Mine production is planned to continue at this rate until Year 25, after which reclamation of the outstanding open pit areas and waste dumps will proceed.

By Year 20 the Long Lake tailings impoundment will have reached ultimate storage capacity. Reclamation activities initiated in Year 5 – and continued throughout the following years – will be carried out in the final cell in Year 21.

In Year 20 the Fox pit will be depleted and reclamation activities will continue. The Koala underground mine will also be depleted by year-end, leaving the Panda/Koala pits available for tailings disposal. Increasing output from the Leslie pit will compensate for shortfalls in ore production due to the depletion of Fox and Koala.

During the last five years of the scheduled project life, Leslie will be the only pit in operation. The Leslie dump reclamation effort will begin in Year 21 as waste dump development (i.e., waste rock production) consistently declines until the end of the mine life (Year 25).

2.2.4 Closure Phase

Upon mine closure, final restoration measures will return any remaining, affected areas to a state compatible with original and undisturbed surrounding areas.

All mine buildings, stationary machinery and most mobile equipment will be removed from the site; concrete walls will be broken up and covered; roads will be graded into the terrain; and drainages will be returned to their natural channels in preparation for decommissioning. The open pit areas will be allowed to fill with water and underground openings will be sealed off.

2.2.5 Post Closure Phase

Following mine closure, a monitoring program will evaluate the success of various reclamation techniques. Any identified problems will be rectified to ensure long-term reclamation and environmental integrity.

2.3 Geology

Diamond-bearing kimberlite deposits have been identified within the Proponent's Exeter Lake property, located in the Slave Geological Province of the Canadian Shield. Section 2.3.1 includes an overview of the relationship between kimberlites and diamonds, explains diamond genesis and kimberlite formation and provides information on world diamond mining and kimberlite morphology. Petrology of the different kimberlite facies is described in Section 2.3.2; regional and property geology are provided in Sections 2.3.3 and 2.3.4, respectively.

2.3.1 Kimberlites and Diamonds

The majority of natural diamonds are derived from deposits of a rare variety of ultrabasic igneous rock called kimberlite. Diamond content is not uniform throughout a diamond-bearing kimberlite pipe. The diamond content can vary both horizontally and vertically from nil to economic concentrations.

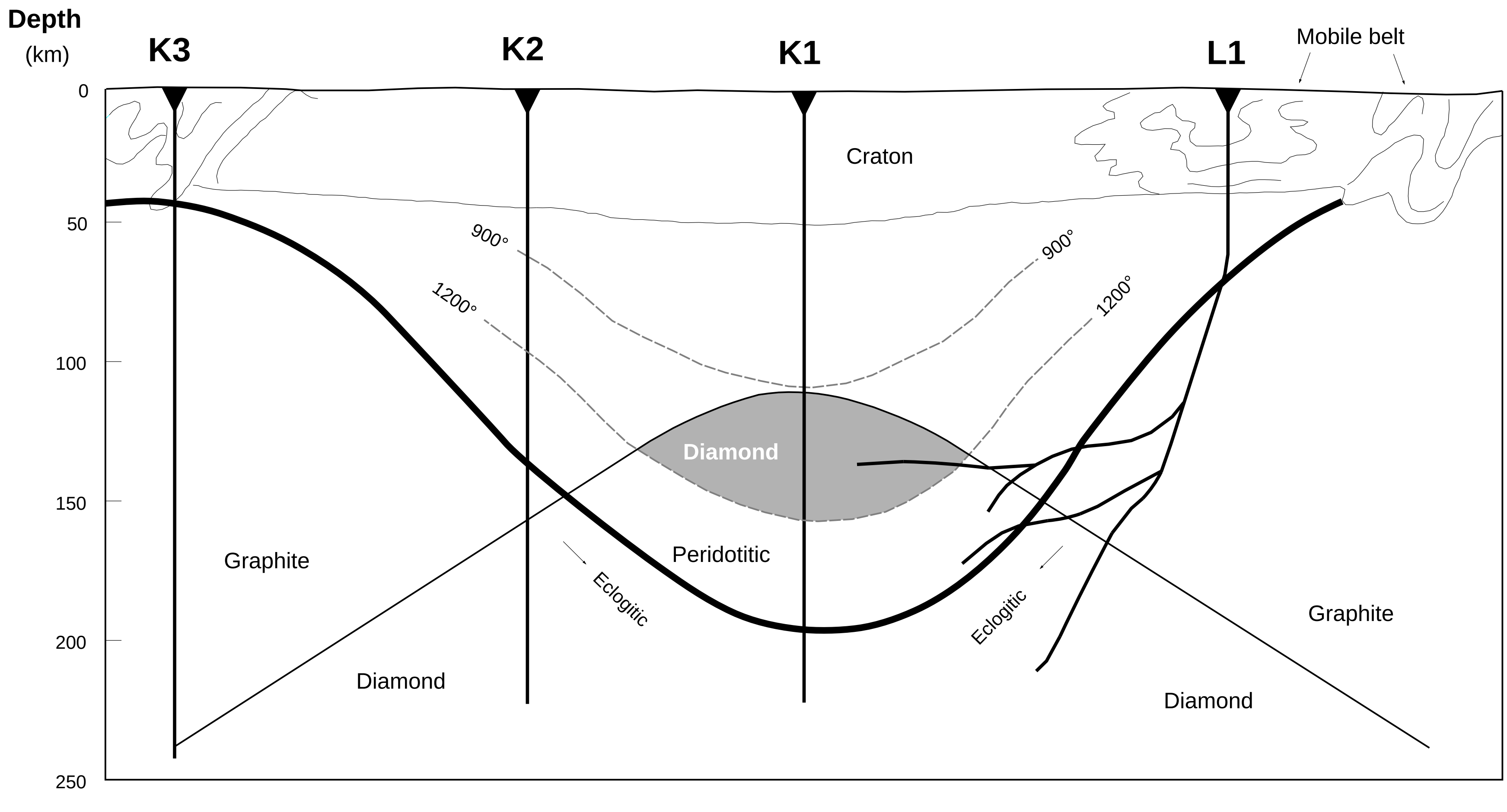
2.3.1.1 Diamond Genesis

Diamonds are a crystal form of carbon that is stable at depths of 150 km or more beneath the earth's surface, in the internal region known as the upper mantle. Kimberlite is a rare volcanic rock type that originates at similar or even greater depths. Kimberlite eruptions are able to carry diamonds from the mantle to the earth's surface.

Diamondiferous kimberlites are confined to continental "cratons" – those regions of continents that have an old, relatively cool "keel" thick enough to extend to the depths of diamond formation. Kimberlites do occur "off-craton" along cratonic margins, but these kimberlites are non-diamondiferous because the crust in such areas is not thick enough to extend into the high-pressure diamond stability field.

Figure 2.3-1 shows an idealized Precambrian Shield, or craton, in cross-section, which can be up to 200 km thick or more. The oldest part of a craton is bounded

Table of Contents



K1 Kimberlite pipe likely to have P-type diamonds

K2 Kimberlite pipe may have E-type diamonds

K3 Kimberlite pipe barren of diamonds

L1 Possible location for Argyle-type lamproite pipes

NWT DIAMONDS PROJECT

Figure 2.3-1
Model for the Genesis of Diamond

Source: Simplified from Haggerty 1986

by younger, deformed Precambrian rocks called “mobile belts”. Carbon will form either graphite or diamond depending on the relationship between pressure and temperature. Silicate mineral inclusions inside diamonds indicate that diamonds crystallize as accessory minerals in peridotite and eclogite, the dominant rock types comprising the earth’s mantle. Isotopic dating of such inclusions has proven that diamonds typically are much older than the kimberlites in which they are found. Peridotitic (P) and eclogitic (E) rocks are brought up towards the surface by kimberlite or lamproite magmas; hence, natural diamonds can be divided into “P-type” and “E-type” categories.

2.3.1.2 Kimberlite Formation

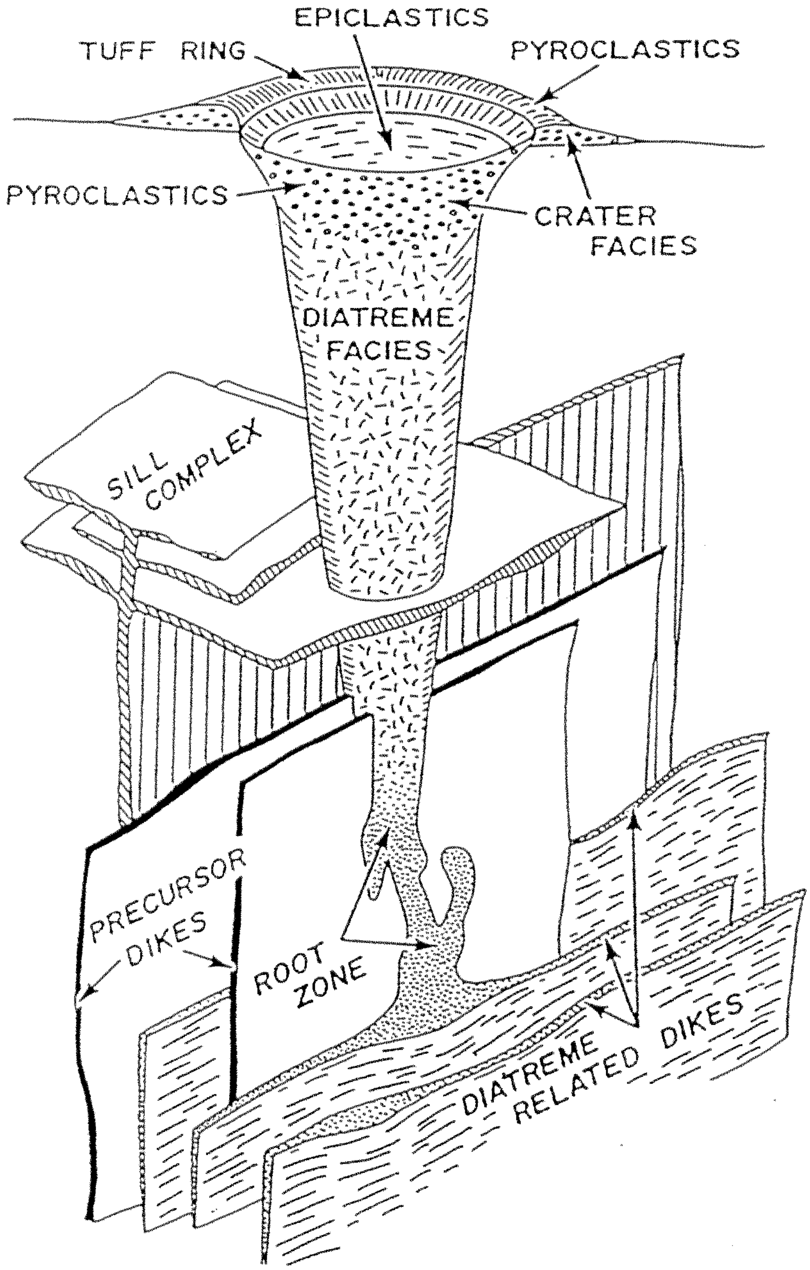
Kimberlite eruptions are gas-charged, relatively rapid and explosive. Initially, kimberlite magma works its way from the mantle through the crust until it reaches a level of sufficiently low pressure that the gases in the magma exsolve. Rock and mineral fragments from the mantle and crust that were picked up en route, as well as minerals that crystallized in the kimberlite melt during transport, then become suspended in CO_2-dominated gas. This gas-solid mixture expands rapidly in the low pressure environment, and a fluidized cell develops, which is very effective at reaming out a carrot-shaped “pipe” or “diatreme”. Much of the gas escapes when the cell breaks through to the surface. At this point some of the suspended rock fragments and mineral grains, including diamonds, are thrown out of the pipe, and the rest are left in the pipe, cemented together by the crystallized residual gaseous products such as calcite ($CaO+CO_2$) and serpentine ($MgO+SiO_2+H_2O$).

Kimberlite Pipes

An idealized kimberlite pipe is comprised of *crater* facies, the surface expression of the diatreme; *diatreme* facies, which consists of the main part of the deposit; and *hypabyssal* or *root* facies below the main part of the pipe (Figure 2.3-2). Kimberlitic materials that fill the crater zone include eruptive volcanic, i.e., pyroclastic kimberlite and epiclastic, reworked material that washes into the crater from its rim. Diatreme materials and hypabyssal kimberlite magma remaining at the base of the pipe crystallize *in situ*. Hypabyssal kimberlite may also be exposed at the surface in the form of dykes, plugs and sills.

2.3.1.3 World Diamond Mining

All continents contain at least one craton, but kimberlites have not been found on every craton (Figure 2.3-3). The Lac de Gras kimberlites were the first to be discovered on the Slave craton of North America. Diamonds have been found elsewhere in North America, but the only diamond mine that has ever existed on this continent was at Prairie Creek, Arkansas. It ceased production in the 1920s.



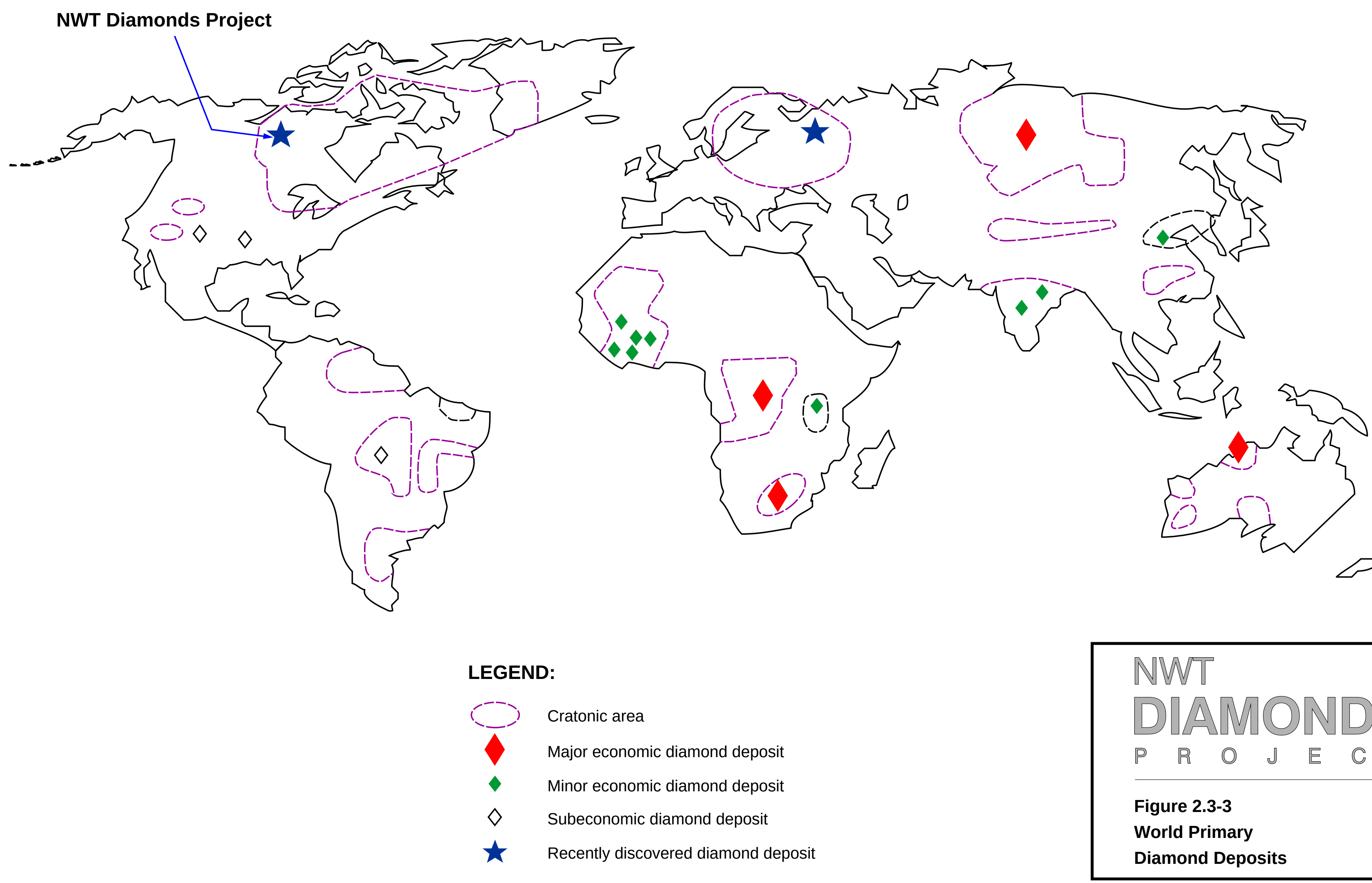
NWT DIAMONDS PROJECT

Figure 2.3-2
Model of an Idealized Kimberlite Pipe

Source: Mitchell 1986

◎ Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



NWT DIAMONDS PROJECT

Figure 2.3-3
World Primary
Diamond Deposits

Source: Modified from Janse, 1984

More than 90% of the 1990 world production of diamonds came from five countries: Australia, Zaire, Botswana, Russia and South Africa (in decreasing order). In Australia the main producer is the Argyle mine, which exploits a lamproite pipe, lamproite being the only other diamondiferous volcanic rock type known besides kimberlite. Argyle, which to date appears to be a one-of-a-kind occurrence (no similar economic deposits have been found), produces more diamonds than any other mine, but only 5% of the production is gem quality. The Zairian diamonds predominantly come from alluvial sources and comprise fewer than 10% gems. Botswana, Russia and South Africa predominantly exploit kimberlite sources and together produce 90% of the world's good-quality diamonds of 1 carat or larger, representing an estimated value of US$3.5 billion in 1990. Geologically speaking, the Lac de Gras kimberlites are similar to the South African and Russian occurrences.

2.3.1.4 Kimberlite Morphology

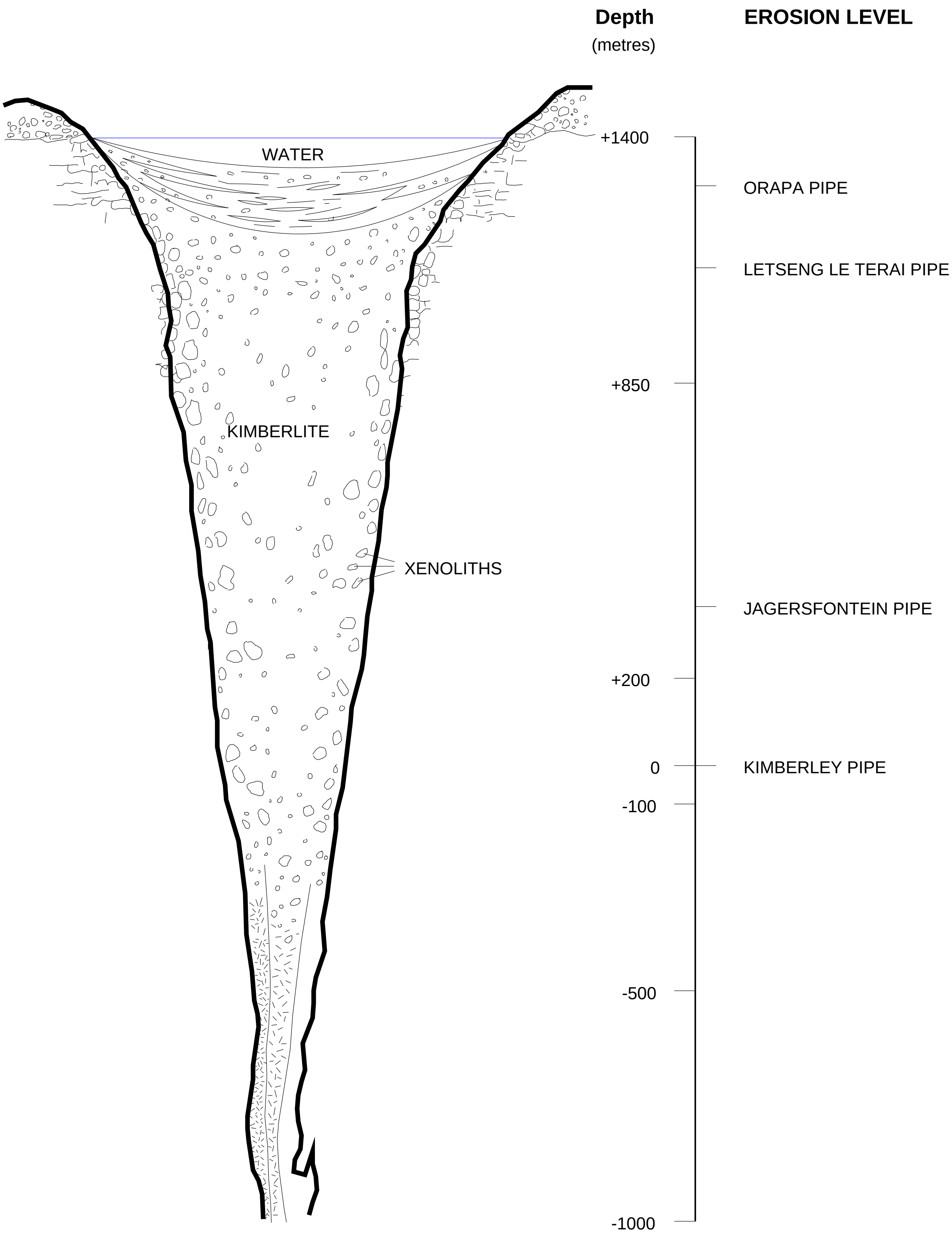
The classic model of a kimberlite pipe is based on the pipes at Kimberley, South Africa (Figure 2.3-4). These pipes were largely eroded away after emplacement, so that the portion that has been mined is only the lower diatreme and hypabyssal or "root" zone. In the mines it was observed that diatreme sidewalls were consistently steep, dipping at more than 80^{o}. Reconstruction of the host rock stratigraphy to the time of kimberlite emplacement, 90 million years (Ma) ago, indicates that the original pipes would have been 2,000 m to 3,000 m deep. Crater zones of the original pipes would have been approximately 60 ha in surface area and roughly 300 m deep (Hawthorne 1975).

In general the Lac de Gras kimberlites conform to the South African model in terms of morphology. The Lac de Gras kimberlites are smaller geological features than the original pipes at Kimberley, but are similar in size to the present-day Kimberley pipes. Kimberlite varieties filling the Lac de Gras pipes cannot be compared directly to those at Kimberley because of the difference in erosional levels. Mineralogy of hypabyssal kimberlite, however, is similar at both localities. The characteristics of the crater, diatreme and hypabyssal kimberlite varieties in the Lac de Gras pipes are described in more detail below in Section 2.3.2.

2.3.2 Petrology of the NWT Diamond Project Kimberlite Varieties

Five kimberlite pipes on the NWT Diamonds Project Exeter Lake property are currently being considered for development; they are Koala, Panda, Fox, Leslie and Misery and are located beneath lakes of the same name (Figure 1.1-2). The geology of the pipes is described in Section 2.3.4.

◎ Table of Contents



NWT DIAMONDS PROJECT

Figure 2.3-4
South African Model of a Kimberlite Pipe

Source: Simplified from Hawthorne 1975

2.3.2.1 Crater Facies

Crater zones are preserved in several pipes, and whether or not crater zones are present, crater material usually occurs as fragments distributed throughout the diatreme zone. Crater materials consists of epiclastic mudstones, siltstones and sandstones and fine-grained to medium-grained pyroclastic tuffisitic kimberlites. Often it is not possible to distinguish the two parageneses. Mudstones are usually black to brown in colour, though locally colours range to grey, red, orange and yellow. Bedding or layering ranges from obvious to subtle or non-existent. Mudstone intervals are usually thin lenses, and mudstones are common as fragments in diatreme facies kimberlite. The mudstones are composed mainly of clay, serpentine, calcite and phlogopite. “Wood slivers” are commonly present. These rocks are soft and poorly lithified.

With increasing amounts of fine-grained (<2 mm) quartz and olivine (or its pseudomorphs), mudstones grade into siltstones or fine-grained tuffisitic kimberlites. Colours are most commonly brownish or greenish black. The groundmass of these fine-grained rocks is soft, serpentine and/or phlogopite-rich and contains variable amounts of calcite. Olivine and quartz contents range from nil to about 30%; and these grains are usually less than 2 mm in size. Fine-grained garnet, chromite and chromium-diopside may contribute to the granular fraction. “Wood fragments” have also been observed in these kimberlitic siltstones and/or fine-grained tuffisitic kimberlite units, which occur as lenses several metres thick to over 100 m thick. Fragments and occasionally horizons of this kimberlite type are also found within the diatreme zone.

2.3.2.2 Diatreme Facies

Diatreme facies kimberlite varieties consist of tuffisitic kimberlite (TK) and tuffisitic kimberlite breccia (TKB). TKs, more common than TKBs, contain less than 15% xenolithic fragments greater than 4 mm in size. TKs typically consist of a fine-grained, mudstone-like matrix surrounding coarse-grained mineral and lithic components. The matrix is usually soft, clayey and composed of microcrystalline serpentine, phlogopite and calcite. Matrix colours vary between grey, green, brown and black or, rarely, translucent and/or bluish-grey.

The coarse-grained mineral component is dominated by olivine, which ranges from mostly to completely altered and averages 2 mm to 3 mm in size. Grains of 5 mm to 10 mm diameter are not uncommon. Olivine contents range from 20% to 60%. The kimberlite indicator mineral suite of garnet, chromite and chromium-diopside is also represented in this coarse-grained fraction. Lithic fragments include granitic host rocks, exotic mudstones and siltstones, crater facies lithologies, kimberlite autoliths and lapilli (mineral or rock components surrounded by kimberlitic rims), and rare to common mantle-derived peridotites and eclogites.

When coarse (>4 mm) lithic fragments comprise over 15% of the kimberlite, it is termed a breccia (TKB). Usually it is the granitic component that reaches this amount, particularly near the margins of pipes.

“Wood fragments” are not uncommon in the diatreme zone, and pieces over 15 cm long have been found. In the Misery diatreme, traces of pyrite were noted as small (1 mm to 2 mm) crystals and nodules and fine-grained pyrite is also observed to accompany serpentine in altered olivine grains.

2.3.2.3 Hypabyssal Facies

Hypabyssal kimberlite may be encountered at depth within a pipe, or may fill the pipe as a sort of plug. Textures are typical of hypabyssal kimberlites elsewhere in the world, with rounded anhedral to subhedral olivine macrocrysts, the predominant coarse-grained phase, set in a fine-grained matrix. Olivine contents average 30% to 40% and macrocryst sizes are usually 2 mm to 4 mm. However, grains over 1 cm in diameter are rarely observed and olivine grades downward in size such that a significant proportion of the olivine in the rock (5%) is less than 1 mm in size. In the case of the Leslie kimberlite, the olivine is very fresh. Other components in the coarse-grained fraction include rare phlogopite, kimberlite indicator minerals, fragments of mantle-derived xenoliths and crustal xenoliths such as mudstones, granite and granulite.

The groundmass surrounding the coarse components is black to brown in hand specimen and brown in thin section, indicating the presence of phlogopite, although the groundmass is commonly cryptocrystalline and distinct mineral components can only locally be discerned. Serpentine and calcite are present in the groundmass and are locally visible in thin section as discrete “pools” or segregations. Concentrations of fresh, microscopic monticellite have also been observed. Remobilized calcite and secondary chlorite occur as veinlets or ragged patches. Opaque, subhedral grains in the groundmass, less than 0.1 mm in size and comprising 10% of the rock, are predominantly ilmenite and spinel. The presence of accessory perovskite, scattered among and rimming the opaques, is also suspected.

Crustal xenoliths in the hypabyssal facies are commonly replaced by calcite and clays and contain remnant or secondary feldspar and quartz. Varying proportions of phlogopite, opaque oxides, brown clays and/or serpentine, chlorite, and clinopyroxene replace more mafic xenolith compositions. Total xenolith content is usually less than 5%.

2.3.3 Regional Geologic Setting of the Lac de Gras Kimberlite Field

The Lac de Gras kimberlites intrude the Slave Province, one of several Archean cratons represent the continental nuclei on which the geological evolution of

North America began. The Slave is a relatively small craton (180,000 km^2) with an extensive and unique history. In addition to containing the earth's oldest known rocks, 3.96 billion years (Ga) old, the Slave differs significantly from younger Archean granite-greenstone terranes in its constituent rocks and in its contacts with bordering proterozoic orogenic belts.

Several lithologic packages, or terranes, comprise the Slave Province (Figure 2.3-5). Greenstone belts concentrated in a narrow north-trending swath through the central part of the province are flanked to the west by the Sleepy Dragon basement terrane, which includes quartzofeldspathic gneisses and banded and migmatitic gneisses. Further to the west is the Anton basement terrane, which includes the oldest known sialic crust and other metamorphosed granodiorites to quartz diorites. Those rocks dip westward under Proterozoic rocks of the Wopmay orogen. Wedged between the southern Anton and Sleepy Dragon terranes is the Yellowknife domain, interpreted as a complete Archean supracrustal basin.

To the east of the central greenstones is the Contwoyto terrane composed predominantly of laterally continuous greywacke-mudstone turbidites exposed in a series of westward-verging folds and thrusts. The Hackett River arc consists of a series of predominantly felsic volcanic piles including cauldron subsidence features, rhyolitic ring intrusions, tuffs, breccias, flows and domes, as well as some synvolcanic granitoid rocks in the south. The eastern margin of the Slave province is defined by a thrust fault contact with the 1.9 Ga Thelon magmatic zone.

2.3.4 NWT Diamonds Project Property Geology

The Archean rocks in the NWT Diamond Project Property area can be divided into three very broad lithostratigraphic groups: metasedimentary schists, migmatites and various syn- and post-tectonic intrusive complexes. Five proterozoic dyke swarms of different ages (varying from 2.4 Ga to 1.27 Ga) and of different orientations, crop out on the property. Table 2.3-1 gives a list of the lithologic units and available age data for the units present in the NWT Diamonds Project Property. The names of these units have been taken from the Geological Survey of Canada published maps, field observations and Kjarsgaard (pers. comm.). A regional geologic map prepared from aeromagnetic interpretation is presented in Figure 2.3-6. An aeromagnetic survey flown by fixed wing aircraft or helicopter will quickly evaluate a large area by detecting subtle differences in magnetism between different rock types.

2.3.4.1 Kimberlites

Kimberlites are the only Phanerozoic age rocks known in the Lac de Gras region, although fossil-bearing mudstone xenoliths within the kimberlites indicate that

◎ Table of Contents

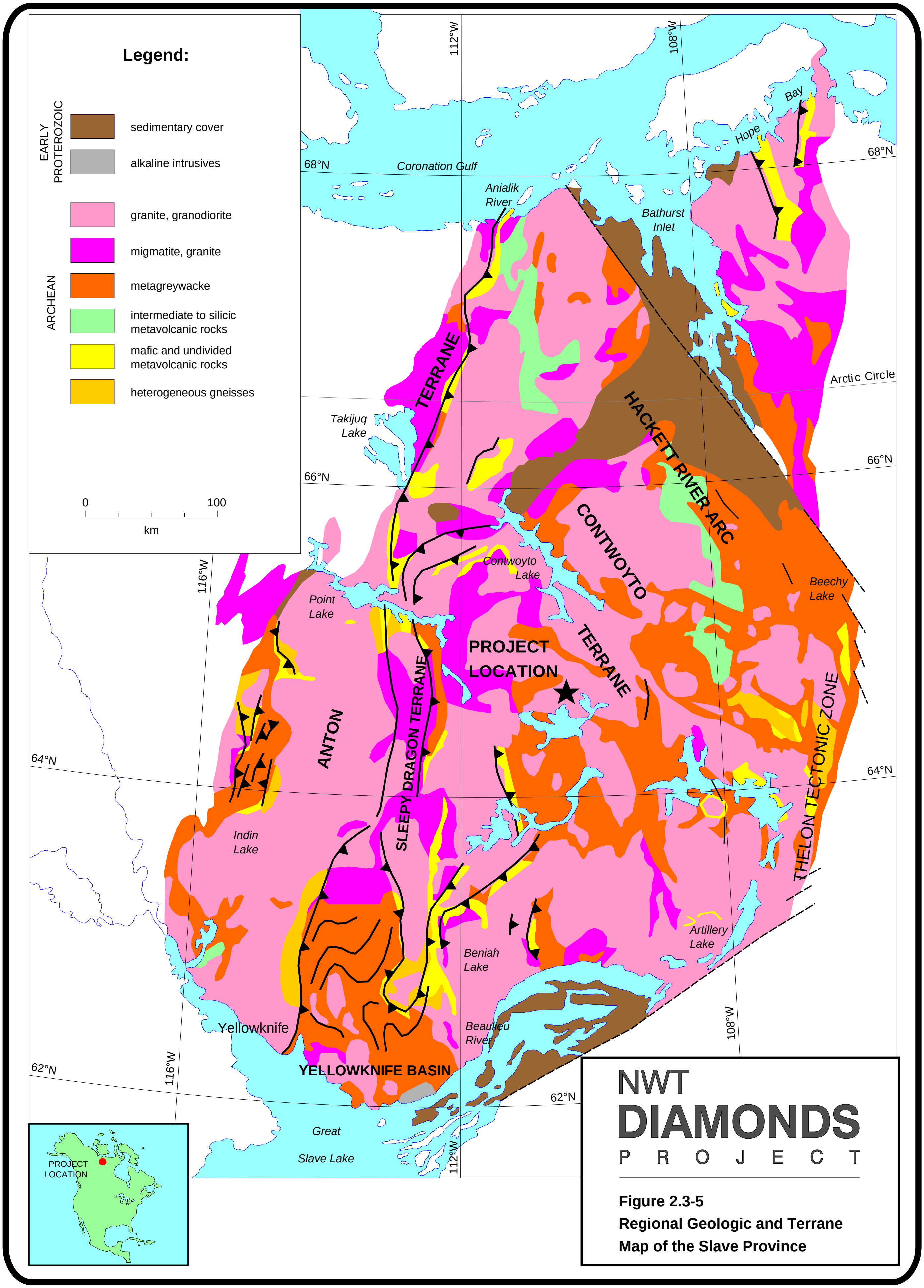


Figure 2.3-5
Regional Geologic and Terrane Map of the Slave Province

Source: Modified after Kusky 1989

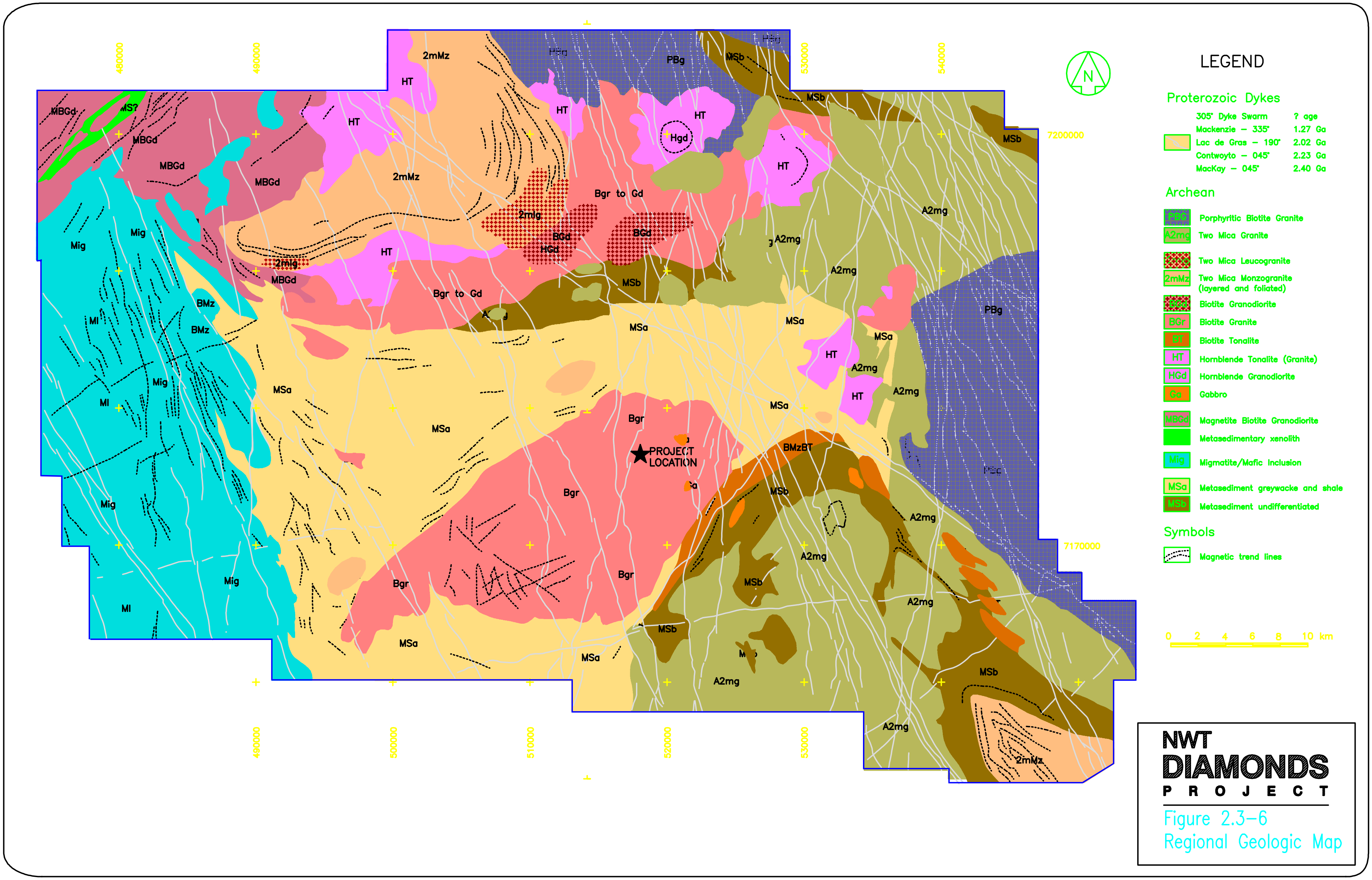
Table 2.3-1
Geological Formations and Events in the
NWT Diamonds Project Property

Geological Formation		Age Billion Years (Ga)
Phanerozoic		
Kimberlite		0.052
Proterozoic Dykes		
305° dyke swarm		Age uncertain
Mackenzie (orientation 335°)		1.27
Lac de Gras (190°)		2.02
Contwoyto (045°)		2.23
MacKay (080°)		2.40
Archean		
PBG	Porphyritic Biotite Granite	2.58
2mg	Two Mica Granite	2.59
2mlg	2 Mica Leucogranite	n/a
2mMz	2 Mica Monzogranite (Layered/Foliated)	n/a
BGd	Biotite Granodiorite	n/a
Bgr	Biotite Granite	n/a
BT	Biotite Tonalite	2.61
HT	Hornblende Tonalite (Granite)	n/a
HGd	Hornblende Granodiorite	n/a
Ga	Gabbro	n/a
MBGd	Magnetite-Biotite Granodiorite	n/a
MSX	Metasedimentary Xenolith	n/a
Bmz	Biotite Monzogranite	n/a
MIG	Migmatites	n/a
Ma	Mafic Inclusions	n/a
MSa	Metasedimentary Rock	n/a
MSb	Metasedimentary Rock (possibly higher metamorphic grade)	n/a

Names taken from BHP drill logs; Thompson *et al.* 1993; Kjarsgaard & Wyllie 1994.
n/a = Not applicable.

Phanerozoic sediments must have covered the Proterozoic and Archean rocks as a thin veneer at the time of kimberlite emplacement (Nassichuk and McIntyre 1995). Dinoflagellates, pollen, spores and teleost fish remains range in age from early Cretaceous (97 Ma, Albian) to Tertiary (56 Ma, Paleocene). A Rb/Sr three point isochron yielded an Eocene age of 52 +/- 1.2 Ma for one of the kimberlites, which is closely supported by the fossil ages.

◎ Table of Contents



Compiled by M. Leake and P. Diorio, July 1994

The kimberlites exhibit a wide range of characteristics. Crater facies, diatreme facies and hypabyssal facies kimberlites are all represented. Fox and Koala have thick (100 m to 150 m) crater kimberlites. Panda and Misery do not have distinct crater zones but their diatremes contain abundant crater material as fragments and horizons. Leslie is dominated by hypabyssal kimberlite. The petrology of these kimberlite types has been described in Section 2.3.2.

2.3.4.2 Geology of the Koala Area

The predominant host rock type for the Koala pipe is a white to grey, medium to coarse-grained, weakly foliated to massive biotite granite. The granite locally contains rounded biotite-rich mafic xenoliths 1 cm to 15 cm in size. A variety of other rock types exist including granodiorite, granite gneiss and small patches of diorite. The granite gneiss, observed about 80 m southeast of the lake, contains traces to 1% almandine garnets that are 1 mm to 2 mm in size and form circular pods up to 3.5 cm diameter. Also within the gneiss are rare occurrences of tabular tourmaline crystals up to about 2 cm in length. Small patches of diorite are scattered throughout the area to the east of Koala Lake. The diorite contains traces of almandine garnet and traces of disseminated sulfides. Granodiorite was noted only on the east side of the lake. On the ridge just east-southeast of Koala Lake, a fine-grained magnetic mafic rock crops out; this may be a fine-grained diabase.

The bottom of Koala Lake and the Koala kimberlite pipe are covered by unconsolidated sediments of glacial origin. This overburden is characterized by a complex interfingering of sediment lenses ranging from mud to gravel. Interfingering of sediment types is far more complex and variable in areas of deeper water, e.g., over the Koala kimberlite pipe. In general the uppermost part of the overburden sequence comprises well sorted silt and mud. Such fine grained sediments form 1 m to 2 m thick beds at a depth of 40 m to 45 m below the surface. Elsewhere sand and gravel dominate. In most cases, fine clay and silt have been washed and weathered out of these coarse grained sediments. Boulders and cobbles are sporadic throughout the sequence and are concentrated along horizons at 30 m and 45 m to 50 m depth. The topography of the uppermost surface of the overburden mimics that of the bedrock surface.

2.3.4.3 Geology of the Panda Area

The granitic host rock of the Panda kimberlite pipe is the same as that described for the Koala area. This granite, however, has an average composition of 40% quartz, 45% feldspar and 15% biotite. In weakly altered zones, 1% to 3% epidote may be present. Granite in the vicinity of Panda is remarkably unaltered and unhematized in comparison with granitic host rocks of other pipes in the area.

Panda pipe is overlain by pebbles and gravel with lesser silt and sand. The pebbles and gravel are mostly subrounded and composed of quartz-biotite granite and pegmatite with lesser amounts of fine grained foliated granite, granite with hematized feldspars and more mafic intrusives (i.e., gabbro). The sand is predominantly quartz and feldspar grains derived from granitoids. Fragments of metasediments (quartz biotite schist), which are often more angular or flattened ellipsoidal or disk-shaped, locally form up to 40% of the overburden but usually comprise only 5% to 15%. Minor fine grey phyllitic mudstones (shiny with crenulation cleavage), as well as sillimanite-bearing quartz biotite schists, have also been observed. Of note is a silt-sand layer that varies from 1 m to 2 m in thickness and is usually observed within the depth interval 22 m to 30 m below surface, though occasionally higher (17 m) or lower (33 m).

2.3.4.4 Geology of the Fox Area

The predominant rock type in the Fox area is also a medium-grained biotite granite. The rock is mostly unaltered, however, weak to moderate potassic alteration occurs at the east end of the ravine near the Fox portal and also along the linear swamp subparallel to the ravine. Two diabase dykes cross the Fox Lake area. These were identified by an airborne magnetometer survey and in the decline and confirmed by small patches of outcrop located to the northeast and south of the lake.

Glacial sediments on the bottom of Fox lake range from 15 m to 25 m thick and consist of silt and sand-sized particles of quartz, feldspar, biotite, epidote, amphibole, and traces of kimberlite indicator minerals. Gravel-sized rock fragments include various granitoid rocks ranging from biotite granite, hornblende granite, granodiorite, tonalite, to quartz diorite, and lesser amounts of biotite schist, diabase, trace amounts of vein quartz and felsic to intermediate volcanic rocks.

2.3.4.5 Geology of the Leslie Area

Medium-grained, relatively unaltered biotite granite is the dominant host rock type in the Leslie area; no sulphides were observed. Airborne magnetics indicate that a diabase dyke which has an orientation consistent with the Lac de Gras swarm (190°) occurs approximately 420 m to the east of the Leslie pipe. This dyke and another which belongs to the Mackenzie swarm (335°) intersect approximately 780 m to the northeast of Leslie.

Lake sediments encountered during drilling on the Leslie pipe range from 20 m to 41 m thick. The overburden is a poorly to moderately sorted mixture of clay, silt, sand and gravel. Sand and gravel usually dominate, with clay rich zones occurring as localized horizons. Gravel fragments include kimberlite, granite and schist components, which are typically subangular.

2.3.4.6 Geology of the Misery Area

Misery Pipe is found at the contact between biotite schist and granite which are described by Kjarsgaard and Wyllie (1994) as greywacke and two mica granite, respectively. The biotite schist is weathered to a buff brown to rusty brown colour and is commonly foliated. Occasionally, it contains andalusite and cordierite porphyroblasts; the latter are frequently replaced by sillimanite.

The granitic rocks generally weather to a white to light grey colour and contain abundant primary muscovite. Textures vary from fine to coarse grained and pegmatitic, and equigranular to weakly porphyritic. The granite is younger than, and intrudes into, biotite schist. In addition, the granite is post-kinematic based on the absence of foliation or alignment of mineral grains. Although rare pyrite was noted in the diatreme facies of the kimberlite, none was observed in the granitic host rock.

The Misery pipe is overlain by approximately 13 m of overburden. The thickness of the lake bottom sediments, which consist of grey to black mud, averages about 3 m. The overburden is composed of poorly sorted gravel (65% to 95%) and sand (5% to 35%) derived from biotite schist and granitic rocks.

2.4 Mining Plan

This section presents the mine plan for the NWT Diamonds Project. It outlines the ore and waste production schedules and describes the mining methods and equipment selected to meet these schedules. Associated mine development activities, including lake dewatering, haul road construction and waste rock disposal, are also discussed. Measures are incorporated throughout to limit the areal extent of disturbances, preserve water quality in adjacent areas and reclaim altered surfaces as early as possible.

2.4.1 General Description

The mine plan is based on multiple pipe development, taking into consideration the process plant capacity, the distribution of the kimberlite occurrences, ore reserve characteristics such as diamond quality and quantity, and the marketing potential of the diamonds. The plan is designed to ensure the health and safety of people and protection of the environment by incorporating the applicable regulations of the *NWT Mining Safety Act* and *NWT Occupational Health and Safety Act*, as well as standards and codes of practices consistent with BHP's other Canadian mining operation, Island Copper, in British Columbia.

Conventional open pit mining has been shown to be the most effective and economic method of extracting the mineable reserves of the kimberlite deposits, given their location in the remote, high cost operational environment of the

Northwest Territories. Increasing costs with depth determine the economic limits of open pit mining, however, and where resources of high value remain below mined out pits, underground mining will be employed for full recovery.

BHP's experience with large-scale mining operations worldwide provides a sound basis for meeting the technical, economic and safety criteria for successful mine design. Planning work carried out in-house resulted in a 25-year mine plan, producing a total of 40 to 45 million t/a waste rock and ore from several open pits and two underground operations.

The development plan involves five diamondiferous pipes, four of which are within a few kilometres of each other in the Koala watershed north of Lac de Gras. The fifth is adjacent to Lac de Gras, approximately 29 km southeast of the proposed plant site. Each pipe is overlain by a lake, which will be dewatered to permit mining. The Panda pit will be developed first, in 1997, followed by Misery, Koala, Panda (underground), Fox, Koala (underground) and Leslie. During the first 9 years of operation, the mine will provide ore for processing at a rate of 9,000 t/d (3.3 million t/a), increasing to 18,000 t/d (6.5 million t/a) from 2006 (Year 10) through 2021 (Year 25). A total of approximately 133 million tonnes of ore will be processed over the currently planned 25-year life of the project. The project life may be extended depending on the results of future exploration and development work.

The mine design is similar for all pits. Both single and double benches will be used, depending on prevailing conditions, with excavated rock loaded into large haul trucks and transported to either waste rock dumps or an ore collection point for subsequent processing. The design ensures the ongoing removal of sufficient waste rock material at each pit to expose a continuous and reliable supply of kimberlite ore to sustain the scheduled process plant requirement. Low unit operating costs will be achieved by utilizing a large capacity truck-and-shovel mining fleet.

The underground mining method selected for the Panda and Koala pipes is sublevel caving, which is a high production technique suitable for massive and steeply dipping, medium-width ore bodies such as those commonly found in kimberlite deposits.

A total of approximately 826 million tonnes of waste rock will be excavated from the open pits and underground operations over the life of the project. Most of the waste rock will be stockpiled in dumps in the vicinity of each pit. Some of the rock will be used for construction purposes, such as road and embankment fill, reclamation recontouring and tailings pond cover.

All waste dumps will be located beyond the existing and possible future pit limits. Potential kimberlite pipes in the planned dump areas will be identified and drill tested before waste dumping begins. The completed waste dumps will be contoured to blend in with the existing topography.

All design work for surface mining and waste dump construction incorporates the NWT Mining Safety Regulations and other features to permit safe and efficient operations.

2.4.2 Mine Production Schedule

Summary production schedules showing the quantities of ore and waste to be removed annually from the five pipes included in the mine plan are provided on Figures 2.4-1, 2.4-2 and 2.4-3. All quantities are reported as dry metric tonnes, based on average densities obtained from geological data. Development planning is based on start-up of the process plant in October 1997. Any significant delays or postponement before this time would adversely affect the entire schedule and defer all activities by a minimum of one year.

Open pit mining will begin with the Panda pipe in 1997, followed by Misery in 1998, Koala in 2001, Fox in 2002 and Leslie in 2006; underground production from Panda will commence in 2002 (Year 6). In total, more than 133 million tonnes of ore and 826 million tonnes of waste will be mined from the five pipes. Total daily production of all materials for the 25-year mine period will average 105,100 tonnes.

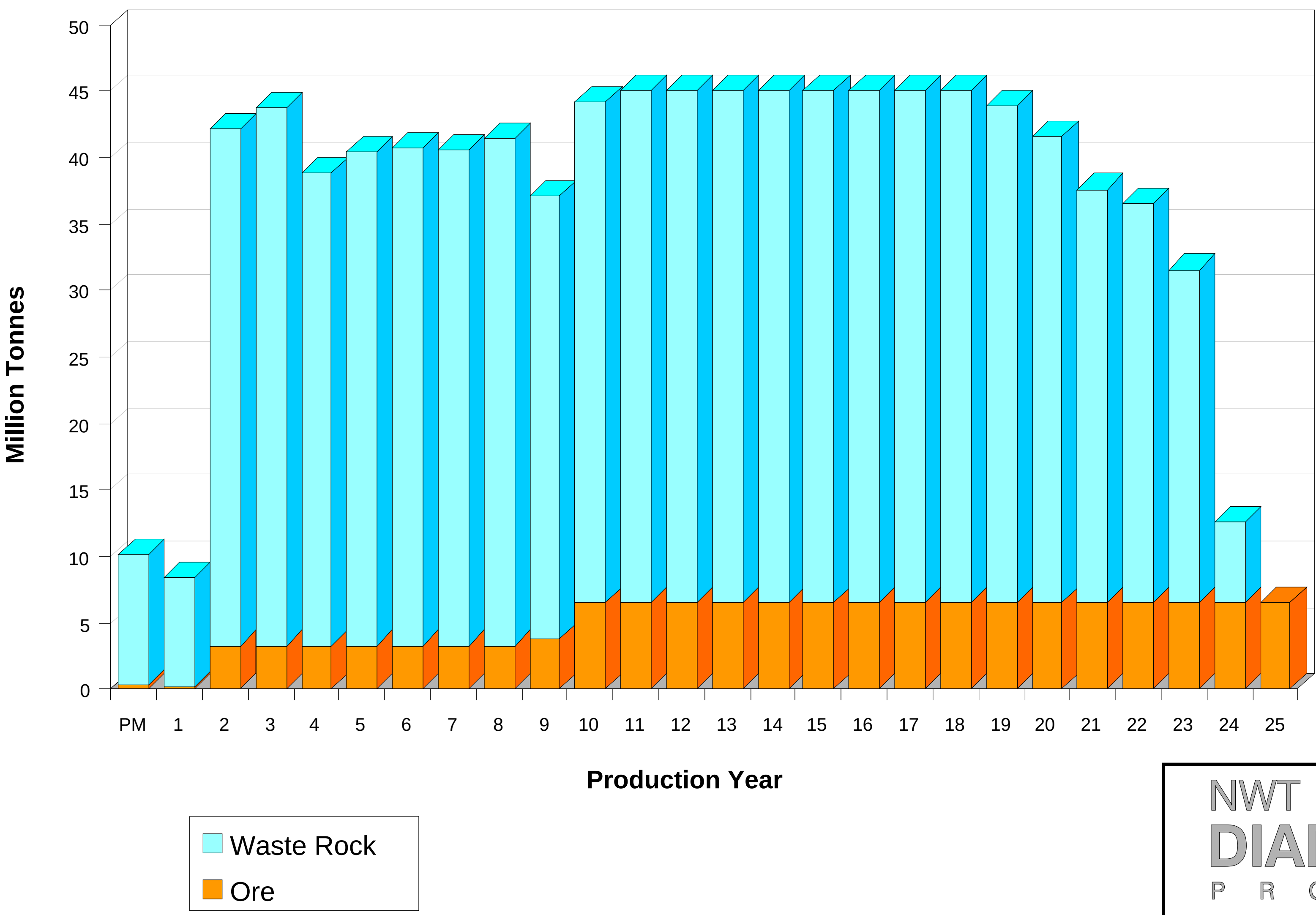
The proposed mining sequence maintains annual ore production of nearly 3.3 million tonnes to meet the initial process plant throughput rate of 9,000 t/d. From 2006 (Year 10) to the end of the project life, production will rise to slightly more than 6.5 million t/a to match the higher processing rate of 18,000 t/d. Total annual waste production will average between 37 and 40 million tonnes.

For the first five years of operation, all ore will be supplied from surface mine ore production. The open pit production rate will drop from 9,000 t/d to 6,500 t/d from 2002 through 2004 (Years 6 through 8), then increase coincident with the process plant expansion in the latter part of 2005 (Year 9), continuing through 2016 (Year 20) at an average of 15,000 t/d. The rate will then increase again to 18,000 t/d until 2021 (Year 25).

The underground mining resources for Panda and Koala are incorporated into the production schedule between 2002 and 2016 (Years 6 and 20) to meet the plant requirements from 2002 to 2005 (Years 6 to 9), when the combined stripping ratios are highest, and from 2006 (Year 10) on, following the plant expansion. Panda underground mining will start in 2002 (Year 6) immediately after surface mining there is complete. The same is true for the Koala underground operation, which starts in 2007 (Year 11) after its open pit is exhausted.

◎ **Table of Contents**

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



NWT DIAMONDS PROJECT

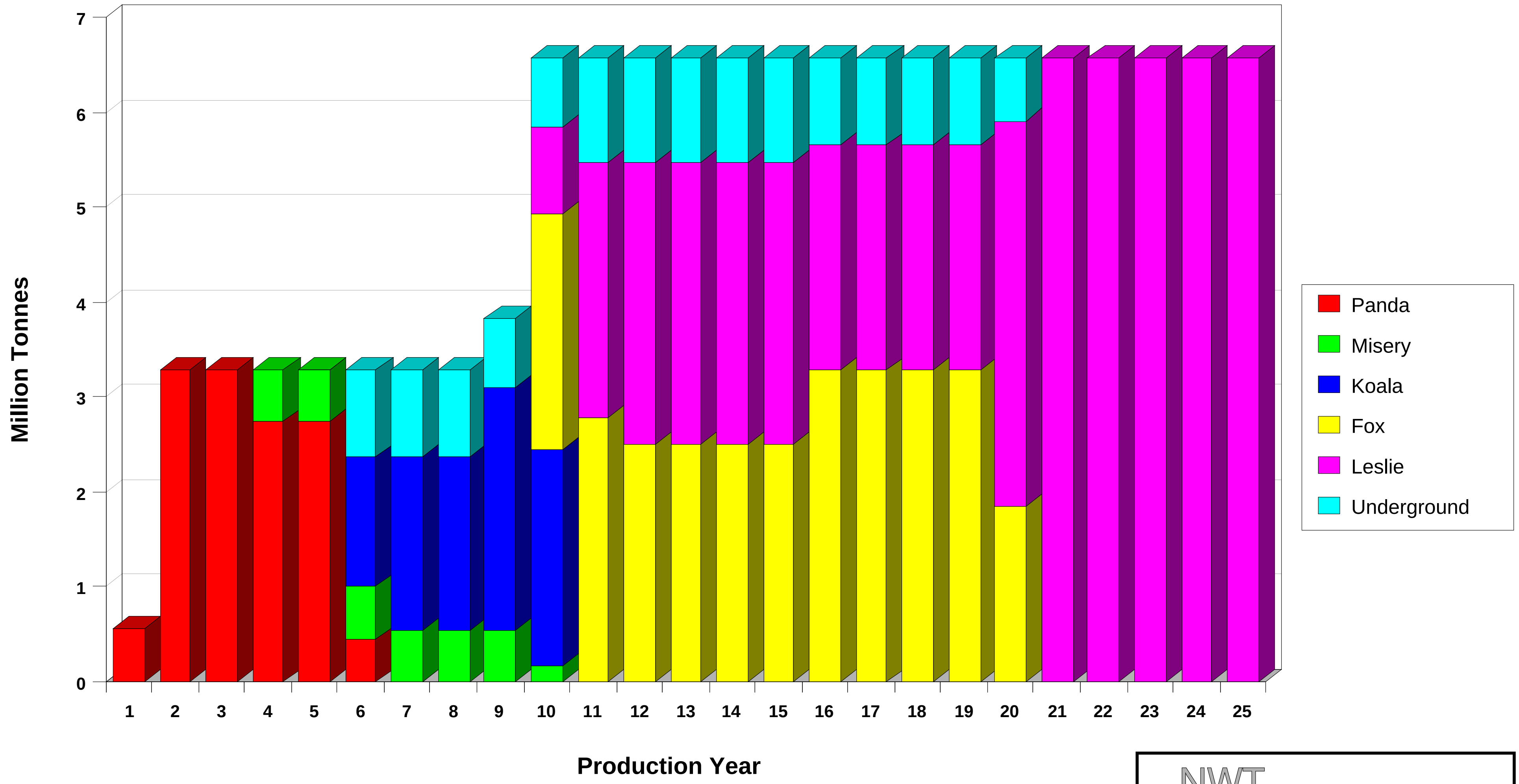
Figure 2.4-1
Total Ore/Waste Production by Year

Note: PM = Tonnes mined during 1996 and 1997 pre-stripping period prior to plant start-up late 1997.

Source: BHP

Table of Contents

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV



NWT DIAMONDS PROJECT

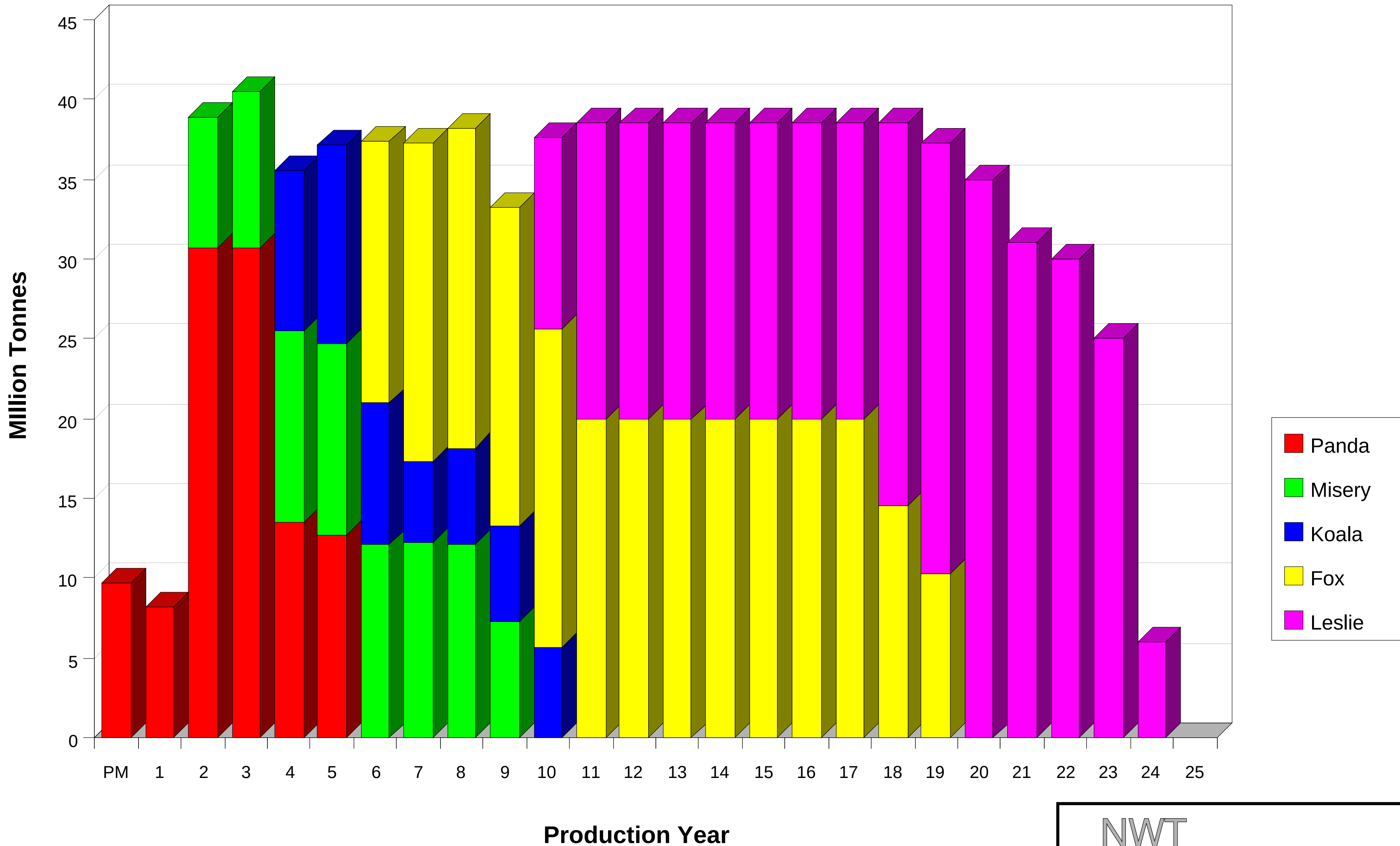
Figure 2.4-2
Process Plant Tonnage by Pipe by Year

Note: PM = Tonnes mined during 1996 and 1997 pre-stripping period prior to plant start-up late 1997.

Source: BHP

Table of Contents

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV



Note: PM = Tonnes mined during 1996 and 1997 pre-stripping period prior to plant start-up late 1997.

NWT DIAMONDS PROJECT

Figure 2.4-3
Waste Rock Tonnage by Pit by Year

Source: BHP

2.4.3 Water Diversion and Lake Drainage

In common with most of the other kimberlite pipes identified to date in the Northwest Territories, the five pipes planned to be mined at the NWT Diamonds Project lie under lakes. These lakes are created by preferential glacial scouring of soft kimberlite surrounded by hard granite, followed by water collection in the resulting depression. To permit open pit mining of a particular kimberlite pipe, the lake above it must be dewatered. Where the lake has significant inflow (e.g., Panda) a diversion channel will need to be constructed to divert the water around the mining area.

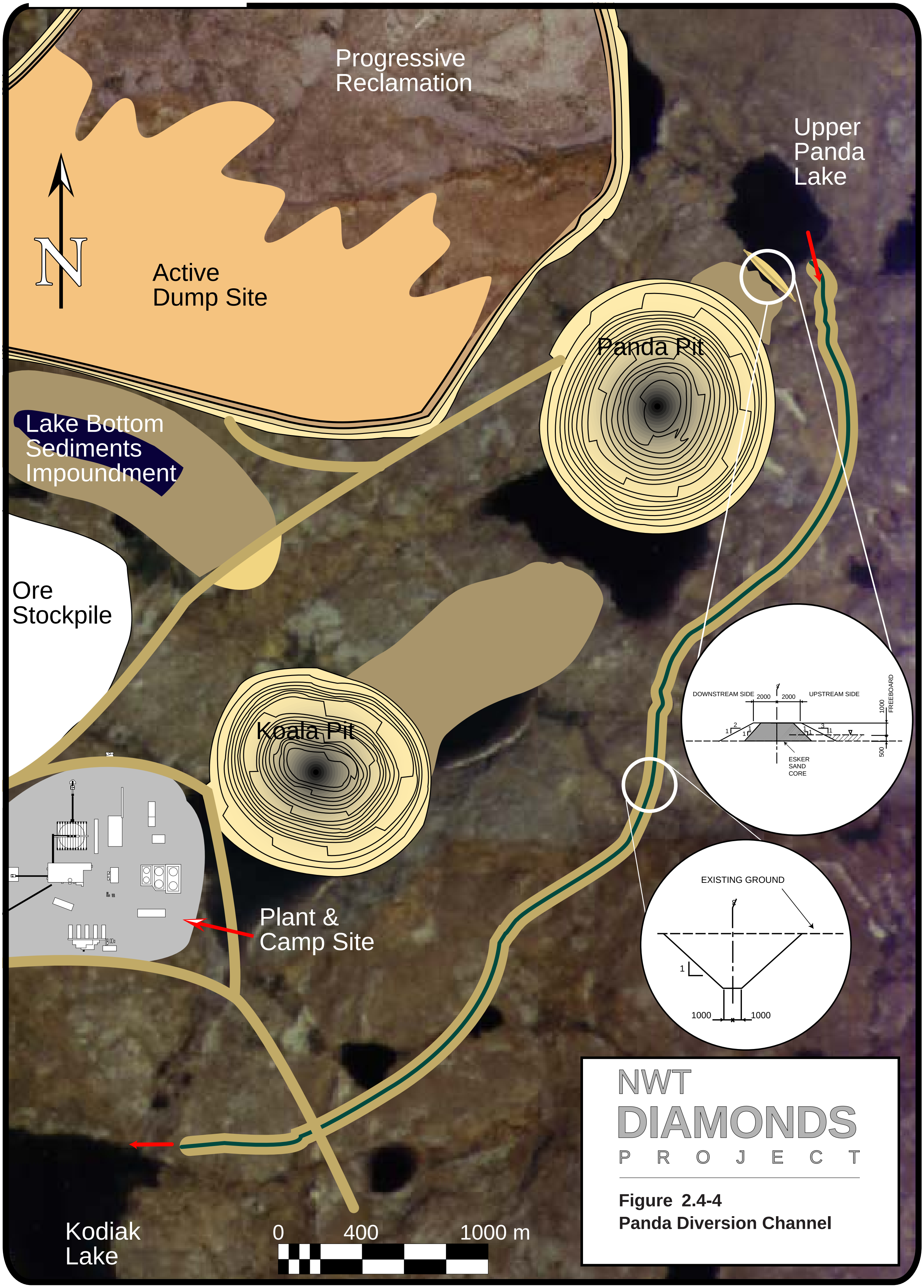
2.4.3.1 Panda Lake

The southern portion of Panda Lake will be dewatered in 1996 by constructing a diversion dam across the northeast arm of the lake, along with a diversion channel to divert water flows around Panda and Koala lakes to Kodiak Lake (Figure 2.4-4). The purpose of the diversion channel is to permit fish passage within the streamflow system so that lake dewatering and subsequent mining of both Panda and Koala pipes can proceed without serious effects on fish habitat. Measures proposed for fish habitat creation and enhancement within the channel are discussed in Volume III, Section 8.

Part of the channel, from Kodiak Lake to the south end of Panda Lake, was excavated during the fall and winter of 1994. In the second quarter of 1996, the second phase of the work will commence at the northern terminus of the existing channel to reach the inlet upstream of the Panda Lake narrows, a distance of approximately 900 m. Most of the excavation will be through bedrock, with steep side slopes bottoming out to an average bed width of 2 m. Depending on soil conditions, flatter side slopes of up to 3H : 1V will be cut in ice-rich tills and backfilled with 1 m to 1.5 m of shotrock. Excess excavation material will be used for various construction fills or road access. The total length of the channel will be approximately 3,530 m.

A temporary diversion dam will be constructed across the shallow Panda Lake narrows immediately upon receiving the water licence approval; an engineered dam will be built downstream of the temporary dam at a later date. Approximately 25,000 m^3 of fill will be required for construction of the temporary diversion dam. On completion of the diversion dam early in the third quarter, water flow from the northern half of Panda Lake will be redirected through the channel. Culvert crossings, sized to ensure that water flows remain unimpeded, will be installed at the existing bulk sample plant access road and airstrip turnaround road. The diversion channel and dam work will be completed so that dewatering of Panda Lake can commence before freeze-up.

◎ Table of Contents



NWT
DIAMONDS
P R O J E C T

Figure 2.4-4
Panda Diversion Channel

Once the pumping equipment is installed, a total of 2.0 million m^3 of water will be pumped from the southern portion of Panda Lake in the third quarter of 1996. The pumping rate of approximately 1,600 m^3/h will minimize downstream flow disruptions by maintaining a flow rate of less than 0.5 m^3/s. Two 800 m^3/h vertical turbine pumps, mounted on a barge in the deepest part of the lake, will be used. The pumped lake water will flow through a buoyant 400 mm diameter x 600 m long HDPE pipeline discharging into the natural channel between Panda and Koala lakes. The pumps will be powered from a single, shore-side 500 kW genset conveying power through a submersible power cable strapped to the discharge pipeline. Dewatering of Panda Lake will take approximately one and a half months.

Particular care will be required toward the end of the dewatering process as the water level approaches the lake bottom and total suspended solids contents approach the total suspended solids discharge limits. The lake dewatering rate will be controlled as required to allow the exposed solids to dry out, or freeze over, to minimize exposed sediment runoff into the remaining lake water. At that time an HDPE discharge pipe will be extended to reach a settling impoundment that will be created for turbid water and lake bottom sediments. The impoundment will be a dammed off stream channel southwest of the Panda pit, constructed from excavated diversion channel and pre-stripping materials. The slimes and water will be pumped into this repository by means of a submersible pump system. Excess water will be released from the impoundment only after suitable retention or treatment to meet the water discharge criteria.

After the Panda dewatering operations are finished, the barge and pumping equipment will be relocated and used to dewater all the other lakes in the planned mining areas, in the scheduled sequence.

2.4.3.2 Misery Lake

Misery is a small lake at the upper end of a stream that drains directly into Lac de Gras. Lake dewatering will be done during the summer of 1998 before pre-production work commences in this pit (i.e., in the third year of the development program).

The dewatering pump discharge line will feed into the Misery Lake stream channel that flows to Lac de Gras. Approximately 1.7 million m^3 of water will be pumped from Misery Lake in a month and a half. An impoundment for turbid water and lake bottom sediments will be created out of pre-stripping waste in the upper reaches of the drained outfall stream channel southeast of Misery Lake. Only water meeting the water discharge criteria will be released.

2.4.3.3 Koala Lake

Koala Lake receives its inflow from Panda Lake. The diversion dam upstream of the Panda pit will enable Koala Lake to be dewatered in 2000, the fourth year of the mine plan. The dewatering pump will discharge into the headwaters of the Koala outflow stream to Kodiak Lake. The pumping rate will be approximately 1,600 m^3/h, requiring 3 months to displace the 3.0 million m^3 of water contained in the lake and runoff during the pumping period. The turbid water and slimes likely to be encountered as the water level reaches the lake bottom will be pumped to the same lake bottom sediments impoundment constructed previously for the Panda dewatering operation. Similar water discharge criteria will apply.

2.4.3.4 Fox Lake

Surface runoff will be diverted and Fox Lake dewatered during the summer before preproduction commences in this pit, in 2002, the sixth year of project development. The discharge pipe outflow will be into the natural discharge stream that flows from Fox Lake into the next downstream lake, known as Fox 2 Lake. With the pump unit to be located at the deepest portion of Fox Lake, the discharge pipe will be 1,200 m long. At a pumping rate of approximately 1,600 m^3/h, it will take four months to pump out the 4.3 million m^3 of water contained in the lake.

The turbid water and slimes encountered as the water level falls will be pumped to a natural containment area diked off with rock fill in the southern portion of the old Fox Lake bottom. Excess water behind this impoundment will be discharged after solids settling or treatment brings the water quality below the discharge limits.

2.4.3.5 Leslie Lake

Leslie Lake is immediately downstream from Long Lake, which will be used for tailings deposition. Consequently, a dam will be installed at the outlet from Long Lake into Leslie Lake. Controlled discharge from Long Lake will be via a spillway to the west of Leslie Lake that will allow flow to a lake just downstream from Nero Lake, thus bypassing Leslie Lake. No additional diversion works will be required to start dewatering Leslie Lake, although a dam will be constructed to create a sediments impoundment area, and another will be required downstream to prevent Moose Lake from backflowing into the Leslie pit.

The pumping system will discharge into the Leslie Lake outfall stream that flows into Moose Lake. A 700 m long discharge pipeline will be required to reach the deepest portion of the lake. Some 2.1 million m^3 of water will be pumped from Leslie Lake over two months, beginning in the summer of 2006.

As with the other dewatering plans, turbid water and slimes will be handled through an impoundment, in this case a shallow reach on the west side of Leslie Lake. This area will be diked off by waste rock to allow the solids to settle as required to meet discharge guidelines before any water is released.

2.4.4 Open Pit Mining

2.4.4.1 Pit Design

Several factors associated with economic open pit mining of the multiple kimberlite pipes controlled the overall direction of mine planning. The pipes have distinct physical characteristics – they are predominantly carrot shaped – that result in a high stripping ratio, which in turn must be met with a high capacity materials handling fleet. In addition, the remoteness of the project site and the severe cold temperatures dictate the need to fly in and accommodate the work force. Therefore, to maximize productivity and minimize labour requirements, the largest practical open pit mining equipment will be used.

To accomplish the productivity demands and meet the operating requirements of the large mining equipment, the following basic parameters were established for mine planning:

- nominal bench height of 15 m in waste rock
- nominal bench height of 7.5 m in ore
- ramp widths of 30 m and a gradient of 10% on the inside edge
- average minimum mining width of 100 m for waste pushbacks
- waste stripping capacity of 38 to 40 million t/a
- pit bottom minimum diameter of 50 m
- additional contact mining dilution of 1 m of barren rock
- maximum incremental strip ratio of 30 waste:1 ore.

A preliminary slope stability evaluation was undertaken to define reasonable slope angles for pit design and to minimize the possibility of wall failures that could disrupt the mine plan and overall design. Steffen Robertson & Kirsten Inc. (SRK) was engaged to conduct this evaluation.

Drill hole data and underground mapping were used to identify probable failure modes within the rock mass. The pit slope walls are primarily in granite country rock with limited faulting and a favourable rock mass rating (RMR). As such, any plane shear and wedge failures will be small-scale (single bench), posing little danger to worker safety, haul roads or potential reserves.

Design values sufficiently accurate for mine planning were determined through computer modelling and analysis. Double bench heights of 30 m and 11 m wide catch berms were adopted, resulting in interramp slope angles of 65° and an overall slope angle, including ramps, of approximately 55° (Figure 2.4-5). It was further assumed that all final pit slopes will be in the granite host rock, that the lake bottom sediments will be stripped off to either bedrock or to more competent overburden at a slope angle of 37° and that the only slopes in kimberlite will be the two deepest benches of each pit, also at a design slope of 37°.

2.4.4.2 Equipment Requirements and Operation

Based on the preceding design criteria, the production requirements and BHP's knowledge of proven operating practices, the approach to open pit mining will be as follows:

- The pits will be developed in a series of pushbacks, with ore and waste excavated concurrently. To provide the necessary flexibility for this type of operation, a conventional truck/shovel operation is required.
- The planned production levels require the use of large open pit mining equipment to achieve low unit operating costs and minimize the infrastructure required to accommodate the work force.
- An electric cable shovel will be used for removal of granite waste rock and some consolidated waste sediments.
- A diesel hydraulic front shovel will be used for the remaining waste sediments, secondary waste rock mining and kimberlite ore production.
- Large mechanical or diesel electric drive trucks will be used for both waste and ore haulage.
- Two smaller diesel hydraulic shovels and smaller mechanical drive trucks will be used for the Misery mining operation.
- The mining operation will be continuous, 24 h/d, 7 d/wk, 365 d/a, with two 12 hour shifts per day.

The major open pit equipment is listed on Table 2.4-1, followed by a discussion of the proposed methods of equipment operation.

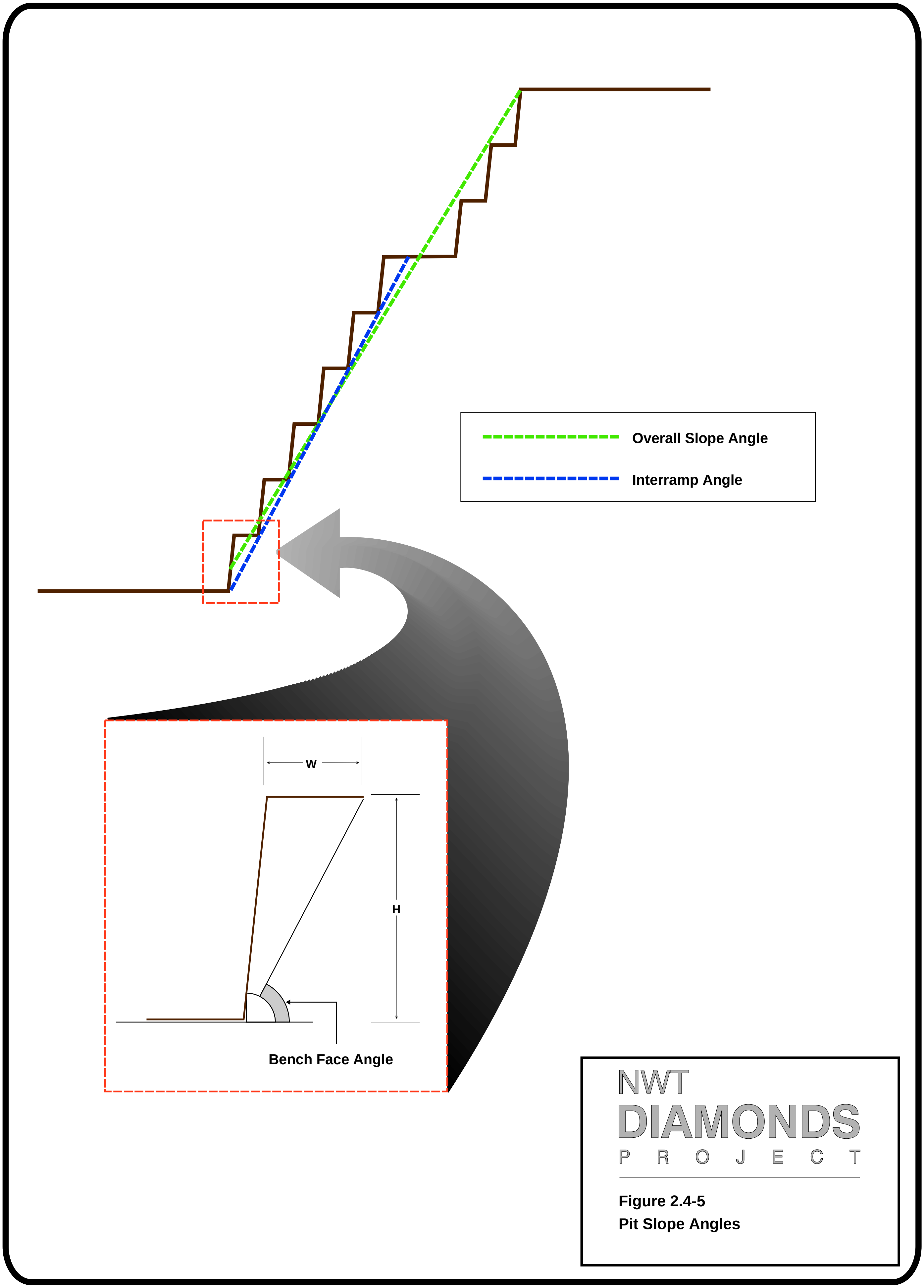


Figure 2.4-5
Pit Slope Angles

Source: Steffen Robertson & Kirsten Inc.

Table 2.4-1
Open Pit Mining Equipment

Description	Number of Units
Major Mining Equipment	
Rotary Drill (31 to 38 cm)	
Electric	1
Diesel	2
Electric Shovel - 36 m^3	1
Diesel Hydraulic Shovel - 22 m^3 and 12 m^3	3
Haul Truck	
218 t	12
86 t	10
Off-highway Truck-trailer - 392 kW	6
Wheel Loader - 18 m^3	1
Motor Grader	
205 kW	2
149 kW	1
Track Dozer - 388 kW	5
Wheel Dozer - 336 kW	3
Explosives Delivery Trucks (contractor) - 22 t	4
Surface Support Equipment	
Haul Truck Retrieve Vehicle	1
Utility Loader	
6.0 m^3 (contractor)	1
3.5 m^3	2
1.0 m^3	1
Excavator/Backhoe	
2.3 m^3	1
1.0 m^3	1
Track Dozer - 123 kW	1
Water Truck - 336 kW, 35,000 L	2
Crane	
135 t	1
60 t	1
30 t	1
Hi-boy Tractor/Trailer - 50 t	1
Low-bed Trailer - 150 t	1
Forklift - 1.4 to 16.4 t capacity	8
Transport Bus - 30 passenger capacity	3
Small Vehicle - ½ t, ¾ t, 1 t	54
Vacuum Truck	1
Ambulance	1
Rescue Van	2
Fire Truck	2
Lube/Fuel Truck	2
Radio (Mobile)	130

2.4.4.3 Drilling and Blasting

The present mine plan involves drilling and blasting between 40 and 45 million t/a of waste rock and ore. Three rotary blasthole drills, capable of producing 230 mm and 312 mm diameter blastholes 15 m deep in a single pass, will be required to meet this production level. Given the nature of the mining operation, two of the drills will be diesel powered and the third electric powered.

The diesel drills will provide the mobility needed to service multiple ongoing open pit operations and multiple benches within each pit. Their ability to operate independently of the site electrical infrastructure system will also be essential, as electric power will not be available before the initial pre-stripping work commences. One of the diesel units will be dedicated primarily to the Misery pit, which will not be serviced with pit electrical power, and the other to ore production. The electric powered drill will not be as mobile because of its trailing cable and connection to the electrical system; this drill will be used in conjunction with the electric shovel, primarily for waste stripping duties.

It is envisaged that all explosives manufacturing, handling and loading of blastholes will be performed by an explosives contractor. As much as 12,000 t/a of bulk explosives will be required for all mining operations. The primary blasting agent will be a combination of ammonium nitrate and fuel oil, commonly known as ANFO.

The annual ammonium nitrate requirements will be delivered in the form of prills by bottom-dump highway trucks over the winter road and stored in a purpose-built facility 1.1 km southwest of the process plant (Section 2.7.9). In some areas, wet ground conditions will require the use of water-resistant emulsion explosives. A manufacturing and emulsion plant will be constructed adjacent to the AN storage facility, in compliance with safe distance regulations. The manufacturing plant will have sufficient space to accommodate tanks, a mixing system, transfer bins and delivery vehicles for the future underground explosives requirements.

From the manufacturing plant, the explosives product will be delivered to the open pit blastholes in dedicated, contractor-provided, 22 tonne capacity trucks. The trucks will be capable of mixing and distributing any type of product from straight ANFO to emulsion, including AN/emulsion mixes of varying proportions and any other blasting agent additives as field conditions warrant.

Priming, connecting, coordinating and detonating of blastholes will be done by the mine site blasting crew. Non-electric detonators will be used for safe and efficient controlled blasting.

All explosives transportation, storage, manufacture and use for open pit and underground mining operations will be carried out in full compliance with the following government acts and regulations:

- *Canadian Employment Standards Act*, Canada Labour Code
- *Controlled Products Act* (Canada)
- *Environmental Protection Act* (Canada)
- *Explosives Act* (Canada)
- *Government Organization Act*, EARP Guidelines Order (Canada)
- *Hazardous Products Act* (Canada)
- *National Research Council Act*, National Fire Code (Canada)
- *Transportation of Dangerous Goods Act* (Canada)
- *NWT Mining Safety Act*
- *NWT Fire Prevention Act*
- *NWT Occupational Health and Safety Act*
- *NWT Labour Standards Act*
- *NWT Workers' Compensation Act*.

2.4.4.4 Loading and Hauling

With the exception of the Misery operation, primary waste loading at the open pits will be done with a 36 m^3 electric cable shovel, matched with 218 tonne haul trucks. A shovel of this size, derated to reflect conditions specific to the site, can load a 218 tonne haul truck in three passes at a rate in excess of 61,400 t/d or 22.4 million t/a.

A smaller, 22 m^3 diesel hydraulic front shovel will be used for the remaining waste stripping and ore loading duties. This shovel will be able to load either granite waste rock or ore into the 218 tonne haul truck in five passes. Its production capacity is more than 40,000 t/d or 14 million t/a.

A 15 m^3 rubber-tired front-end loader, capable of loading the 218 tonne haul trucks in seven passes, will provide backup for the electric cable and diesel hydraulic shovels. The production capacity of the loader is 21,600 t/d or 7.9 million t/a.

The total capacity of the shovels and loader will be more than 45.0 million t/a. The three units will be interchangeable, essentially eliminating any haulage interruption or shortfall due to loading capacity. During periods of lower loading demand, the loader will be used for general pit service associated with maintaining haul roads, stockpile management and external pit loading operations as required.

The 218 tonne haul truck, either mechanical or electrical, matches the production capabilities of all three large loading units. Twelve of these trucks will be required at the peak production periods from year 2000 to the end of mine life.

Different loading and hauling equipment will be required at the Misery pit, 29 km distant. The remoteness, the small size and the high stripping ratio associated with the deposit dictate that the mining operation should be carried out on a stand-alone basis. Two 11.5 m^3 diesel hydraulic shovels will be used for both ore and waste loading to achieve the average annual production rate of 14 million tonnes. Each shovel will be capable of producing 7.1 million t/a when matched with 86 tonne haul trucks. One will be configured as an excavator for above-bench capability and the other as a front shovel to provide full face capability. The combined annual capacity of 14.2 million t/a will meet the peak annual production requirement while providing significant operating versatility for the development of multiple waste stripping headings.

The 86 tonne mechanical haul truck chosen for Misery matches the production capabilities of the 11.5 m^3 shovels, with four passes required to load each truck. A total of nine trucks will be required at the peak production period in year 2005 to haul both ore and waste rock out of the pit.

A stockpile for run-of-mine (ROM) ore will be established at the Misery pit crest for subsequent ore haulage to the plant site. A front-end loader will load the ore into off-highway truck/trailers for transport over the Misery haul road to the plant site. The truck/trailers are better suited to this haulage because they can operate on a narrower road than the 86 tonne haul trucks and have faster cycle times.

It is possible that a contractor will be employed to carry out all or a portion of mining operations.

2.4.4.5 Mobile Support Equipment

A fleet consisting of large tracked dozers, rubber-tired dozers, graders and water trucks for dust suppression will be required to build and maintain the haul roads and secondary access roads, to doze dump material and generally to keep the dump and shovel working areas flat, smooth-surfaced and free of spilled rock. This fleet is included in the support equipment list (Table 2.4-1). Service vehicles to support the mine production operations, including mobile cranes, lube and repair trucks and pickup trucks, are also listed in this table.

2.4.4.6 Other Support Equipment

Pumping: Pit dewatering by pumping will be an ongoing aspect of each pit development. The amount of water involved will vary throughout the year. Because all ore will be mined from the lowest bench of each pit, the bottom will have to be kept dry. Staged pumping using submersible pumps and temporary sumps constructed in the pit will be established, depending on the water inflow rates and system head characteristics. Each concurrent mining operation will have a dedicated pumping system, which will be modified as the pit deepens. Turbid mine water pumped from the pit will be collected and treated as required in a specially constructed impoundment in the associated waste dump area (Section 2.4.5). All water eventually discharged from the impoundment to the environment will meet discharge limits for total suspended solids (TSS) and all other regulatory water quality criteria. Once process plant operations commence, it is possible that water from all pits except Misery could be pumped to the Long Lake tailings disposal impoundment or to the process plant.

Portable Lighting: Field lighting will be required in the dumping and mining areas during the night shifts and dark winter months. A total of four diesel powered portable lighting plants will be provided for the active areas. The units selected are rated at 2 kVA and are trailer-mounted for easy relocation.

Electrical Power: Electrical power will be required at the four main pits surrounding the process plant to supply the 36 m^3 shovel, rotary drill and pit dewatering pumps.

Electric power generated at the centrally located diesel power plant (Section 2.7.5) will be transmitted to each open pit except Misery by 29 kV overhead lines. A high voltage power line loop will encircle each pit crest perimeter, with multiple high voltage feeder lines extending down the pit walls to the operating areas.

An independent diesel power generating system will be established at the Misery operation, but power will be provided to the surface facilities only. No electrical mining equipment except pit dewatering pumps will be used at the Misery pit.

2.4.4.7 Equipment Maintenance

The equipment maintenance schedule takes into account the effects on equipment of the harsh operating conditions and the remote location by assuming an average mechanical availability of 75% for the primary drilling, loading and hauling units and of 65% for the 15 m^3 loader and support equipment.

All maintenance on haul trucks, the 15 m^3 loader and other mine mobile support equipment used in the four main pits will be carried out inside the truckshop/ offices/warehouse complex at the plant site. A retrieve vehicle and lowbed located at the surface plant will ensure that all these units can be brought to the truckshop. The large production equipment (i.e., drills, diesel shovel and electric shovel) will remain in the field for service and maintenance. A separate repair truckshop will be constructed at Misery to perform minor service on the equipment used at that operation. The equipment will be sent back to the main Koala shop for major servicing.

The primary drilling and loading equipment will have large, purpose-built equipment houses to allow maintenance work to be performed from a relatively sheltered and yet spacious area. During field service, self-contained mobile shop facilities (trailers) will be brought to the unit. Where maintenance on the outside of a production unit must be done in extreme cold weather, a large cargo parachute shelter and diesel-fired space heaters will be used to maintain a productive working temperature.

The maintenance activities necessary to keep the mine and mobile equipment in good working condition include regular inspections, oil change, lubrication, filter changes, tire rotation and regular tire air pressure checks, as well as changeout of parts after failure and prior to predicted failure. Workshops and small mobile equipment will be necessary to carry out this work. Equipment maintenance will be performed on a 24 h/d, 7 d/wk schedule. At present it is assumed that most maintenance personnel will be employed by the mine, although certain equipment dealers who offer full contract maintenance programs will perform the major component rebuilds (engines and transmissions) off site.

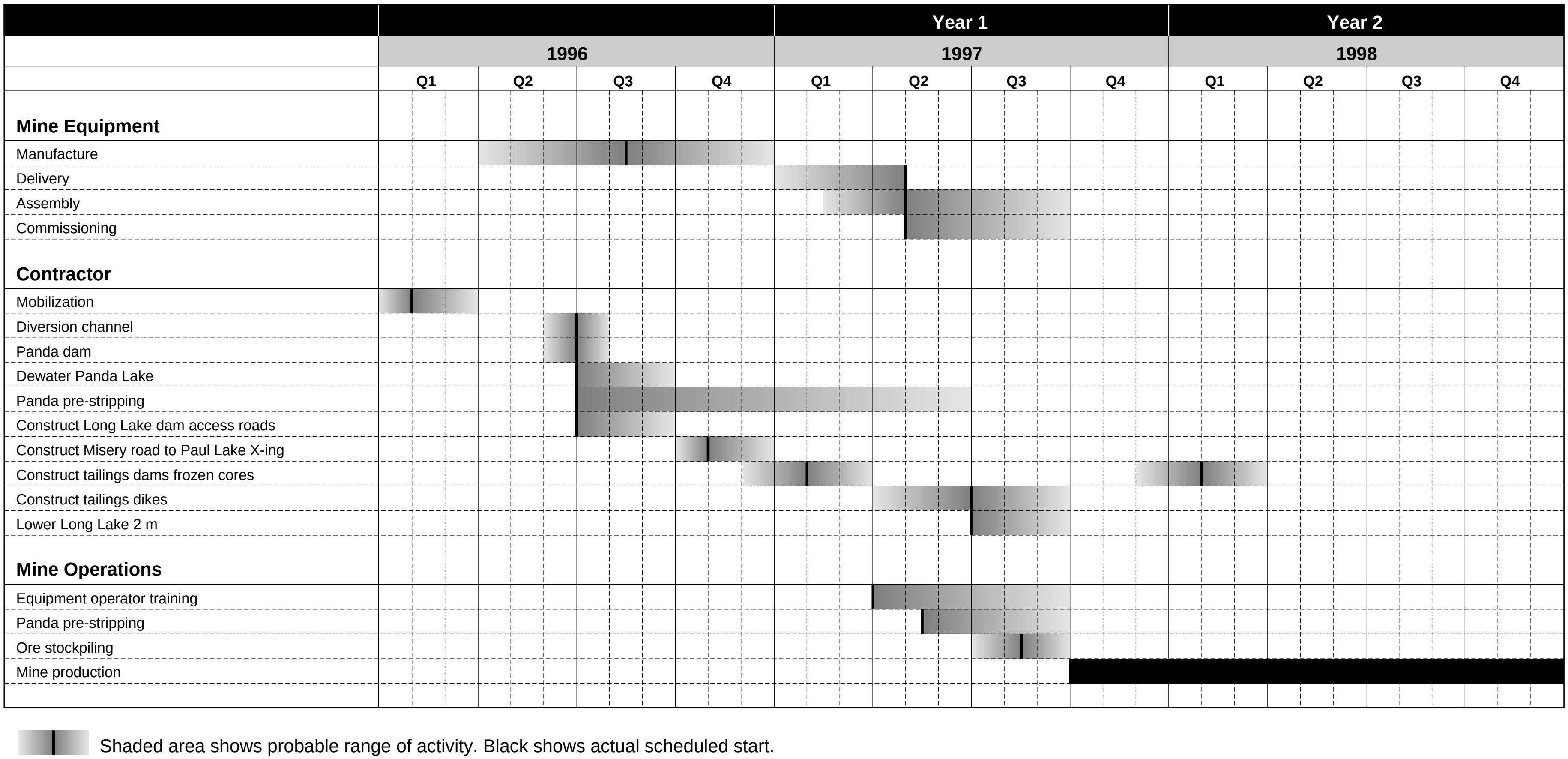
2.4.4.8 Preproduction Stripping Operations

During the pre-stripping phase of the project, a total of 10.1 million tonnes of lake bottom sediments, overburden and waste rock will be excavated from the Panda pit to expose a year's supply of ore for the process plant.

As shown on the start-up schedule (Figure 2.4-6), an earthworks contractor will complete the final Panda diversion channel excavation and the temporary dam in mid-1996. Once the water flow into the lake is dammed off, the contractor will proceed with pre-stripping to remove the initial 5.1 million tonnes of waste materials over the next several months. The contractor will operate on a two shifts per day, 7 d/wk work schedule until the permanent mining equipment is delivered.

Mine operations personnel will begin working at Panda in the second quarter of 1997 on a single shift per day, phasing out the earthworks contractor after two months and removing another 1.0 million tonnes of waste materials. The

Table of Contents



NWT DIAMONDS PROJECT

Figure 2.4-6
Mine Start-up Schedule

Source: BHP

contractor will then proceed with the Long Lake tailings dam construction, utilizing the waste stripped from Panda. With completion of the last 4.0 million tonnes of pre-stripping over the next three months, the timing of open pit ore production from Panda will coincide with the process plant start-up in the last quarter of 1997.

A substantial amount of the pre-stripping material will be used as general construction fill for the tailings dam, roads and other surfaces. Embankment dam construction will require both granite waste rock for the shell of the structures and suitable esker material for the frozen cores. An estimate of the quantities of materials to be used for embankment construction is given on Table 2.4-2.

Table 2.4-2
Embankment Fill Volumes (m^3)

Dam	Airstrip Esker	Minus 15 cm Mine Rock	ROM Mine Rock	Riprap Mine Rock
Long Lake Tailings Impoundment				
East Dam				
north leg	6,800	9,300	43,000	4,700
south leg	42,100	35,500	147,000	14,000
Dike A	46,000	46,000	335,000	-
Dike B	29,000	29,000	168,000	-
Dike C	76,000	76,000	476,000	-
Dike D	57,000	57,000	348,000	-
Outlet Dam	37,900	26,300	108,000	9,100
South Dam	24,700	22,400	95,000	8,700
Panda Diversion Dam	10,700	5,300	19,000	not required
Total	320,200	306,800	1,739,000	36,500

Additional waste rock from Panda pre-stripping will be used to construct the access road to and initial lift of the Panda waste dump, which will be on the south slope of the small ridge west of the Panda ultimate pit limit. Lake bottom sediments and overburden not used for construction fills will be stockpiled for future reclamation in a strategic location adjacent to the dump to permit easy retrieval, as required. The saturated, fine-grained sediments will be dumped immediately south of the Panda waste dump in a natural catchment area diked off with rockfill.

Mining benches developed in competent host rock during pre-stripping will be 15 m high. Under the lake bottom, where the material is expected to be unconsolidated, bench heights may have to be shallower, depending on the thickness of the unconsolidated layer. Pioneering work would proceed along the competent bedrock contact to strip the unconsolidated material to the contact elevation. Figure 2.4-7 provides a section view of planned pre-stripping operations at the Panda pit.

Pit dewatering during the initial pre-stripping and subsequent first year of production will be done by developing regularly spaced temporary collection sumps from below the lowest active mining bench. Water collected in these sumps will be pumped up to the pit crest and into the lake bottom sediments impoundment. Provision will be made for water treatment to ensure that all subsequent outflow meets the applicable discharge criteria. At the end of the lowest preproduction bench (420 m level), a sinking cut ramp will be driven to the bench below. Water collection and pumping facilities will be installed at this bench for the first year of production mining to keep the water level below the working level. The piping system will be on sufficient grade to allow complete free-draining of the water back to the sump, to prevent freezing during cold weather.

To permit the operation of electric mining equipment by the planned production start date, the overhead power line to Panda, the open pit 29 kV power line loop and feeder lines will be installed during the pre-stripping phase. The loop will be located a minimum of 50 m beyond the planned ultimate pit perimeter. With the power plant planned to be in operation at the scheduled time of full production, electrical service, including step-down transformers, will be fully available to supply the 36 m^3 electric cable shovel and 312 mm electric rotary drill.

2.4.4.9 Production Phase Operations

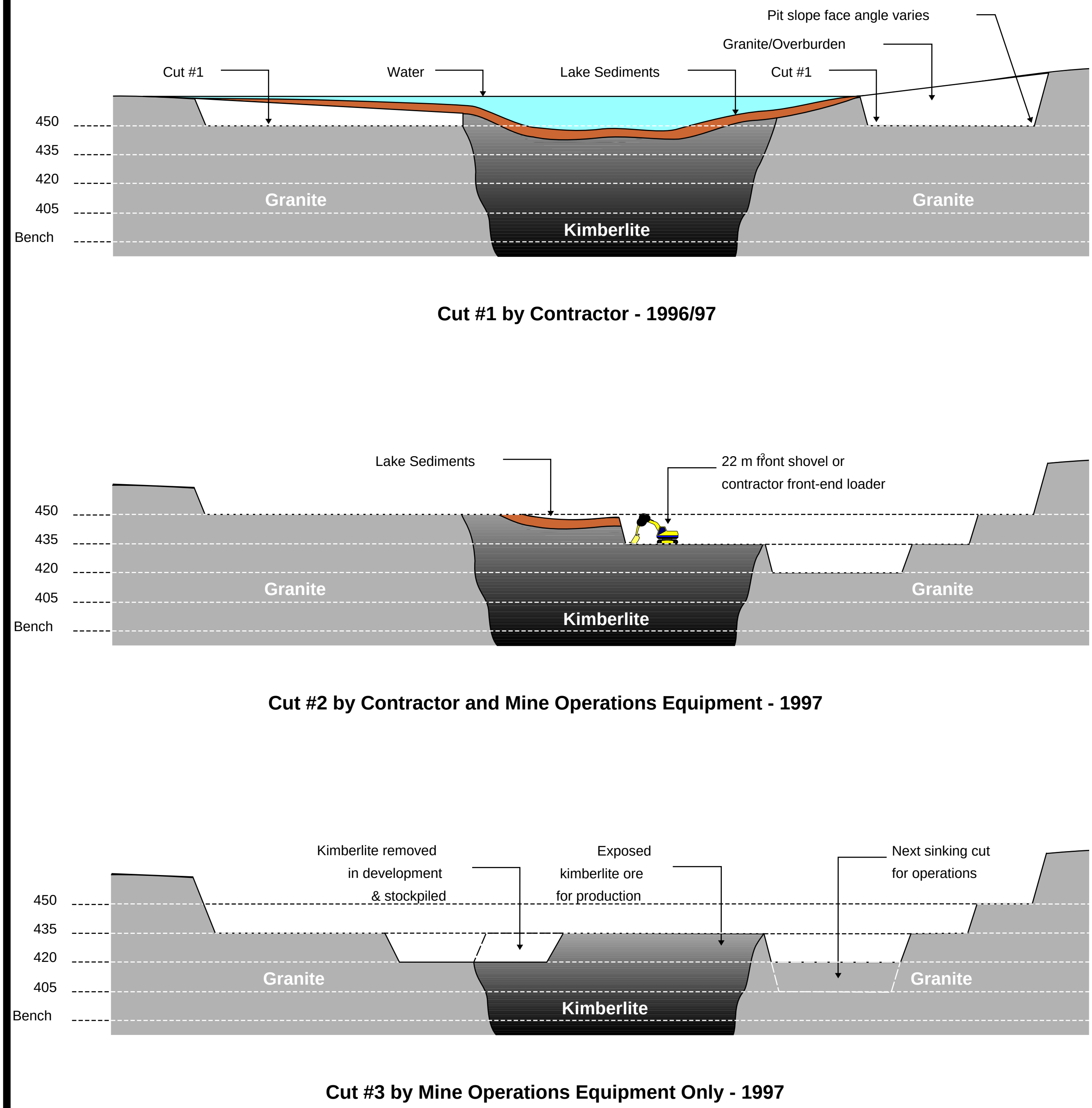
The preliminary mine planning work undertaken to date is based on using the most economical open pit mining methods to develop the diamondiferous pipes. Successful coordination of the mining sequence to match the capacity of the processing plant will be a complex task, given the selected multiple pipe development approach. To demonstrate the proposed development, the sequence has been divided into logical timing units, and a series of incremental pit design drawings showing the site configuration at the end of each period has been prepared (Figures 2.4-8 to 2.4-12).

The basic pre-stripping development work and the dewatering system for each pit will be the same as described previously for Panda.

1997 to 1999 (Years 1 to 3)

Production mining will begin at Panda at the end of the pre-stripping period. Panda will be the only pit producing ore from Years 1 to 3 to meet the constant plant throughput rate of 9,000 t/d.

◎ Table of Contents



Note: *Pit walls are not at ultimate limits on 420 to 465 benches during preproduction sequence.*

NWT
DIAMONDS
P R O J E C T

Figure 2.4-7
Panda Preproduction Section Views of Mining Sequences

Source: BHP

◎ Table of Contents

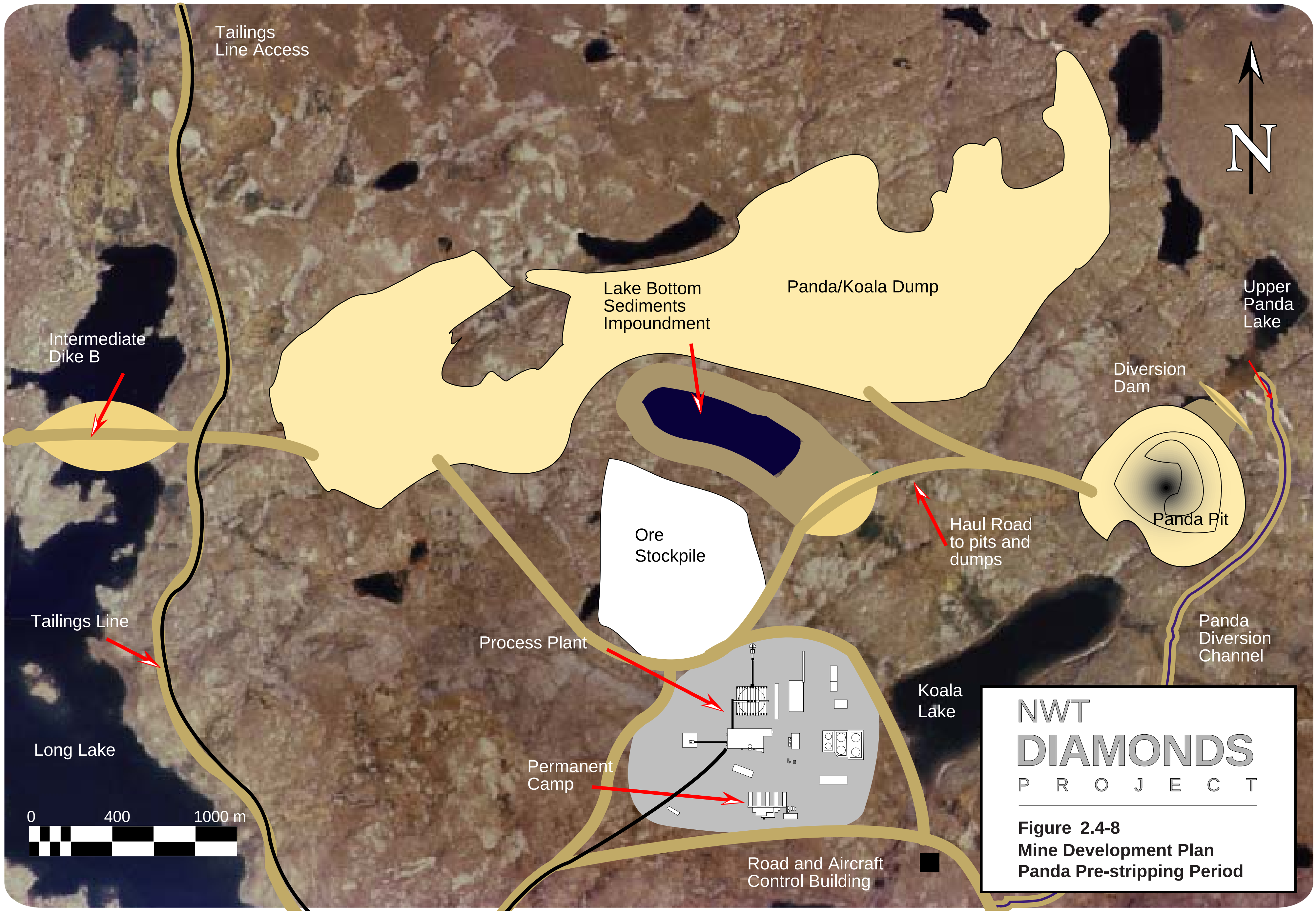


Figure 2.4-8
Mine Development Plan
Panda Pre-stripping Period

◎ Table of Contents

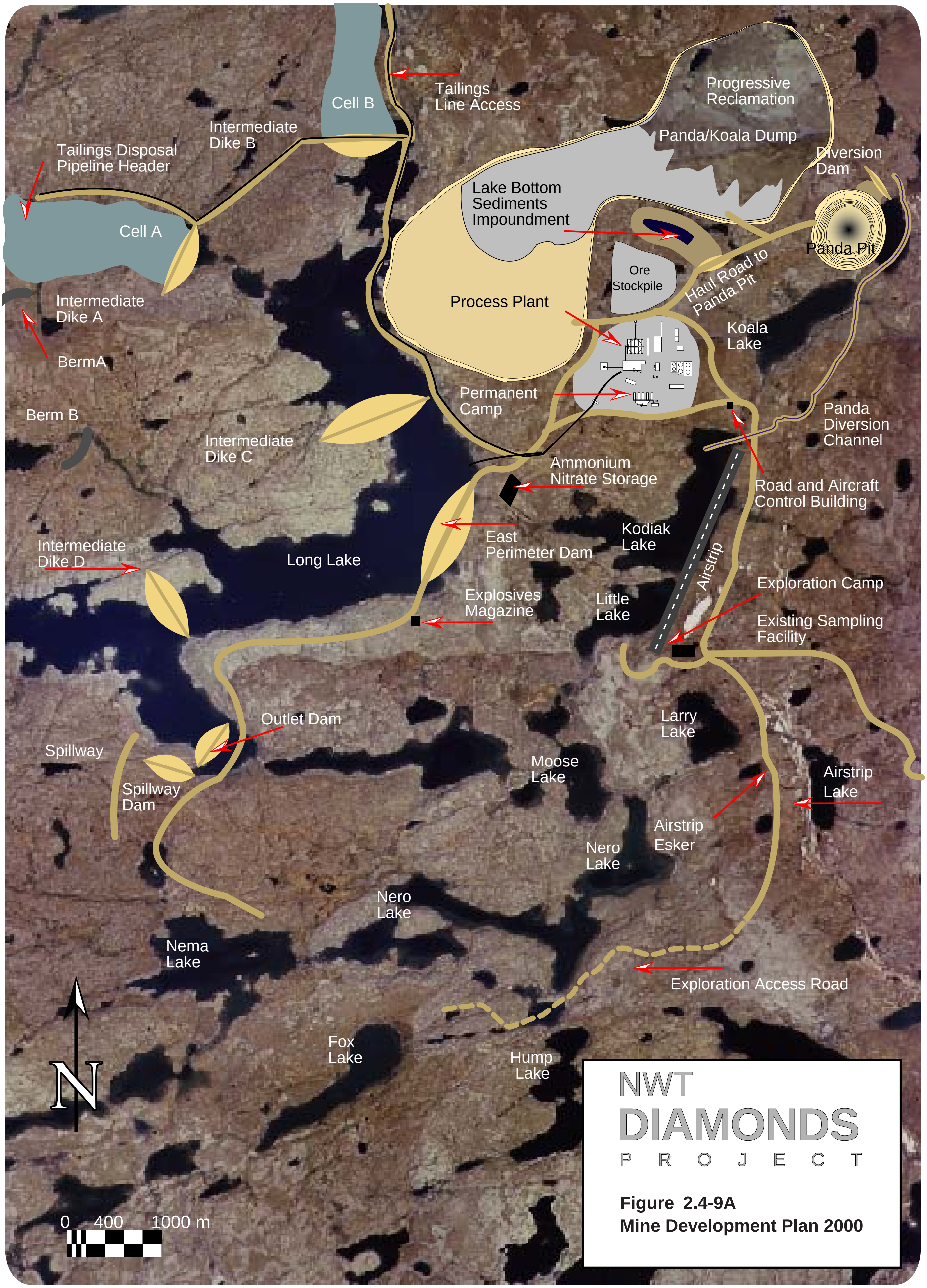


Table of Contents

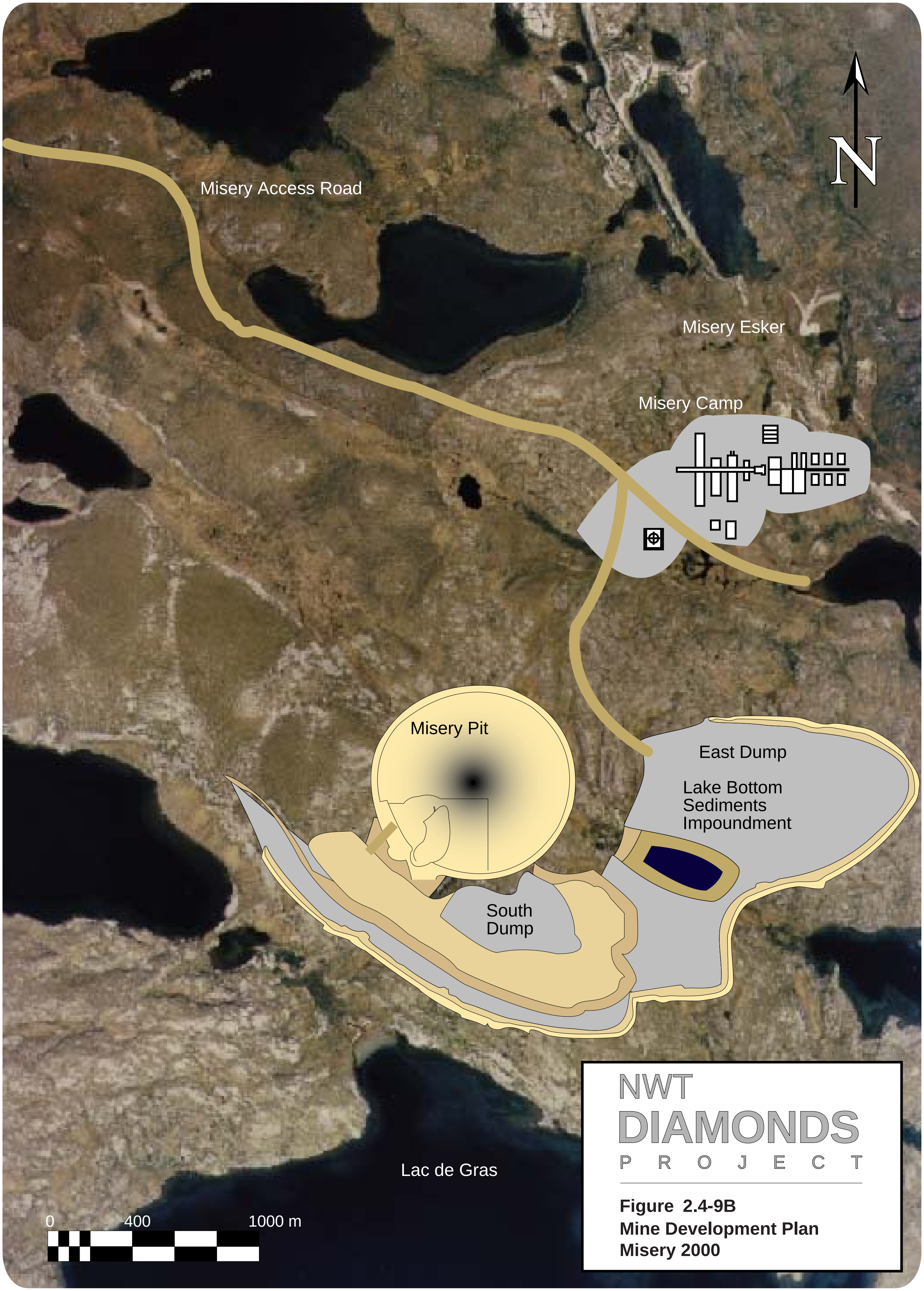


Figure 2.4-9B
Mine Development Plan
Misery 2000

◎ Table of Contents

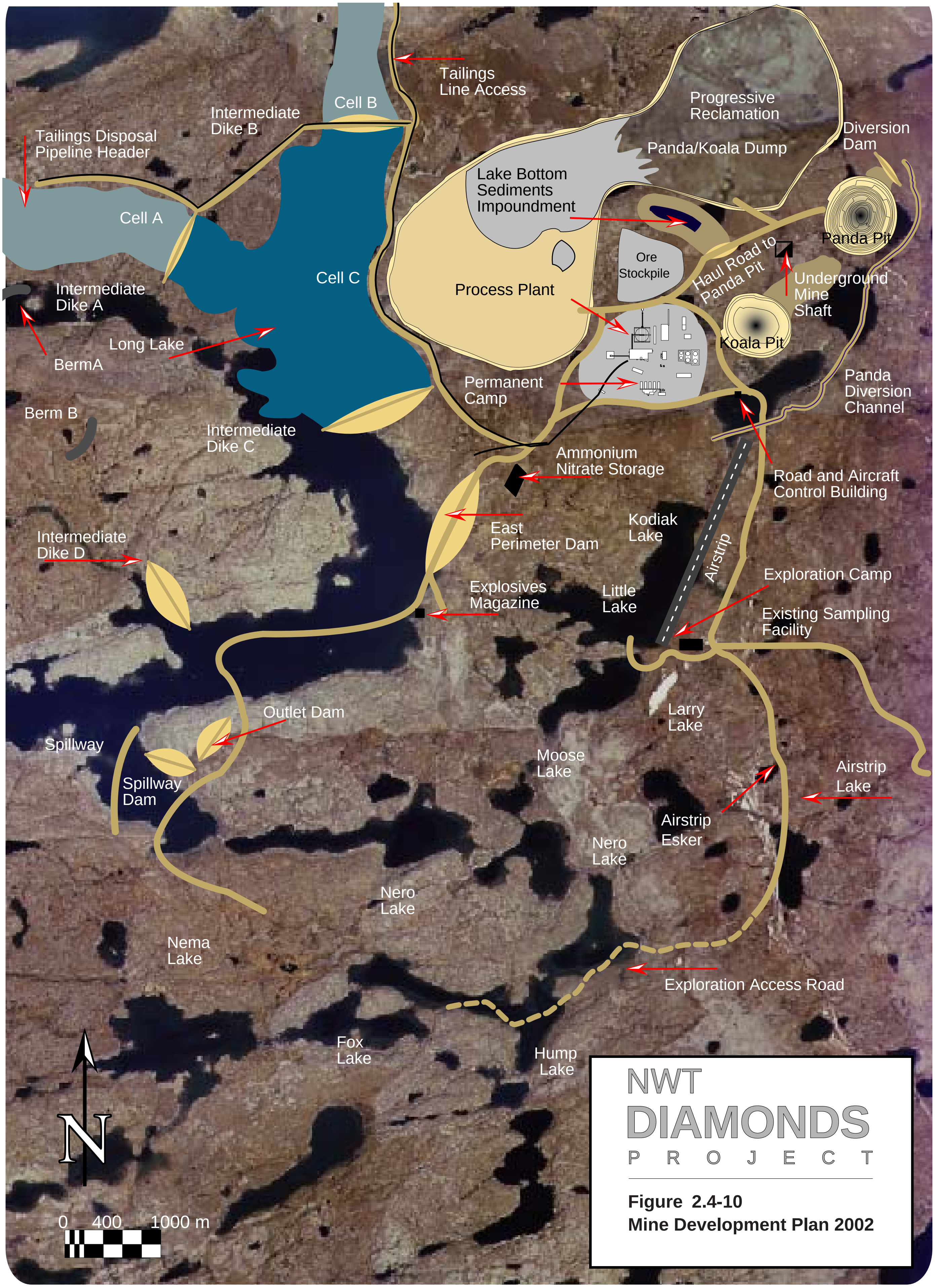
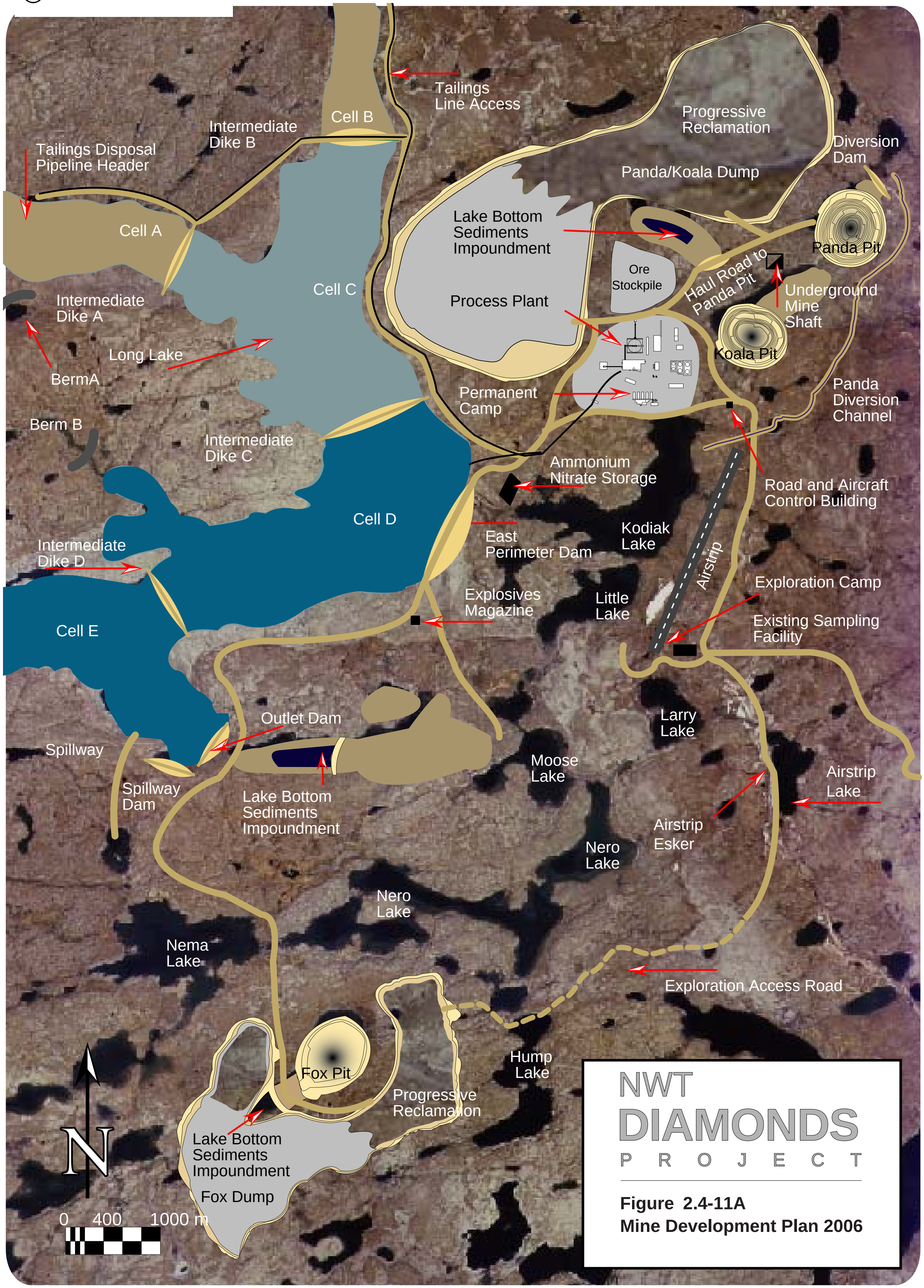


Figure 2.4-10
Mine Development Plan 2002

Table of Contents



NWT
DIAMONDS
P R O J E C T

Figure 2.4-11A
Mine Development Plan 2006

◎ Table of Contents

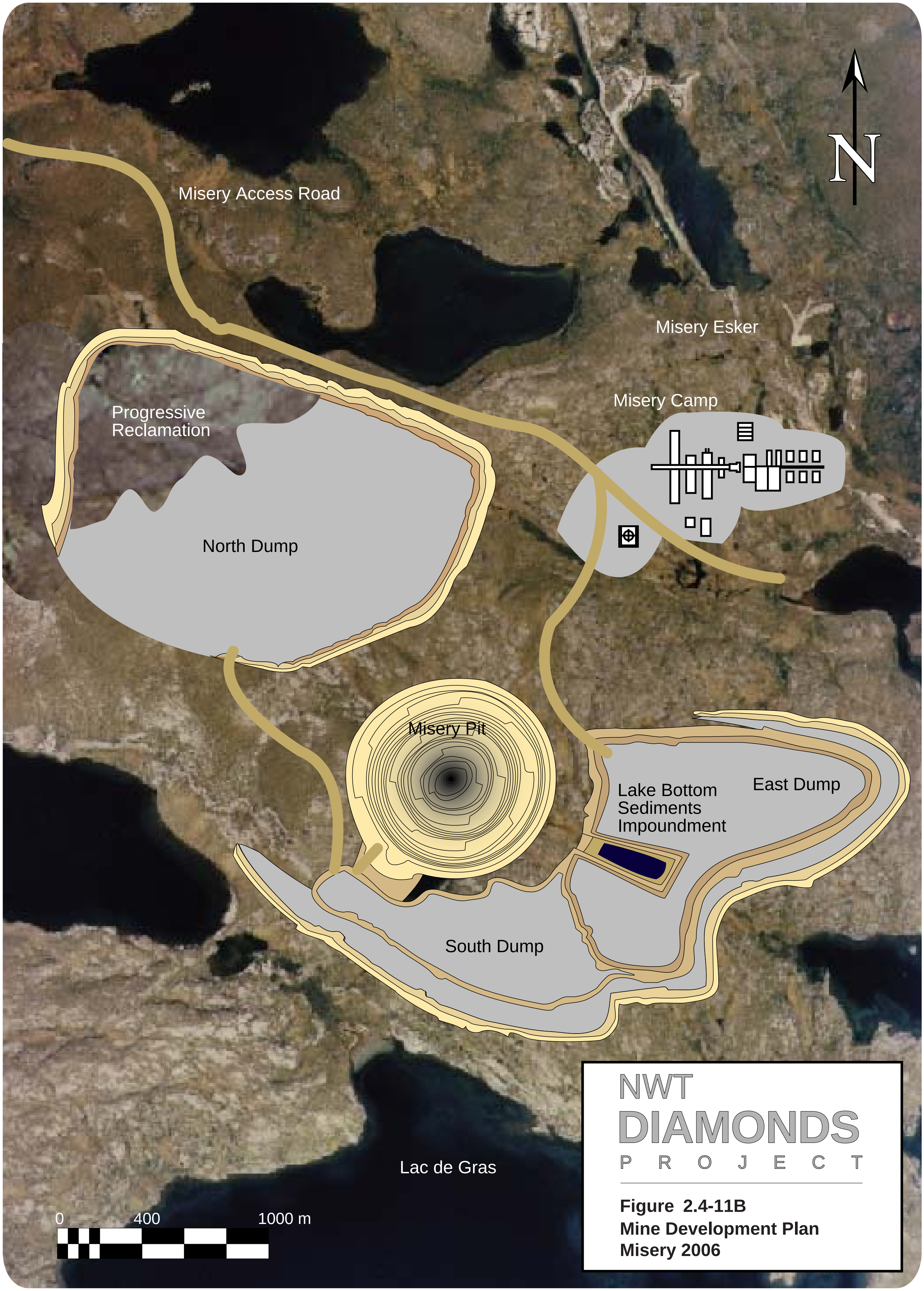
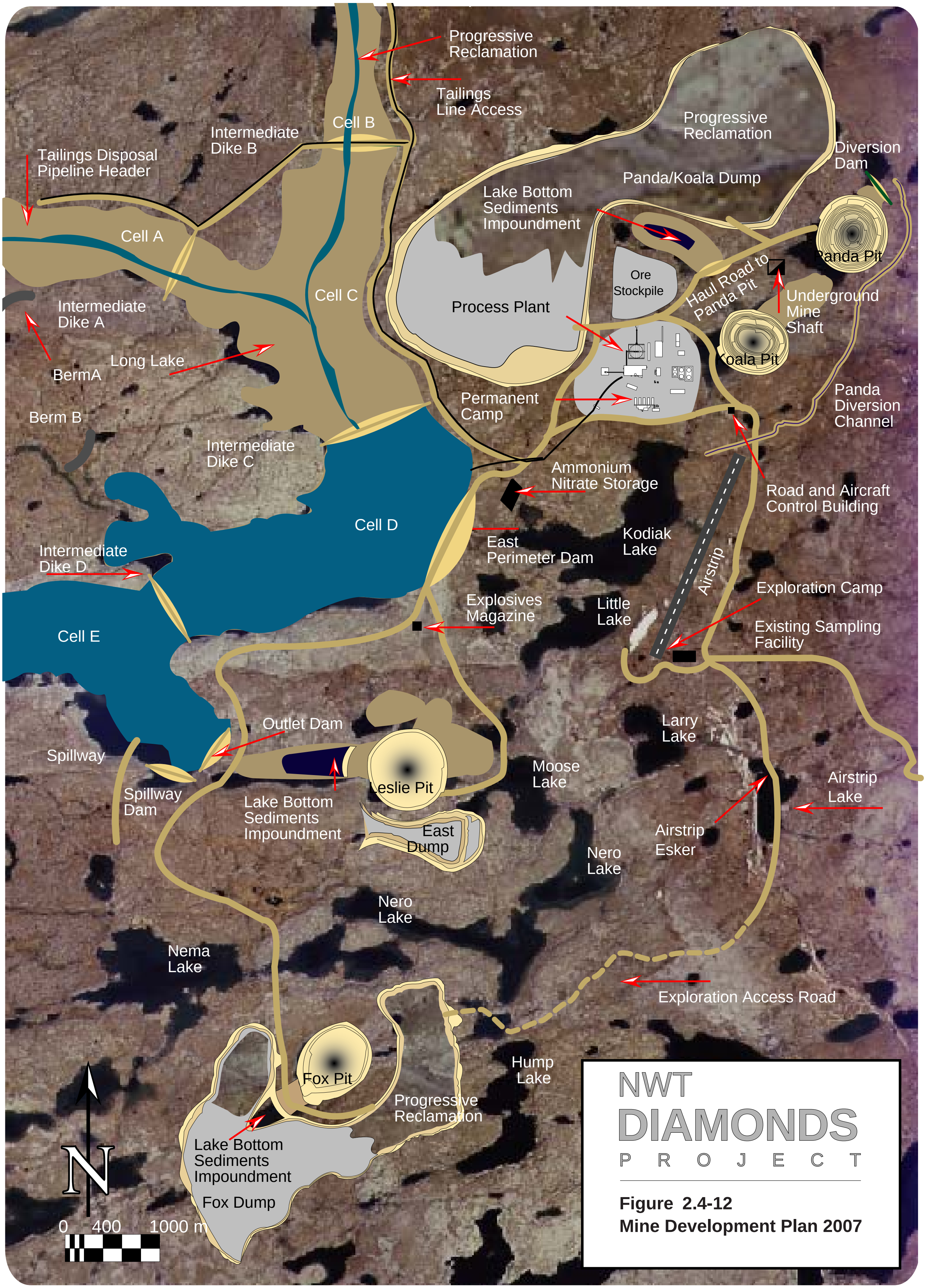


Figure 2.4-11B
Mine Development Plan
Misery 2006

◎ Table of Contents



NWT DIAMONDS PROJECT

Figure 2.4-12
Mine Development Plan 2007

Misery Lake will be dewatered into Lac de Gras Lake in the summer of Year 2, and waste pre-stripping of the Misery pit will begin, continuing through Year 3. Pre-stripping at Misery will total 18 million tonnes. The combined annual waste production from the Panda and Misery pits will average 40 million tonnes in production Years 2 and 3.

2000 to 2001 (Years 4 and 5)

Ore production from Misery will commence in Year 4 and remain constant at 0.5 million t/a (1,500 t/d) until the pit is depleted in Year 10. As Misery comes on line, Panda ore production will be cut back to 7,500 t/d to maintain a constant feed rate of 9,000 t/d to the plant.

The Panda ultimate pit limits will be reached by early Year 6, requiring that pre-stripping of the Koala pipe to remove approximately 28 million tonnes of waste begin in Year 4. Koala production will fully off-set the previous Panda production until the Panda underground operation commences. Also during Year 5, Fox Lake, at the upper end of the Fox drainage, will be dewatered to Fox 2 Lake and surface runoff water diverted in preparation for pre-stripping the Fox pit.

2002 to 2005 (Years 6 to 9)

The process plant will continue to operate at 9,000 t/d until Year 9. Koala will maintain its 5,000 t/d ore feed rate for Years 6 to 8, while Misery will supply 1,500 t/d. Production from the Panda underground operation at a rate of 2,500 t/d to 3,000 t/d will commence in early Year 6. The Koala and Misery pits will be exhausted of open pit reserves by Year 10. With 84 million tonnes of overburden, lake sediments and waste rock to be removed at Fox, pre-stripping there is expected to take four years.

To permit dewatering of Leslie Lake in Year 9, two additional dams will be constructed. One will be immediately upstream of Leslie Lake to create a lake bottom sediments impoundment, and the other will be downstream to the east of the Leslie ultimate pit. Leslie Lake will be dewatered to Moose Lake, which is the downstream drainage feature.

The throughput capacity of the process plant will be increased in Year 9, reaching 18,000 t/d in Year 10.

2006 (Year 10)

In Year 10, the Fox pit will provide 10,000 t/d to the processing plant. Waste stripping at Fox will continue to maintain ore exposure during the 15-year life of the pit. Both Koala and Misery pits will be exhausted in Year 10, and preproduction development of the Koala underground mine will commence.

The stripping capacity previously utilized at the Koala and Misery pits will be redirected to the Leslie pit for the commencement of waste stripping. After the removal of 12.5 million tonnes of pre-stripping waste, ore production will commence, with 904,000 tonnes of ore to be mined from Leslie in the second half of Year 10.

2007 to 2021 (Years 11 to 25)

The Fox pit will continue to provide about 6,800 t/d of ore to the processing plant while stripping progresses to maintain ore exposure during Years 11 to 15. Ore production from Fox will then increase to 9,000 t/d for the remaining years of the pit, which will be depleted in Year 20.

Underground preproduction development of the Koala pipe will continue into Year 11, at which time it will contribute 3,000 t/d of ore feed to replace production from the exhausted Panda underground mine. The Koala underground operation will be finished in Year 20.

The Leslie pit will continue to supplement the process plant at a rate varying from 6,500 t/d to 9,000 t/d until Year 19. Since the Fox pit will be fully depleted by Year 20, the Leslie pit will supply the process plant at a rate of 18,000 t/d beginning in Year 21 and continue to Year 25.

Because of the lower value of the ore, there are no plans at present to go underground at either Fox or Leslie pipes. It is anticipated that other pipes will have been developed to either enhance or continue production. Otherwise, the project will proceed to the decommissioning and abandonment phase.

2.4.5 Waste Rock Dumps

2.4.5.1 Design and Construction

The predominantly granite waste rock excavated from surface and underground in the course of exploration and development work to date has been sampled and analyzed regularly to determine its potential for producing non-neutral drainage. As detailed in Volume III, Section 4.1, negligible potential is indicated. Therefore, waste rock removed during mining operations will be disposed of in designated external dumps near each pit. In the event that non-neutral drainage should become a concern at any time, appropriate contingency measures will be undertaken. These measures could involve blending materials to produce a neutral drainage or disposing of the waste rock in such a way that the drainage could be collected and neutralized.

In addition to granite waste rock from open pit mining, the waste rock dumps will be used for low grade and crater phase kimberlite, schist from the Misery pit and kimberlite coarse ore fraction rejects from processing. As shown on Table 2.4-3,

Table 2.4-3
Waste Rock Dump Capacities (million m^3)

Pit	Rock	Mill Rejects	Excess	Total
Panda/Koala	80	17	8	105
Misery	43	0	7	50
Fox	131	0	14	145
Leslie	160	0	20	180

Note:
Rock = Granite waste rock with an average density of 2.72 and swell factor of 1.3.
Mill Rejects = Kimberlite coarse fraction rejects from the processing plant, estimated at 20% of total kimberlite, with an average dry density of 2.1 and swell factor of 1.3.
Excess = Overcapacity allotment of 10% to 20% (variable to round the total up to nearest 5 million tonnes).

the greatest proportion of the waste material will be granite. Storage areas will be provided within or adjacent to the dumps for waste materials suitable for reclamation use, including glacial till overburden and silty/sandy/gravelly lake bottom sediments removed during pre-stripping of each pit.

Separate impoundments will be constructed for the saturated, unconsolidated organic-rich portion of the lake bottom sediments.

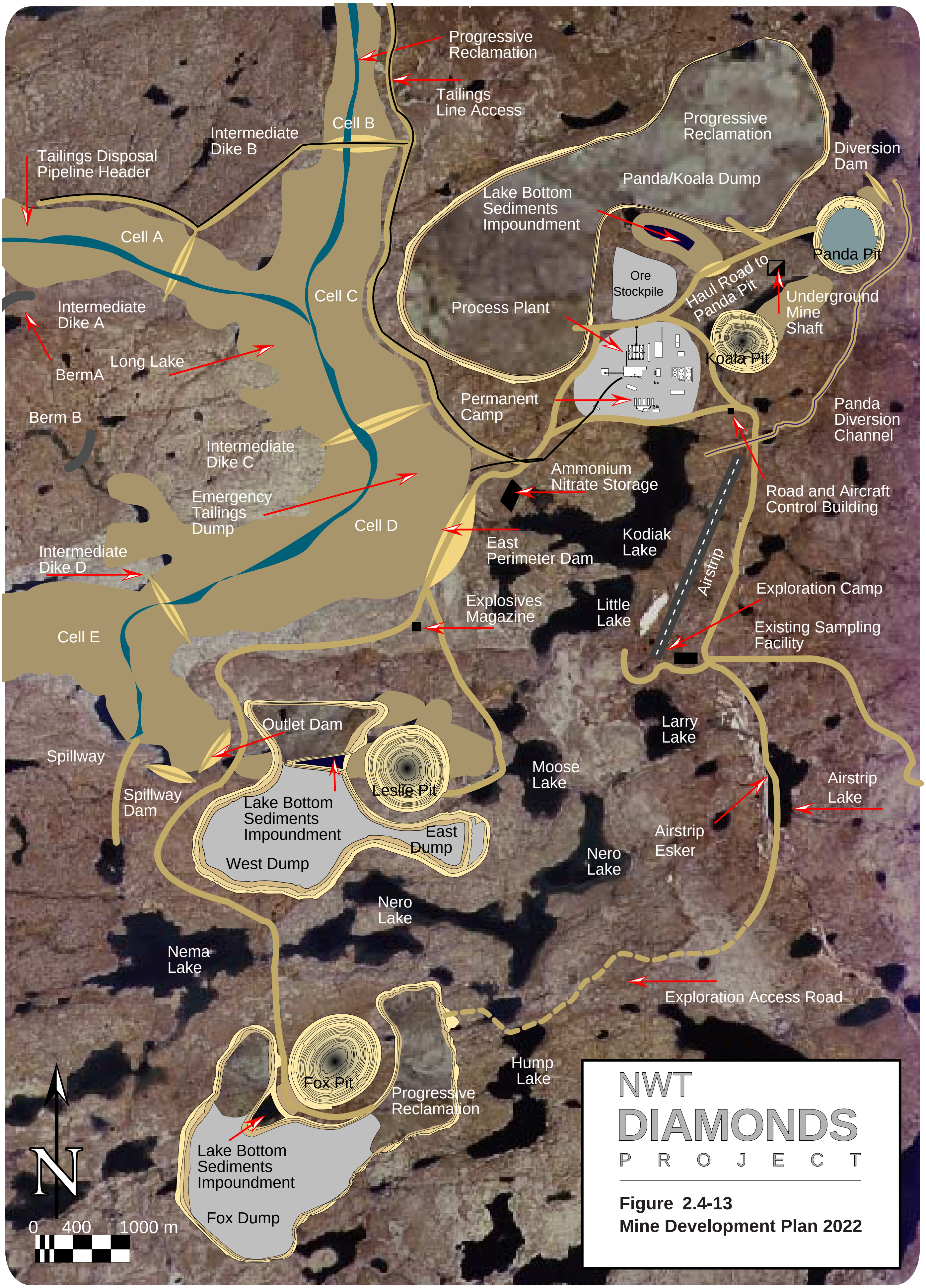
The waste rock dumps for all pits will be similar in design and construction. They will be built up by means of inset lifts approximately 10 m deep, with dumped rock face repose angles of 35°. The final slopes will be contoured to 25° before surface rehabilitation. To ensure long-term stability at this face angle, the dump heights will vary according to the underlying topography.

The dump and impoundment locations were selected to confine impacts to the Koala watershed and avoid involving any other adjacent watersheds. No dumps will encroach within 100 m of any undisturbed lakeshores or major stream channels not already affected by project activities. The ultimate layout and configuration of the dumps are shown on Figure 2.4-13.

2.4.5.2 Waste Rock Dumps

Each dump configuration takes advantage of the natural topography by filling in valleys and side slopes, resulting in flat haulage profiles from the ultimate pit crest that conform to the surrounding contour relief. A large, flat base will be constructed initially for each dump, in a shallow 10 m lift over its design area, to permit orderly dumping and ensure readily available dump space over this base. The dumps planned for each pit are described below.

Table of Contents



The first dump will be a shared repository for waste from the Panda and Koala pits and about 17 million m^3 of kimberlite coarse fraction rejects from the mill. The waste rock from Panda will be entirely granite and that from Koala will be granite and crater phase kimberlite. The sloping topography north and west of Koala Lake will serve as the primary rock dumping area. The dump will reach a maximum elevation of 505 m from the lowest toe elevation of 450 m. Sites will be designated within the dump for the disposal of scrap metals, incinerator ash, sludge from the sewage treatment plant and certain other non-hazardous solid wastes. These sites will be away from any stream channels or confluences.

Dump space near the Misery pipe, some 28 km southeast of the Panda pipe, is somewhat restricted due to the proximity of Lac de Gras and several other small lakes. Three dump areas are planned, including one to the south and one to the east, both of which will be limited in size and will toe out at an elevation of 435 m. The area to the east will be a lake bottom sediments impoundment, and the area to the south will be an overburden reclamation stockpile. The main Misery rock dump, which will progress to the northwest of the ultimate pit, will take full advantage of the existing flat topography and rise from the base elevation of 450 m to a final crest elevation of 475 m. Waste rock will consist of granite and schist.

The dump constructed for the Fox pit will contain granite and crater phase kimberlite. The dump will be concentrated to the south of the pit but will have two “wings” wrapping around the east and west sides, which will be used for reclamation stockpiles. The finished crest will reach a maximum elevation of 490 m. The south portion of the dump will fill in the Fox Lake basin from the shoreline elevation of 445 m resulting in a maximum dump height of 45 m.

The last two dumps will be for the Leslie pit. The smaller dump to the southeast will be terraced, with an elevation limit of 472 m on the lowest bench because of its proximity to the airstrip. This area will be used for the organic sediments and till materials and will be reclaimed upon completion of the pit.

2.4.5.3 Overburden Reclamation Stockpiles

Glacial till overburden and the silty to gravelly lake bottom sediments stripped from each pit will be stockpiled at the margins of each rock dump to allow easy access for eventual use during the reclamation phase of the project.

The lake bottom till sediments are layered beneath the saturated organic sediments in depths ranging from approximately 20 m at the centre of each lake to 0 m at the edges. Up to four layers have been identified under some lakes, alternating between silty and sand horizons. These sediments will be spot dumped on top of the flat waste rock base and allowed to drain. Providing it is suitable as root zone material, the drained sediments can be blended with overburden tills and used as topdressing for the completed portions of the ultimate rock dump. Alternatively, the blended material could be used as aggregate for other construction purposes, such as roads or dams. The finished dump face will be contoured and sloped to an overall angle of 25°.

2.4.5.4 Lake Bottom Sediments Impoundments

The saturated organic-rich sediments occur as a 1 m to 2 m layer at the bottom of the lakes. The material is unconsolidated and very fine-grained. The amount of these sediments on each pipe is difficult to ascertain, but some general estimates have been made by comparing lake bathymetry and drill core contacts: the quantities vary from 1 million m^3 to 2 million m^3 per pipe. These sediments will be stored separately from the main waste rock dumps because of their high water content. Any excess water released from these storage areas to the environment will be allowed to settle or otherwise be treated as necessary to lower the TSS to below discharge criteria.

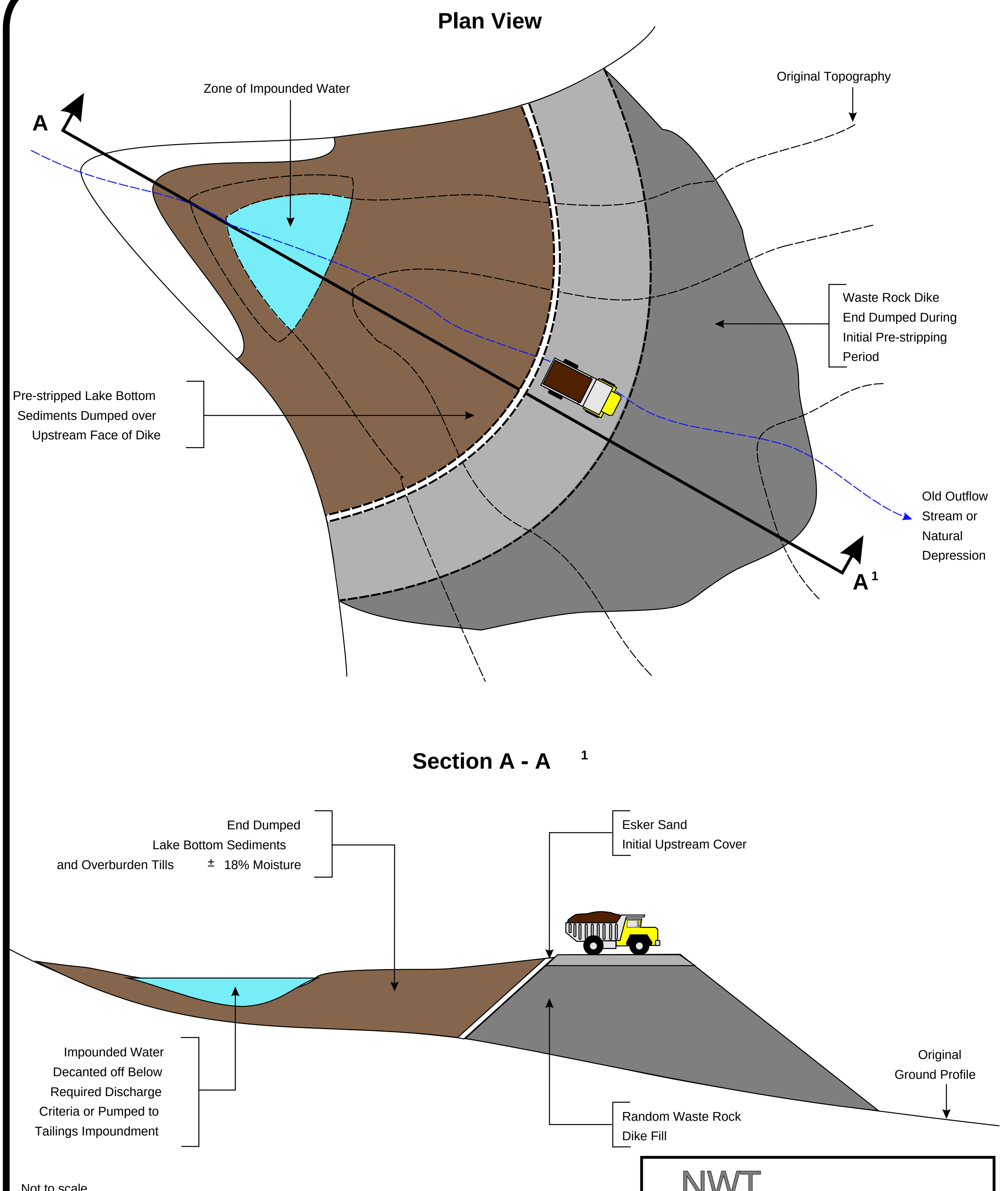
As described previously, the impoundments will be constructed during pre-stripping operations. The impoundment design will be similar in all areas (Figure 2.4-14). Pre-stripping materials and till from higher elevations above the lake will be used to construct a dike at the downstream opening of an existing topographic basin. The entire upslope face of the dike will then be covered with a lift of esker material dumped down the sloped face from the crest. This layer will serve as an initial gradation filter between the dike and the finer sediments to be placed behind it. The initial dewatered lake sediments from the shoreline will be end-dumped over the upstream crest of the dike and around the perimeter of the natural basin, then spread over the entire surface area of the impoundment by a spreading dozer.

As pre-stripping proceeds deeper into the lake bottom, the moisture content of the sediments will increase. This wetter material will be trapped, loaded out and dumped over the dike crest into the impoundment. With natural alluvial settling, a pond of water will develop within the impoundment in the summer months.

Sediment dumping into the impoundment will continue as long as high water content materials are encountered, although the operation will be suspended temporarily when the last of the lake water, which is expected to have high levels of suspended sediments, is pumped into the impoundment. At this time, the pre-stripping work will be redirected to higher waste rock elevations until the remaining lake bottom water and the pumped-out turbid water have settled sufficiently to meet the TSS discharge criteria. The ponded water will then be decanted to a suitable discharge point.

The lake bottom sediments impoundment for the Panda/Koala mining area will be located between the plant site and the main rock dump, in a small stream drainage above Koala Lake. The Misery impoundment will be at the existing outfall

◎ Table of Contents



NWT DIAMONDS PROJECT

Figure 2.4-14
Lake Bottom Sediments Impoundment

Source: BHP

stream channel east and downstream of Misery Lake. At both Fox and Leslie, the portions of the respective dewatered lakes lying beyond the pit limits will be diked off and used for lake sediment impoundments.

At all the open pit sites, lake sediments and tills that have lesser water content and do not require impoundment will be stockpiled for retrieval during reclamation activities.

2.4.5.5 Dump Reclamation

A rehabilitation plan has been developed for the waste rock dumps, to meet the following goals:

- re-establish stable, physical landforms (slopes, surface water drainage)
- re-establish productive land use (wildlife habitat)
- protect the local water resources.

The suitability of the available tills and organic sediments as plant growth media will be monitored throughout all stages of reclamation, and modifications made as required, to ensure the success of the rehabilitation plan. Contouring, topdressing and reseeding – the three major processes involved in dump reclamation – are described below.

Contouring: Each waste rock dump will be contoured into the shape of a plateau with graded slopes of 25°. Wherever possible, diffuse channels and internal depressions lined with clayey lake bottom sediments will be sculpted, and the top of the plateau will be gently contoured to produce a more natural slope. Shallow slope angles and added landscape features will provide terrain diversity, thereby improving the available habitat for wildlife.

Topdressing: The slopes and surface of the plateau will be topdressed with available plant growth media consisting of the overburden till and lake bottom sediments from pre-stripping. To further simulate natural conditions, rock piles will be distributed randomly on top of the plateau while small boulder fields with water harvesting features will be created on its slopes. The surface will then be reseeded.

Reseeding: The plateau and slopes will be reseeded to closely resemble pre-mining conditions. In the case of depressions and diffuse channels, sedges and cotton grasses will be sown to simulate bottom lands. These efforts will stimulate vegetation growth and establishment, provide slope stability and reduce erosion.

2.4.6 Underground Mine Operations

The kimberlite pipes will be mined by surface methods until the cost of stripping waste becomes prohibitive or the cost of underground mining on the same pipe becomes more economical. In the latter case, an evaluation will be made on the viability of underground mining.

The Panda and Koala pipes will provide the first opportunity for underground mining because of their high grade, proximity to each other and timing in the production plan. Both will be developed initially as open pits, beginning with the Panda pipe. The Panda open pit will be mined for only five years, and will be followed immediately by production from the Koala open pit. At the same time, underground development of Panda will commence, with the first underground ore becoming available in 2002 (Year 6). Continuation of underground mining on the Koala pipe in 2007 (Year 11) will be a logical extension of the Panda underground development when the Koala pit reaches its economic limit.

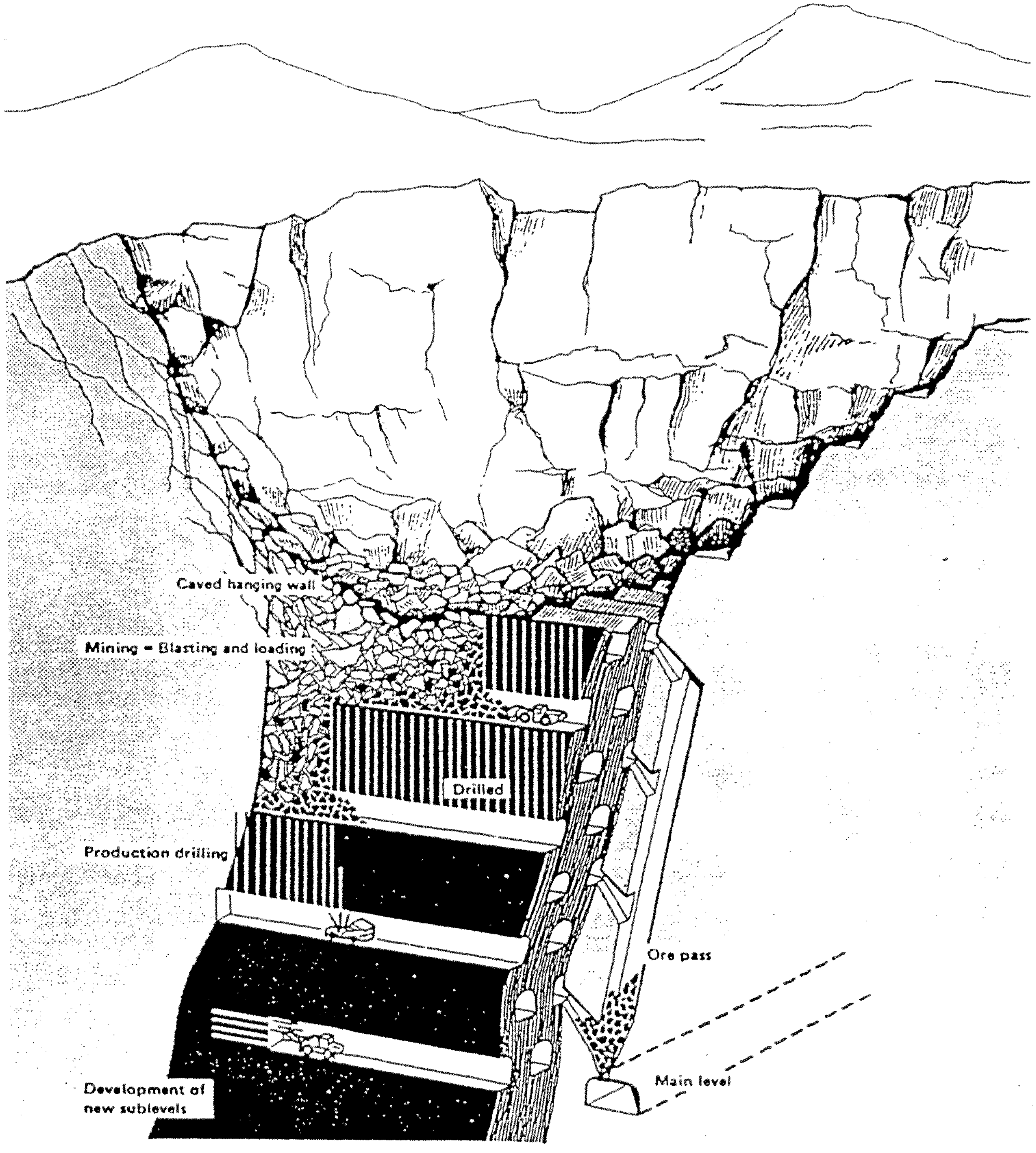
An underground mine life of five years is currently projected for Panda, followed by ten years of underground mining at Koala. The average production rate during this time will be 2,500 t/d, which will be combined with ore from the other simultaneously operating open pits to meet plant feed requirements.

Sublevel caving has been selected for underground mining. Based on fracturing the mineralized rock and allowing the surrounding waste rock to cave under its own weight, sublevel caving is an efficient mining method that incorporates a high level of mechanization and thus minimizes labour requirements. Mining consists of driving a series of sub-levels, starting from the top of the orebody, and then drilling a small vertical raise as a break against which a series of holes is drilled and blasted. The broken ore is mucked after each blast, trammed to an ore pass at the shaft and hoisted to the surface for processing. Waste rock adjacent to the ore is allowed to cave and fill the voids created by removal of the ore. A graphic representation of a sublevel caving operation is shown on Figure 2.4-15.

2.4.6.1 Mine Access

The depth to top of ore and the timing of the open pits makes shaft access the best way to initiate underground mining of the Panda and Koala pipes. The proximity of these pipes to each other also makes it desirable to provide common access to both with a single production/service shaft (Figure 2.4-16). Drift access from the shaft will be kept to one access ramp and one ventilation raise on the +80 m level (and the two haulage levels below) for each pipe.

The first haulage level for the Panda underground operation will be driven on the -50 m elevation in the preproduction phase. The other, on the -225 m elevation, will be driven as required by the vertical advance down the pipe. Production

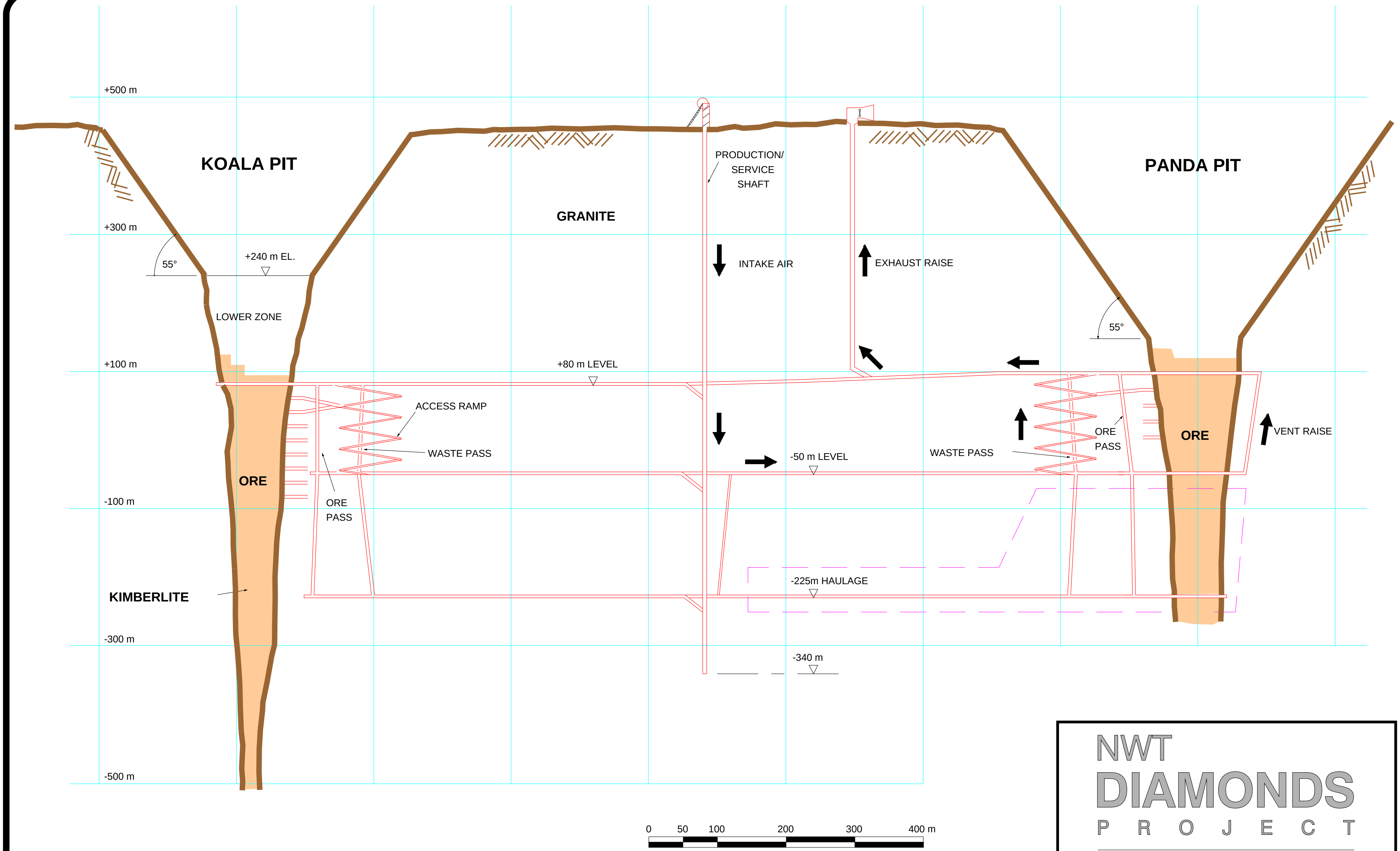


NWT DIAMONDS PROJECT

Figure 2.4-15
Sublevel Caving
Operation

Source: Guide to Underground Mining and Applications, Atlas Copco, 1980

◎ Table of Contents



NWT DIAMONDS PROJECT

Figure 2.4-16
Schematic View of Koala and Panda Underground Mines

Source: Rescan

access will be via a 16% ramp driven in the granite approximately 100 m from the pipe itself. All rock passes and support facilities such as ventilation raises and electrical substations will be located in the granite country rock. Along with the ore, all waste will be hoisted out of the mine, as the mining method leaves no empty stopes in which to dispose of the waste underground. A bored rock pass will connect the decline and sublevels to the -50 m haulage level, which in turn will be connected to the -225 m skip pocket via a bored raise at the shaft station. Storage capacity is thus available for both ore and waste, allowing a versatile skip haulage schedule.

The Koala pipe will be developed in much the same way and will utilize the existing ventilation circuit established for Panda. If it is decided to mine Panda and Koala simultaneously, additional ventilation (and possibly hoisting) capacity will be required.

2.4.6.2 Mining Conditions

The underground bulk sampling program, which involved underground declines on the Fox and Panda pipes, has provided important information on the mining conditions to be expected during full-scale underground operations. The data have been used to ascertain a Rock Mass Rating (RMR) for the rock units in order to determine rock support requirements and anticipated caving characteristics.

Based in part on visual inspection of each round in the decline, the RMR system provides an estimate of the strength of a rock mass by incorporating the properties of the intact rock and modifying this strength with the frequency and characteristics of discontinuities in the rock mass.

It has been confirmed that the strength and integrity of the granite wall rocks will allow large, stable openings to be mined with a minimum of support. Both the Fox and Panda declines, although highly fractured in isolated areas, required only spot bolting (with 1.8 m point anchor bolts) for a 4.3 m x 4.3 m opening. In areas of more fractured ground surrounding faults and intrusions, such as those found in the Fox decline, some screening and strapping was needed to tie blocks together. Point anchor bolts and screening were used to support faults filled with granite breccia and ice encountered in the Fox decline, along with 1.8 m split sets in the fault itself. Unless one of these breccia zones was exposed along an extended length (>3 m), no shotcrete or additional support was required.

Thermistor data collected at 20 m vertical intervals down the Fox decline showed the existence of permafrost all the way down to the kimberlite contact. The shallow Panda decline, on the other hand, intercepted water at the lake boundary, which is 180 m horizontally from the nearest kimberlite contact. Permafrost was found to be an excellent aid to support when drifting through the breccia zones in the Fox decline. Unfortunately, the support properties of permafrost cannot be relied upon in the kimberlite or in deep underground mining, as the kimberlite is within the lake talik zone.

The application of shotcrete was found to be the most successful means of support in the kimberlite. Where used, the shotcrete acted as a moisture seal and there were few slaking problems. Further testing will be conducted without shotcrete to determine the support requirements in short lived openings.

The underground work found that large granite boulders and breccias occur randomly within the kimberlite pipes. This greatly affects the viability of the mining methods considered. Block caving, for example, could be subject to operational and support problems, as these car- to house-size boulders bear upon the draw levels. This inhomogeneity favours a somewhat more selective method, or one capable of sizing the material rather than relying on caving.

In both the Fox and Panda declines, contact and breccia zones not under the influence of permafrost contained relatively large amounts of water. The water problem will likely be mitigated by the time underground mining commences, however, because the lake above each pipe will have been dewatered and any water-bearing zones above the pipe will have been removed while dewatering the pit. Provisions have been made for adequate mine dewatering to handle annual spring runoff from accumulated snow in the pit above the mine workings and water from aquifers intercepted during underground mining.

2.4.6.3 Mining Method Selection

For mine planning purposes, sublevel caving has been selected as the underground mining method, based on the available geologic and geotechnical drill data and the information from the Fox and Panda declines. As further information becomes available about the characteristics of the individual kimberlite pipes, specific design parameters, such as sublevel spacing, drift cross section and support requirements, may need to be adjusted. Sublevel caving was chosen for the following reasons:

- The orebody is weak but not necessarily fractured enough to cave well in a block caving system.
- The orebody can be mined as needed from the top down from temporary development at a high rate and low cost, rather than incurring the large expenditure of building and maintaining a permanent draw level.
- The method can be implemented at relatively low capital cost.

With underground bulk sampling information currently available for the Fox and Panda pipes only, the specific design parameters for each pipe cannot yet be established. The general scenario foreseen at present relates to mining a soft orebody, surrounded by competent walls, that daylights to the bottom of an open pit. Thus, dilution and stress on sublevel drifts, which are of prime concern in a sublevel cave system, become somewhat less important. The design reflects this condition by maximizing the vertical sublevel spacing to 23 m. This large spacing effectively takes advantage of the accuracy of modern drill equipment and the minimal dilution potential afforded by the air hanging wall. It also protects the sublevel drifts themselves by distancing them from each other and from the effects of adjacent openings.

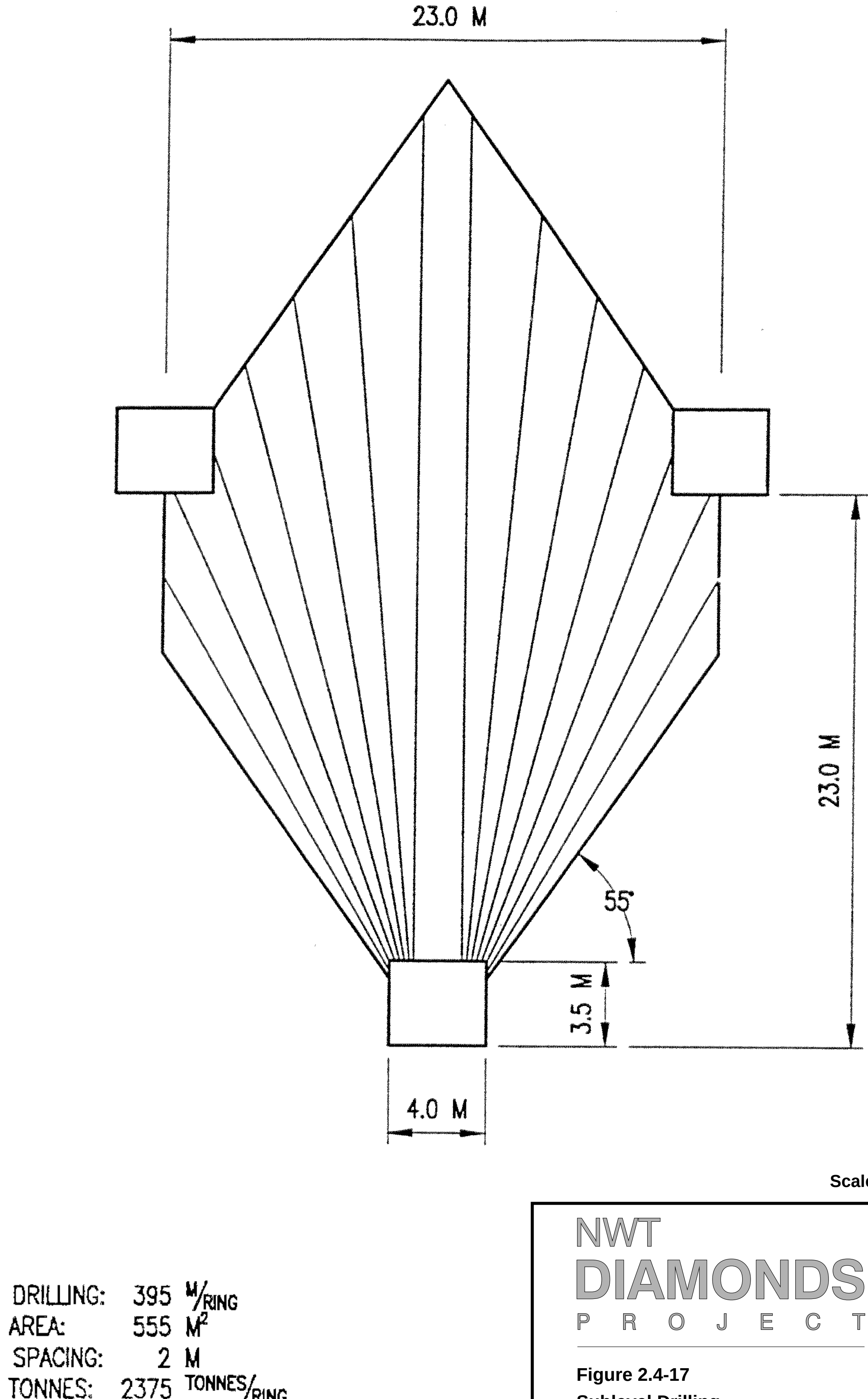
The Panda pipe will be mined using a glory hole method. As the ore is assumed to be continuous and homogeneous past the bottom of the open pit, 100% extraction of the pipe can be expected. The method is basically sublevel stoping in the open air. The sublevel spacing in a caving system is normally designed to minimize dilution of the waste behind the broken ore. In this case, however, the absence of waste makes the length of hole that can be drilled accurately – assumed at present to be 30 m – the limiting factor of sublevel spacing. The proposed sublevel drill pattern is illustrated in Figure 2.4-17. It is envisioned that mining will be cyclical, with two to three production rings drilled and immediately blasted. The weakness of the kimberlite will not allow production long holes to be drilled too far in advance of blasting; therefore mobile drilling and charging equipment are essential to maintain steady production from several sublevel drifts simultaneously.

The Koala pipe will be mined in a similar manner to Panda, with one important difference: a low grade horizon of the Koala pipe that restricts the vertical advance of the open pit will be undermined with a true sublevel caving operation, beginning in the higher grade unit below (Figure 2.4-16). The sublevel spacing will be shortened to 20 m, which offers more stability without sacrificing productivity. The low grade horizon above will be caved and drawn as dilution.

Each pipe is anticipated to have its own unique difficulties arising from differing mining conditions and properties of the kimberlite. The effectiveness of the mining method itself is dependent on the stability of the sublevel drifts, addressed in this case by intensive high production mining, which minimizes the number of drifts and the length of time they must be kept open. The Koala pipe will have the added complication of kimberlite caving above the active mining, and will have to be monitored for the potential of mud rushes. The Panda pipe, on the other hand, will be open to the atmosphere and vulnerable to slabbing of the pit walls.

2.4.6.4 Preproduction Development

Preproduction development will begin in Year 3. The critical feature of the development will be to establish the ventilation system as quickly as possible to permit stope development to advance. The production buildup time will be very short, since relatively little development will be required per tonne of ore.



Scale: 1:250

NWT DIAMONDS PROJECT

Figure 2.4-17
Sublevel Drilling Pattern

Source: Rescan Engineering 1994

The Panda pre-development plan is shown on Figure 2.4-18. Sublevel access drifts from the existing ramp will surround the pipe about 20 m into the granite, driven at angles and lengths dictated by the panel delineation and required spacing. No duplication or extension of the initial ore pass and ventilation openings will be needed during the first several years of production.

For the most part, preproduction development will consist of the haulage and ventilation circuits described earlier and the stope development required for full production stoping. In general, access to sublevels on the +97 m and +74 m levels will be developed along with the ventilation circuit required to service these levels. The ramp is currently designed to be driven as required, but additional drifting capacity, if available, could be used to the advantage of the ventilation system if the ramp were driven more quickly and connected to the haulage level below. The number of open sublevel drifts must be maximized for versatile production capacity, balanced by the need to keep them open as briefly as possible for stability reasons. To this end, ten drifts – six on the +97 m level and four on the +74 m level – will be driven to their full length. This arrangement satisfies both requirements and will permit efficient mucking. A typical sub-level layout is shown on Figure 2.4-19.

2.4.6.5 Mine Operating Plan

Ore mining will be done by drilling the sublevel with small diameter (55 mm) rings of upholes on 2 m spacings. Each ring will require a total of 395 m of drilling using a single boom electric hydraulic ring drill. Until more experience is gained in the kimberlite, it will not be possible to predict how well the drill holes will hold up and thus how far in advance the production drilling can be done. All indications from the bulk sampling program point toward blasting all drilled holes as soon as possible.

Loading and blasting of the rings will be as mechanized as possible; a bulk emulsion mobile pumping unit will be used to charge the rings. After blasting, a drift preparation crew will reinstall ventilation and water sprays and repair any blast damage in preparation for mucking with 4 m^3 LHD units.

Haulage will consist of loading from the drawpoints with 4 m^3 diesel LHD machines directly to the nearest orepass, which will be equipped with a grizzly and serviced by a mobile hydraulic rock breaker. The orepass will provide storage capacity for haulage between shifts. The ore will then be loaded via power chutes at the base of the orepass into diesel trucks on the -50 m level for haulage to the shaft ore pass system and subsequent gravity feed to the -225 m pocket for hoisting to surface. On the surface, the ore will be dumped directly into a stockpile chute for haulage in surface trucks to the plant.

◎ Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV

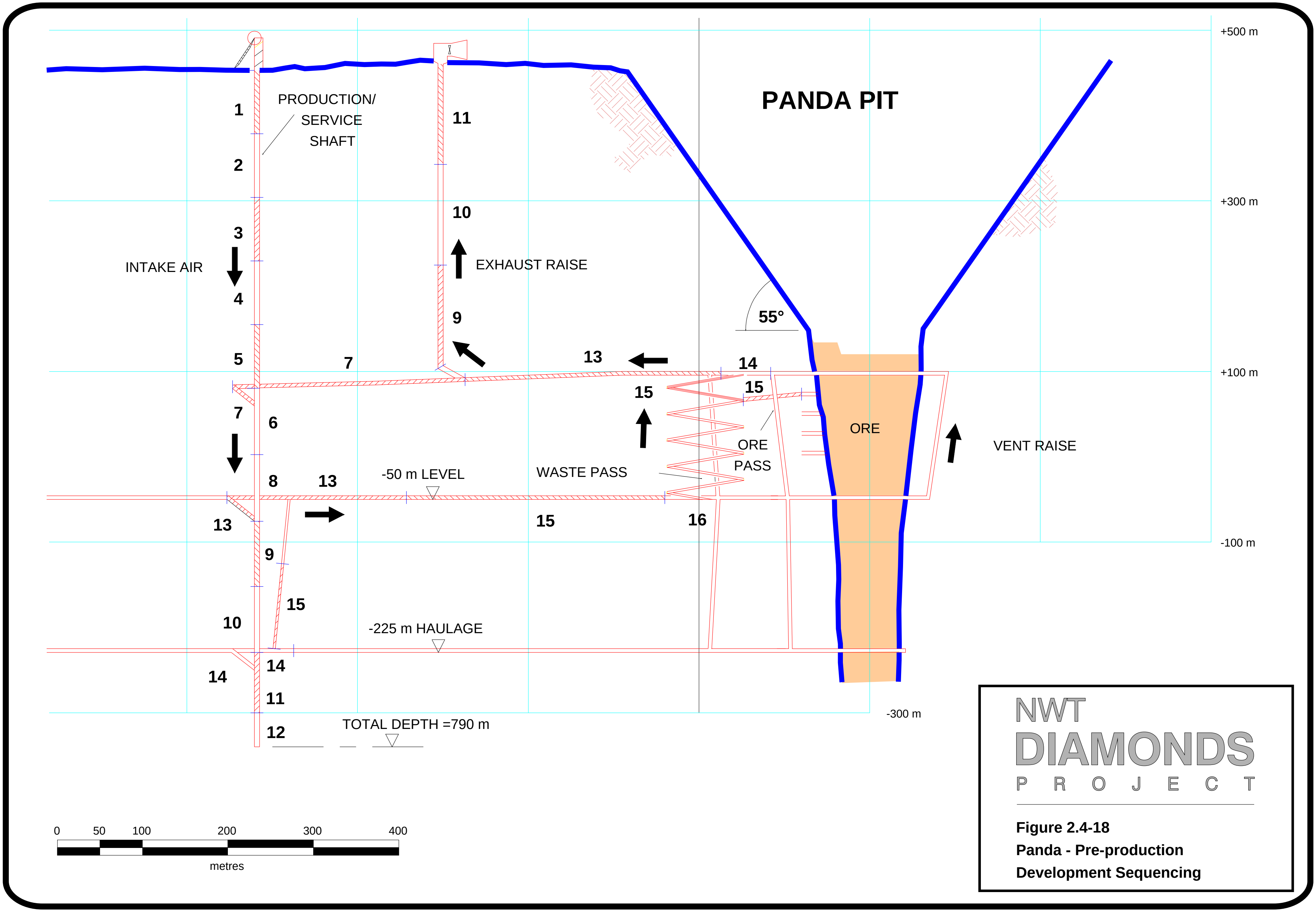


Figure 2.4-18
Panda - Pre-production Development Sequencing

Source: Rescan

◎ Table of Contents

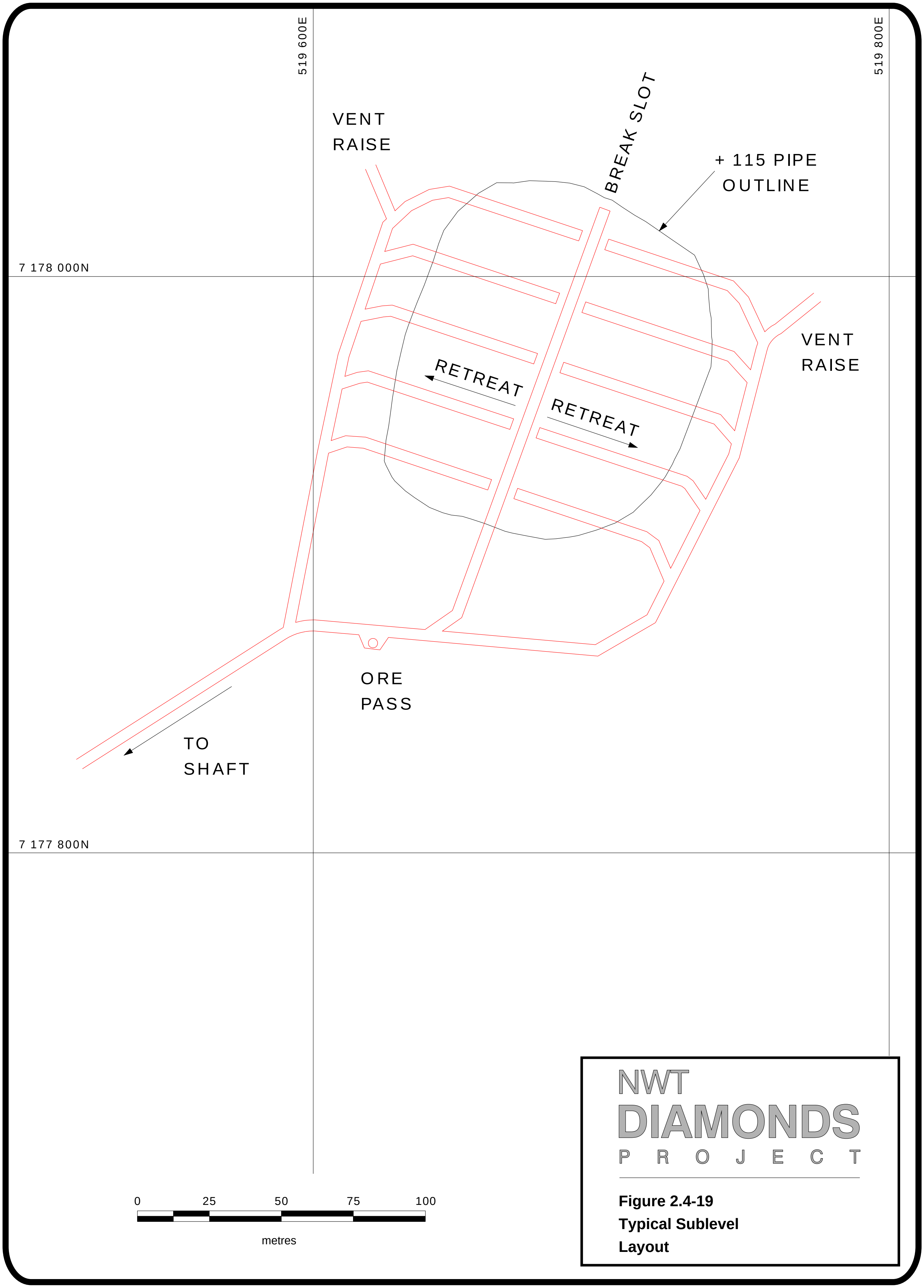


Figure 2.4-19
Typical Sublevel
Layout

Source: Rescan 1994

The proposed ventilation system is very simple, as can be seen in Figure 2.4-20. The only planned intake is the production shaft, although another intake could be opened into the Panda pit if required (this will depend in part on the amount of air ultimately drawn through the cave and its effect on the system). The system will be powered by a main exhaust fan on top of the 3.1 m diameter vent raise, with one main booster fan installed in a bulkhead on the +80 m level for decline development and auxiliary fans provided as required to ventilate production headings. Based on diesel equipment needs, approximately 7,400 m^3/min of fresh air will be required. Mine air heating will also be provided.

The design mining rate of 2,500 t/d (912,500 t/a) will require that approximately two sublevels be stoped per year. Therefore, if the development is scheduled carefully, the sublevel drifts will need to be open for only four to seven months. This will be an important factor in keeping the mine openings stable with as little auxiliary ground support as possible.

2.4.6.6 Equipment Requirements

Production Equipment

The key to realizing the potential of the underground mining system designed for these orebodies will be speed and versatility of operation. This will require the ability to mine with intensity on a few drawpoints, thus minimizing the time they must be kept open and supported, and then to move quickly to other drawpoints. The production equipment selected will be critical to meeting these goals. The proposed equipment is listed on Table 2.4-4.

Table 2.4-4
Underground Mining Equipment

Description	Quantity
Production Equipment	
Hydraulic Production Drills	3
LHD (4 m^3)	2
Mobile Impact Breaker	1
Haul Trucks (26 t)	3
Bulk Explosives Charger	1
Development Equipment	
Twin Boom Drift Jumbo	1
Spare Jumbo Drill	1
LHD (4 m^3)	2
Shotcrete Equipment	2
Scissor Lift Truck	1

◎ Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV

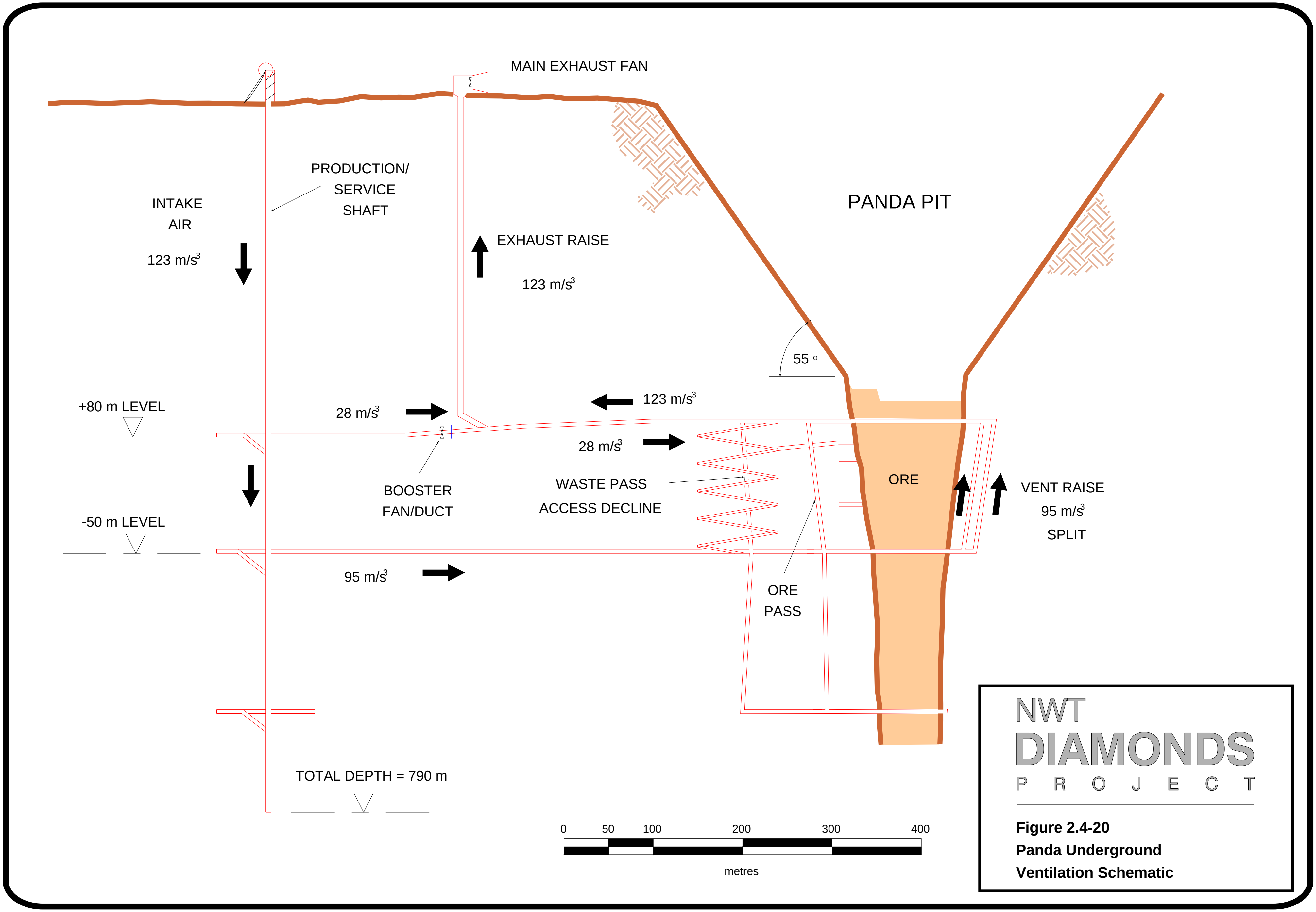


Figure 2.4-20
Panda Underground Ventilation Schematic

Source: Rescan 1994

The entire mine production operation will be dependent on a small fleet of three hydraulic production ring drills, two 4 m^3 scooptrams and a custom bulk explosives charger. From the scram, the ore will be delivered by scooptram to the dump system, where a mobile impact breaker will keep the grizzlies free of oversize. A fleet of three 26 tonne diesel trucks will then move the ore to the shaft on the haulage level below. The explosives charger will be custom-designed, while the other equipment will generally be standard, readily available units.

Development Equipment

Total development requirements will be approximately 8 m of drifting per day, which can be achieved with one drill jumbo and one 4 m^3 scooptram. As the development work will be spread throughout the mine, mobility is the most important criterion for equipment selection. A twin-boom drifting jumbo drill has been selected, serviced by a single 4 m^3 scooptram. This equipment will travel together as a unit, leaving the support work to a separate crew who will use a scissor-lift truck for bolting and other support installation including shotcrete. This arrangement will best accommodate the production equipment advance and allow the support work to be done without slowing the advance rate.

Underground General Equipment

The general underground mine equipment includes all the ancillary systems for the underground mine operation, as follows:

- The hoisting plant is designed for a capacity of 260 t/h from a depth of 750 m and will be installed as the shaft is sunk. Similarly, a service hoist for personnel and materials will be installed in the same shaft as sinking progresses. As this is the only piece of fixed equipment, the unit selected at the outset must be capable of meeting any potential increase in production. At the currently planned production rate, requirements can be met in approximately 11 h/d of hoisting time.

- The pumping system is designed to handle 63 L/s of dirty water influx and to pump to the surface in two 350 m lifts. Along with water intercepted during actual underground mining operations (which may be substantial, based on experience in the bulk sampling declines), the underground workings will be exposed to spring runoff caused by melting snow in the open pit above. Two Flygt type pumps will be provided on the +80 m level and one pump on the -50 m level, with one spare. Sumps have been designed to capture most of the solids before they reach the pumps. At the surface, the water will be discharged if it meets water quality guidelines or will be pumped to the process plant or tailings pond.

- The main ventilation fan will be located on the surface above the main exhaust raise and will be designed to exhaust 7,400 m^3/min at a pressure of 165 mm (water gauge). A large booster fan, estimated at 75 kW, will be required on the +80 m level to supply 1,700 m^3/min of fresh air to the dead-end development headings. Fresh air will be supplied to each production heading by an auxiliary fan 15 kW to 30 kW in size, depending on the activity in the area being ventilated.

- A diesel fuel fired mine air heating system will be installed at the main shaft to heat mine air during the winter months.

- Two compressors installed in the mine surface facility will provide compressed air for general mine services. The compressed air will be distributed by a pipeline running through the production shaft, with branch lines to the work headings at each level.

- Personnel vehicles and "boss buggies" will be provided for supervisors and maintenance crews to ensure efficient use of their time.

2.4.7 Haul Roads and Ore Delivery

2.4.7.1 External Haul Roads

External haul roads will be constructed to provide access from the pits to their respective waste dump areas and to the plant site. The waste rock material produced from pre-stripping of each pit will be suitable for use as haul road fill. As stripping progresses in each mining area, granite waste rock will be trucked to a spreading dozer, which will advance the haulage road network toward the associated waste dump and the plant site.

The haul roads in the four central mining areas will be no less than 25 m wide, which is three times the width of a 218 tonne truck, or the minimum required for two-way haul truck traffic. No shoulder barriers will be provided, as the drop-off will be less than 3 m and wind action must be unimpeded to prevent drifting snow from building up on the road. Intersections along the roads will accommodate the 15 m turning radius of the haul trucks on an inside corner. At the designated waste dumping sites, suitable flat turnaround areas approximately 50 m wide will allow for safe passage of haul trucks while a loaded unit is turning to back up and dump.

Panda/Koala

As Panda is the first pit to be mined, the initial haul road network will be in the Panda/Koala area. The haul road from Panda to the process plant will pass close by the planned Koala ultimate pit limits, which will ensure easy integration of the future Koala haulage activities. The road will continue on to the primary crusher area adjacent to the process plant, where it will be widened to provide a haul truck turnaround and queuing area. Access will also be constructed between the ROM stockpile area, the primary crusher and the coarse ore stockpile area to accommodate a front-end loader and a dozer. The haul distance from the Panda ultimate pit crest to the primary crusher will be approximately 2 km; the distance from the Koala pit will be only 0.5 km.

Fox and Leslie

Haul roads similar to those for Panda/Koala will be constructed to connect the Fox and Leslie pits with their corresponding waste dumps and with the process plant. The two roads to the plant site will converge at the head end of Nema Lake narrows, where a multiple culvert causeway crossing will be installed. The total ore haulage distance to the primary crusher is approximately 6 km from the Fox and 4 km from Leslie pit crests.

2.4.7.2 Misery Haul Road

Waste haul roads from the Misery pit area to nearby dumps will be constructed from the pit waste rock as required for ongoing operations. To maintain two-way haulage for the 86 tonne trucks, the minimum road width will be 17 m, although most roads will be incorporated into the actual dumps and will generally be wider for operational convenience.

The Misery ore haul road to the process plant, 29 km to the northwest, will follow the alignment designated as Route Option #2 in the "*Bulk Sampling Project Description Addendum Report – Misery Lake, August 1994.*" The Regional Environmental Review Committee (RERC) indicated that this alignment was preferred over Route Option #1, which crossed a large esker. Option #2 is the most direct routing from Misery to the plant site. It passes between lakes and boulder fields and avoids eskers and stream crossings wherever possible.

The Misery haul road will also serve as the access road for heavy B-train truck-trailers delivering freight during the Echo Bay winter road season. Each winter an ice road extension will be constructed to the east of the Misery operation, across Lac de Gras, to join the Echo Bay winter road.

The design of the Misery ore haul road incorporates fill thicknesses ranging from 1.8 m to 3.0 m and averaging 2 m, which will support the traffic loading on the active layer and minimize thawing of the underlying permafrost. The design crest width will be 10 m to accommodate two-way traffic by conventional off-highway truck-trailers. Side slopes will be 3H : 1V, resulting in a nominal footprint of 22 m.

The road alignment intersects several stream crossings where drainage is visible. The design calls for two types of culverts, those at defined stream crossings, where flows are fairly constant, and equalization culverts, required to prevent upslope ponding during spring runoff. The culverts will be installed in accordance with DFO and NWT land use guidelines. Particular culvert installation considerations are as follows:

- invert to be placed 200 mm below grade
- no vertical drop allowed at outlet
- slope of 0.1%
- side slopes at culverts to be at least 3H : 1V
- riprap placed at upslope and downslope ends.

The stream connecting Paul Lake and Lac de Gras is the widest along the route and has the highest flow rate. A 40 m long, single-span bridge, with 2 m clearance, will be erected to cross this stream. A bridge structure was selected over emplacing multiple culverts to ensure unimpeded flow and subsequent fish movement.

During the first phase of haul road construction, in the winter months of 1996, the segment from the process plant to Paul Lake will be developed using waste material from the Panda pit operations and borrow from the existing quarry at the Koala site, known as the Airstrip esker. The road will be completed in the winter of 1998 by advancing northwest from Misery to Paul Lake. Construction materials for this second phase will comprise waste rock and additional fill from the Misery esker, 1.5 km northwest of Misery Lake.

The proposed quarry at the Misery esker will encompass an area of approximately 15 ha. With borrow extraction to a depth of 3 m below existing grade, the volume of material available from this source is estimated to be more than 150,000 m^3. Development of the quarry will be in accordance with the "*Environmental Guidelines for Pits and Quarries*" (INAC 1989). The area of excavation will be developed to its fullest to minimize the extent of surface disturbance and the overall impact on the rest of the esker system. Summer construction is planned so that the borrow source can be developed through progressive thaw and strip cycles. Drainage of the pit floors will be maintained to eliminate standing water that initiates irregular thaw and deep holes in ice-rich zones.

2.4.7.3 Ore Stockpiling and Haulage

A stockpile area will be established at the Misery pit crest for run-of-mine ore. Given the relatively low average daily ore production rate at Misery and the long 29 km haul to the process plant, ore rehandle, loadout and haulage to the primary crusher will be done as a shift operation. This will ensure high utilization of a front-end loader to transfer the ore into the off-highway transport trucks.

Pit crest stockpiles are not anticipated to be necessary at the other four pits. Ore will be hauled in the 218 tonne trucks from Panda, Koala, Fox and Leslie directly to the primary crusher area. Because all four pits are relatively close to the process plant, haulage can be scheduled periodically to meet the plant throughput requirements.

An ore stockpile will be required in the area of the primary crusher. During initial pre-stripping of the Panda pit, it will be used for low grade crater material and ore encountered on partial benches before the process plant is commissioned. Throughout the rest of the project life, the stockpile will accommodate any production surges in ore mining and allow for constant feed of ore directly into the primary crusher as the process plant requires. The stockpile will be approximately 50 m north of the primary crusher and have an available capacity of 200,000 tonnes. During operations, stockpiled ore adjacent to the primary crusher will be trammed to the primary crusher as required by a front-end loader and a dozer. When the tramming distance becomes unwieldly (100 m), the ore will be loaded into a haul truck and then dumped into the crusher.

Ore produced from the Panda and Koala underground operations will be stockpiled at the surface by the skips discharging into a chute located in the production shaft head facility. The stockpile will be filled with ore throughout the day and loaded out as required into a surface haul truck for transport to the primary crusher stockpile. Underground development waste skipped to surface will be handled in the same way and trucked to the Panda/Koala waste dump. Haulage of both ore and waste will be done on a periodic daily basis using the 86 tonne truck assigned to the process plant.

2.5 Mineral Processing

Mineral processing is based on the unique physical properties of diamond that allow for standard reduction and recovery by means of three main unit operations:

- crushing and scrubbing of kimberlite ore
- primary concentration by heavy medium separation
- secondary concentration by X-ray sorting.

All of these operations will be performed on site and incorporate experience gained during the bulk sampling stage of exploration. Final diamond cleaning and sorting will be done at an off-site facility.

2.5.1 Process Design

Diamonds occur as discrete particles within a kimberlite pipe and must be recovered as intact entities to be of commercial value. Given the low concentration of diamonds in a particular ore – one to two parts per 20,000,000 on average worldwide, one to two parts per 10,000,000 at the NWT Diamonds deposit – large volumes of material must be processed to obtain economical quantities of product, i.e., pure diamond. Throughout the processing operations, every effort is made to liberate diamonds without breaking or damaging the individual stones.

Diamond has distinctive physical characteristics that enable its separation from host rock material through relatively straightforward mechanical, gravity-related processing methods, as opposed to the chemical leaching or flotation processes used to recover gold and base metals.

- Diamond has a specific gravity of 3.52, compared to 2.7 for waste rock and 2.2 to 2.4 for kimberlite.
- Diamond is the hardest of all known substances but is also brittle.
- Diamond is luminescent (emits light) under X-ray irradiation.
- Diamond is hydrophobic (not wetted by water) and adheres to grease.

Based on these unique physical properties, the standard reduction and recovery process used in the diamond industry has three main steps, as follows:

Crushing, Scrubbing and Screening: Several stages of crushing and screening are involved to liberate diamonds from the kimberlite host rock and produce a sized material for gravity concentration. This begins with primary and secondary crushing in conventional gyratory or jaw and cone crushers. To maximize diamond recovery, the kimberlite is treated in high pressure grinding rolls (HPGR) after primary scrubbing and screening. The purpose of scrubbing, which is essentially washing in rotary drum scrubbers, is to disagglomerate (break up) and remove soft fines and clay minerals from the crushed ore. The resulting sized material is normally between 1 mm and 25 mm.

Heavy Medium Separation (Primary Concentration): The second stage of diamond processing is heavy medium separation (HMS), in which high density particles, including diamonds, are separated from low density particles (barren waste rock) through gravity concentration. The washed and sized HMS feed is mixed with a suspension medium, generally a slurry of ground ferrosilicon and water, and then pumped to a heavy medium cyclone. The separated light and heavy mineral fractions are commonly denoted as floats and sinks. Ferrosilicon is a chemically inert compound (iron and silica) of particularly high density that enhances the separation by allowing the low density materials to float on the surface of the slurry, while the diamonds and any other remaining high density materials sink in the slurry.

Recovery (Secondary Concentration): Diamond plant processes are the least standardized in the recovery section, although all use either X-ray sorting, vibrating grease tables or grease belts, high intensity magnetic separation, chemical cleaning, sizing and grading, or a combination thereof, to extract individual diamonds from the HMS concentrate product. At the NWT Diamonds plant, the initial recovery will use X-ray systems. The final diamond cleaning and sorting operations will be done off site.

This broad sequence of diamond recovery operations for the project – from run-of-mine ore to saleable product – is depicted on Figure 2.5-1, followed by block flowsheets of the process in Figures 2.5-2 and 2.5-3. The process design is based on the metallurgical testwork and bulk sample programs completed to date and takes full account of the following key considerations:

- In accordance with the mine plan, the plant is designed for an initial throughput rate of 9,000 t/d, increasing to 18,000 t/d in Year 9 of the project.

  Ore from the various areas to be mined will have differing processing characteristics, as will the ore from within each orebody as the depth of mining increases. The design accommodates the expected range of variation that will be encountered in plant feed and plant operating conditions over the life of the mine. Figure 2.5-4 illustrates the design envelope that has been adopted based on these variations, and also shows how this compares with the corresponding envelope for the full range of kimberlite ore types encountered elsewhere.

- The emphasis throughout is on simplifying the design by having as few process treatment steps as possible using large-scale, proven equipment. The production modules are generally segregated according to process surge storage locations and allow for the installation of additional equipment when the plant production rate increases. To achieve economies of scale and minimize the maintenance and spares stockholding requirements at the remote project site, the equipment has been standardized as much as possible between modules.

- The design maximizes diamond liberation and recovery by using the latest and most efficient technology, including HPGR, available to the diamond industry worldwide.

◎ Table of Contents

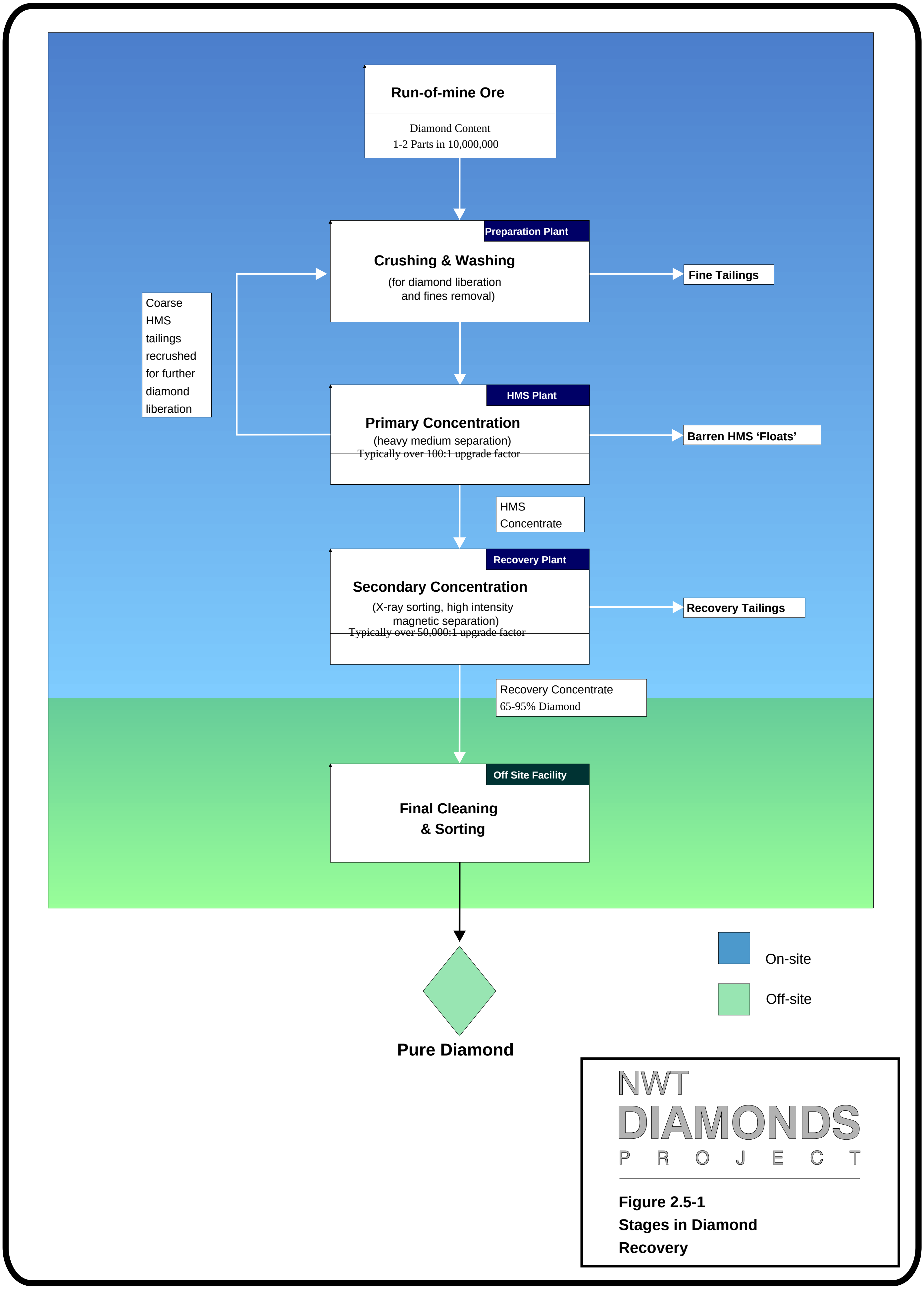


Figure 2.5-1
Stages in Diamond Recovery

Source: Fluor Daniel Wright Signet

◎ Table of Contents

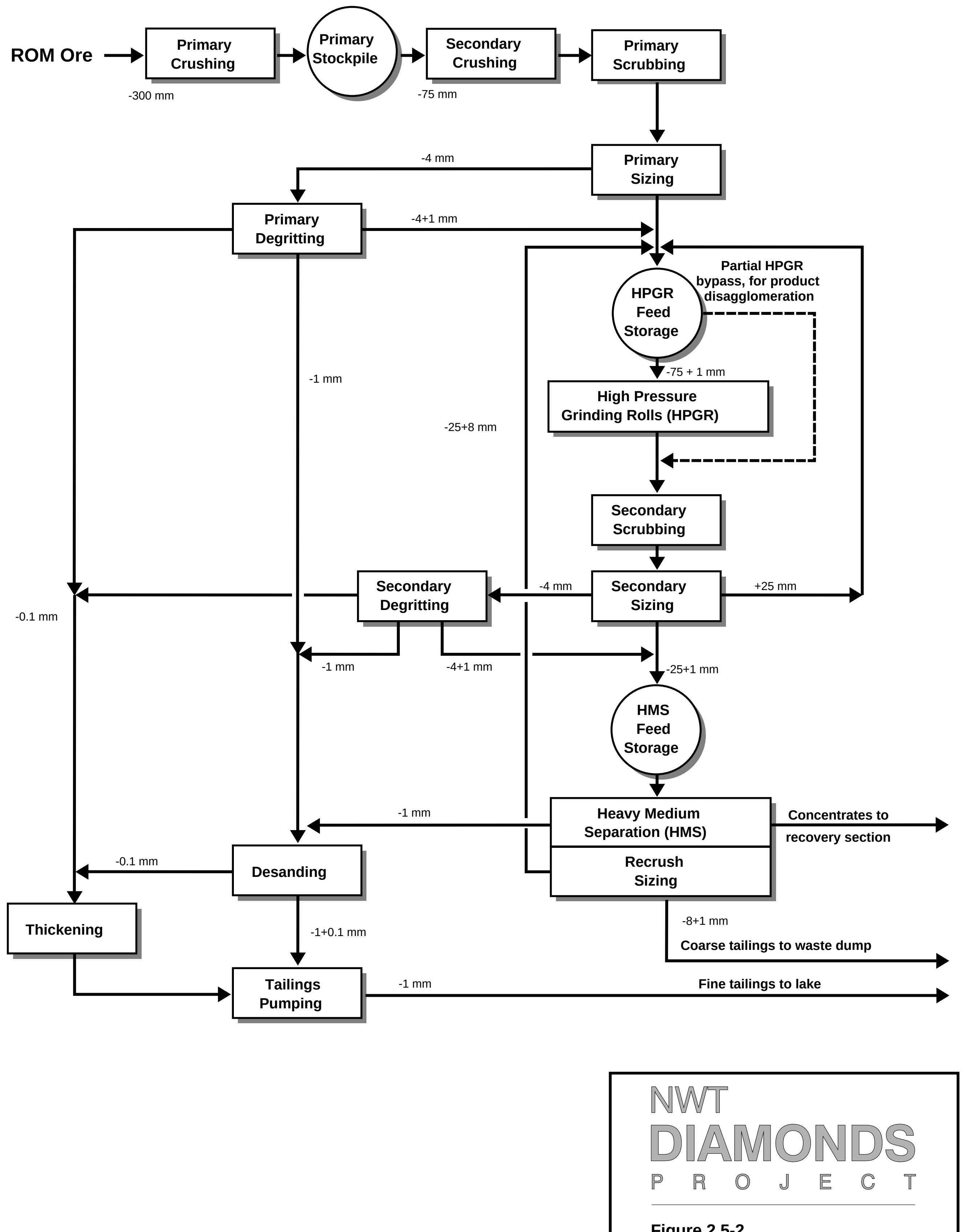
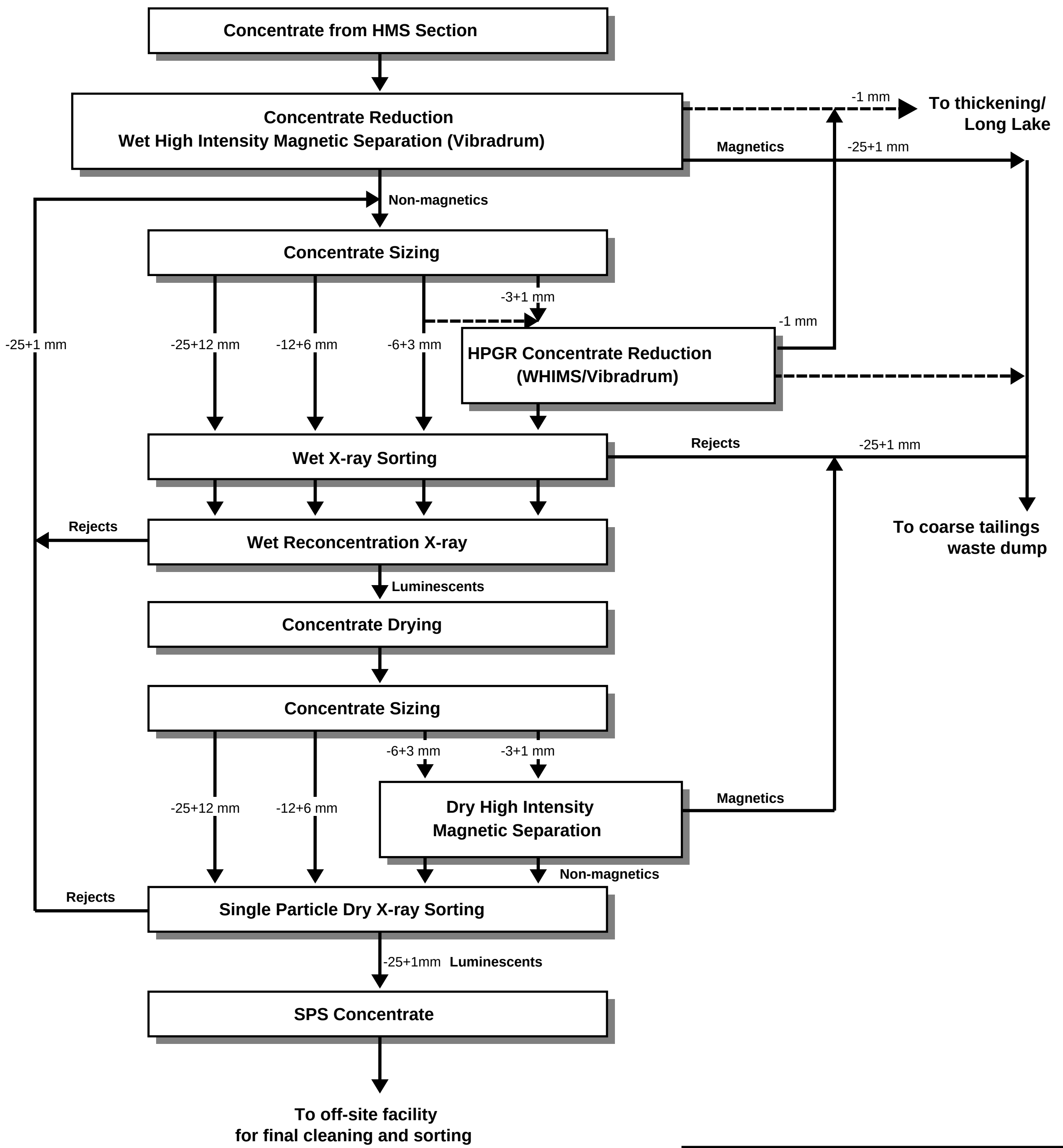


Figure 2.5-2
Process Block Flowsheet
Primary Concentration Section

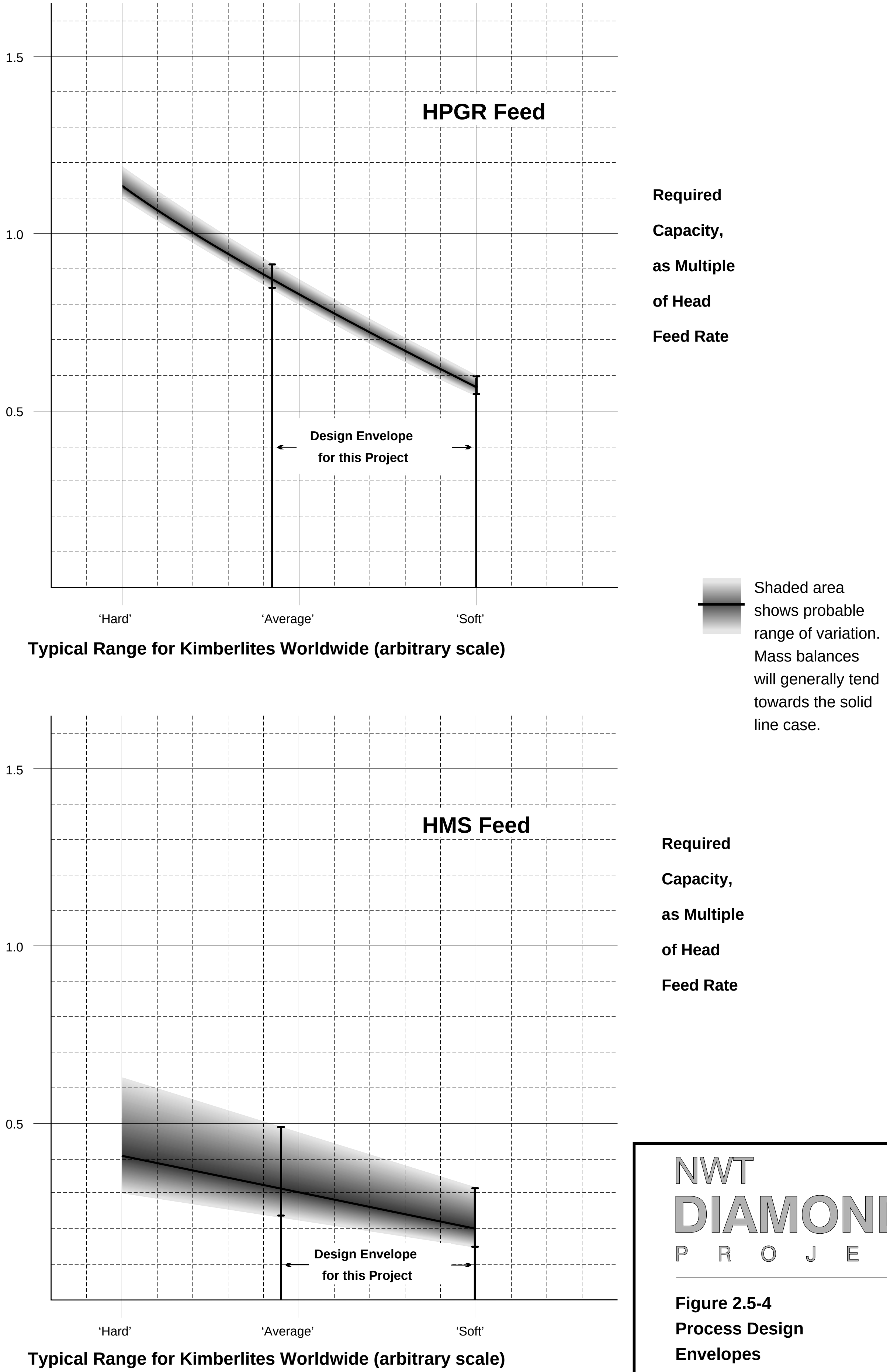
Source: BHP



NWT DIAMONDS PROJECT

Figure 2.5-3
Process Block Flowsheet
Recovery Section

Source: BHP



NWT DIAMONDS PROJECT

Figure 2.5-4
Process Design Envelopes

Source: Fluor Daniel Wright Signet

- There is a strong emphasis throughout the processing stages on security requirements for dealing with such a high-value, easily transportable product. All stages of the processing on-site are designed to be 100% "hands-off". In particular, access to all sections from HMS concentrating onward will be highly restricted.

- Particular account is taken of the effect of the arctic environment and harsh climate on the processing requirements, notable in the area of ROM ore crushing and subsequent handling and stockpiling of crushed ore upstream of the main treatment plant. The design capitalizes as much as possible on the advantages of handling frozen kimberlite ahead of the primary scrubbing stage during colder months. It also minimizes the extent of the equipment and process operations exposed to sub-zero winter temperatures, and, conversely, to the difficulty of handling thawed, sticky kimberlite during the summer months. The main processing operations will be carried out in a temperature controlled environment within the main process plant building.

2.5.2 Primary and Secondary Crushing

2.5.2.1 Primary Crushing and Stockpiling

Primary Crushing Station

Run-of-mine (ROM) ore from the various mining areas will be delivered by the haul trucks to the primary crusher area at the plant site. The trucks will dump either directly into the primary crusher or into a nearby 200,000 tonne ROM stockpile. From the stockpile, material will be trammed to the crusher by a front-end loader.

The crushing station will be a permanent installation consisting of a truck dump hopper, an inclined apron feeder, a gyratory crusher module, a services building and a discharge conveyor. The station will have a design crushing rate of 1,500 t/h and will operate on two 12 hours shifts per day to match the plant operation. The nominal top size (one side) of crusher discharge will be 300 mm, although most of the material will be less than 150 mm in size.

Gyratory crushers have been used successfully in the northern part of North America for many years. The design will incorporate modular and pre-assembled equipment, structures and buildings that can be erected quickly on site.

A dust collection system will be provided in the primary crushing area. An insulated, pulse jet fabric filter (winter use) and/or wet scrubber (summer use) will discharge the collected dust to a skip by means of a screw conveyor. The system will capture approximately 300 kg/h of dust, so that the resultant emission levels will not exceed 50 mg/m^3.

The ore processed through the crushing system will vary considerably, from sticky clay material with high moisture content to hard rock. In winter the ore will be frozen, making the clay materials easier to handle. For this reason, all areas where ore is being crushed, conveyed or stored in the primary crushing system will be unheated, though enclosed for weather protection for personnel.

Dump Hopper

Because the terrain in the area of the plant site is flat, an elevated turnaround area will be required to permit trucks to dump into the hopper. The turnaround area, as well as the haul road approach, will be constructed from mine waste and have a reinforced earth retaining wall. To minimize truck waiting and turnaround time, access will be from two sides of the dump hopper to permit one 218 tonne truck to position itself while another is dumping. The capacity of the hopper will be approximately 400 tonnes, or approximately two truckloads.

ROM ore will either be dumped directly by haul trucks hauling from the pits or trammed by a front-end loader from the nearby ROM ore stockpile. Ore from Misery will be dumped from off-highway truck/trailers used for the haul.

Apron Feeder

The apron feeder, which will carry the dumped mine ore from the hopper to the crusher, will be mounted on a fabricated steel structure, inclined at an angle of approximately 23°. Based on handling ROM ore with a maximum lump size of 1.2 m x 1.2 m x 1.5 m and the design crushing capacity of 1,500 t/h, the pan width will be approximately 2,500 mm.

The apron feeder will be powered by a variable speed hydraulic drive sized to start the feeder under full load at temperatures as low as -50°C.

A collection conveyor will be mounted under the apron feeder to catch any material carried back on the apron feeder pans that does not discharge into the crusher; this material (“dribbles”) will be redeposited into the crusher chute.

Crusher Module

The crusher is planned to be a 42 x 65 gyratory unit suitable for mounting to the structure of the crushing station. A rock breaker mounted on the crusher structure will break up large rocks that cannot pass the opening in the crusher or that become lodged in the crusher feed chute.

The module will include a fully clad and insulated services building, which will contain most of the electrical and hydraulic equipment for the crusher. This building will be heated to ensure that the hydraulic and lubrication systems are protected from the harsh climate. The top level of the services building will be the control tower for the crushing station, from where the operator will monitor the hopper filling and rock breaker operation. The control tower will be equipped with cyclone fence protected windows to guard against fly rock and with heating and ventilation systems. As the crushing station will be some distance from the main plant, an electric toilet and associated services will be provided.

A deck-mounted crane will be installed to permit maintenance of the crusher and the general area adjacent to it. Stairs and walkways through the services building and the rest of the crushing plant will allow suitable maintenance access to major components.

Crusher Discharge Conveyor

Material discharged from the crusher will be conveyed to the plant feed conveyor. Because of its width (approximately 1,800 mm) and slow running speed, this belt is an ideal location for the self-cleaning magnet, which will remove tramp iron. The conveyor will be mounted in an enclosed, unheated gallery to protect personnel from the outside environment during inspection or maintenance.

Coarse Ore Storage and Reclaim

The primary crushed ore can be fed to the process plant either directly from the primary crusher or indirectly via a crushed ore stockpile, depending on the ore handling characteristics. During white-out conditions and when the primary crusher is down, coarse ore will be fed into the plant from the coarse ore storage and reclaim system.

The coarse ore stockpile will be housed within an unheated A-frame building. The stockpile will hold approximately 20,000 to 50,000 tonnes with a bulk density of 1.4 t/m^3. To minimize dusting and provide protection during white-outs, the building will be totally enclosed. Two large access doors on the east and west sides of the building will allow for passage of mobile ore reclaiming equipment.

The coarse ore storage system will have three main sections: stockpile conveyor, standby coarse ore storage building and reclaim system complete with plant feed conveyor. All conveyors in this area will be approximately 1,200 mm wide. The stockpile conveyor will deliver primary crushed ore from the crusher discharge conveyor to the coarse ore storage building. The belt will be enclosed in an unheated gallery with a service walkway on one side. Three reclaim feeders will be provided, with two feeding directly from the stockpile and the third fed by a front-end loader pulling ore from the stockpile. When the ore is frozen in clumps, or is thawed and sticky, a dozer or front-end loader will be used to break up the clumps for feeding through a grizzly mounted over the third reclaim feeder hopper.

Investigations of other open pit mining operations in arctic and subarctic areas, including Red Dog, Colomac and Key Lake, have indicated that if the ore is frozen *in situ* and is expected to remain frozen through intermediate stockpiling, then direct reclaiming with feeders will work. When ore comes out of the pit thawed and sticky, however, or is likely to thaw during stockpiling, mobile equipment will be required to reclaim the ore from the stockpile.

Each reclaim feeder will have sufficient capacity for the initial process plant feed requirements; a minimum of two feeders will be required when the plant is expanded. The ore reclaim system will have a design capacity of 660 t/h initially and 1,320 t/h when the plant is expanded. An emergency tunnel at the rear of the reclaim tunnel will provide a second means of egress and also serve as a service passage to bring replacement parts to the reclaim area. This tunnel will exit immediately outside the standby coarse ore stockpile building.

Ore discharged by the feeders will fall onto the reclaim belt conveyor, which, in turn, will discharge directly onto a plant feed conveyor. The plant feed conveyors, one directly from the primary crusher and the other from the coarse ore stockpile reclaim system, will be fitted with a weigh scale to monitor feed rates to the secondary crusher. Each conveyor will also be equipped with a metal detector that will cause the belt to stop to prevent tramp iron from passing to the crusher.

2.5.2.2 Secondary Crushing

The secondary crushing section will reduce the 150 mm to 300 mm primary crushed material to 75 mm in a water flushed cone crusher. One crusher will be required for the initial operations and a second for the expansion. The water addition will ensure unimpeded material flow through the crusher, especially in the summer months when the ore is expected to be very sticky. Process water will be used for this purpose.

When the ore is frozen, the water addition rate will be reduced, and the water will be heated to thaw the ore ahead of the rest of the process. It is estimated that during the fall and spring, sufficient waste heat will be available from the power plant gensets to supply the required flush water heat. During the winter months, a heat shortfall from the power plant heat recovery system is anticipated, and two 5,885 MJ/s hot water boilers will be required to make up the difference. The estimated annual heat shortfall to be made up by the boilers is approximately 42 million MJ for 9,000 t/d of ore feed. Assuming high efficiency boilers with 84% thermal efficiency, the annual diesel fuel requirements for this purpose are estimated to be 1,400,000 L.

2.5.3 Scrubbing

Two stages of scrubbing will be carried out in the treatment plant. Primary scrubbing will follow secondary crushing, and secondary scrubbing will follow the high pressure grinding rolls.

Primary Scrubbing

The purpose of primary scrubbing is to disagglomerate the friable ore particles and disperse any clay that may be present. One 4 m diameter x 7 m long scrubber with a fixed speed drive will be required for the 9,000 t/d plant operation and a second, identical unit for the 18,000 t/d operation. The primary scrubbing section will use heated process water to thaw any remaining frozen ore.

The scrubber will discharge onto a double-deck horizontal vibrating screen, which will dewater and size the scrubber discharge at 4 mm. The +4 mm material will report to the HPGR section feed conveyor, and the -4 mm material, along with excess water, will report to the primary degritting section.

Secondary Scrubbing

The function of the secondary scrubbing section, which will be fed from the HPGR section, is to ensure complete disagglomeration of the HPGR product. The equipment will consist of a 3.3 m diameter x 7.5 m long rotary drum scrubber, a double-deck horizontal vibrating screen and underflow pumps. One module will be required for the 9,000 t/d operation and two for 18,000 t/d.

The scrubber product will discharge onto the screen for sizing. The top deck oversize product (+25 mm) will return to the HPGR section, and the bottom deck oversize product (-25 +4 mm), which represents a washed and sized diamond bearing ore feed, will report to the HMS section feed conveyor. Screen undersize (-4 mm) will be pumped to the secondary degritting section.

2.5.4 High Pressure Grinding Rolls (HPGR)

The HPGR section will consist initially of one or two high pressure grinding rolls plus a bypass module. Provision has been made in the layout for an additional HPGR module for the plant expansion.

The HPGR feed is the sized (nominally -75+1 mm) product from the primary scrubbing/degritting sections and recrush float material (-25+8 mm) from the HMS section. Each HPGR will be fed from a 175 tonne live capacity bin by means of a variable-speed, retractable belt feeder. The HPGR product subsequently becomes feed for the secondary scrubber.

The bypass module will permit some of the coarse material from primary scrubbing to be added to the HPGR product to assure disagglomeration in the secondary scrubbing process. Material leaves the grinding roll as a compacted cake, which will not break down completely in the secondary scrubber without the aid of some coarse material. The bypass section can be expected to contribute between 10% and 20% of the total feed to the secondary scrubber.

A dust extraction system with a high energy wet Venturi scrubber will be provided in this area.

2.5.5 Degritting and Desanding

The purpose of the degritting and desanding sections shown on the flowsheet (Figure 2.5-2) is to assist in removing fine waste material from the products of the various cleaning and separating stages. All -1 mm particles that pass through these sections will eventually be disposed of as tailings.

Primary and secondary degritting will follow primary and secondary scrubbing, respectively. The primary degritting module will receive feed from the primary scrubber screen undersize, and the secondary module will receive feed from the secondary scrubbing screen undersize. In both cases the -1 mm fraction will be removed from the -4 mm solids product and passed to the desanding section, and the +1 mm fraction will be returned to the process. The +1 mm particles from primary degritting will be returned to the HPGR section feed conveyor, while the +1 mm particles from secondary degritting will report to the HMS plant feed conveyor.

Each degritting module will consist of a sump, two cyclone feed pumps, two 1.2 m diameter cyclones, a single-deck banana screen and two transfer pumps. The feed distributor system will have automatic switching capability between the two modules, and an agitated emergency bypass tank will be provided for cyclone underflow in the event of an equipment problem. The agitator will keep the slurry in suspension until the tank can be pumped out back to the sump.

The desanding section will receive feed from the primary and secondary degritting modules and from the HMS modules. The feed will be a dilute slurry containing all -1 mm solids intended for disposal as fine tailings; the various incoming flows will be collected in a single sump. The other desanding equipment will consist of two cyclone feed pumps, two 1.2 m cyclones, two single-deck dewatering screens and two screen underflow pumps. This equipment will separate the feed into 0.1 mm and +0.1 mm particles, with the smallest material passing to a thickener before joining the rest of the fine tailings. As an emergency bypass, the dewatering screen discharge can be diverted for disposal with the coarse tailings.

2.5.6 Heavy Medium Separation (HMS)

Heavy medium separation (HMS) is a gravity concentration process that separates high density particles, including diamonds, from low density, non-diamond material in a conventional separating cyclone. The purpose of the HMS section is to upgrade the feed and produce a small proportion of high grade diamond concentrate suitable for the recovery section. The separation medium will be a slurry of water and ground ferrosilicon. Heavy minerals, including diamonds, will report to the spigot of the cyclone, while lighter particles will exit the top of the cyclone via the vortex finder.

It is of note that ferrosilicon is a very effective but very expensive product. Being iron-based, it is magnetic and can be recovered by standard magnetic separators. Effluents from the various HMS section end products will, therefore, be directed to such separators to permit capture and recycling of as much of the ferrosilicon medium as possible.

The HMS section will consist of two 120 t/h modules for the initial 9,000 t/d operation, each module having integrated primary and reconcentration sections. Four modules will be required for the plant expansion. Each HMS module will treat the full size range (-25+1 mm) of crushed ore, rather than having separate modules for coarse and fine feed. This will ensure full use of the available capacity and greatly simplify the plant layout, which is an important consideration in an enclosed building in the Arctic.

Feed for each HMS module will be stored in a 335 tonne live capacity bin and fed to a pulping box by a variable-speed belt feeder. The feed in the pulping box will be combined with magnetic separator effluent (dirty water) and process water before reporting to the feed preparation screen. The water will help remove undersize (nominally -1 mm) material from the screen; this underflow will be pumped to the desanding section. The oversize material (-25+1 mm) from the feed preparation screen will discharge to the primary mixing box, where it will be mixed with ferrosilicon. From the mixing box, the slurry will be pumped to three 400 mm diameter separating cyclones operating in parallel.

Centrifugal forces within the separating cyclones will cause the high density material (“sinks”) to be separated from the low density material (“floats”). The floats product, which constitutes the HMS tailings, will be discharged to a double-deck drain-and-rinse screen. This screen further separates the cyclone floats product into a coarse fraction (+8 mm), which is recrushed in the HPGR section, and a fine fraction (-8 mm), which is discarded as plant coarse tailings. Ferrosilicon slurry recovered from the drain section of the screen will return to the circulating medium pumpbox. The underflow from the rinse section of the screen will be pumped to the magnetic separator.

The diamond-bearing sinks product from the primary separating cyclones will report to a diverter, which will direct the material to either the 400 mm diameter reconcentration cyclone or the final sinks product drain-and-rinse screen. The screen product will be collected on the HMS concentrates conveyor and transported to a feed storage bin for the diamond recovery section. Overflow (floats) from the reconcentration cyclone will be recycled to the primary HMS mixing box.

Throughout these operations, drain panels and spray rinses will remove adhering medium for return to the medium circulation system. The density of the medium will be measured by a nuclear density gauge and controlled before being redistributed to the circulating medium headboxes. Low density ferrosilicon slurry from the screen rinse sections will be transferred to a dilute medium pumpbox and from there to a double drum magnetic separator. The magnetic separator will recover the ferrosilicon as a relatively high density slurry for recycling; the excess effluent water will be the dirty water supply for the HMS feed pulping preparation and the drain-and-rinse screens. A de-magnetizing coil in the magnetic separator product line will remove any remnant magnetism from the ferrosilicon so that it will disperse evenly through the slurry fed to the medium pumpboxes.

As ferrosilicon is slowly consumed in the process, the circulating medium pumpbox level will have to be topped up periodically from the ferrosilicon make-up facility, which is described briefly below.

Ferrosilicon Medium Make-up

The ferrosilicon medium to be used in the HMS process will be supplied in 1,000 kg bags and discharged into a dry storage bin. Material from the bin will be fed by a slow-moving belt feeder to an agitated preparation tank. Water will be added as required to produce the correct medium density.

In the dry storage area, a dust extraction system will capture any fine ferrosilicon particles that escape and return them to the storage bin. The extraction system will include a dry element-type baghouse and use a reverse air pulse system to clean the filter elements.

2.5.7 Recovery Section

The diamond recovery section will be based on X-ray sorting, which has become the industry standard for this stage of the separation process. The operating principle of the X-ray sorter is that diamonds luminesce when irradiated with X-rays. Detection of this luminescence causes an ejector to separate the luminescent, mostly diamond material from non-luminescent, non-diamond material.

To reduce the amount of feed to the X-ray sorters (which generally have low capacities), the design of the recovery plant incorporates high intensity magnetic separation (HIMS), which separates magnetic (non-diamond bearing) material from non-magnetic material, and a comminution step using HPGR equipment similar to that upstream. Testwork is ongoing to determine the optimum types of equipment to perform these concentrate volume reductions.

The recovery plant is divided basically into two sections, wet and dry. Diamond bearing material treatment sizes will be -25+12 mm, -12+6 mm, -6+3 mm and -3+1 mm. As currently designed, the wet section will comprise wet screening, HPGR comminution of the -3+1 mm fraction (and possibly the -6+3 mm fraction) and two stages of wet X-ray sorting. The product from the wet section will be dried before being transported to the dry recovery section, which will comprise further HIMS on the -6+3 mm and -3+1 mm fractions and one stage of single particle X-ray sorting.

The recovery process flowsheet is shown on Figure 2.5-3 and described in more detail below.

Concentrate Reduction

HMS concentrate will be fed to wet HIMS units to reduce the bulk of the material fed to the X-ray recovery section. Magnetic tailings will discharge into a surge bin and subsequently to the HMS tailings conveyor. The concentrate product will be discharged automatically at a controlled rate to one of two (one operative, one standby) pneumatic conveying vessels, which will, in turn, discharge into a concentrate storage bin in the recovery section.

Alternatively, this reduction may be carried out in a Vibradrum (vibrating grinding mill), again discharging the reduced concentrate into a storage bin.

Concentrate Sizing

Concentrate will be discharged from the storage bin by a dewatering vibrating feeder onto a sizing screen of semi-double deck configuration. The top deck will have 3 mm, 6 mm and 12 mm cut sizes. Polyurethane panels on the bottom deck below the 3 mm and 6 mm cut sections will drain off any excess water and -1 mm material, which will gravitate to the tailings pumpbox for disposal.

The -25+12 mm, -12+6 mm and -6+3 mm products will report to respective primary X-ray sorter feed storage bins. The -3+1 mm fraction, which contains most of the diamonds, will normally be diverted to another reduction (or comminution) stage, to remove additional impurities. Provision is also made in the layout for diversion and communition of the -6+3 mm fraction if considered appropriate.

Comminution

The comminution design for the sized -3+1 mm material is based on the use of an HPGR. HIMS and Vibradrum units are also currently under evaluation for this service. The HPGR product will be pumped to a dewatering screen via a hydrocyclone; the shear forces encountered during pumping will be sufficient for disagglomeration. Screen oversize will report to the -3+1 mm X-ray sorter feed bin, and screen undersize will be sent to tailings.

Primary X-Ray Sorter Feed System

Material will be withdrawn from the X-ray sorter feed storage bins by vibrating tube feeders discharging into motorized distributors. Each size fraction will have a dedicated distributor, which will be positioned over a pre-determined channel in a trough feeder. Each channel will be dedicated to a primary X-ray sorter, with only one distributor permitted to discharge into a specific channel at any given time. Material will discharge from the trough feeder into X-ray sorter feed surge bins above each primary X-ray sorter.

Primary and Reconcentration X-Ray Sorting

The primary X-ray sorters will each consist of two stages. The tailings product from the first stage will subsequently report to the second stage. The concentrate from both stages will report to the reconcentration X-ray sorters, which will be close-coupled to the primary sorters. The product from the reconcentration sorters will report to a wet concentrate surge bin for subsequent drying and further treatment in the dry single particle X-ray sorter (SPS) section. The reconcentration rejects will be recycled back to the recovery plant feed storage bin via a dewatering cyclone and vibrating dewatering screen.

The tailings (non-luminescing material) from the primary X-ray sorters will be dewatered on a vibrating screen and conveyed pneumatically, along with the HIMS magnetic product, to a surge bin above the HMS tailings conveyor for co-disposal with the HMS tailings.

Concentrate Drying

The reconcentration sorter products will be withdrawn from the concentrate surge bin by a screw feeder to a dryer. The dryer will be combined with a pneumatic conveyor allowing the concentrate to be dried with hot air while being conveyed to a dry concentrate storage bin. This bin will be equipped with a dust hood, to exhaust the hot air, and with a dust scrubber.

Single Particle X-Ray Sorting (SPS)

The dried concentrates will be withdrawn from the dry concentrate storage bin by a variable-speed vibrating feeder and fed onto a vibrating sizing screen. SPS treatment sizes will be -25+12 mm, -12+6 mm, -6+3 mm and -3+1 mm. In addition, the screen will have a 1 mm aperture section to remove fines resulting from degradation. Ambient air will be blown across the screen surface to cool the concentrate. The screen will be enclosed by a dust hood, and air and dust will be ducted away to the dust scrubber.

To reduce the mass of material reporting to the SPS units, the two finer fractions (-6+3 mm and -3+1 mm) may again be treated by HIMS to remove additional magnetic material. These HIMS units will have three stages, with the magnetic product from the first and second stages being retreated in the third stage, to maximize diamond recovery while ensuring a high mass rejection. The magnetic product from the third stage will be sent to tailings, and the non-magnetic product from the second and third stages will report to the SPS feed storage bins.

Material will be withdrawn from the SPS feed storage bins by tube feeders discharging into motorized distributors above a multi-channel vibrating trough feeder. Each channel will be dedicated to one SPS unit; to prevent cross-contamination of the size fractions, only one distributor will feed to a given channel at any time. The SPS feeders will present a single stream of particles to the ejection system, which will ensure a relatively pure diamond concentrate, provided that little non-diamond material exhibits luminescence. The SPS concentrate will be collected in a bin and gravitate to a concentrate container standing on a platform scale. These containers will be transported periodically to the off-site facility for final cleaning and diamond sorting.

The SPS rejects will be recycled to the recovery plant feed storage bin along with the reconcentration X-ray sorter rejects, thus closing the loop and ensuring optimum diamond recovery.

Dust extraction will be used extensively in the dry section of the recovery plant in order to maintain a clean operating environment. The dusty air will be ducted to a high energy wet Venturi scrubber, which will remove most of the airborne dust. The scrubber effluent will be pumped to the desanding section in the main treatment plant.

2.5.8 Tailings Thickening and Transport

Fine tailings and coarse tailings will be handled separately, with -1 mm material pumped to disposal in Long Lake and -8+1 mm material trucked to the Panda/Koala waste dump.

Fine tailings originating in the degritting and desanding sections of the plant, typically comprising -100 µm particles in a very dilute slurry, will be laundered to a thickener within the plant before being pumped to Long Lake. To reduce the footprint, as well as consequent heating and water storage requirements, a single, 25 m diameter, high rate type thickener, fitted with an automatic rake lift system, has been allowed for in design. Alternatives to a conventional high rate thickener, such as a Wren-CAT thickener/clarifier, are being evaluated to determine the potential for saving floor space and simplifying the overall process. The Wren-CAT unit is more compact and has no moving parts.

Powdered flocculant will be fed to the thickener from a flocculant make-up package plant. Based on the testwork to date, flocculant consumption in the order of 50 g (solid) plus 120 g (liquid) per tonne of plant feed solids is predicted.

Thickener overflow will gravitate to the process water tank as recycle water, and underflow will be pumped to a thickener underflow distribution box by three variable-speed underflow pumps (two duty, one standby). The underflow will then gravitate to the desanding section, where it provides the carrying medium for the -1 mm desanding screen oversize product, which is collected and pumped to the tailings pumpbox.

The tailings pumpbox will be a 100 m^3 capacity agitated tank. Tailings will be pumped by centrifugal pumps from the tank into one of two tailings lines, each sized for the 9,000 t/d operation. To accommodate the expected range of variation in the volume of tailings being pumped and to ensure stable operation, variable-speed drives will be required on the final pumping stage(s). Two pumping systems, one operating and one standby, will be provided to ensure high tailings pumping system availability.

All the tailings lines will be insulated and heat-traced. The tailings line bench will be constructed to provide a minimum hydraulic gradient of 0.4%. This will enable the tailings line to be substantially self-draining through strategically located actuated dump valves. The valves will be heat-traced and housed in heated, insulated shelters. The details of tailings deposition within Long Lake, together with the reclaim water management, are addressed separately in Section 2.6.

Coarse tailings (-8+1 mm) originating in the HMS section (float screen bottom deck oversize), which constitutes about 10% to 20% of the total tailings by weight, will be conveyed through a heated gallery to a heated 220 tonne capacity bin or open stockpile for transport by haul truck to the Panda/Koala waste dump. Experience gained from the on-site pilot plant operation indicates that the dewatered coarse tailings will remain essentially free flowing, even upon freezing after leaving the plant, because the clay content will have been removed and only particle surface moisture will remain. Truck transport of the coarse tailings fraction was deemed necessary because of the characteristics of the material. Investigations showed that hydraulic transport of coarse material (>3 mm in size) through a pipeline would result in either extremely high pipeline wear, as the particles drag across the pipe bottom, or the consumption of excessive pumping energy to keep the particles adequately suspended in the slurry.

2.5.9 Process Water Reticulation

There will be two main water circuits in the treatment plant, raw water and process water. Raw water will be obtained from Long Lake and pumped to the combined raw/fire water tank. The raw water will be strained in a self-cleaning strainer to remove solids before use in the plant, where "clean" water is required for the HMS and recovery sections and the gland water system. Where water quality is not critical, such as the secondary crushing and the primary and secondary scrubbing sections, the process water will be obtained from the tailings thickener overflow, augmented with raw water as required. Additional process water will be required for automatic line flushing, washdown and other duties. Where required, the process water will be heated by a heat exchanger using waste heat from the power plant augmented by boiler heat.

The line pressure in both the raw and process water circuits will be maintained automatically by means of pressure regulating valves.

Provision has been made in the layout for the installation of additional raw and process water pumps for the future expansion to 18,000 t/d.

2.5.10 Final Concentrate Cleaning and Sorting

Recovery plant concentrates will be transported from the mine site to an off-site facility for final cleaning, sorting and preparation for sale. The facility will be housed in a stand-alone building in an urban area, which has not yet been selected.

Delivery: Incoming concentrates will be delivered by armoured vehicle to a securely enclosed unloading bay on the ground floor. The concentrate containers will be unloaded under security supervision and weighed to confirm the recorded weight of concentrates dispatched from site.

Acidization: After weighing, the concentrates will be treated in a two-stage acidization process. They will be boiled in concentrated hydrochloric acid to remove ironstone and other soluble, non-silicate constituents and then be subjected to an automated hydrofluoric acid treatment (at ambient temperature) to dissolve any silicates and remove any organic or metal oxide coatings on the diamond surfaces. If required, a final boil in concentrated hydrochloric acid will be done to remove any residual impurities. Acid addition, agitation and washing will be controlled automatically to eliminate operator exposure to the acid. The treatments will be carried out in a well-ventilated, enclosed acidization area in the building, with two exits and an emergency shower nearby.

After the acid treatment, the concentrates will be dried and visually examined. Further manual cleaning will be conducted if impurities are observed, and the clean concentrate will then be weighed to determine the weight loss during acidization.

Waste and Effluent Treatment: Fumes from the acidization vessels and air drawn from the acidization area extraction hoods will be scrubbed in an acid fumes scrubber before being vented from the building. Scrubber effluent and spent acid from the acidization vessels will gravitate to neutralization tanks and subsequently be pumped to tanker trucks for disposal by an appropriate waste management contractor.

Sieving, Counting and Sorting: Pure diamonds, free of contaminants and surface coatings or staining, will be sieved and weighed individually, then counted in a stone counting machine. Parcels of counted and weighed stones will pass to an area having unobstructed natural lighting for final hand sorting. The extent of sorting required will depend on the sales agreement reached.

2.6 Tailings Disposal Plan

The diamond processing plant will produce 133 million tonnes of mine tailings during the planned 25 years of operation. The tailings are ground kimberlite rock that will have no chemical additives except water treatment flocculants, along with minor amounts of acid generating minerals and heavy metals. However, unlike other mine tailings in the NWT, they contain a component of smectitic clay minerals that are slow to settle and consolidate in water. The proportion of clay minerals varies significantly from pipe to pipe and to a lesser extent within any individual pipe. Design of the tailings management system is therefore controlled by requirements to contain and recycle any turbid water, to discharge only water that meets permit criteria and to provide a stable restored landscape at closure. On abandonment, natural precipitation must flow freely over the restored landscape into surrounding streams and lakes without increasing suspended solids or other contaminants above the permit discharge levels.

The tailings will be separated into fine and coarse fractions at the process plant. The coarse sand and gravel sized (1 mm to 8 mm) tailings fraction will be trucked to a dry disposal location at the waste rock dump described in Section 2.4.5. The fraction finer than 1 mm, which comprises approximately 80% to 90% of the tailings, will be hydraulically pumped to a confined disposal basin and discharged onto a beach or directly into a pond within the basin at a solids content of 45% by weight. Two heat-traced, insulated pipelines (one operating, one standby) will convey the tailings to the pond.

Long Lake will be the tailings disposal pond for the first 20 years of operation. Tailings generated beyond the 20-year period will be disposed of in deep pits that were once kimberlite pipes. The storage volume within the existing lake will be increased by construction of a total of 2,300 m of perimeter dams designed for complete water and tailings containment. The dams have been designed with a permafrost core that is very strong and impervious to water or tailings. Four intermediate interior dikes will be constructed from waste rock to subdivide the basin into five cells. Sequential filling of individual cells will optimize available storage volume and increase the flexibility of the disposal scheme.

Water will be pumped from the lake to lower its level at least 2 m before initiating tailings deposition. The upper portions of the basin will be filled first, progressively moving from the uppermost cells to the lowermost cells. This sequence will confine the ponds of turbid water during the first 18 years of operational life, allowing continued discharge of clean runoff collected by cells lower in the basin before tailings deposition at these locations.

The water in the impoundment may be discharged if it meets the permit criteria, it may be stored and recycled to the process plant or it may be treated and released. Design of the intermediate containment dikes will allow some seepage from the upper to lower ponds within the basin. The seepage will be through a constructed sand blanket that will filter clay solids. During the first 12 years of operation, the water must pass through two filter dikes to reach the discharge station, located at the south (lower) end of the basin. This water will be monitored before being pumped over an emergency spillway to rejoin the watershed.

The deposition plan provides a minimum of 20 years of tailings storage in the Long Lake basin and through at least 16 years of storage of turbid water. Excess turbid water beyond the 16-year period will either be treated to remove suspended solids prior to discharge or will be pumped to a surplus open pit for clarification and settling. The tailings surface will be progressively reclaimed as each cell within the basin is filled. All surface water will be drained and frost penetration will be encouraged to form a firm crust. An engineered cover of select waste rock, layered with coarse sand and gravel tailings, will be constructed on the frozen surface. A final cap of organic material will be spread on the surface in accordance with the reclamation plan.

Revegetation of the surface will convert the tailings basin into a wetland environment. Surface undulations will result from soil movements related to consolidation and frost heave as permafrost aggrades into the thick tailings, improving the wetland environment. The cover will be sufficiently thick to contain the new active layer. Permafrost is predicted to form in at least 80% of the tailings within 50 years and in 100% of the tailings approximately 150 years after the rock/soil cover is placed. Thus, all of the tailings that are hydraulically placed in Long Lake will eventually revert to permafrost conditions.

A drainage channel will be constructed over the restored tailings to conduct surface water to a residual pond that will remain at a south (lower) end for at least five years after tailings filling. The channel has been engineered to provide a non-erosive cover over the permafrost tailings. Runoff water conducted to the pond will be used in the process plant for a number of years after the basin has been restored. This will allow time for the restored landscape to stabilize and the water to naturally flow clear. The final stage of restoration of the Long Lake basin will begin near the end of the planned mine life when natural runoff is anticipated to meet all requirements of the water licence and the emergency spillway will be deepened to form a permanent, uncontrolled outlet. The water level will be drawn down to near the original lake level. The remaining basin will be selectively filled with waste rock, and the drainage channel will be connected to the permanent spillway outlet channel.

Tailings generated after Long Lake is filled will be directed to exhausted mine pits. Either the Panda or another pit will be the first to receive tailings. The tailings will be discharged from a pipeline that extends at least 50 m into the pit. The initial tailings consolidation in the deep pits (340 m deep in the case of Panda) will leave a turbid water cover of at least 30 m. With further solids consolidation over time, the depth of water cover will increase. Suspended solids in the water cover will be monitored until the top 20 m of clarified water meets the discharge criteria. The water in these infilled pit lakes will then be returned to the watershed. If the water has not cleared sufficiently and will soon reach the crest of the lake, excess turbid surface water will be pumped to an alternative pit or to a treatment facility, if required, and then be discharged.

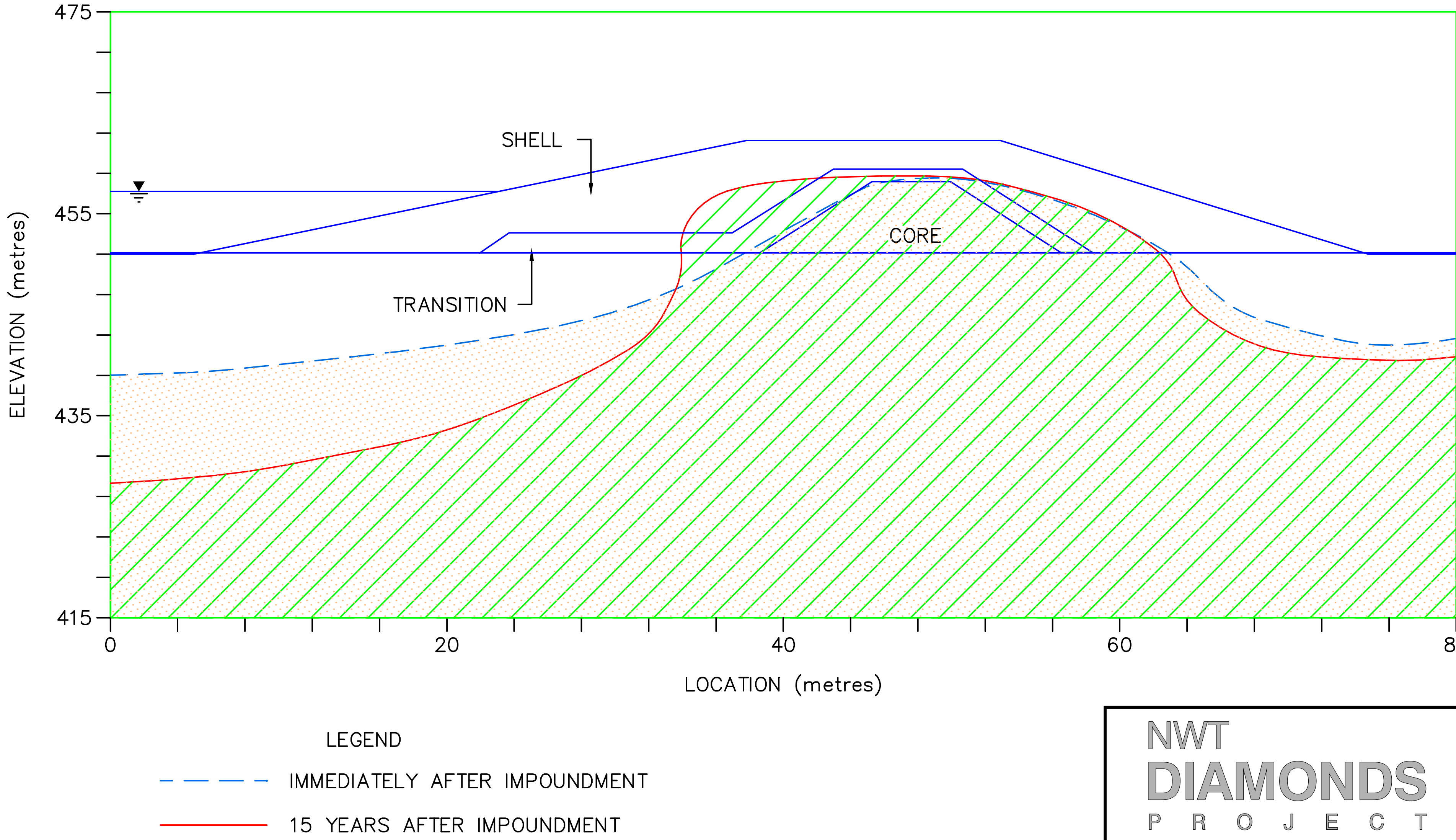
2.6.1 Long Lake Preparation

A number of structures will have to be constructed before tailings can be disposed of in Long Lake. These structures include containment dams, retention dikes, diversion structures and an emergency spillway.

2.6.1.1 Perimeter Containment Dams

Three perimeter containment dams will be constructed to allow the water level of Long Lake to temporarily rise to elevation 457 m. The maximum embankment elevation is 462 m, which includes 1 m of design freeboard above the emergency spillway discharge elevation plus 4 m of extra embankment to provide thermal protection for the permafrost core. The total length of the three dams is 2,300 m. The location of the perimeter dams is shown in Figure 2.6-1. They are referred to as the East Dam, Outlet Dam and Spillway Dam. The Outlet Dam is located at the river from Long Lake to Leslie Lake. This is the only dam on an existing watercourse. The fill quantities required for dam construction and their sources are summarized in Table 2.6-1.

◎ **Table of Contents**



NWT DIAMONDS PROJECT

Figure 2.6-1

Tailings Impoundment

Table 2.6-1
Dam and Dike Fill Volumes

Perimeter Dam Fill Volumes	Volume (m^3)			
	Core	**Transition**	**Shell**	**Riprap**
East Dam				
north leg	6,800	9,300	43,000	4,700
south leg	42,100	35,500	147,000	14,000
Outlet Dam	24,700	22,400	95,000	8,700
Spillway Dam	37,900	26,300	108,000	9,100
Panda Diversion Dam	10,700	5,300	19,000	not required
Totals	122,200	98,800	412,000	36,500

Intermediate Dike Fill Volumes	Volume (m^3)			
	Rock Core	**Transition**	**Filter 1**	**Filter 2**
Dike A	335,000	46,000	46,000	–
Dike B	168,000	29,000	29,000	–
Dike C *	476,000	76,000	76,000	–
Dike D	348,000	57,000	–	57,000
Totals	1,327,000	208,000	151,000	57,000

* Not required until tailings filling into Cell C commences.

Material Sources
Core - Airstrip esker (sand portion)
Transition - Processed rock (<150 mm) (coarse Airstrip esker and screened select waste rock)
Shell - Mine waste rock (run-of-mine)
Riprap - Select waste rock boulders
Rock Core - Mine waste rock (run-of-mine)
Filter 1 - Coarse (sand and gravel) tailings
Filter 2 - Airstrip esker (sand portion)

The design of the perimeter dams was developed from geotechnical site data collected at all of the dam sites during the summer season of 1994 and is documented in a comprehensive report (EBA 1995). The climate sustains cold permafrost soil and rock at the site everywhere except below lakes. Permafrost is depressed below the river bed at the site of the Outlet Dam.

The only embankment construction materials available in useful quantities are quarry rock stripped as mine overburden and, to a lesser extent, glaciofluvial sand and gravel from eskers. The permafrost foundation soil commonly contains abundant excess ice. These site-limiting factors determined that the most appropriate design for combined water and tailings retaining structures is a frozen core embankment on a permafrost foundation. A design geometry and construction schedule that will sustain permafrost in the foundation and core is the chosen concept. The permafrost soil core will be placed as a frozen ice-saturated sand to function as the seepage barrier for the dam. The frozen foundation will effectively eliminate seepage through the foundation soils below the dam.

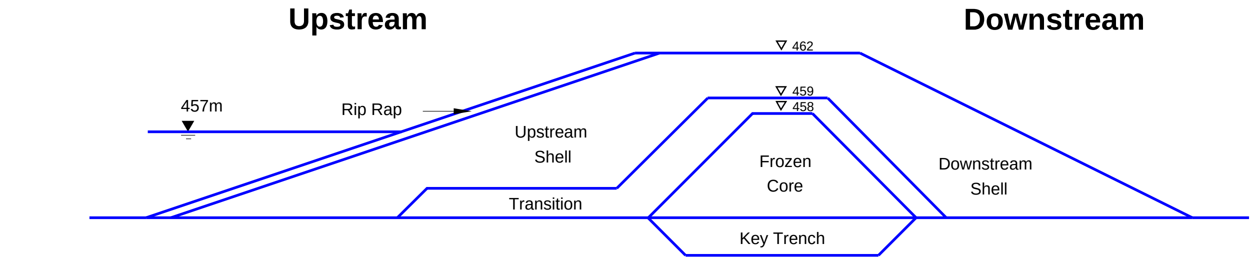
A number of frozen core water retaining dams have been built and are functioning well in regions of continuous permafrost. Several well-documented cases are in service in Russia (Sayles 1987) and two are in service in the NWT. The Canadian experience includes the Garrow Lake dam at Polaris Mine on Little Cornwallis Island (Cathro *et al*. 1992). That dam is 8 m high and has sustained a full head of water behind a core of frozen gravel since 1991. The dam has been monitored by EBA for the past four years. Performance has been excellent, with ground temperatures consistently below predicted values. The tailings dam at Lupin mine was constructed as a frozen fill on a frozen foundation. This dam contained a synthetic liner as a temporary seepage barrier, but it was designed to function for only several years and was not keyed into the foundation (Holubec and Dufour 1986). A 20 m high frozen core water supply dam has been designed for the proposed Raglan nickel mine on Ungava Peninsula in Québec. That dam is scheduled to be constructed during the 1995/1996 winter season.

Typical design cross sections for the perimeter dams are shown on Figure 2.6-2. All embankment materials will be placed in winter. The sand core (fines from screened esker material) will be pre-thawed and mixed with water to ensure complete saturation, then placed in lifts that will be allowed to freeze before subsequent lifts are placed. This staged freezing procedure will ensure that the entire embankment will be frozen at the end of construction and the core will be ice saturated. The frozen sand core will be covered with a rock shell that will contain seasonal summer thaw and provide protection against erosion.

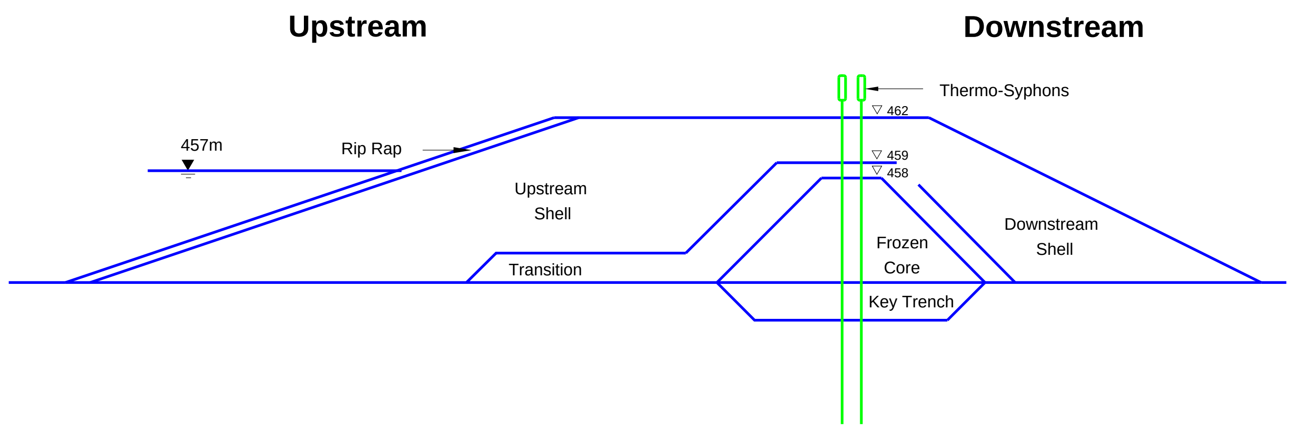
The dam section across the river valley, where there is a natural depression in the permafrost table, will be provided with thermosyphons to enhance heat removal from the foundation. Thermosyphons are vertical steel tubes that extend from 3 m above the embankment through the fill and into the foundation, as shown in Figure 2.6-2. They are installed in holes drilled through the embankment after construction. The tubes are charged with working fluid that undergoes an evaporation-condensation cycle in winter, extracting heat from the ground and dissipating it to the cold air. The thermosyphons will accelerate formation of a frozen barrier cutoff below the dam before any water is allowed to rise against the upstream slope.

The dam design sections have been based on extensive geothermal analyses, which balance heat load from the reservoir with annual heat removal at the crest and the downstream slope of the embankment. A two-dimensional finite element

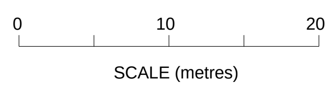
◎ Table of Contents



Perimeter Dam – Typical Cross Section
(Applicable to all Dams)



Perimeter Dam Founded on Talik – Typical Cross Section
(Applicable to Segment of Outlet Dam Only)



NWT DIAMONDS PROJECT

Figure 2.6-2
Perimeter Dam
Typical Cross Section

Source: EBA Engineering

thermal model, with 20 years of design history, was used to predict the temperatures within the embankment and foundation throughout the operational life of the structure. The base case analyses utilized long-term mean climatic data and a criterion of -2°C as the maximum allowable temperature within the core over the 25-year design life. In each case, the designs were tested for a condition of several consecutive warm years, with statistical return period of once every 100 years, and were found to perform satisfactorily.

All of the dams will be constructed on permafrost foundation soils, and several years will elapse before heat from the reservoir will affect the frozen embankment and foundation. The water level rises slowly from its drawdown condition, providing ample time for the thermal conditions to stabilize. Figure 2.6-3 shows the extent of frozen and unfrozen zones predicted within and below the embankment for the short-term (1 year) and the medium term (15 years). Time-temperature relationships for the most critical upstream point within the core are shown in Figure 2.6-4. These results from the thermal analyses show that the frozen core and foundation will remain as an effective seepage barrier throughout the life of the structure and beyond.

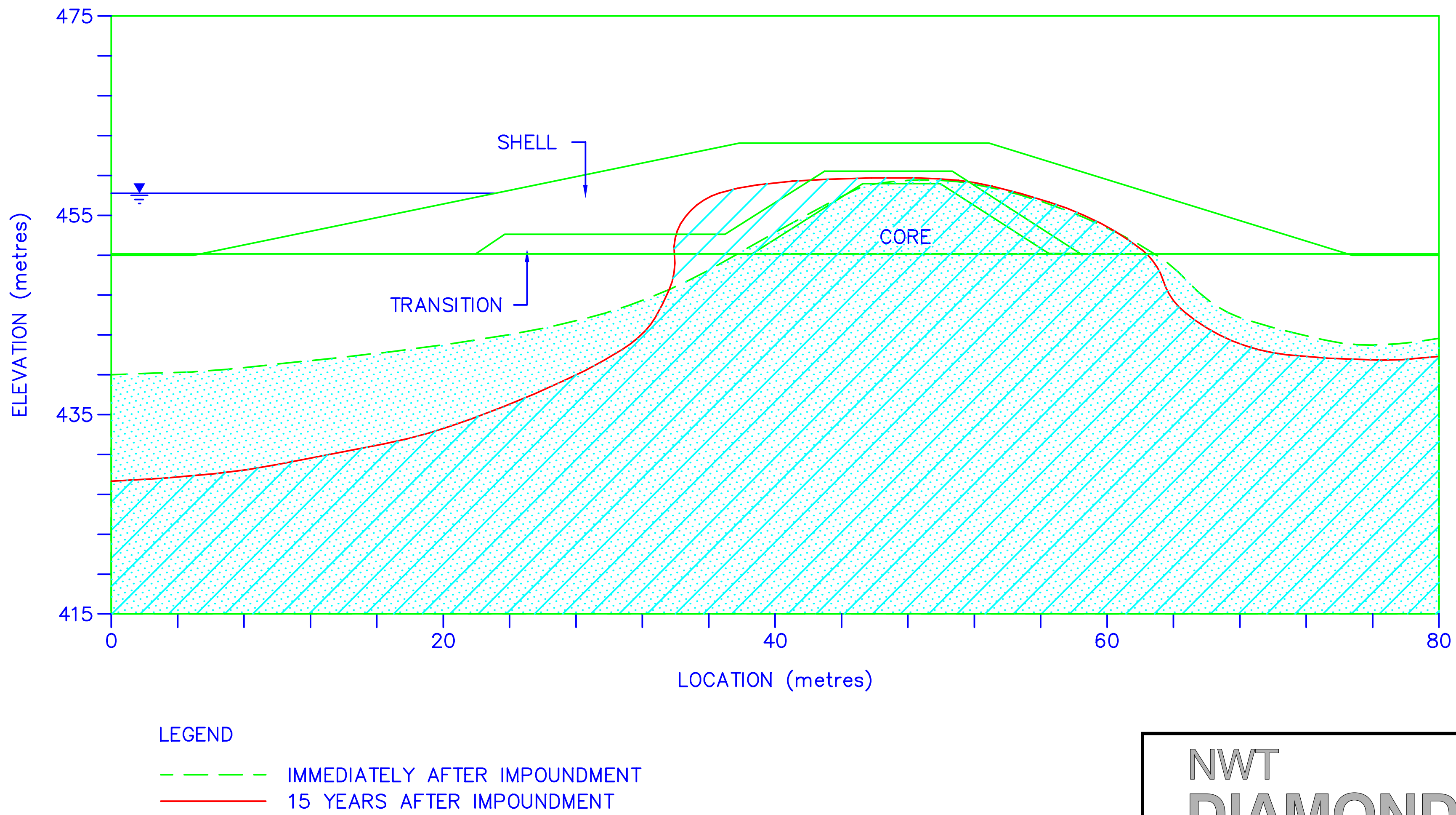
The site lies within seismic zone “0” for earthquake resistant design according to the National Building Code of Canada. The stability of the highest dam section has been evaluated for a peak horizontal ground acceleration of 0.04 g, which has a probability of exceedence of about 10% in 50 years. A computed factor of safety of 1.46 provides a greater-than-normal margin of safety against failure under earthquake loading.

2.6.1.2 Intermediate Tailings Retention Dikes

The basin will be subdivided into four cells by rockfill tailings retention dikes. The locations, shown in Figure 2.6-1, were selected at shallow water crossings. Two dikes (A and B) will be constructed on the lakebed after lowering of the lake level, whereas the remaining two will be constructed in water. Dikes A, B and D will be constructed before tailings are deposited, and Dike C will be constructed before tailings are deposited into Cell C, about five years after mine start-up. The dikes will also serve as access roads for tailings disposal pipelines and maintenance activities.

The design has been developed for either permafrost or non-permafrost foundation conditions anticipated in the lakebed or at shore crossings. A typical cross section for the intermediate dikes is shown in Figure 2.6-5. They will be constructed during the summer season by end-dumping waste rock fill followed by two zones of filter transition material placed on the upstream face. The waste rock fill dike at location D will be surfaced with esker sand and gravel rather than coarse tailings to reduce the risk of early contamination of Cell D. The dams are

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



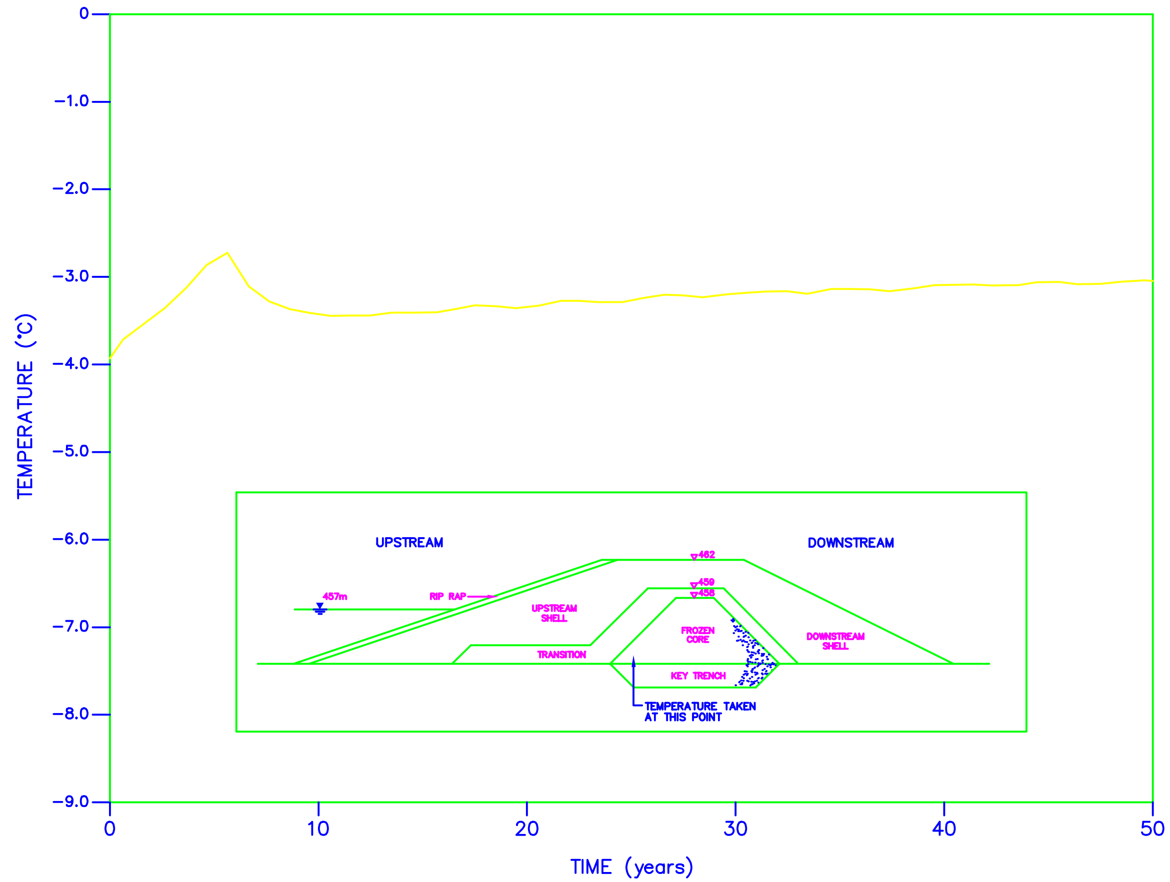
NWT DIAMONDS PROJECT

Figure 2.6-3
-2°C Isotherms in Perimeter Dam Over Intially Frozen Foundation

Source: EBA Engineering

Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



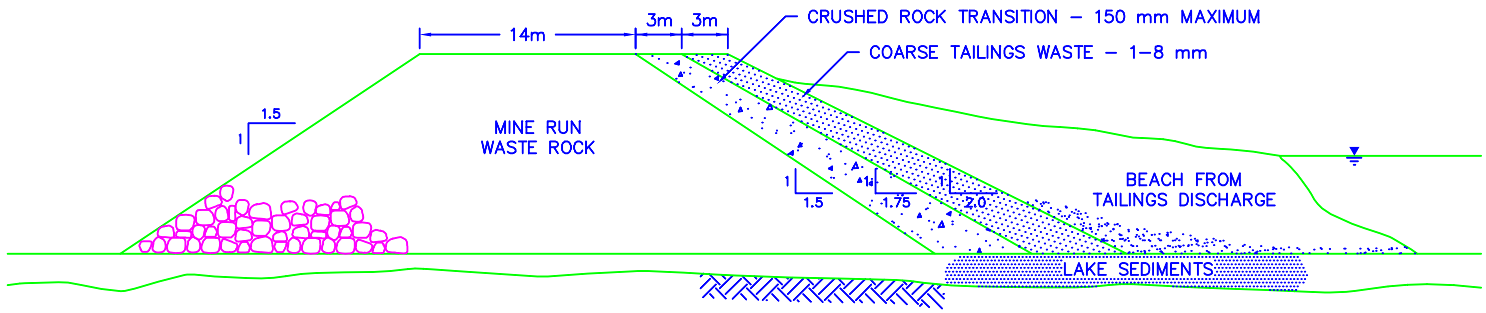
NWT DIAMONDS PROJECT

Figure 2.6-4
Permafrost Core Dam, Temperature History of Base at Core

Source: EBA Engineering

Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



NWT DIAMONDS PROJECT

Figure 2.6-5
Intermediate Dyke
Typical Cross Section

Source: EBA Engineering

designed either to provide full containment of tailings water or to act as a filter to remove suspended solids from water that seeps through the dam. It is anticipated that some seepage will occur; however, most of the water will be contained behind the dams. The design has been developed for an operating differential water head of 14 m and an emergency differential head of 16 m followed by possible overtopping. Water level behind the dikes will be controlled when required by pumping surface water to the next cell to be filled. At the beginning of cell filling, a beach will be created against the upstream face with tailings. This beach will seal the upstream foundation contact, minimizing the risk of leaking through the foundation.

2.6.1.3 Basin Diversion Structures

Minor diversion structures are incorporated into the tailings management plan to maximize the amount of natural runoff that can be released from the Long Lake basin without treatment. The water diversion structures consist of low dikes and one channel at the location shown in Figures 2.6-2 and 2.6-6. Area A currently discharges into the part of Long Lake that becomes Cell A, and Area B currently discharges into what will become Cell D. Berm B will block the flow of runoff from Area B into Cell D, such that it will overflow into Cell E. Berm A and the channel between Areas A and B will force a portion of the runoff from Area A into Area B and from there into Cell E. Cell E is to remain free of tailings; therefore, runoff that enters that cell can probably be discharged without treatment.

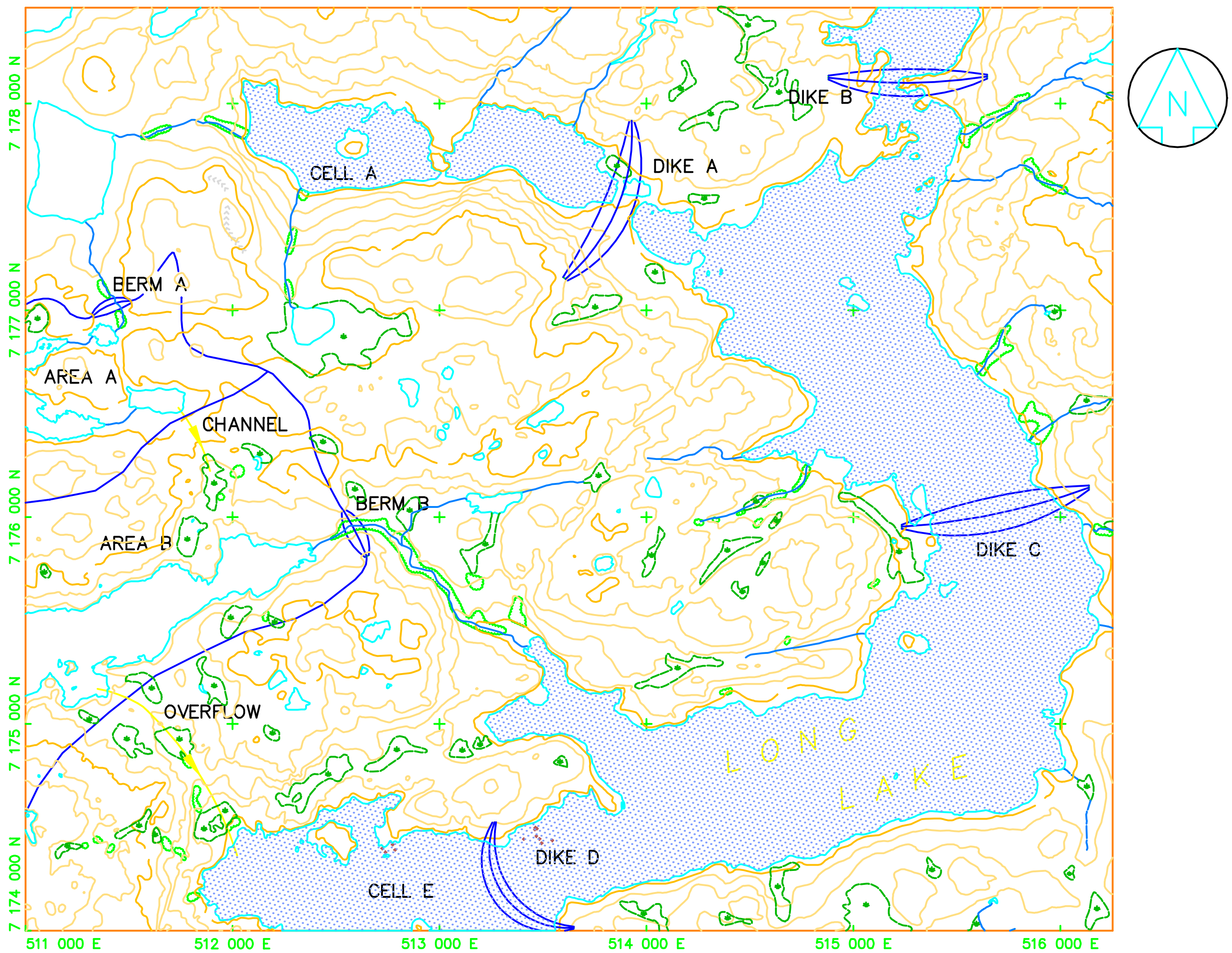
The low berms will be constructed of waste rock, with either a frozen sand core or a geotextile liner. They will not sustain any continuous head of water but will function only during snowmelt runoff and periods of heavy rain.

2.6.1.4 Emergency Spillway

Dams with a permafrost core provide excellent containment of water, but they are susceptible to thermal erosion if they are overtopped. To avoid any possibility of overtopping, an emergency spillway will be constructed just west of the Spillway Dam (Figure 2.6-7). Clearly, it is undesirable to have to use the emergency spillway, because the quality of the water that is discharged in such a situation can not be controlled. Cell E will be operated as a surge basin in a manner that reduces to an absolute minimum the risk that the spillway would ever be used. The water level in Cell E will be lowered to approximately 448 m before spring runoff. The outlet level of the emergency spillway is at an elevation of 457 m, or 9 m above the Cell E drawdown level. At this operating level, the storage capacity of Cell E is 21 million m^3, or approximately three times the estimated average yearly runoff from the entire Long Lake basin. Sufficient reserve volume is available in Cell E to store a flood greater than a 1:1,000 year event.

◎ Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



Scale: 1:30 000

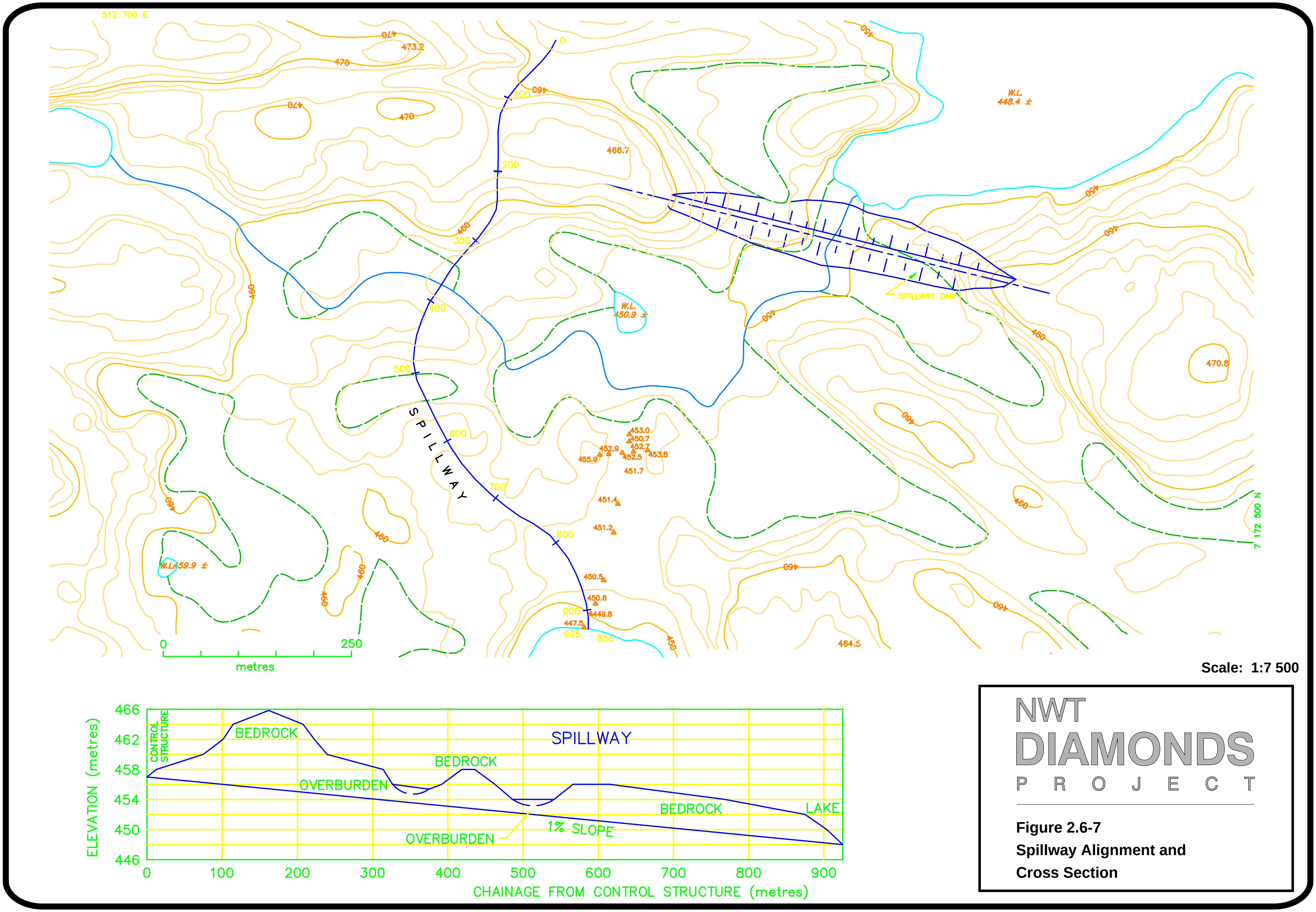
NWT DIAMONDS PROJECT

Figure 2.6-6
Water Diversion Structures

Source: EBA Engineering

◎ Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



Scale: 1:7 500

NWT DIAMONDS PROJECT

Figure 2.6-7
Spillway Alignment and Cross Section

Source: EBA Engineering

The emergency spillway is to be constructed with a width of 15 m, such that the discharge equivalent to the average annual inflow volume can be handled within one week with a corresponding reservoir rise to 457.6 m.

2.6.2 Long Lake Operations

The operations at Long Lake will be discussed in terms of the filling sequence and water management, as well as the effects of seasonal deposition.

2.6.2.1 Filling Sequence and Water Management

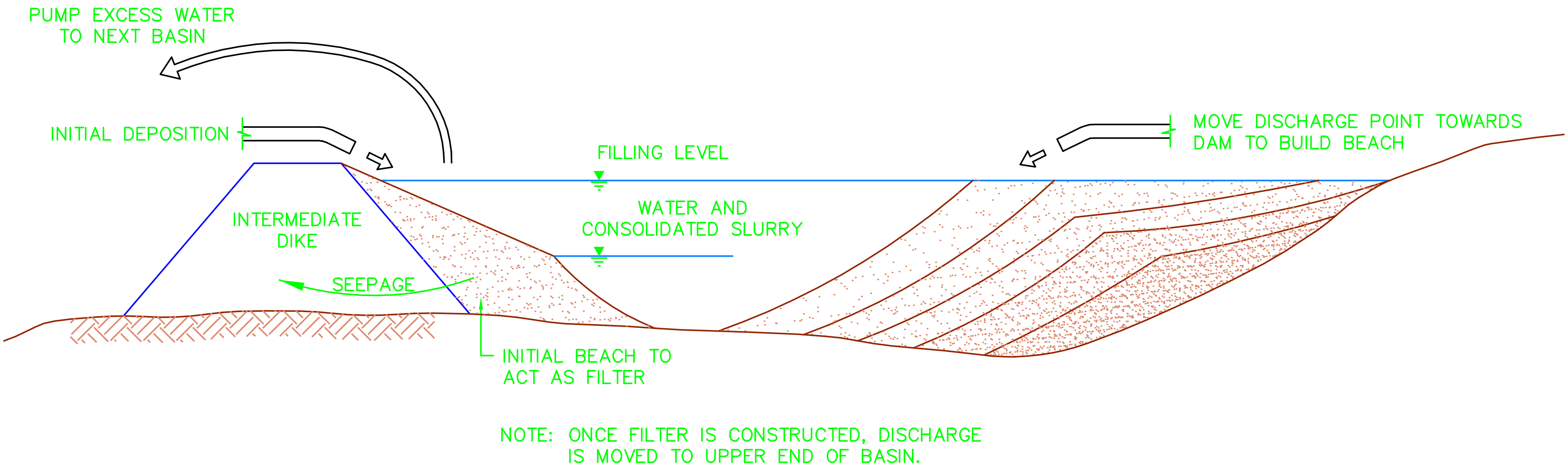
The basin will be filled from the upper end in cell sequence A, B, C and D. Cell E will not receive tailings but will act as a final clarifier pond where water quality is monitored and treated if required before discharge. Cells A and B will both be ready to receive tailings at mine start-up. Cell A will be filled first by beaching from the upstream slope toward the dike. The beach will form with a slurry of fines in front of it as shown in Figure 2.6-8. When the water level rises to near design elevation, 2 m below the top of the dike, surplus slurry and water will be pumped into Cell B.

Filling will continue until the design tailings beach or slurry elevation is reached. The slurry will then be allowed to consolidate as the discharge is changed to Cell B. The cell may be topped up following consolidation of the slurry. All free water will be drained from the tailings surface following filling and the exposed surface left to freeze. Surface restoration will be initiated in winter as soon the frozen crust has formed to sufficient depth to support equipment and the cover material.

Filling will proceed from cell to cell moving down the basin. In each case surplus slurry and turbid water will be pumped into the next cell. The predicted average tailings elevation and maximum water elevation in each cell with time is shown in Figure 2.6-9. Seasonal runoff water that enters the basin through a cell downstream of the tailings deposition will be routed through Dike D, which does not have a tailings beach. The water will be monitored and may be discharged each year from Cell E if it is considered surplus and meets the water quality criteria.

By Year 16 the turbid water will reach design elevation in Cell D. At that time a treatment plant may be required to flocculate the suspended solids, allowing water to be discharged. Alternatively, excess turbid water may be pumped to an exhausted pit for storage and settling. The basin filling plan, shown in Figure 2.6-9, assumes that all water is contained as each cell is filled, with no allowance for loss to the adjacent cell through the filter dike. Further benefits may be realized from water clarification resulting from freezing. Filtering,

Table of Contents



NWT DIAMONDS PROJECT

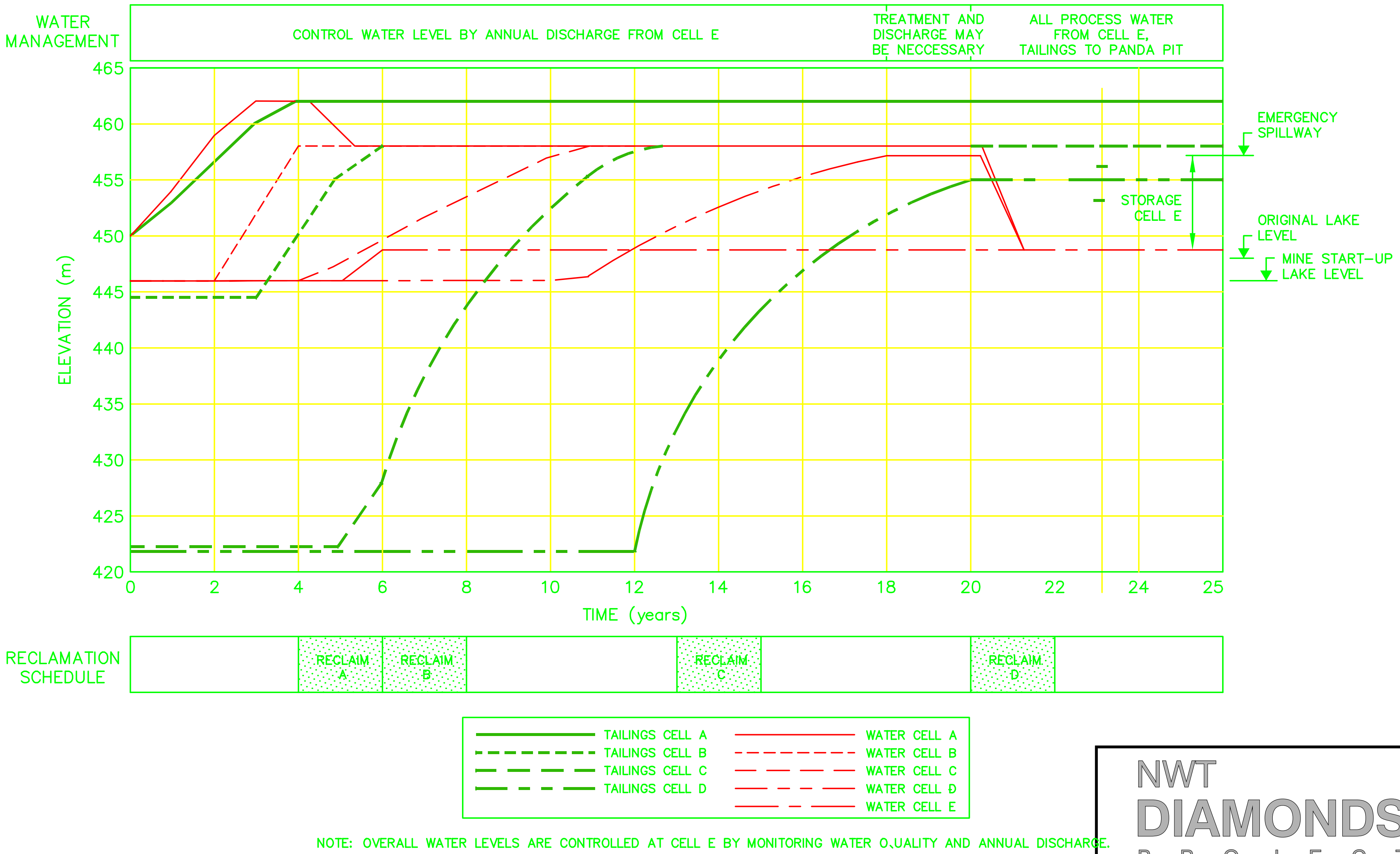
Figure 2.6-8

Tailings Disposal in Cell

Source: EBA Engineering

◎ **Table of Contents**

Cad No. a371s **Job No. 455** **03/29/1994-05:22pm** **Res_AV**



NWT DIAMONDS PROJECT

Figure 2.6-9
Tailings and Maximum Possible Water Levels in Cells A Through E

NOTE: OVERALL WATER LEVELS ARE CONTROLLED AT CELL E BY MONITORING WATER QUALITY AND ANNUAL DISCHARGE.

Source: EBA Engineering

freezing and dilution may eliminate the four-year period where water treatment is included in the plan. The multicell concept of tailings storage and water management provides maximum flexibility to achieve these potential benefits.

2.6.2.2 Seasonal Deposition

The tailings deposition methodology will be varied from summer to winter, as shown in Figure 2.6-10, to accommodate severe sub-freezing weather. A long beach will be built in summer and a short beach will be maintained in winter. The estimated beach profile has been determined from published data on behaviour of similar tailings beaches at South African diamond mines (Blight 1994).

2.6.3 Long Lake Reclamation and Abandonment

The reclamation and abandonment of Long Lake involves four main activities:

- beach and slurry reclamation
- water monitoring
- residual lake management
- dam and dike maintenance.

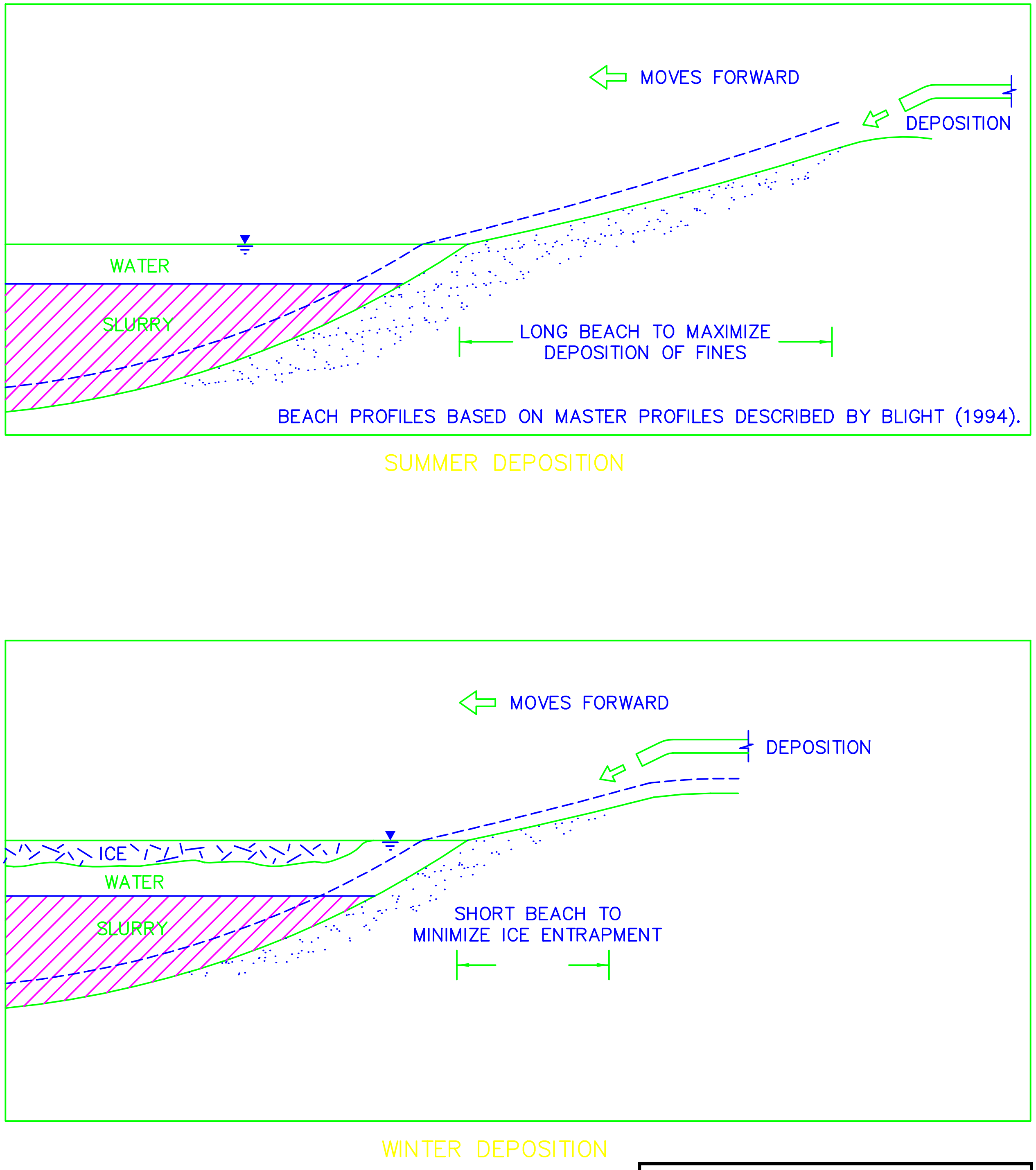
Section 9.3.2 of Volume III discusses these four main reclamation activities in more detail.

2.6.4 Pit Disposal and Restoration

The Panda pit will be the first to be exhausted, approximately five years following mine start-up. However, underground mining below the pit will require that it remain dry until about Year 20. By that time, three abandoned pits will be available, Panda, Fox and Koala. Only two, Panda and Koala, are within close proximity of the process plant. The tailings discharge would be directed to one of those two pits at Year 20. Panda is the largest of the three cone shaped pits, approximately 700 m in diameter at the top and 340 m deep. The overall pit volume is 43 million m^3, providing storage for all tailings and water discharged from the process plant for approximately five years of mine production. This storage capacity will be sufficient for the balance of the planned mine life. Other pits are available to receive tailings if required beyond the planned mine life.

The tailings discharge point will be at least 50 m below the top of the pit. The tailings and water will initially cascade into the pit, building a water cover on top of the tailings as they segregate and settle. The projected rate of rise of the water cover is shown in Figure 2.6-11. This rate assumes that no water will be

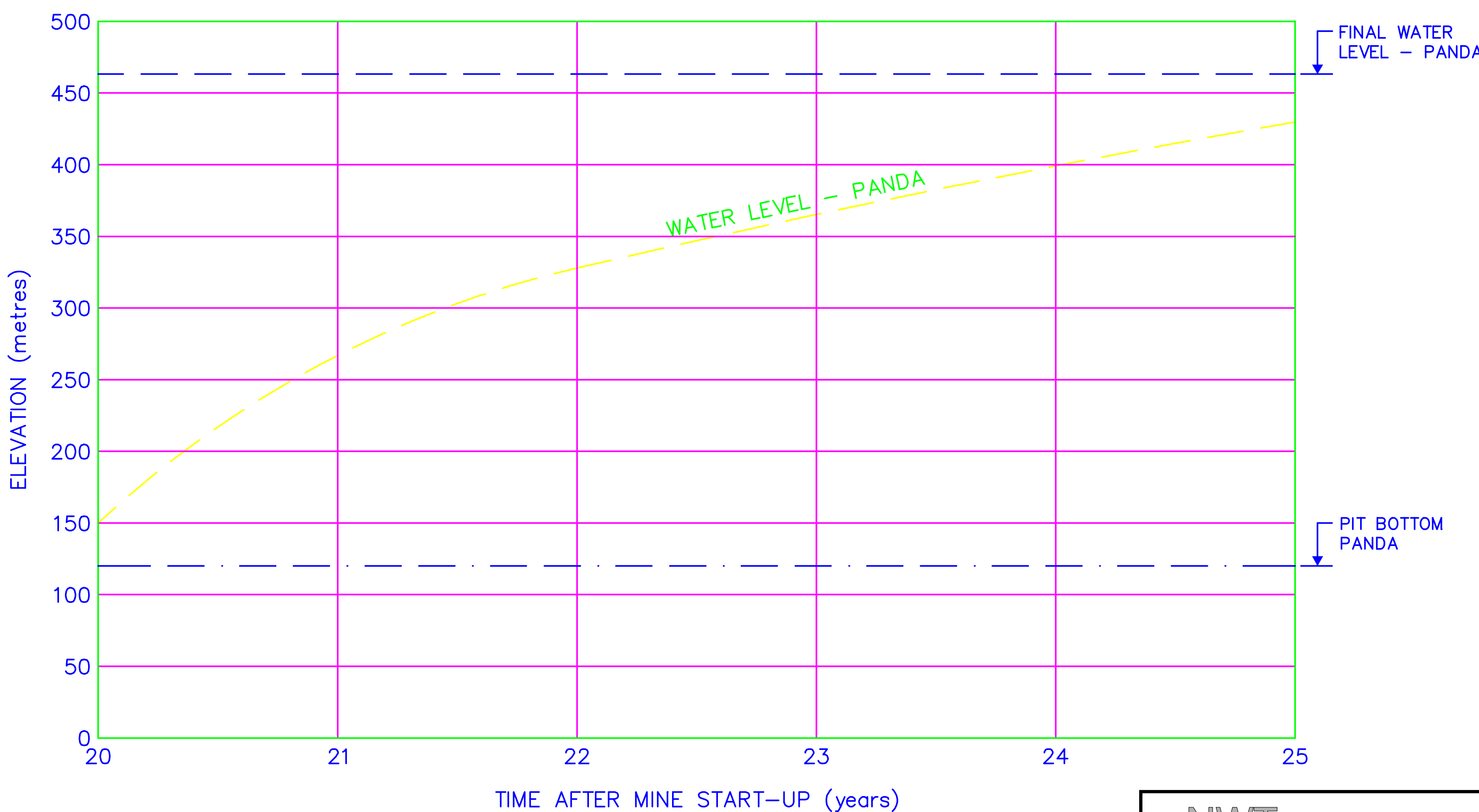
◎ Table of Contents



NWT DIAMONDS PROJECT

Figure 2.6-10

Seasonal Deposition of Tailings



NOTE: PANDA PIT IS ASSUMED TO BE FILLED FIRST BUT ALTERNATE SIMILARLY SIZED PITS MIGHT BE FILLED FIRST.

NWT DIAMONDS PROJECT

Figure 2.6-11
Water Rise in Panda Pit During Tailings Infilling

reclaimed from the pit and that natural recharge by groundwater is insignificant. Natural groundwater recharge to the pit will occur to some degree and will result in a hydraulic gradient towards the pit. This natural inflow of groundwater will ensure there is no outflow of turbid water, since the pit water level will be well below the surrounding water table level while the pit is being filled with tailings.

Raw water for the process plant will continue to be taken from Cell E at Long Lake during this phase of mine operation. Process water may be reclaimed from the pit when the water elevation is within 20 m to 30 m from the top to allow further tailing depositions. Alternatively, the tailings discharge may be moved to another pit, allowing the deep deposit of tailings to consolidate and the surface water to clarify.

Ice that forms in the pit during winter deposition is expected to thaw during the summer months. Ice that persists from one year to the next will eventually be flooded by the rising water level and will thaw following immersion.

Pits that receive tailings will be restored to form deep lakes at mine shutdown. The tailings will continue to consolidate for a long time after filling, resulting in a progressive increase in lake depth. A minimum water cover of 30 m will be maintained over the settled tailings. Water that discharges from the pit lake will meet the guidelines for discharge to natural watercourses. If additional years of pit tailings settling are required to meet the guidelines, then the excess water to keep the pit from cresting will be treated before release. Natural processes such as consolidation and seasonal freezing will assist in progressive water clarification.

2.7 Infrastructure

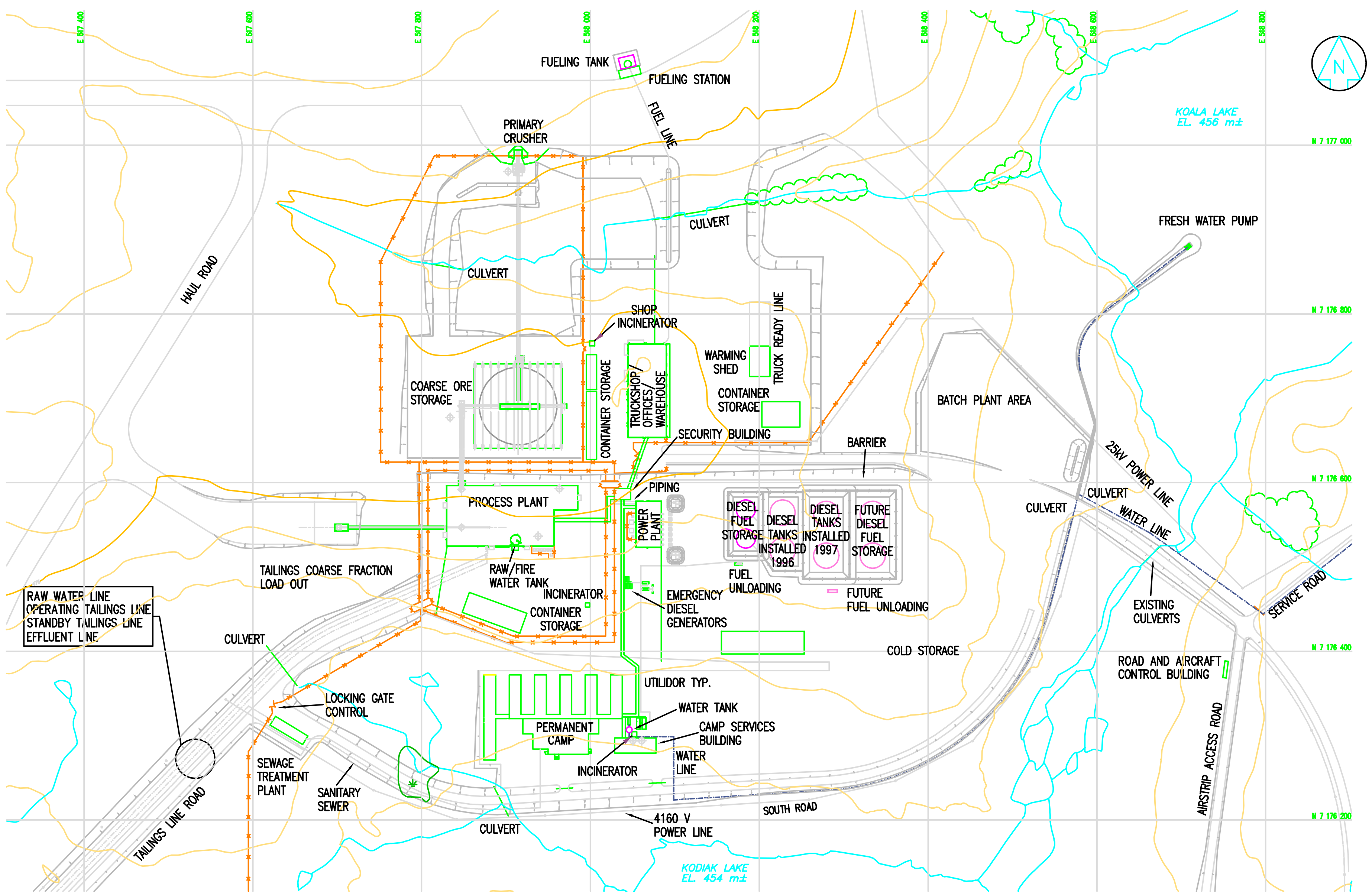
Various buildings and services will be provided at the site to support the mining and process plant operations. Most of the major facilities, including the process plant building, a diesel power plant, an integrated truckshop/offices/warehouse complex, a security building and a permanent camp, will be constructed in a central area southwest of the Koala pit. Other services and utility systems such as fuel storage and distribution, water supply, sewage collection and waste disposal will be established to supply these main buildings.

This section describes the proposed project infrastructure for the NWT Diamonds Project. It outlines in general terms the type and size of the project installations and facilities, with finalization of size and design to be undertaken during the final design phase of the project.

2.7.1 Facility Layout and Design

The facilities will be laid out in a compact arrangement that takes advantage of the natural contours of the site (Figure 2.7-1). The remoteness, the extremely cold

◎ Table of Contents



Scale: 1:4 500

NWT DIAMONDS PROJECT

Figure 2.7-1
Layout of Plant Site Facilities

Source: Rescan

climate and the limited access that characterize the project site were major considerations in the development of designs. Engineered, pre-assembled and modular structures will be used wherever possible. Other design features intended to ensure personnel safety and operational reliability in these harsh conditions are as follows:

- The process plant, fuel tanks and other major structures will be founded on bedrock to minimize structural problems associated with permafrost.
- Where founding on rock is impractical, footings will be placed on compacted granular fill of sufficient quality and depth to ensure permafrost stability. Steel piles will be used to minimize concrete and fill requirements.
- Concrete slabs on grade will be insulated to prevent permafrost under buildings from thawing.
- Low temperature, 300 WT, structural steel will be used in certain structures. This grade of steel will maintain ductility at low temperatures and reduce brittle impact failures during delivery over the winter road, during erection and *in situ*.
- Totally enclosed and heated corridors for utility piping and personnel access (“utilidors”) will connect the permanent camp to the security building and other work areas and facilities. Fire protection water will be distributed to the buildings through the utilidors.
- Waste heat from the diesel generators will be utilized for heating buildings and process water in the main plant area.
- All conveyor galleries will be enclosed. Conveyor belting will be designed for a combination of cold weather operation and abrasion resistance. Low temperature bearings and grease will be used for conveyor idlers and pulleys.
- Most external piping will be insulated and heat-traced.
- Electrical outlets will be provided at all designated parking areas for mobile equipment and vehicles.
- Storage facilities for diesel fuel, bulk supplies, consumables and spare parts will be sized for 12 months of operation.

All applicable NWT and Canadian codes and regulations will be incorporated into the design, construction and operations of the site facilities.

The main plant site facilities will be used to support all processing and mining activities except those at the Misery pit, which is approximately 29 km to the east, near Lac de Gras. Limited infrastructure, including diesel fuel storage, a truckshop/office complex and a small camp, will be established at Misery for the life of the Misery open pit. An independent power generation system will service this infrastructure but will not extend into the pit, as the mining equipment will be diesel powered. Separate communications systems, sewage treatment and fire protection water will also be provided for the Misery operations.

Any other remote mineable pipes that might be discovered later in the project life would be equipped with similar infrastructure.

All facilities at the main project site will be protected by an extensive security control system intended to prevent and detect theft of diamonds.

2.7.2 Property Access

The site roads and airstrip providing access to and around the NWT Diamonds property are described in this section.

2.7.2.1 Roads

On-site access roads will be of two different widths based on general traffic type. The descriptor "access" is generally used to refer to 10 m wide roads for small vehicle traffic. These roads include the plant site and service roads as well as the Misery haul road. The term "haul road" is applied to those roads in pits, to/on waste dumps and for ore haulage to the coarse ore handling area at the plant site. These roads will be designed to NWT Mining Safety Regulations requirements and will be about 30 m wide.

General Access Roads

There is no permanent road network in the Mackenzie area of the Northwest Territories that permits year-round surface access to the site from Yellowknife. Vehicle traffic is possible only during a 2½ to 3 month period each year via the Echo Bay winter road, which runs northeast from Tibbit Lake (70 km east of Yellowknife), past Lac de Gras to the Lupin mine (Figure 2.7-2). Since 1990, subsequent road access to the NWT Diamonds property for the ongoing exploration work has been over an approximately 35 km long winter road branching off the Echo Bay road at Lac de Gras. As discussed further in Section 2.9, the project plans to continue using the Echo Bay winter road for bulk transport of materials and supplies during both construction and operations. Other winter roads have been required at the property to permit access to exploration targets and to service the remote temporary camps. As many of the kimberlite

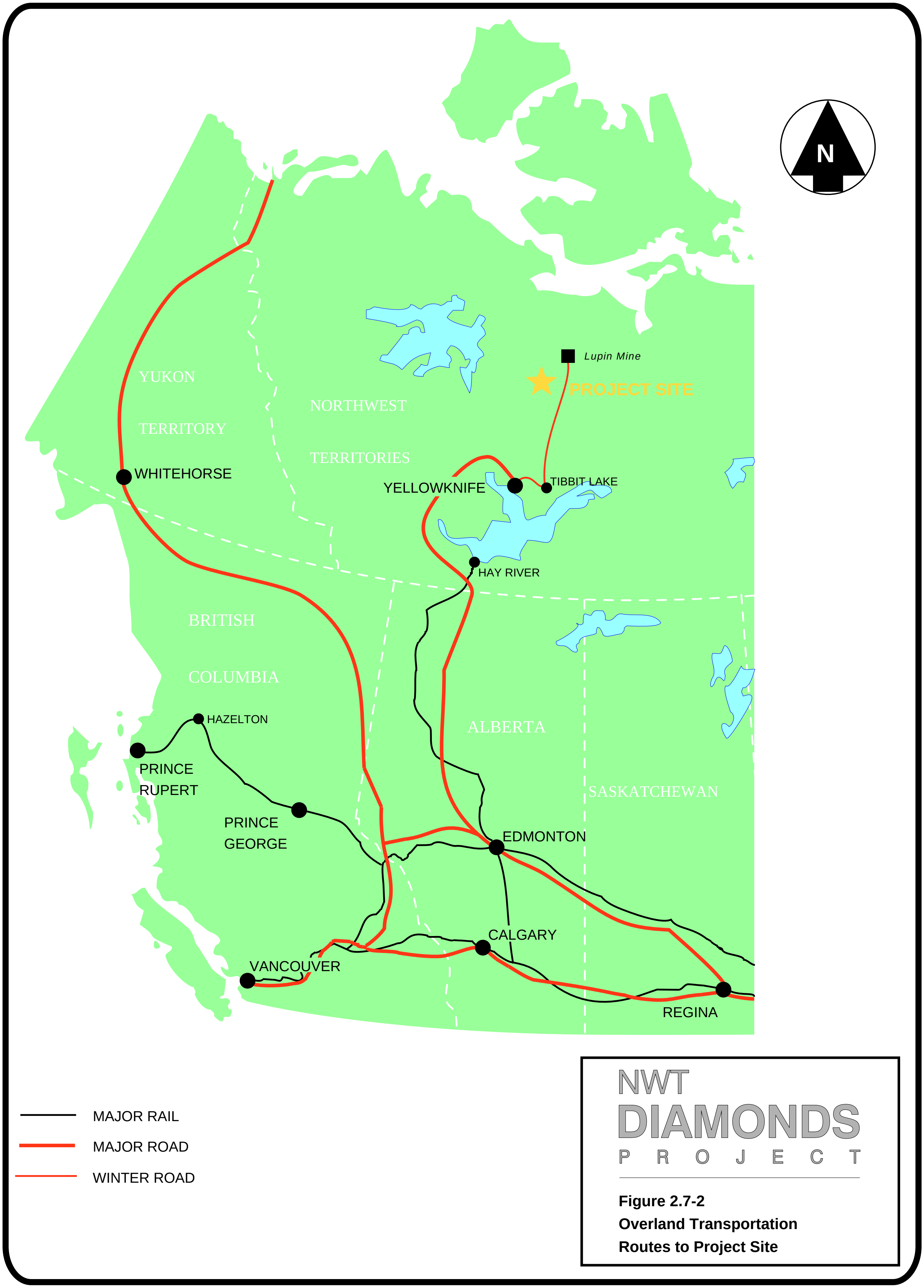


Figure 2.7-2
Overland Transportation Routes to Project Site

Source: BHP

deposits lie beneath lakes, drilling for the acquisition of bulk samples has been done from the frozen lake surfaces in winter. The Proponent has also constructed approximately 20 km of access roads around the property as part of the bulk sampling program.

Misery Haul Road

A permanent 29 km long road for ore haulage will be built to connect the Misery mining operation with the plant site. To be constructed of waste rock and surfaced with quarried material on top of permafrost, the road will have a 10 m wide travel surface to accommodate two-way traffic, as required in the GNWT Mining Safety Regulations for trucks 3.3 m wide. Each winter a temporary ice road extension will be developed to the east of the Misery operation, across frozen Lac de Gras, to join the Echo Bay winter road. This will allow the Misery haul road also to serve as an access road for the delivery of supplies during the winter. The current winter road system will continue to be used for access until the haul road is completed. The Misery haul road is addressed in more detail in Section 2.4.7.

Plant Site and Service Roads

The access roads to be constructed around the main plant site will have 8 m wide travel surfaces and 1 m shoulders to accommodate two-way traffic. The roads will be built on fill where possible so as not to disturb the natural ground surface and to prevent blowing snow from building up.

Service roads will be constructed along the pipelines to Long Lake (tailings and raw water) and Grizzly Lake (potable water). These roads will have 4 m wide (one-way) travel surfaces with 1.5 m shoulders and will also be constructed on fill for the same reasons.

A haul road network for 218 tonne size haul trucks will be constructed between the open pits (except Misery) and the coarse ore handling area at the plant site, and also between each pit and its respective waste dump area(s). The haul roads will have 25 m to 30 m wide (two-way) travel surfaces and will be constructed principally on fill. The haul roads are described further in Section 2.4.7.

Road Construction

Winter roads generally follow an alignment that incorporates frozen lake surfaces as much as possible. Portages between the lakes are made by alternately building up and flooding layers of packed snow. Roads constructed in this way usually result in minimal damage to the tundra and cannot be identified after the snow has melted. Where feasible, this method of road building will continue to be used to support ongoing exploration work.

The routing of and construction techniques used for permanent site access, service and haul roads will be selected carefully to avoid environmentally sensitive areas, prevent erosion and siltation and reduce the number of stream crossings.

Ground subsidence problems will be limited by placing adequate layers of fill over permafrost surfaces. Care will also be taken to ensure that drainage patterns are not affected and that free fish passage is maintained through the provision of appropriately designed culverts.

2.7.2.2 Airstrip

The 600 m long airstrip constructed at site in early 1994 was extended and upgraded later in the year to accommodate increased air traffic for exploration and development. The strip, which runs north-northeast/south-southwest, parallel to Kodiak and Little lakes, is now approximately 1,950 m in length. This extension allows the site to be serviced by Hercules, Boeing 727 and 737 aircraft, modified for operations in the Arctic. Aviation transportation is described further in Section 2.9.

An area for aircraft parking, loading and servicing is provided near the north end of the strip, approximately 800 m southeast of the plant site. A control building (reporting centre) will be constructed at this location, adjacent to the site access road. All surface vehicles and aircraft entering and leaving the site will be monitored and directed from the control building.

An aircraft fuelling station with contained bulk storage for approximately 500,000 L of jet fuel will be located next to the airstrip. A small cache of fuel for piston-driven engine aircraft will be provided in 55 gallon drums. Portable diesel-fuelled air heaters will be used to preheat aircraft engines, as required.

A runway lighting and approach system will be provided at the airstrip, as well as navigational aids and equipment for weather observation and recording.

2.7.3 Coarse Ore Handling Area

Open stockpile areas for the temporary storage of up to 200,000 tonne of run-of-mine ore will be provided in the vicinity of the primary crusher feed hopper. This stockpile will accommodate the cyclic delivery of ore from the pits and ensure ore supply during periods of relatively severe weather, when mining operations are shut down but a front-end loader can still tram ore between the stockpile and hopper.

2.7.4 Process Plant

The process plant area will be north of the permanent camp and will be surrounded by two security fences. The plant building will be approximately 70 m wide x 154 m long x 30 m high. The proposed layout is intended to achieve the smallest footprint and keep the building rectangular, so as to minimize the buildup of snow drifts. Sufficient space has been allocated within the building for future additional processing modules as required for the future expansion from 9,000 t/d to 18,000 t/d.

The plant building will be constructed of structural steel sheathed with insulated steel panels. The supporting structure for equipment, bins, conveyors, cranes, buildings, platforms, stairs and walkways within the building shell will be independent of the main structure. Floors will be concrete on insulated ground slab or on metal deck formwork, with interior concrete curbs for containment of spills from bins, screens and recovery equipment. Areas within the process plant will be connected by a series of elevated steel grating walkways, with additional access provided along conveyor galleries.

Access doors (6 m x 6 m) will be positioned strategically to accommodate the movement of large equipment into the building during initial construction and future expansion. Two overhead travelling cranes will be provided to service the process equipment; these cranes will be installed as early as possible to assist in plant construction.

A 12 m x 32.5 m x 18 m high, three-storey area in the southeast corner of the process plant, adjacent to the recovery section, will house the control office, motor control centres (MCCs) and offices of the support facilities. Control rooms and offices are separated for the two different levels of security in the crushing/ scrubbing/heavy medium separation sections and the recovery section.

The recovery section will be an 18 m x 30 m x 28 m high, six-storey structure. The layout of the wet and dry circuits is based on maximizing gravity flow and thus minimizing the use of mechanical handling. For security, the interior walls of the recovery structure will be clad with steel panels.

To maintain security, all waste oils and burnables generated in this area will be consumed in a dedicated incinerator. Process plant supplies will be stored either inside the heated process building, outdoors in shipping containers or outdoors under tarps to suit operation and commodity storage requirements. Certain mobile equipment will be dedicated for plant area use and will have its own secured fuelling station.

2.7.5 Power Plant

After several forms of power generation were investigated, an on-site diesel generator system was selected. Backup systems, power distribution and energy conservation are discussed in the following sections.

2.7.5.1 Power Generation and Distribution

An on-site power generating plant will be required to provide electricity for the project. The estimated electrical demand takes into account the requirements of the plant site facilities, the open pit mining operations, the fresh and reclaim water systems, the airstrip, electrically operated equipment, building heating, lighting throughout the site and heat tracing of pipelines. To meet these requirements, a diesel power plant incorporating a waste heat recovery system will be constructed adjacent to the process plant. An emergency diesel generating system will also be installed to supply initial construction power and later serve as a backup to ensure power supply to critical areas under all circumstances.

The main power plant will consist initially of approximately six 4.4 MW (or equivalent total MW) diesel generating sets for the 9,000 t/d operation. Additional units will be required later in the project life for the planned underground mining operation and the increase in process plant capacity. The power plant building will be designed for expansion to the south to allow space for the future units.

Four of the six initial generators will be in operation at any time, with the other two on standby for use during maintenance and repair periods. All the generators will run in parallel to minimize the effects of cyclical loading when the electric mining equipment is in operation. The power plant is designed with sufficient overload rating for the peak mining demand. The firm continuous capacity of the plant with four generating sets running is approximately 17,600 kW, with the average load when the plant is operating estimated to be 70% of the continuous rating. The initial load requirements for the various project use areas are summarized in Table 2.7-1.

Table 2.7-1
Estimated Initial Electrical Load

Area	Estimated Connected Load (MW)	Estimated Maximum Demand (MW)	Estimated Typical Load (MW)
Mining	5.0	4.2	1.6
Process Plant	12.9	10.2	8.7
Ancillary Facilities	4.6	3.2	2.4
Total	22.5	17.6	12.7

The control room for the power plant and the main 4160 V switchgear equipment will be enclosed within the facility. Access to the switchroom will be available in all weather conditions at all times. The computerized programmable logic control

(PLC) system will monitor individual engine performance and initiate alarms and engine shutdown as required in the event of a problem. The PLC system will permit fully automatic, semi-automatic or manual operation, as required.

Power will be distributed around the plant site by Teck cable carried in cable trays along the utilidor access routes. Underground duct banks will also be used where appropriate. Motor control centres (MCCs) and non-PCB, oil-filled transformers will be installed near each major load centre as required. Power for the open pits and other remote facilities beyond the plant site perimeter will be delivered on overhead lines mounted on wooden poles. Transformers designed for cyclical loads will be provided at the pit substations to supply the mining equipment.

The emergency power system will consist of three 725 kW generators in separate modular enclosures south of the main power plant building, a 160 kW generator at the airstrip and the existing three generators (two 545 kW and one 750 kW) at the exploration camp. The control and security systems will also have uninterruptible power supplies (i.e., short-term battery backup). The emergency generators will start automatically following a loss of main power and will supply the emergency MCC of the main power plant so that the main generators can be started to power any other critical equipment. They will also supply power to the permanent camp and to the pipeline heat tracing system to minimize the possibility of pipe freeze-up.

Diesel fuel for the main generators will be stored in two sets of insulated day tanks at opposite ends of the power plant building. The day tank for the 725 kW emergency generators will be connected to the permanent fuel distribution system, while the airstrip and exploration camp generators will be supplied from adjacent day tanks that will be refilled by truck. The day tanks will be installed in lined and diked containments or secondary tanks. Engine lubrication oil will be stored in a secondary contained area in the north end of the power plant

Waste heat from the power plant diesel engines will be recovered by means of glycol heat exchangers in the jacket water and exhaust gas chambers of each engine. The recovered heat will be used to heat buildings and process water (to thaw frozen ore) as required. The amount of heat available will vary depending on the number of engines on line and the load at a given time. The amount of heat required for these purposes will also vary with changing ambient conditions. During the summer months, when most of the waste heat is not required, it will be dissipated through the use of radiators located immediately east of the power plant. When temperatures are very low, there could be an overall heat deficiency, and the heating system will be supplemented with heat produced from two auxiliary boilers fired with diesel oil. The boilers, which will be installed at the permanent camp, will be sized to maintain the camp at normal comfort levels and the other plant site buildings above freezing when the main power plant is down.

All lighting will meet Illumination Engineering Society (IES) standards. Additional lighting will be provided in areas where security video cameras are installed. Approved runway and approach lighting will be provided at the airstrip.

2.7.5.2 Energy Conservation

Various means to conserve energy (both fuel and heat) will be used on the project. Additional fuel savings can be realized by the compact site arrangement, energy-efficient systems, abundant insulation and heat recovery systems.

Electrical Power

Power conservation will be achieved through the use of energy-efficient lighting, motors and diamond recovery processes. Where possible, high pressure, energy-efficient sodium lighting will be installed, complemented by high efficiency fluorescent lights where the colour spectrum of sodium lights would be unacceptable. Most site electric motors will be high efficiency type.

The design of the process plant was based in part on minimizing site labour, which reduces the energy consumption required for staff support. In addition, the selection of low energy, high pressure grinding roll technology over high energy semi-autogenous grinding (SAG) mill technology to liberate the diamonds from the kimberlite will result in substantial direct energy savings.

Electrical heating will be minimized through maximum use of the power plant waste heat recovery system.

Heat Conservation

Buildings: All heated structures and buildings will be heavily insulated to minimize fuel consumption and conserve energy. Specific thermal resistance ratings will be established for building construction. The permanent camp, for example, will be built with a roof (ceiling) RSI factor of 6.2 (R-35), an exterior wall RSI factor of 4.4 (R-25) and a floor (plenum) RSI factor of 6.2 (R-35). Frequently used exterior ingress/egress points to heated structures will be provided with vestibules or air curtains to minimize heat loss. Augmenting this, heated utilidors will intertie the major core facilities so that staff can remain indoors under most circumstances and minimal outdoor piping will be required, reducing the need for electrical heat-tracing. Where layouts permit, buildings will be kept as cubic as possible to minimize the exterior skin area.

Air-to-air heat recovery units to recover heat from building exhaust air were investigated but were found to work poorly in the far north. When air temperatures fall below -20°C, condensate in the warm air being exhausted tends to freeze up when exchanged with the extremely cold incoming air.

Power Plant: As described previously, the power plant diesel gensets will be provided with an extensive recovery system for heat from the engine jacket water, turbocharger cooling, lubrication oil cooling system and exhaust air. The recovered heat will be used in the major core structures and for thawing the ore when necessary. Radiated heat from gensets will be used in the power plant.

Process: In part to minimize site energy consumption, frozen ore will not be thawed until it enters the main process building. Because of the regular air changes required to control dust and the large skin area of the covered coarse ore stockpile, it was considered impractical to heat this structure sufficiently to thaw frozen ore. In addition, the inclusion of a tailings thickener allows the recovery of heated process water; this heat would otherwise be lost in the tailings pond if all process water were recycled from that source.

2.7.6 Truckshop/Offices/Warehouse

The truckshop/offices/warehouse complex will be constructed immediately north of the power plant, in the northeast quadrant of the plant site. The layout has been designed to permit future expansion to the north, as necessary. The building will be an engineered steel structure with a single-storey section and a three-storey section. The footprint of the building will measure 110 m x 46 m, for a total ground floor area of 5,106 m^2. Facilities will be provided for heavy and light vehicle maintenance, heated warehouse storage, change-rooms, an environmental laboratory and offices for technical, clerical and administrative personnel.

Light vehicles and crew buses will approach the building through the adjacent yard to the west and heavy vehicles through the yard to the east. Personnel will enter the truckshop/offices/warehouse complex at the south end, via the utilidor from the security building.

2.7.6.1 Main Complex

The truckshop facilities will be in the single-storey portion of the building and will include five repair bays, one tire-shop bay, one lube bay, one bucket welding bay and one vehicle wash bay. The floor slabs in the bays will be heated to prevent ice buildup near the exterior doors. The bays are sized to accommodate the largest trucks and loaders in the mining equipment fleet and will be serviced with two 25 tonne overhead cranes. One of the five repair bays will be devoted to light vehicle maintenance. The bucket welding bay will be separated from the rest of the shop by permanent and moveable wall panels and will be provided with a welding fume exhaust system that meets all applicable work site regulations. A 6 m wide internal access aisle running the full length of the building will contain small offices, the truck wash water system, tool storage and tire change equipment.

Dirty water from vehicle washing will be settled, filtered and recycled in the wash system. A vacuum collection truck will reclaim the skimmed oil scum and settled dirt sludge separately. If testing shows the sludge to be non-hazardous waste, it will be disposed of in the Panda waste dump; if it tests as hazardous waste, it will be treated appropriately on site before disposal or will be hauled off site to a suitable hazardous waste disposal facility. Likewise, the oil scum will be processed for proper disposal.

The ground floor of the three-storey portion of the complex will be divided into various support shops, the warehouse, a first aid room and two more light vehicle repair bays, all distributed along the internal access aisle. The shops will include separate lube storage, welding, machining and electrical repair areas; the welding area will be separated from the rest of the shop by permanent walls and be equipped with a welding fume exhaust system. Battery charging and maintenance will be done in an isolated masonry structure inside the shop building. The battery room will have a completely separate ventilation system. Items that require complex repairs or overhauls using specialized equipment will be sent off site.

The warehouse will cover a ground floor area of 700 m^2 and contain an additional 420 m^2 of mezzanine storage space. It will include the main tool crib and an enclosed, internal loading vestibule to minimize heat loss during the winter.

The mine operations offices, mud-rooms, male and female changerooms and environmental laboratory will be located on the second floor (1,314 m^2). The changerooms will be equipped with lockers, benches, showers, wash basins, urinals and toilets in accordance with NWT Mining Safety Regulations. Three staircases will provide access to the various areas. The mechanical room containing heating and ventilating equipment for the building will be on this floor.

The third floor (1,098 m^2) will be the main office facility, with modular offices provided for senior management and administrative personnel. Space is also available for reception and conference rooms. Access will be from two staircases.

2.7.6.2 General Bulk Storage

Large objects, bulk materials and other supplies that are unaffected by weather and low temperatures will be stored outside the truckshop/offices/warehouse building. Small supplies excess to those kept within the warehouse will be left in shipping containers, which will be stored in designated areas in the adjacent yards. Larger or heavier excess supplies that need to be protected from the elements but are not suitable for container storage will be stored in the cold storage building.

The rest of the bulk supplies will be stored outside in the yards, covered with tarps as required.

Secondary containment will be provided in any area or facility where significant amounts of liquids that require such containment are stored. In addition, areas of significant flammable liquid storage will be isolated by either enclosures or distance, in accordance with fire regulations and guidelines.

Welding gases/acetylene, MAPP (propane), oxygen, argon, etc., will be stored in isolated shipping containers, with small quantities available in securely stored receptacles at local use areas around the plant site.

2.7.6.3 Truck Ready Line and Warming Shed

A ready line complete with compressed air and electrical supply will be constructed in the east yard of the truckshop/offices/warehouse complex for haul trucks and large mobile equipment.

A four-bay warming shed for heavy vehicles will be provided as an extension of the truck ready line. The shed will be heated sufficiently to maintain the temperature of critical mobile equipment above -15°C.

2.7.7 Permanent Camp

The camp complex will comprise the main camp and a camp services building. Vehicular access to all buildings will be via the access road immediately south of the camp building.

The main camp building will consist of a two-storey support area linked to five three-storey dormitory blocks by a continuous east-west corridor. The footprint of the building will cover 6,604 m^2, providing a total floor area of 15,474 m^2. A utilidor will link the camp building to the security building.

The current design includes a total of 375 dorm-rooms, with 25 dorm-rooms on each dorm wing level, arranged on both sides of a central corridor. Each wing level will also have areas for laundry, linen storage and telephone booths. All dorm-rooms will be identical in size and layout and will have a bathroom, two closets and an exterior window. On-site staff will normally share a room with an off-site rotation counterpart. Senior staff on weekly duty will have their own assigned room. Additional dormitory blocks will be added as future requirements dictate.

The support area will house the dining and recreational facilities, including food storage and preparation, a gymnasium, exercise area and games room. Space will also be provided for camp administration, check-in/check-out control and a meeting room.

The adjacent, single-storey camp services building will be linked to the permanent camp building by a utilidor. Along with supplies storage and offices, the building will contain a heated camp maintenance shop and a hospital equipped in accordance with NWT Mining Safety Regulations. Enclosed parking will be provided for two 40-passenger buses, a rescue vehicle and an ambulance. The hospital will be next to the ambulance parking stall and will have an interview/records/meeting room, an examination room and an emergency ward. The camp services building will also contain two auxiliary boilers. The overall size of the camp services building will be approximately 60 m x 18 m, for a total floor area of 1,080 m^2.

An emergency response/mine rescue station, complete with training and storage rooms and meeting NWT mine regulations, is tentatively planned to be set up in the camp services building. This facility could also be located in the truckshop/ offices/warehouse complex.

A trash incinerator and potable water pumping equipment will be enclosed in self-contained modules close to the camp.

2.7.8 Fuel Supply and Storage

The power plant and most mobile equipment will operate on No. 1 Arctic grade diesel fuel, which will be delivered to site in B-train tanker trucks over the annual Echo Bay winter road. Given the limited duration of road availability – generally less than three months – sufficient site storage and distribution facilities will be provided to handle the quantities of fuel required for a full year's operation. Total annual diesel fuel requirements for the first three years of full operation are estimated to be approximately 52 million L/a, representing 1,300 tanker truck shipments per year.

2.7.8.1 Bulk Fuel Tank Farm

A central tank farm serviced by two independent unloading stations will be constructed at the plant site for bulk storage of diesel fuel (Figure 2.7-1). Each station will be equipped with two pumps to permit the unloading of both B-train tankers at the same time. This duplicate design will minimize operational risk in the event of shutdown or malfunction of one of the systems; the philosophy of providing dual sets of equipment has been extended to the day tanks for the power plant generators as well.

The tank farm will ultimately consist of eight tanks, installed two by two in adjoining bermed areas. Two of the tanks have already been erected to provide fuel storage for the ongoing exploration work. One tank will be set up initially at Misery and then be relocated to the plant site tank farm when the Misery mining operations are finished. Three more tanks will be installed during the construction phase and the last two later in the project life as required. All of the tanks will be constructed on impervious lined pads and surrounded by berms to contain spillage and prevent ground contamination. The fuel storage area will meet all requirements of the National Fire Safety Code. The total effective storage capacity for the 18,000 t/d operation will be approximately 61,000 m^3.

Dedicated pumps at the unloading stations will transfer fuel from the bulk storage tanks to day tanks at the power plant and other use areas, including the emergency generator locations and the auxiliary boilers at the permanent camp. Each day tank is sized for approximately 12 hours' storage.

Glycol (antifreeze) and lubricants/oils will generally be shipped to site in bulk tankers over the winter road. Storage tanks for limited quantities of glycol, hydraulic fluids, transmission fluids and lubricating oils for mobile equipment will be kept inside the truckshop, with larger quantities stored outdoors in tankers. Other lubricants and greases with low annual consumption will be shipped and stored in drums or 1,600 L shipping cubes. Only minor amounts of gasoline and propane will be required, and a limited supply of aviation fuel will be maintained at the airstrip for emergency aircraft refuelling.

Waste oils will either be used as fuel for the incinerators and warming shed heaters or consumed in the ANFO emulsions. All significant waste oil collection tanks will be stored in curbed containments.

A station containing equipment for the containment and cleanup of any oil, lubricant and glycol spills will be established in the plant site area.

All staff involved in fuel handling will be trained in fuel transfer, handling and storage, spill response and reporting procedures. The general contingency plan for spill response is discussed in more detail in Volume III, Section 4.2.

2.7.8.2 Mobile Equipment Fuel Stations

Four fuelling stations for small and medium-sized mobile vehicles will be provided, one in the unsecured area north of the permanent camp, one in the secure mining area next to the truckshop/offices/warehouse building, one in the secure process plant area and one at Misery. In addition, two large haul truck fuelling stations will be provided. One of these will be north of the truckshop and capable of fuelling two trucks simultaneously. The other will be at Misery and able to fuel only one truck at a time. The haul truck fuelling stations will also be equipped to "top up" the trucks' coolant and lubricant levels. Fuel and lubricants will be delivered to the less mobile mining equipment by fuel service trucks.

2.7.9 Ammonium Nitrate Storage and Emulsion Plant

It is planned to contract out the supply and preparation of explosives required for the mining operations. Most blasting will be done with ANFO (ammonium nitrate/fuel oil) at an estimated annual consumption of 10,000 tonnes to 12,000 tonnes. The contractor will be responsible for supplying process equipment and operating an emulsion plant, as well as equipment and staffing for all transportation, storage, reclaim and blending of explosives, plus delivery to the pit and loading of blastholes.

A site 1.1 km west of the permanent plant has tentatively been allocated for these facilities. The ammonium nitrate and storage area will be a minimum of 80 m away from the emulsion plant. The plots will be leveled and graded to drain to a perimeter ditch and catchment basin. The facilities will be serviced with power, water, telephone, sewage and diesel fuel systems. Figure 2.7-3 details the site plan for the AN storage and emulsion plant.

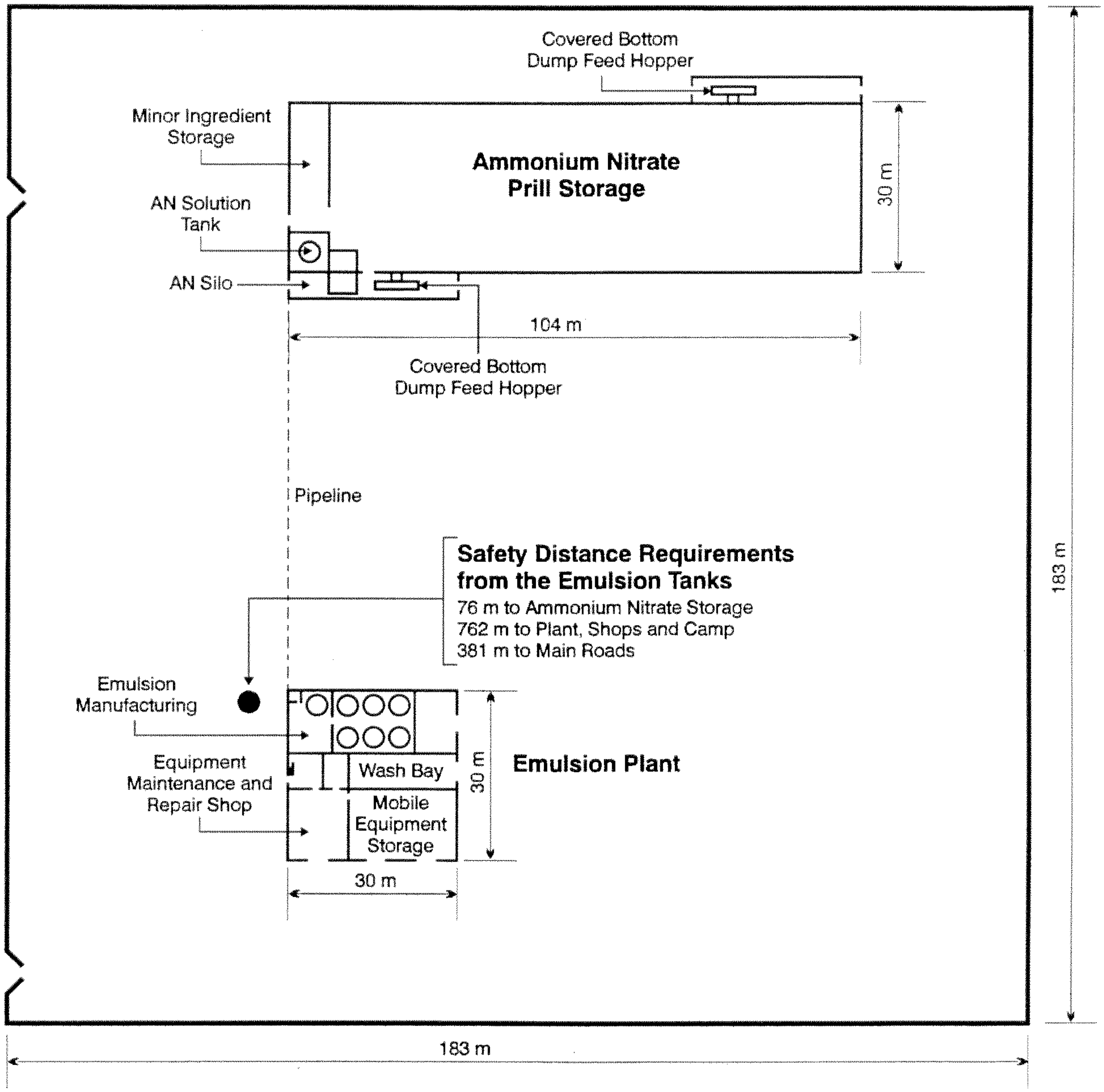
The ammonium nitrate storage building will be 30 m x 100 m in size to withhold up to 15,000 tonnes of ammonium nitrate (AN) prill; the structure will have a concrete floor. The prill will be delivered annually over the winter road and discharged directly by bottom-dump highway trucks into one of two in-ground hoppers. A bucket elevator will raise the prill for gravity feed into the storage building. Some blasting agent ingredients will be transported to site in drums, which will be stored on pallets in a separate section of the building. Emulsifier and wax can be transported in bulk tanks and stored in the contained tank farm at the emulsion plant, reducing the handling requirements for empty drums or residue. All unloading areas will be covered to provide shelter from the elements, contain AN dust and aid cleanup, thus reducing potential fugitive AN migration.

Inside the AN storage building, the prill will be moved by front-end loader into a bucket elevator and elevated into an overhead storage silo. From the silo, the prill can be loaded directly into explosives delivery trucks or fed to the AN solution tank for melting into AN liquor. This liquor will be pumped through a pipeline to their respective storage tanks and mixed with the AN liquor to form the emulsion matrix. The emulsion matrix will subsequently be pumped into an overhead storage tank to allow gravity loading of the bulk explosives delivery vehicles.

The delivery trucks for loading open pit blastholes will have a capacity of 22 tonnes and be capable of mixing and distributing straight ANFO for dry holes or any degree of ANFO/emulsion mix up to straight emulsion for wet holes. The trucks will auger the ANFO dry products or pump the emulsion into the holes.

Underground mining operations, scheduled to begin in Year 6, will also be supplied with bulk explosives from the explosives manufacturing plant. A separate system encompassing the manufacture, distribution and loading of repumpable bulk emulsion will be available when the underground work begins.

An explosives manufacturing laboratory in the plant will ensure that rigid quality control standards are met in all aspects of the manufacturing process. Equipment and procedural standards will be maintained in full compliance with government



Utility Requirements

Electrical Power	600 Volts 400 Amps
Product Fuel	1.1 million L/a
Truck Fuel	18 L/h
Boiler Fuel	900 L/d
Water Intake	4.3 m^3/d
Water Discharge	1.5 m^3/d

Mobile Equipment

4 x Explosives Mix & Transport Trucks 22 t
1 x Front-end Loader
1 x Forklift
1 x Crew Cab 4x4 P.U.
1 x Standard Cab 4x4 P.U.

Manpower

1 x Supervisor
1 x Plant Operator
3 x Operators

NWT DIAMONDS PROJECT

Figure 2.7-3
Ammonium Nitrate Storage Area Site Plan

standards, from the receipt of raw materials to the final discharge of finished product down the borehole. All bulk storage tanks will be constructed in compliance with the National Fire Code requirements. All tanks, pumps and hoses used in the transfer and/or storage of deleterious liquids will be secure within an approved containment.

A separate explosives magazine site for packaged products such as cartridge explosives, primers and detonating cord will be tentatively located 1 km southwest of the AN storage building and emulsion plant. These materials will be stored in 2.5 m wide x 6.0 m long shipping containers set off the ground on 1.3 m high stands for ease of unloading. Detonator storage houses for non-electric detonators and blasting caps will also be provided. Comprising shipping containers similar to those at the explosives magazine, the detonator houses will be kept a minimum safe distance of 50 m away from the magazines.

Waste management at the explosives manufacturing site will be reviewed and improved continuously through point-of-source segregation, better storage, on-site recycling and reduced consumption by applying innovative manufacturing technologies.

2.7.10 Water Supply and Distribution

Total make-up water demand for the 9,000 t/d operation is estimated to range from 468 m^3/h to 567 m^3/h, with a maximum peak demand of 625 m^3/h. This demand, which includes raw, process make-up, washdown, potable and miscellaneous uses, will approximately double at 18,000 t/d. Process water make-up requirements will account for approximately 99% of the total make-up demand.

Water drawn from Koala Lake will be used for all water supply requirements at the site during construction and for potable water requirements during initial operations. Upon plant start-up, raw water make-up for process uses and fire protection will be obtained from Long Lake. Potable water for domestic consumption will be obtained from Grizzly Lake after Koala Lake is dewatered to permit open pit mining.

2.7.10.1 Process and Fire Protection Water

Raw water for plant operations will be reclaimed from Long Lake. The water will be pumped from a heated and insulated pumphouse through a heat-traced pipeline to the raw water storage tank at the process plant. The total storage capacity of the tank will be 1,600 m^3.

Raw water will be stored in the 900 m^3 upper part of the storage tank and will be distributed to specific use areas in the plant and the truckshop/offices/warehouse complex through carbon steel piping. The lower portion of the raw water storage tank will be reserved for fire protection water. This part of the tank will be sized for a 90-minute fire water reserve of 700 m^3, based on a design flow of 454 m^3/h. Two main fire pumps will be provided, each rated for the full design flow, as well as a small jockey pump to maintain constant fire main pressure. Fire water will be distributed to all the plant site buildings in wet main headers routed through the heated utilidors.

Process water will consist primarily of overflow water from the in-plant tailings thickener, augmented with raw water as required. Process water required for thawing frozen ore will be heated by glycol heat exchangers supplied from the power plant waste heat recovery system. Process water requirements will vary depending on the characteristics of the ore.

2.7.10.2 Potable Water

Grizzly Lake is relatively deep and has ample storage volume and watershed recharge for potable water supply over the life of the project. To preserve the water quality and guard against contamination, no mining or processing activities are planned in the headwaters of this lake. Potable water requirements will be 5 m^3/h for the 9,000 t/d operation, increasing to 7 m^3/h for the 18,000 t/d operation when the work force increases.

From a heated, insulated pumphouse at the lake, water will be pumped through a 3.8 km long, insulated and heat-traced pipeline to a water treatment module at the permanent camp. The water will be filtered, chlorinated and then fed to the adjacent 211 m^3 potable water tank; this storage capacity represents one day's consumption at the ultimate demand rate. The treated water will be distributed to the plant site buildings by main headers routed through the heated utilidors. Piping will be insulated for freeze protection outdoors and for anti-sweat protection in heated buildings.

2.7.11 Site Services

Site services are among the most important features of project infrastructure. The services that will be provided include fire protection, sewage and waste disposal and communications.

2.7.11.1 Fire Protection

The fire protection systems for the project facilities will be designed and installed to meet all applicable codes and ordinances. A combination of wet, dry and chemical systems will be provided, depending on the building type, use and criticality. A central fire alarm system will be installed and coordinated with the project security computer system. The main fire alarm control panel will be located in the control room at the security building to ensure 24-hour monitoring.

The fire water reserve will be sufficient for 90 minutes' fire fighting, based on the automatic sprinkler and fire hose capacities. Fire water will be distributed from the raw water storage tank through the heated utilidors to ring mains in the process plant, power plant, truckshop/offices/warehouse building, security building and camp. Exterior wall hydrants and interior hose stations will be installed at each building. Automatic sprinkler systems will be provided in fire risk areas.

Dry standpipe systems, insulated and heat-traced, will be provided for outside protected areas. Dry chemical and/or foam fire extinguishers will be located at the fuel storage areas, the power plant and other facilities as required.

Smoke detectors wired into the central fire alarm system will be installed in all electrical and control rooms and in all sleeping quarters at the camp.

A fire truck, fully equipped to deal with any type of fire, will be stationed at the camp services building for ready access by the fire rescue team to intervene quickly in case of fire.

2.7.11.2 Sewage and Waste Disposal

The slow assimilative capacity of the tundra environment makes it particularly important that waste generation be minimized and that any waste materials produced be carefully managed. Recycling and incineration will reduce the volume of solid waste to be disposed of at the project site. Any non-hazardous waste that can be recycled, such as aluminum cans and other metals, will be sent off site for recycling if deemed reasonable in terms of resource conservation. Otherwise such non-hazardous wastes will be buried in the waste dumps.

Domestic Sewage

A sanitary sewer system and a completely enclosed sewage treatment plant will be installed at the plant site to treat domestic waste water and effluent from the camp and other facilities. Local lift stations in each building will pump the sewage via the utilidors to a holding tank at the permanent camp. The sewage will then be pumped through a heat-traced, insulated HDPE pipe to the treatment plant, which will be housed in a heated, insulated building 250 m west of the camp.

The sewage treatment system will comprise primary and secondary levels of treatment. The final effluent will be pumped through an insulated and heat-traced pipeline to either Kodiak Lake or Long Lake for disposal with the tailings. The sludge from the treatment plant will be buried in specifically designated areas of the Panda waste rock dump.

The design parameters of the plant are based on a very conservative estimate of 0.28 m^3 per capita per day of input, with a biological oxygen demand (BOD_5) of

600 mg/L. The treatment process will be designed to produce an effluent with less than 45 mg/L of BOD_5 and 60 mg/L of total suspended solids (TSS).

Domestic Garbage

Combustible, non-hazardous, organic solid waste from the camp, power plant, security building, truckshop/offices/warehouse complex and mining areas will be placed in covered, bear-proof metal containers located at strategic points around the operation. This garbage will be collected and disposed of daily in a 2 t/d capacity, diesel fuel fired, dual chamber incinerator at the permanent camp. A small solid waste incinerator for combustible waste produced in the process plant will be installed within the double-fenced secure area, and another for combustible waste produced in the truckshop/offices/warehouse facility will be installed within the single-fenced secure mine shop area. A similar small incinerator will be provided near the camp area at the Misery operation. The incinerators will meet Canadian Council of Ministers of the Environment (CCME 1989) guidelines for operation and emission. Ash from the incinerators will be buried in designated areas of the waste rock dumps.

It is anticipated that clean wood scraps and corrugated cardboard boxes will be open burned.

Ethylene Glycol

Waste ethylene glycol (antifreeze) will be refurbished for reuse on site as much as possible. Used glycol that cannot be refurbished will be stored in containers at a secured facility on site pending transport to an off-site waste disposal company for recycling.

Waste Oil and Grease

Spent oil filters will be drained on site and then stored in drums for removal to a licensed off-site disposal facility.

Waste oils, mainly waste engine lubricating oil, will either be used as supplementary fuel in the incinerators or the heaters in the truck warming shed, blended with the power plant diesel fuel or consumed in ANFO emulsions. Alternatively, waste lubes and greases will be stored temporarily in secured drums for regular annual removal to an off-site recycling facility.

Hazardous Wastes

All hazardous wastes will be treated on site to render them non-hazardous and disposed of accordingly or backhauled off site to an appropriate licensed hazardous waste recycling or disposal station.

2.7.11.3 Heating, Ventilating and Air Conditioning

The main plant site buildings will be heated by the glycol system using waste heat from the power plant. Oil-fired hot water heating from auxiliary boilers will be provided as backup to the waste heat recovery system. Small buildings will be heated with electric or oil-fired heaters. All buildings will be pressurized to reduce cold air infiltration in winter.

Ventilators and forced air will be used for ventilation in summer. Air conditioning will be provided only in control rooms, offices in the truckshop/offices/ warehouse, the security building and the kitchen in the permanent camp. Where electrical and control rooms are adjacent to particularly dusty areas, make-up air intakes will be equipped with pre-filters. Wall-mounted propeller fans will be installed near areas of high moisture generation.

Extractors for vehicle fume exhaust will be provided in each of the large truck bays, with mechanical ventilation systems and fans used for fume control in the other shop areas as appropriate.

Welding areas will be isolated by walls from the other shop areas. Dedicated extractor systems for welding fumes will be provided with dust collection systems in conformance with all applicable federal and NWT laws and regulations.

The heated truck warming shed will be ventilated to remove vehicle exhaust gases.

2.7.11.4 Communications Systems

Telephone service and other communications systems will be established at the site. A PABX based telephone network will link certain enclosed work areas, offices and senior staff rooms in the various buildings at the plant site. Mobile equipment and facilities in remote areas will be provided with a VHF (FM) radio communications grid system. Connection to off-site telecommunications systems will be by means of a satellite link with 20 to 24 trunk lines. It is tentatively planned to relocate the present satellite-linked communications system at the Koala site to the Misery operation to provide an intersite connection and to serve as an emergency backup communications system to the outside. In addition, emergency short-wave radio communication sets with battery backup will be provided at the main plant site, Misery site and Yellowknife.

2.7.11.5 Plant Site Drainage Control

The plant site is a local high point and will be graded to divert surface runoff into four sedimentation ponds. Drainage channels/culverts will be installed at all low points around the site and along the service roads. Criteria for minimum flows will be based on the 50-year return period storm. To minimize icing problems, all culverts will be free-draining and a minimum of 1 m in diameter. The final grades and surface material of the foundation benches for the process plant, security building, power plant and truckshop/offices/warehouse complex will be finalized during detail design.

2.7.12 Misery Lake Facilities

The Misery open pit mining operation will be approximately 29 km by road southeast of the Panda/Koala mining area and the plant site. Daily work force commuting over this distance from the Koala site is considered to be impractical, and therefore it is planned to establish the following infrastructure facilities in the Misery area:

- two 1 MW modular gensets and a 4.16 kV electrical distribution system to supply electrical power to the Misery surface facilities. Power will not be distributed to the pit area.

- diesel fuel storage and handling facilities, including a 9.9 million L bulk fuel storage tank, a fuel unloading and transfer module, a haul truck fuelling station, a fuelling station for small and medium-sized vehicles and three day tanks at the primary use areas. The fuel unloading module will permit the bulk storage tank to be filled directly from fuel tanker trucks traversing the winter road. All significant storage and day tanks for fuel, lubricants, hydraulic fluids and glycol will be located in secondary containments.

- a truckshop and office complex. The complex will contain two high bays to perform lube and light repair on the mining equipment and a low bay extension with partition walls for mine operations and maintenance offices, parts storage, changerooms, lunchroom, first aid and small vehicle warming bay. Major mining equipment will be repaired at the main truckshop/ offices/warehouse complex at the process plant site.

- a camp facility with approximately 50 dorm-rooms, dining facilities and recreation facilities. This camp may consist of dormitory units relocated from the construction and bulk sampling camps, augmented with new or reconditioned sections for the kitchen/dining/recreation areas. Camp services will include potable water supply from the nearest suitable lake, a sewage treatment system and a waste disposal incinerator similar to those provided at the main plant site.

- ancillary facilities and services, including telecommunications systems, explosives storage, access roads and a fire water storage and distribution system.

The plots for these facilities will be leveled and graded to drain to perimeter ditches directed to sediment pond(s).

2.7.13 Underground Mine Facilities

Surface facilities at the Panda and Koala underground mines will consist of a headframe and hoist house, ore and waste bins with truck loading facilities and a shop building. All other services will be supplied from existing site infrastructure, which will be expanded where necessary. Electric power will be tapped from the 25 kV overhead Panda pit feeder line to a substation at the hoist house for mine distribution. Potable and mine water will be supplied by a branch line off the Grizzly water line. The small amount of raw sewage produced will be trucked to the sewage treatment plant at the permanent camp. Office space, mine dry facilities, etc., will all be incorporated into existing facilities, with bus transport provided to and from the shaft. The proximity of the shaft to the central facilities enables most of the underground mine servicing requirements to be met with existing infrastructure.

2.7.14 Security

Diamonds are highly valued, low in volume and weight and easily concealed. Such characteristics make them an attractive target for both petty theft and organized crime. The security goals of the project, prevention and detection of theft, will be reached through a multi-discipline approach to security that will include

- automating processes to create a “hands-off” environment as part of the plant design

- establishing the concept of auditability and, in certain cases, dual accountability of plant processes

- conducting frequent but irregular audits of security, plant control systems and stocktaking.

The security arrangements will be extensive. It is important that strict yet workable measures be implemented.

All staff and visitors, with no exceptions, will be subject to the same security environment. As diamond content increases in the material being handled, security measures will become more severe. The recovery sections at site will be subject to the most stringent level of security.

2.7.14.1 Security Measures

The basic components of the proposed security system will be as follows:

Access Control System: The access control system will supervise personnel access and egress and the operation of alarms through the main security computer system. All persons, employees and visitors will enter the mine operations and plant area via the security building with the use of an individualized access card. The movements of a cardholder will be tracked by the system from the time he/she first logs in. The card must be prominently displayed and worn at all times outside the camp area. The access control system will also arbitrarily select individuals to be searched.

Security Fencing: Concertina fencing (coiled barb wire) will surround all facilities at the plant site that support “material flow” activities, i.e., from initial ore handling in the coarse ore crushing area through to shipment of product. The process plant area will be enclosed within a double fence.

Security Building: The security building will be the prime facility for monitoring the movement of all personnel, including security department employees. The building will be equipped with an uninterruptible power supply (UPS) to maintain the integrity of the security systems in the event of a general power outage.

Alarm Systems: An alarm system will monitor doors controlled by the access control system, emergency doors and field equipment tamper alarms.

The central fire alarm monitoring panel will be located in the security control centre. All fire alarms will be received at that point and be reported to the affected sector.

Cameras: Closed circuit television cameras with video recording (CCTV) will be used for surveillance and to view alarmed areas.

Searches: A search regime, of both property and person, will be applied impartially and uniformly to all persons, including visitors, leaving the applicable areas. Agreement to be searched will be a condition of employment. Any search will be carried out with proper regard for the privacy, comfort and sensitivity of the person being searched.

Persons leaving the recovery area of the plant will be searched frequently. The percentage of employees searched when leaving other areas will be lower, commensurate with the exposure to diamonds, but searches will still be performed to prevent collusion.

Baggage and certain equipment being transported to or from the site will be examined by X-ray.

Vehicle Control: It will be a requirement that no vehicle arrives without prior notification and vehicle/driver information. Traffic flow will be controlled at the road and aircraft control building, where all drivers will be required to report.

Shipments: Shipments of final diamond product from the mine to the off-site facility will be made on an irregular basis.

2.7.14.2 Operation of Security Building

The three-storey security building will be located centrally at the plant site. The first floor will be a garage, the second floor will be used for security control operations and the third floor will serve as an office area accessible only to security staff. The footprint of the building will be 13.5 m x 19.3 m.

Personnel access from the camp to most work areas will be through the security building by means of the identification card access system. Mine and plant staff will log on to the security control system at their first point of access and will remain in the system until their departure through the security building at the end of their shift. That final egress will be recorded, along with whether or not a search was carried out. Security personnel will be subject to the same search regime as other staff.

The layout of the security control floor and the traffic flow patterns are designed to permit or deny personnel entry to controlled areas on the basis of four security classifications:

C1 Security staff

C2 Mine and truckshop/offices/warehouse staff

C3 Process plant staff (excluding recovery section)

C4 Recovery section staff

Full-height glass or clear plastic/polycarbonate screens will divide passageways into one-way pedestrian corridors for staff entering or leaving work areas. Turnstiles activated by the access cards will control access to these corridors, which will pass by a security viewing room. The turnstiles will also direct personnel selected to be searched into the search area.

To meet fire codes, emergency exit stairways, entered only through alarmed panic doors, will be provided.

2.7.15 Off-site Facility

The off-site facility will be located in a large urban centre, dependent on market considerations. Diamonds from the mine will be delivered to this facility for final cleaning, sorting and preparation for sale.

The facility will operate on a five-day week during normal business hours. Security policies and procedures at the off-site facility will be similar to those at the mine site; access control, alarms, CCTV and random searches will function as primary security components.

Facilities will include a security office and search area, concentrate cleaning and diamond sorting areas, a vault for storage of diamond concentrates and diamonds, and a diamond display and sales/negotiation room.

2.8 Construction and Plant Commissioning Plan

This section presents the proposed execution plan for development and construction of the surface facilities for the NWT Diamonds Project. It outlines strategies for procurement, contracting, construction and plant commissioning.

The overall project construction schedule will span a period of 20 months from the assumed permit authorization date in 1996 to full operations in late 1997.

Overall management of the project will be the responsibility of BHP Diamonds Inc. The Proponent will appoint a major, established contractor(s) to perform the engineering, procurement and construction management (EPCM) of the project. The EPCM contractor's work will be monitored by the Proponent's staff.

2.8.1 Procurement

The EPCM project procurement and contracts task force will be headed by the project procurement manager and supported by buyers, expeditors, contract administrators, a logistics specialist and a project inspection coordinator. Satellite offices will be established in Edmonton and Yellowknife to support bulk materials purchase and transport logistics (Section 2.9).

It is anticipated that most process equipment, instrumentation and construction materials will be obtained from North American sources, with preference given to Canadian sources to the extent that the materials are available and technically acceptable and can be delivered in a suitable timeframe for the project schedule. Due to their complexity, some of the process equipment items will be procured from other international sources. These include the high pressure grinding rolls (Germany) and the X-ray diamond sorters (Australia or South Africa).

As part of the basic engineering phase of the project, investigations have been carried out to finalize the construction materials and capital equipment needed to support the construction program. This program will commence immediately after government permit issuance. A work schedule has been prepared to ensure that deliveries meet the winter road windows.

The following items were purchased during 1994 in support of the ongoing exploration work:

- certain bulk items - electrical temporary services and grounding
- certain construction materials and equipment
- potable water tank
- sewage treatment package
- one fuel pump module and unloading arms
- certain fuel day tanks
- certain piles
- temporary camp incinerator
- certain generators
- partial instruments and valves for fuel system.

In 1995, procurement activities will focus on obtaining vendor and shipping information for critical equipment items so that engineering can be completed. These critical items include the following:

- primary crusher
- secondary crusher
- rotary drum scrubber
- high pressure grinding rolls
- generator package
- X-ray sorters.

To ensure that key bulk construction materials are available for transport over the 1996 and 1997 winter road windows, it is proposed to procure the majority of these items and treat them as owner-supplied to the construction contractors. The balance of the construction materials and capital equipment will be procured during the project EPCM phase.

2.8.2 Contracting Approach

The proposed contracting approach for the project entails the award of multiple contract packages to established contractors with the experience and resources to successfully undertake multi-million dollar work programs at this extremely harsh and remote site. Given the location of the site, it is appropriate to minimize the number of contracts and contractors and thereby mitigate mobilization and redundant indirect costs, although in some key areas of work it may be advisable to assign two contractors with similar capabilities on site to provide flexibility in work assignment.

Most contracted services will be made with and provided from Canadian sources, with emphasis on maximum use of local NWT sources consistent with availability, technical expertise and commercial viability. Table 2.8-1 provides a list of possible contract packages that can be handled by contractors based in the Northwest Territories.

Table 2.8-1
Possible Northwest Territories-based Contracts

1. Survey services
2. Aviation services
3. Catering services
4. Small contract services
    - unloading/transport/expediting/courier
    - temporary mechanical/electrical installations, water/power services
    - site maintenance services - snow removal, road maintenance
    - laundry/cleaning/janitorial
    - temporary buildings/warehouse/security
    - road work
    - lighting
    - fencing
    - recreational supplies
    - soil testing
    - concrete testing
5. Excavation and minor concrete packages
6. Drilling/rock removal
7. Aggregate crushing
8. Architectural design of the permanent camp

2.8.3 Pre-construction Support

The Proponent will work closely with the EPCM contractor to develop the following plans and procedures to support the proposed construction effort:

2.8.3.1 Safety Program

The establishment of a comprehensive and highly visible safety and health program will be a top priority for the construction management team. This program will include orientation and training, an awareness and incentive program and the assignment of a dedicated safety and health team to educate and enforce the safety objectives established for the project. The program will address all aspects of heavy industrial construction, as well as the special requirements for working in the Northwest Territories.

2.8.3.2 Community Relations Plan

The visibility and importance of the project makes the establishment and maintenance of sound community relations a key success factor in the program.

A community relations plan will be developed to involve Aboriginal people in the construction effort. Residents of Yellowknife are accustomed to the realities of constructing and maintaining facilities and infrastructure in an arctic environment. The Proponent and the EPCM contractor will establish a dialogue with representative groups to determine a proactive plan to involve the local population in the project. The community college, employment centre, local contractors and band councils are examples of the resources available to provide the personnel and local knowledge necessary to enhance the success of the project. The EPCM contractor will make effective use of the local population for support positions on the job site and will structure a contracting plan to use local contractors where deemed appropriate.

2.8.3.3 Schedule Development

Construction management personnel will contribute to the project schedule and the engineering and procurement philosophy in order to rationalize construction force and duration levels at the site. Emphasis will be placed on confirming that materials and equipment are delivered to site ready for installation so that construction delays and expensive air freight are avoided.

2.8.4 Construction Execution Plan

The exact timing and duration of construction activities will be determined by such factors as the date full project authorization is granted, seasonal limitations on transport and site activities and project development permitting. The current construction execution plan is divided into six phases, based on assumptions about the winter road program timing. The progression of the construction work during these periods is illustrated on Figures 2.8-1 to 2.8-6 and detailed below.

2.8.4.1 Completion of Exploration Facility Work (1995)

Based on the overall schedule and the parameters of the existing bulk sampling program permit, the following work will be undertaken:

- erect and equip the cold storage building currently on site for storage of bulk sampling equipment and materials
- install airstrip runway lighting
- complete outstanding geotechnical testing and analysis required for foundation design for the permanent plant facilities.

2.8.4.2 Initial Construction Phase

Early 1996 to end of 2nd quarter 1996 - The construction effort during this period will focus on the development and installation of the temporary infrastructure and utility support facilities necessary to support the project.

General Tasks

- prepare the appropriate areas with aggregate to allow for erection of the temporary batch plant/maintenance building, fabrication shops and construction laydown areas
- install bases, berms and liners to allow erection of the initial fuel storage and loading/unloading facilities. Two storage tanks were erected in 1994
- commence site preparation, including bulk excavation and analysis of bedrock location and elevations for the process plant building, power plant, truckshop/offices/warehouse building and coarse ore storage area
- mobilize construction equipment to site
- off-load, store and protect construction material and equipment
- establish construction maintenance facility/batch plant facility
- install temporary construction power distribution systems
- crush aggregate for construction requirements.

◎ **Table of Contents**

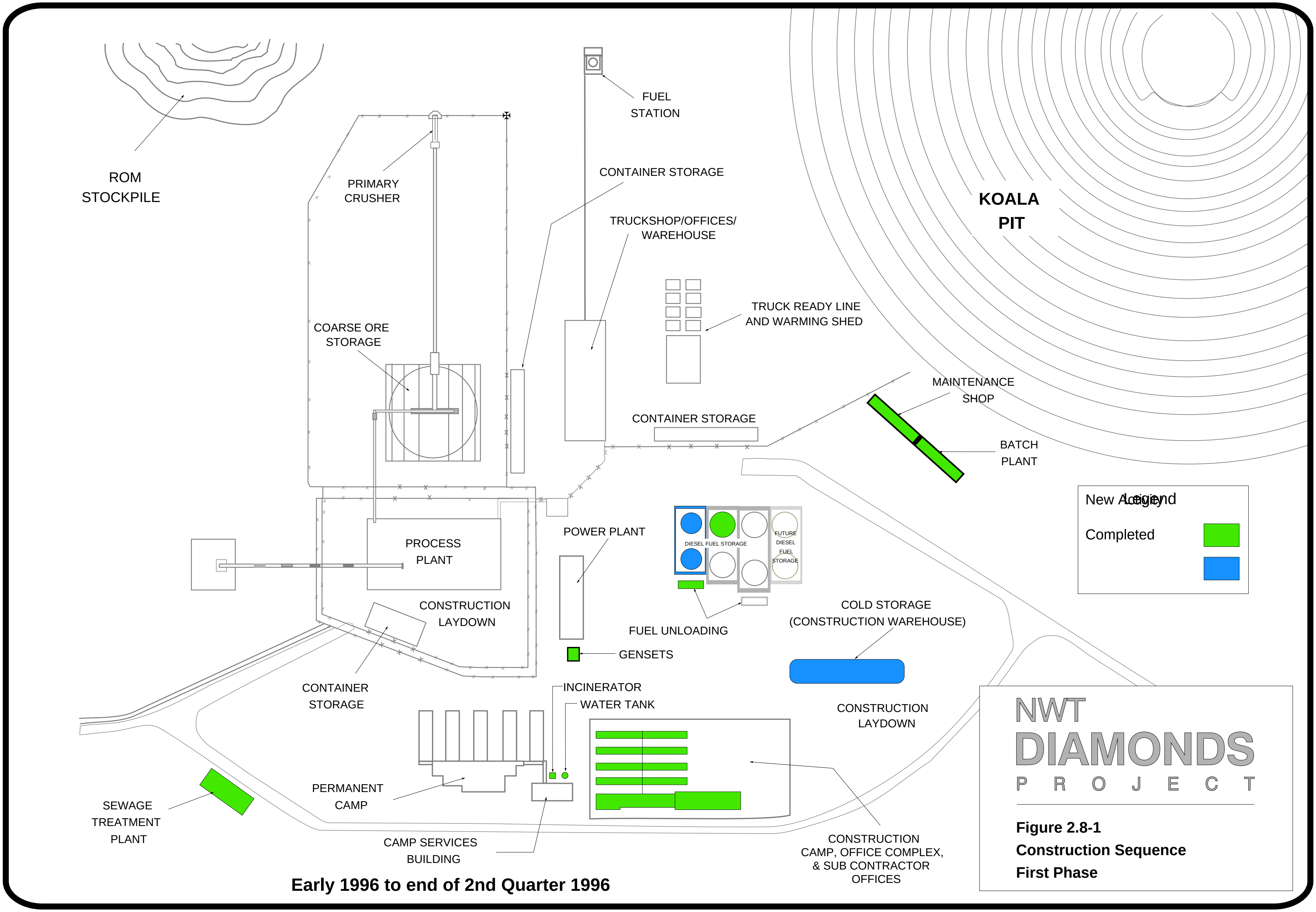
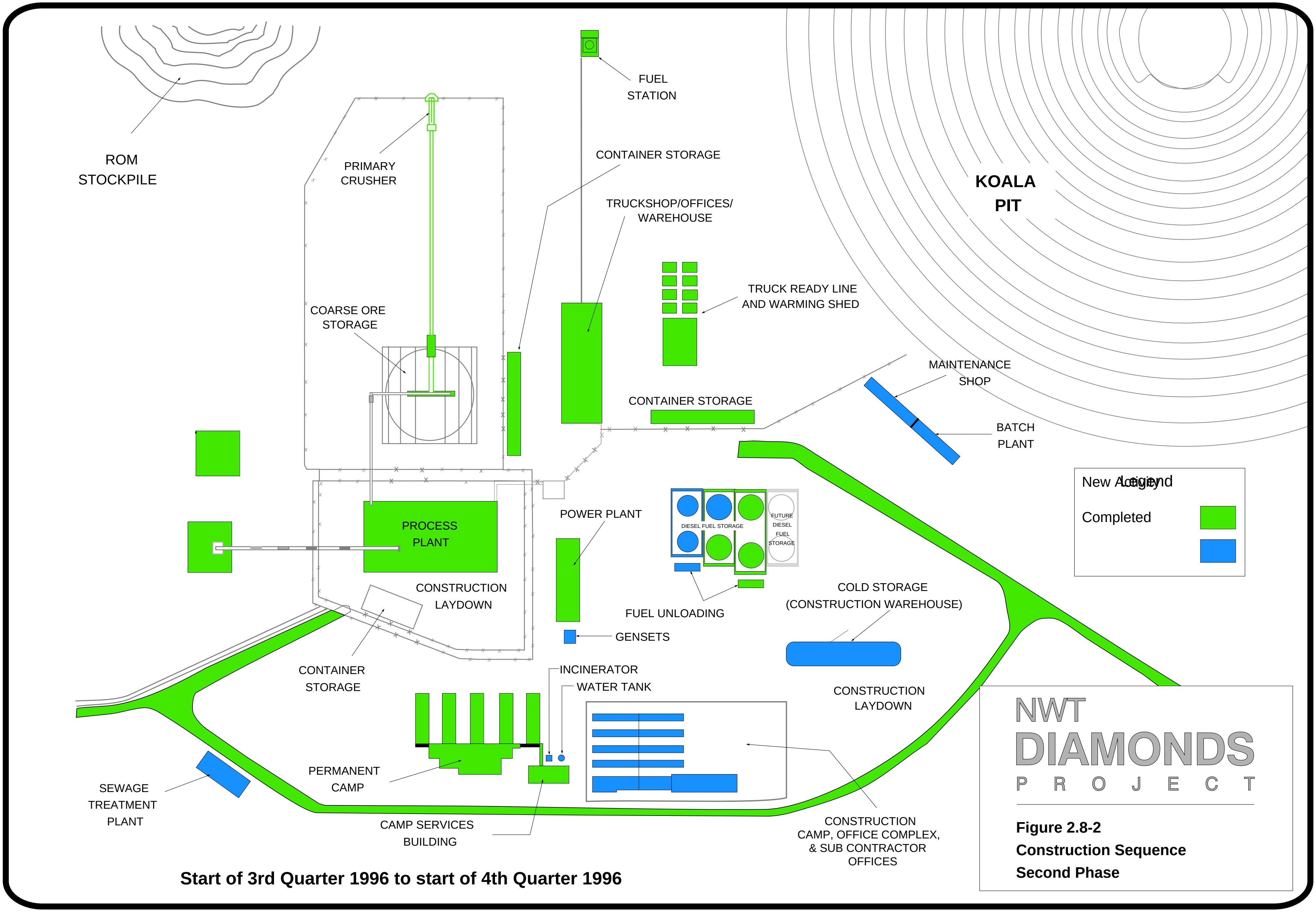


Figure 2.8-1
Construction Sequence
First Phase

Source: Fluor Daniel Wright Signet

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



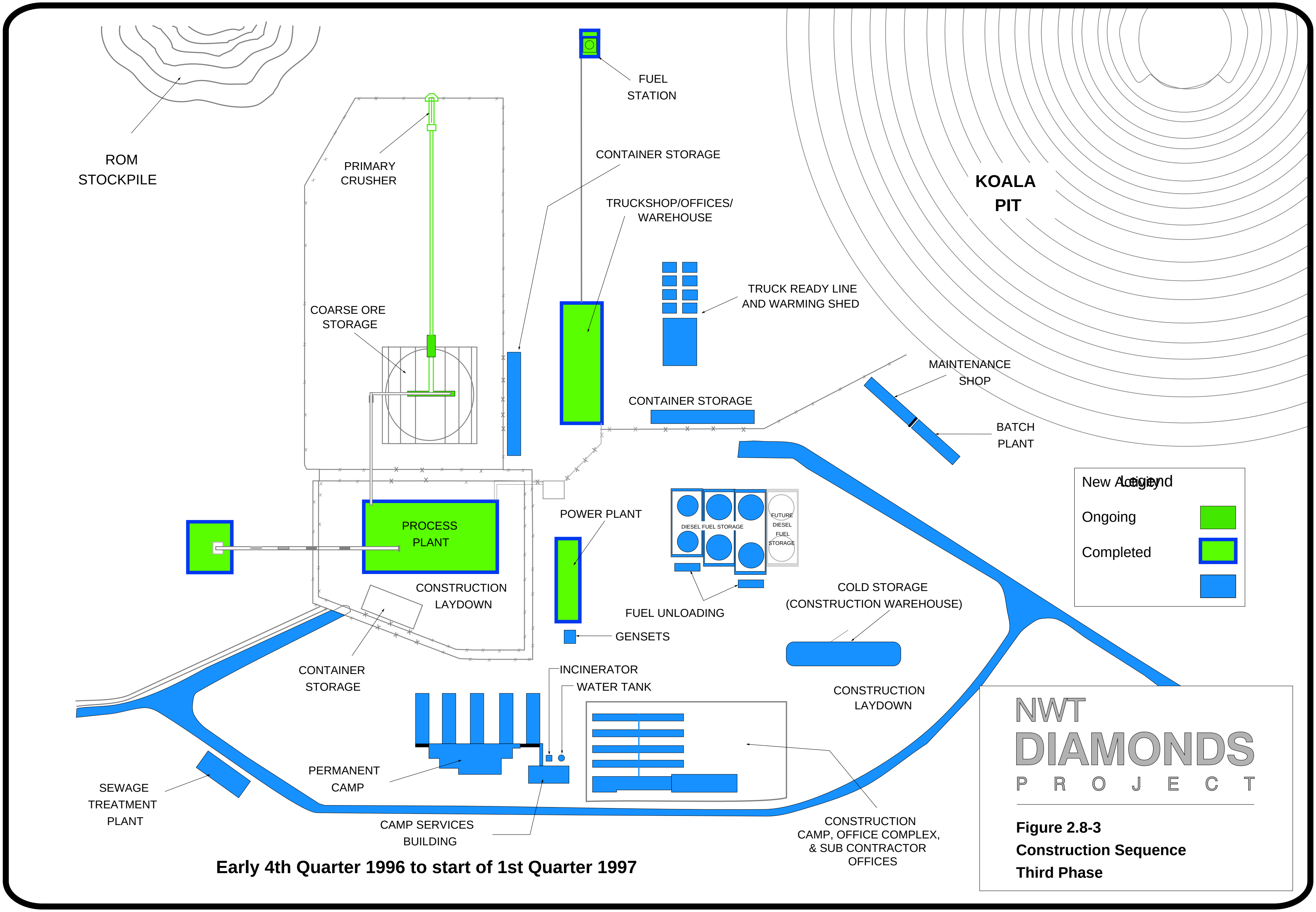
NWT DIAMONDS PROJECT

Figure 2.8-2
Construction Sequence
Second Phase

Source: Fluor Daniel Wright Signet

Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV



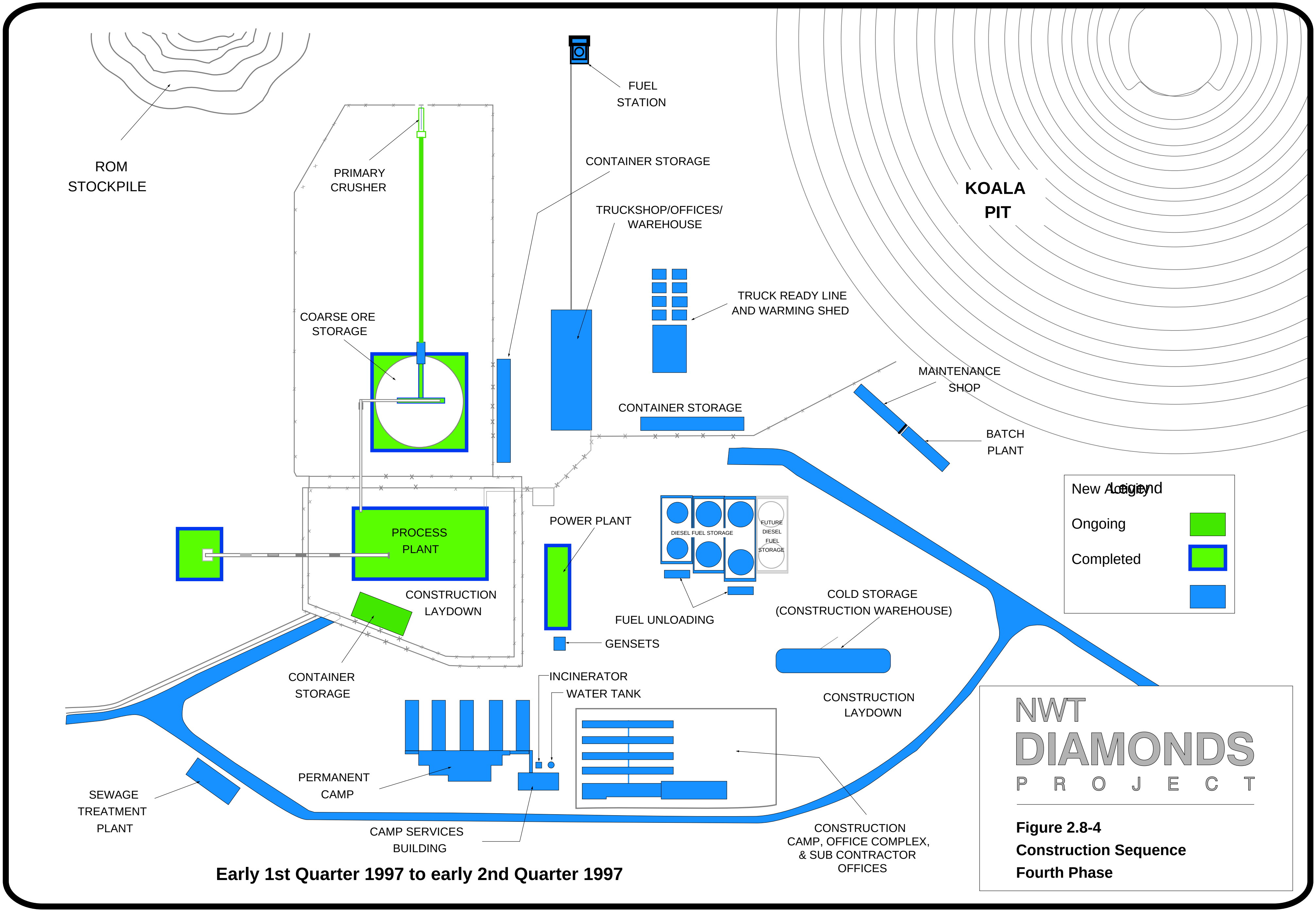
Early 4th Quarter 1996 to start of 1st Quarter 1997

Figure 2.8-3
Construction Sequence
Third Phase

Source: Fluor Daniel Wright Signet

◎ Table of Contents

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV

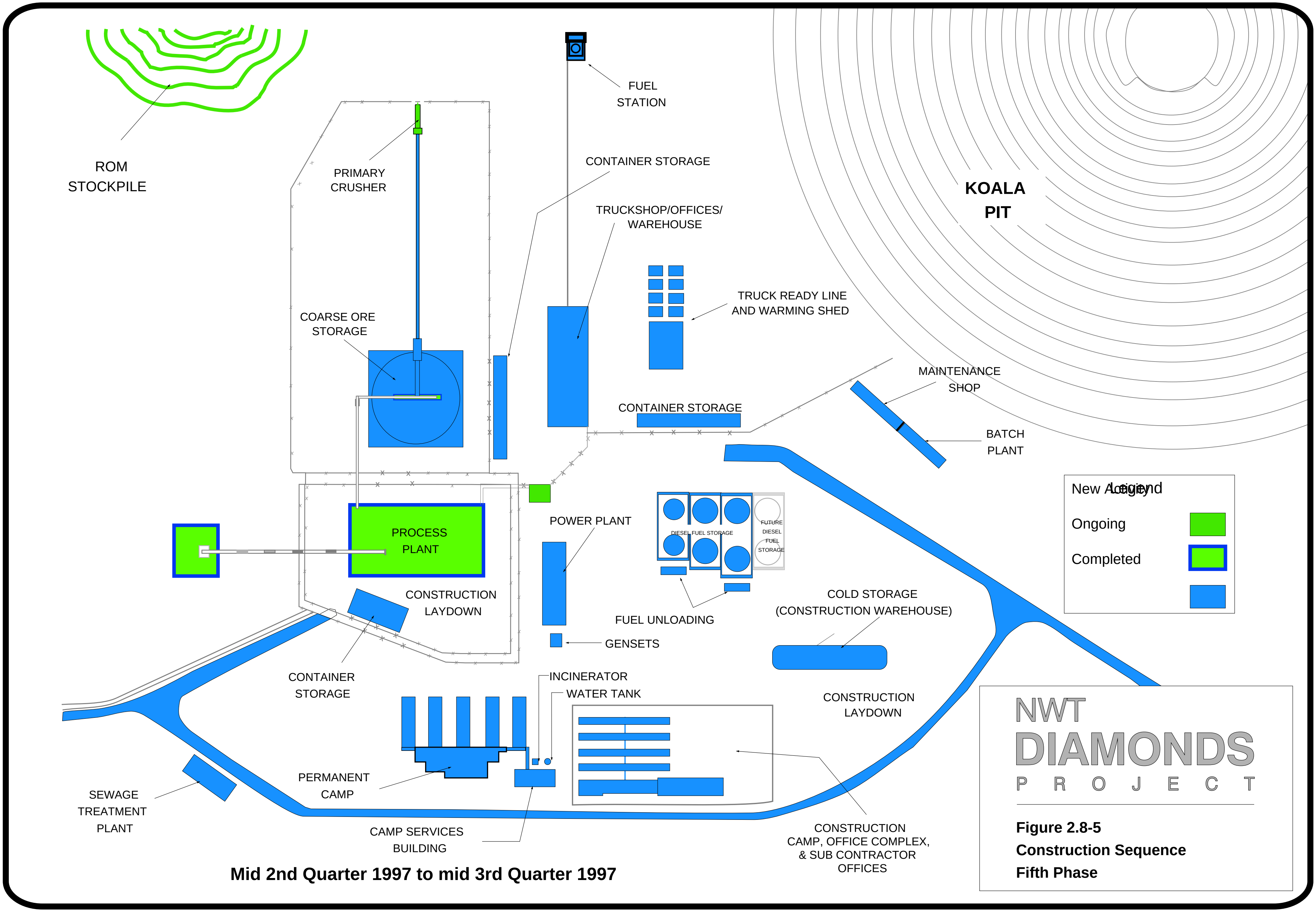


Early 1st Quarter 1997 to early 2nd Quarter 1997

Figure 2.8-4
Construction Sequence
Fourth Phase

Source: Fluor Daniel Wright Signet

◎ **Table of Contents**



Mid 2nd Quarter 1997 to mid 3rd Quarter 1997

Figure 2.8-5
Construction Sequence
Fifth Phase

Source: Fluor Daniel Wright Signet

◎ **Table of Contents**

Cad No. a371s | Job No. 455 | 03/29/1994-05:22pm | Res_AV

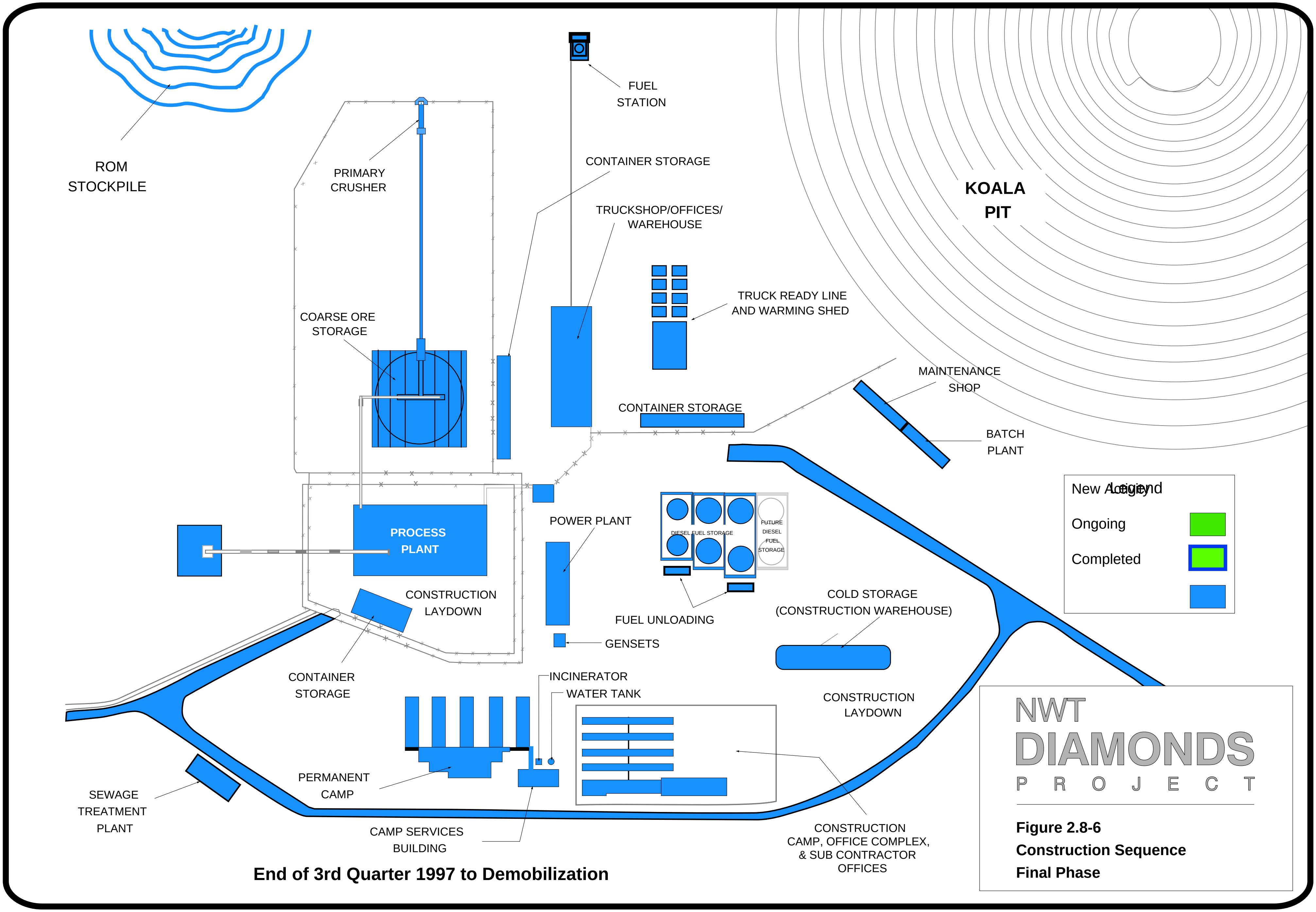


Figure 2.8-6
Construction Sequence
Final Phase

Source: Fluor Daniel Wright Signet

Temporary Construction Camp

- off-load and install temporary construction camp trailer units in defined sequence as they arrive
- install temporary utilidors and utilities
- install modular diesel generator for construction camp use.

Temporary Construction Offices

- off-load and install units for main complex
- install temporary field site construction trailers at required locations
- install temporary first-aid facilities
- install temporary utilidor and utilities.

Fuel Depot

- install temporary fuel distribution system required for 1996 construction season
- fill fuel storage tanks.

Water Supply

- commence installation of temporary water distribution system
- install temporary potable water pumphouses and commence with hook-up.

Sewage Treatment and Disposal

- commence installation of intake piping system from temporary construction camp
- commence installation of temporary sewage discharge piping to Kodiak Lake or Long Lake
- commence installation of sewage disposal facility.

General Site Development

- commence intersite construction access roads.

2.8.4.3 Second Construction Phase

Start of 3rd quarter 1996 to start of 4th quarter 1996 - It is imperative that as many structures be erected and closed-in as possible. The construction camp and support utilities will be operable by this time, and construction work will be carried out in 10-hour shifts.

Primary Crushing

- blast and excavate for foundation
- erect reinforced earth retaining wall
- place fill for access ramps and haul road.

Coarse Ore Storage

- blast and excavate for conveyor from primary crushing to drive tower
- form/place concrete for footings for the conveyor, strip, backfill and compact
- form/place concrete for the stockpile reclaim tunnel.

Process Plant

- form/place concrete for building foundations
- commence structural steel installation to enclose with cladding as practical
- install overhead cranes in building for use during construction
- commence form/place concrete for grade slabs and trenches.

Water Supply

- install raw water pipeline to Long Lake.

Power Plant and Distribution

- form/place concrete for foundations, grade beams, trenches/slabs, strip, backfill and compact
- erect engineered building
- place concrete for equipment foundations

- commence erection of interior structural steel
- commence installation of mechanical equipment and piping.

Fuel Storage and Distribution

- excavate and build berm for fuel tank farm
- install liner and foundations for equipment
- complete erection of fuel storage tanks
- complete installation of fuel off-loading facilities.

Truckshop/Offices/Warehouse

- form/place concrete for building foundations, strip, backfill and compact
- commence structural steel installation and building cladding when practical.

Vehicle Warming Shed

- form/place concrete for foundations
- install engineered building.

Permanent Camp

- erect camp dormitories and kitchens
- commence installation of utilities.

General Site Development

- construct the Panda diversion dam
- commence fill for road/pipeline berms to Long Lake.

2.8.4.4 Third Construction Phase

Early 4th quarter 1996 to start of 1st quarter 1997 – Preparation for the installation of equipment and materials delivered over the 1997 winter road will be done during this period of construction. This will include elevated foundations and supports, as well as completion of permanent lighting where feasible. Work will shift to inside the enclosed structures to maintain productivity.

Primary Crushing

- erect primary crushing area structural steel.

Coarse Ore Storage

- complete installation of escape tunnel
- complete installation of reclaim tunnel.

Process Plant

- continue form/place of equipment foundations
- commence installation of mechanical equipment and piping
- commence erection of interior structural steel.

Water Supply

- complete installation of raw water supply pipeline.

Power Plant and Distribution

- commence form/place of grade slabs, trenches and equipment foundations.

Truckshop/Offices/Warehouse

- commence form/place of grade slabs and trenches
- erect interior structural steel.

Permanent Camp

- install utility systems
- install architectural finishes
- install furnishings.

2.8.4.5 Fourth Construction Phase

Early 1st quarter 1997 to early 2nd quarter 1997 – The receipt and installation of equipment and materials being delivered to site over the 1997 winter road will be emphasized. Installation of equipment in the process plant and power plant will be top priority. All materials required for the 1997 summer construction season and project completion will arrive during this time. Any non-required containers, construction equipment and non-disposable items will be shipped out through the winter road window, utilizing the trucks returning to Yellowknife and Edmonton.

Primary Crushers

- commence installation of primary crusher mechanical equipment.

Coarse Ore Storage

- commence installation of feeders.

Process Plant

- complete erection of interior structural steel
- install equipment in secondary crushing, primary scrubbing, secondary scrubbing, degritting, high pressure grinding rolls, desanding, dense medium separation, recovery and reagent storage and distribution areas
- continue installation of piping in all areas, starting with large bore
- commence electrical installation.

Water Supply and Distribution

- install plant water distribution systems
- install raw water pumphouse and mechanical/electrical equipment.

Sewage Treatment and Disposal

- install building related equipment and materials
- install plant sewage collection piping.

Power Plant and Distribution

- install generators
- install waste heat exchangers
- erect power distribution system (poles and lines) for electric shovels.

Fuel Storage and Distribution

- fill fuel storage tanks with fuel for final construction and initial plant operation requirements.

Truckshop/Offices/Warehouse

- complete erection of interior structural steel
- pour elevated slabs
- complete installation of offices and architectural items
- install HVAC, fire protection, permanent power, maintenance equipment and furnishings.

Utilidors

- commence installation of utilidor modules
- install plant distribution piping in utilidors.

2.8.4.6 Fifth Construction Phase

Mid 2nd quarter 1997 to mid 3rd quarter 1997 – The emphasis will be on completion of all areas in accordance with schedule requirements to enable pre-commissioning of the plant to commence at the end of the third quarter of 1997. Final concrete pours and final site grading will be done, and security fencing will be completed.

Primary Crushers

- complete installation of mechanical equipment
- install electrical and instrumentation equipment.

Coarse Ore Storage

- complete mechanical, piping, electrical and instrumentation installation.

Process Plant

- complete installation of process equipment in all areas
- complete installation of piping, electrical, instrumentation, HVAC, fire protection, painting and insulation.

Water Supply and Distribution

- complete installation of permanent systems
- paint tanks, check out and test systems for final turnover.

Sewage Treatment and Disposal

- complete installation of lift station and associated plant collection piping.

Power Plant and Distribution

- complete installation of equipment and structural steel platforms
- complete installation of piping, electrical, instrumentation, HVAC, fire protection, painting and insulation
- complete architectural work
- complete installation of power grid systems.

Utilidors

- complete installation of utilidor modules
- complete piping, electrical, instrumentation, HVAC, fire protection, painting and insulation.

Security Building

- form/pour building foundations
- install structural steel and cladding
- install plumbing, utilities, electrical, architectural finishes, equipment and furnishings.

Communications

- complete installation of permanent communications system
- complete plant internal telephone system.

Security System

- install security system.

2.8.4.7 Final Construction Phase

End of 3rd quarter 1997 to Demobilization – The emphasis at this stage is on plant pre-commissioning, turnover to operations and construction demobilization. Certain temporary construction facilities will be dismantled and prepared for demobilization. The construction equipment required for operations will be turned over, and construction staff will be demobilized.

Process Plant

- complete check-outs and testing of systems
- turn over complete systems for start-up.

Security System

- test and check systems and turn over.

General Items

- commence start-up by operations
- ship out construction facilities and equipment not required for operation
- demobilize construction staff as per staffing schedule.

2.8.5 Work Force Requirements

The total construction effort is estimated to require 180,000 work days, which is the sum of direct and indirect contractors' labour, construction management and vendors' representatives. The total work force requirement is assumed to be spread over the 20-month construction and pre-commissioning period. The work schedule is based on a three weeks in/1 week out, 70 h/wk construction schedule.

The remote location of the site dictates that the project will be a fly-in/fly-out operation during construction.

The construction work force requirements are illustrated in Figure 2.8-7. The chart indicates a peak of 600 persons during the months of June through September 1996.

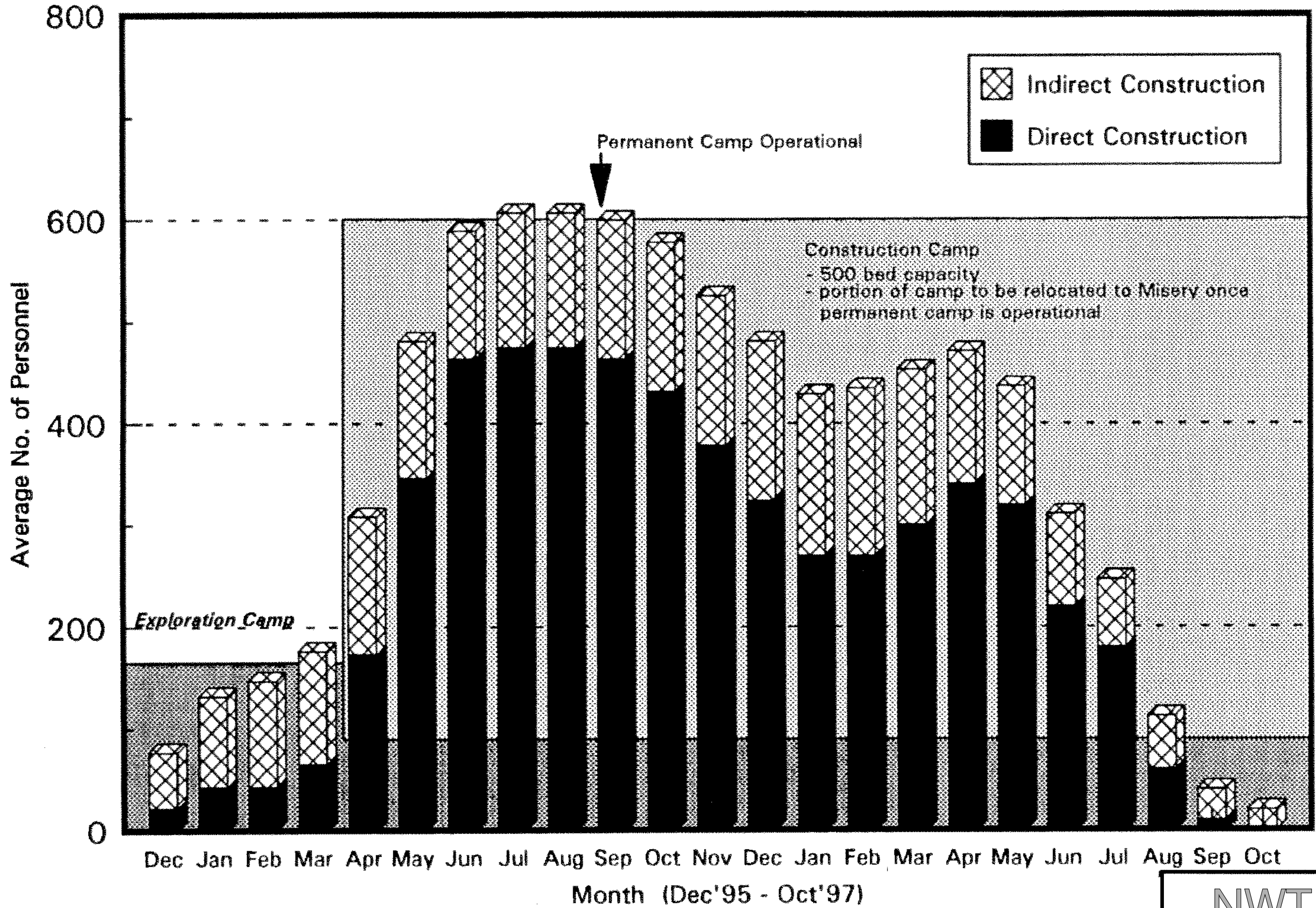
2.8.6 Construction Materials

Construction of the facilities will require large quantities of fill, gravel and aggregate, which will be obtained locally. The estimated quantities required for each major facility are summarized in Table 2.8-2.

Waste rock from the open pit pre-stripping operations will be used for haul road and dam construction. A quarry will be developed to provide the gravel required for construction of the plant site facilities and as fill for the ice core dams. It is planned to drain the small Airstrip Lake and to excavate the adjoining eskers and underlying gravels for this purpose. Sufficient quantities of construction materials will be available from this single source, so that no eskers or other potential borrow areas will have to be disturbed in the Koala area. Construction materials for the Misery haul road will be obtained from eskers at Lac de Gras and the Airstrip quarry, as well as waste rock hauled from the Panda and Misery pit operations. Approximately 30% of the total rock fill and gravel quantities will be obtained from the Airstrip quarry.

◎ **Table of Contents**

Cad No. a371s Job No. 455 03/29/1994-05:22pm Res_AV



NWT DIAMONDS PROJECT

Figure 2.8-7
Construction Work Force Requirements

Source: Fluor Daniel Wright Signet

Table 2.8-2
Earthworks and Concrete Materials Required by Facility

Facility	Rock Fill (m^3)	Gravel (m^3)	Concrete Aggregate (m^3)
Site Development/Dams	1,715,000	163,000	–
Materials Handling	–	16,500	3,320
Process Plant	–	2,000	4,135
Utilities	27,000	7,500	2,300
Ancillary Buildings	–	6,700	4,660
Construction Facilities	141,000	11,200	–
Total	1,883,000	206,900	14,415

The remaining construction materials – approximately 27,000 tonnes in the first year of construction and 28,500 tonnes in the second, as listed in Table 2.8-3 – will be transported to site from elsewhere.

Table 2.8-3
Other Construction Materials Requirements

Item	Tonnes		
	1996	1997	Total
Fuel	6,700	10,200	16,900
Cement	5,720	560	6,280
Equipment	270	4,450	4,720
Fabricated Platework	1,470	720	2,190
Reinforcing Steel	1,040	105	1,145
Engineered Building Structures	3,045	–	3,045
Structural Steel	12	3,520	3,532
Pipe	130	1,545	1,675
Housing (temporary and permanent)	3,470	–	3,470
Miscellaneous	5,250	7,375	12,625
Total	27,107	28,475	55,582

2.8.7 Construction Equipment

Equipment requirements during construction will vary from year to year, depending on the scheduled activities for the periods between winter road transport. Some equipment will be demobilized after construction, while the rest will remain on site for use during operations. Summary estimates of the total requirements are given in Table 2.8-4.

Table 2.8-4
Estimated Construction Equipment Requirements

Item	Quantity
Concrete Batch Plant	1
Concrete Mixer Trucks	3
Pick-up Trucks	5
Service Trucks	15
Personnel Vehicles	6
Welding Machines	19
Air Compressors	7
Generator Sets	13
Compactors	6
Pile Drivers	1
Backhoe	1
Loader	1
Cranes: - 205 t	1
- 136 t	1
- 55 t	1
- 40 t	1
- 16 t	1
- 7 t	1
Water Pumps	1
Manlifts	11
Storage Trailers	82

Preventive maintenance and equipment repair, logistical coordination of construction tools/equipment, equipment fuelling and procurement of tools/ equipment and related accessories will be performed by the dedicated on-site personnel.

2.8.8 Construction Facilities

The construction facilities will consist of those already established for the exploration and bulk sampling work together with additional buildings and services to cater for the large amount of construction to be accomplished in the relatively short timeframe.

2.8.8.1 Construction Accommodation

The existing exploration camps will be used as base camps for the erection of the temporary construction camp, which will be transported to site at the start of the winter road access period. The temporary construction camp will be positioned adjacent to the permanent camp location, for which materials will also be transported over the 1996 winter road and erected at a later date.

Existing Exploration Camp Facilities

Construction management staff and personnel needed to establish the construction site infrastructure will stay at the existing exploration camp. These personnel are required for the following work:

- erecting the temporary and permanent camp facilities
- off-loading/assembling construction equipment
- off-loading construction materials
- off-loading fuel.

Temporary Construction Camp

The construction work force for this project will require the installation of a 500-person prefabricated trailer-style construction camp. This camp will include kitchen facilities, a recreation area and wash facilities. It will be installed adjacent to the permanent camp and cover a ground plot area of approximately 13,000 m^2. When the permanent camp is available, some of the temporary construction dormitory facilities will be moved to Misery.

A unit in the construction camp will be dedicated to safety and first aid. This will include a basic hospital, which will be staffed at all times by a qualified nurse. All the sub-components of the construction camp will be interconnected with covered walkways to provide comfortable access to the various parts of the complex.

Permanent Camp

Construction of the permanent camp will begin with piling work in mid-1996 and will be completed by early 1997. The Proponent’s personnel, construction management and contractor management personnel will be housed in the permanent camp upon commissioning. It will also accommodate overflow construction senior staff and trades personnel from the temporary construction camp.

2.8.8.2 Construction Offices

A central office complex approximately 2,300 m^2 in size will be established adjacent to the construction camp. This complex will be used by the Proponent’s representatives and construction management personnel; an annex will be provided for contractor management. The office complex will be the central location for the following activities:

- telecommunications – external and internal communication linkups for the Proponent's staff, the construction manager and contractors
- engineering – CAD station, print machines, drawing files, vendor information files, etc.
- reception area and conference rooms.

The central office complex will be installed at the same time as the construction camp and will be available for occupancy before construction activities commence. Satellite offices will be established as required; most will be demobilized after the project buildings are enclosed.

2.8.8.3 Warehouse and Laydown

Equipment and materials for construction of the plant and ancillaries will be stored in the cold storage facility, shipping containers and outside laydown areas to the east of the power plant and camps. Secondary containment will be provided wherever required in areas used for storage of significant quantities of combustible liquids or other materials.

2.8.8.4 Ancillary Construction Facilities

The concrete batch plant and maintenance shop, covering an area of approximately 1,200 m^2, will be enclosed for year-round use. A boiler will be supplied with the batch plant to heat water and to steam heat aggregate/sand as required. Three concrete mixer trucks and one concrete pump truck will be required for moving and placing concrete.

Construction generated waste oils will be consumed in the preproduction mining ANFO mix. Other wastes deemed hazardous will be collected and stored temporarily on site in proper containments for haulage off site during winter road periods.

A main 8,900 m^2 field office/lunch facility and 600 m^2 of other secondary field offices will be provided. In addition, temporary mobile equipment ready lines will be set up to support the construction equipment for winter operation.

2.8.8.5 Construction Power

It is currently estimated that three 725 kW generator sets will be required to provide electrical power during the construction period; these generators will eventually serve as emergency power units. The gensets will be located south of the future power plant and will supply power for the temporary camp, construction offices, sewage plant, fresh water pumps, temporary construction lighting and power, and heat-tracing for the fresh water and effluent pipelines.

One 250 kW diesel generator will be required for temporary construction power and lighting at the primary crushing facility. One 250 kW and one 50 kW diesel generator will be required for the construction maintenance shop and batch plant.

Four 50 kW portable generators will be required for various construction activities, including pipeline construction, sewage plant construction, utility construction and backup emergency power.

Temporary construction power will be distributed throughout the project site via 600-120/240 V power distribution panels set up in strategic locations.

A 160 kW diesel generator will supply power to the airstrip until permanent power is available. All significant day fuel tanks required for the construction power gensets will be provided with secondary containment.

2.8.8.6 Temporary Water Supply

Water supply during the early construction phase will be obtained from Koala Lake. Based on work force projections and construction considerations, temporary potable water supply requirements are estimated to be 500 m^3/d (21 m^3/h).

The permanent potable water tank will be installed for use in the construction phase. A water line will branch directly from the fresh water line to the batch plant water tank. A temporary fire water pump will also be fed from this tank.

2.8.8.7 Construction Effluents and Emissions Disposal

The effluents and emissions attributable to the construction phase will be much the same as those generated during the operations phase. Exhaust and noise from both mobile and stationary equipment will be nominal and similar to those expected during operations. Inert, solid, non-combustible wastes will be separated for deposition in the Panda waste rock dump. Combustible, non-hazardous wastes will be incinerated and the ash also deposited in the Panda dump. Clean wood shipping crates/pallets and cardboard shipping boxes will be burned in open fires in the mine waste dump area. Hazardous waste will be back-hauled on the winter road to Yellowknife or Edmonton for approved disposal.

The temporary construction camp will generate approximately 250 L/d per person of sanitary waste, a combination of sewage and grey water. This liquid effluent will be treated and discharged into either Kodiak Lake or Long Lake. The sludge produced will be deposited in the Panda waste rock dump.

2.8.9 Commissioning and Start-up

The construction work will be scheduled to accommodate a phased commissioning period. As they reach mechanical completion, plant sections will be handed over to the pre-commissioning team. The pre-commissioning activities will be performed by the EPCM pre-operational testing team in conjunction with the Proponent's staff, with the completion of pre-commissioning marked by the turnover of the section to the Proponent for ore commissioning.

Pre-commissioning will involve such activities as motor rotation checks, P&ID conformance, valve stroking, controller action, point-to-point testing (field to PLC) and instrument calibration. Water will then be introduced into the system where relevant and pumped through to check for leaks and splash points. Operator training by the Proponent will commence before the end of construction and will form an important part of the pre-commissioning activity.

The ore commissioning and start-up phase will be controlled by the Proponent's operations staff, with assistance from the EPCM contractor and vendor representatives on an as-required basis. Since diamondiferous ore will be processed at this stage, the security system will be fully operational. Ore commissioning will be done initially with barren or low-grade material where possible to fill any dead areas in stockpiles and chutes, thus reducing potential losses and security risks.

2.9 Transportation Plan

The NWT Diamonds Project will be located in an undeveloped, virtually isolated part of the Northwest Territories not accessible by permanent all-weather roads. The Proponent therefore plans to transport personnel and materials to the site from Yellowknife by air and by means of the winter road already established and operated by Echo Bay Mines Ltd. to provide access to the Lupin mine, north of Lac de Gras. Based on cost and fuel efficiencies, most bulk materials and operating supplies will be shipped over the more economical annual winter road, while personnel, foodstuffs and special needs materials will be flown in year-round on commercial air carriers.

Access to Yellowknife from the south will be via the existing highway network and by air. The public highway system, the Echo Bay winter road and the airports in the vicinity of the project and to the south are shown in Figure 2.7-2.

2.9.1 Road Transport

2.9.1.1 Yellowknife to Site

Ground transportation to the NWT Diamonds Project site is possible only when the Echo Bay winter road is in operation. The total road distance from Yellowknife to the site is 442 km, including an initial 70 km east along Highway 4 from Yellowknife to Tibbit Lake, where the Echo Bay winter road begins. The winter road distance from Tibbit Lake to Lac de Gras is 337 km, with approximately 72% constructed over ice and 28% over portages. Subsequent access to the project site will be over the 35 km long BHP exploration/winter road extending from Lac de Gras to the Koala area until the permanent haul road from the Misery pit to the plant site is completed.

BHP has held discussions with Echo Bay about becoming joint operators of the winter road from Tibbit Lake to Lac de Gras once the mine permit is received. Joint operation will be subject to the government regulatory approvals required to include the Proponent on the operating permit. Existing agreement conditions for use of the winter road are defined in Appendix I-B1.

During the periods of winter road availability, 24 h/d (round-the-clock) trucking operations will be implemented to move equipment, fuels, consumables and other supplies and materials needed for construction and operations to the job site. The estimated travel time from Yellowknife to the plant site, assuming no weather delays, is approximately 14 hours.

During 1994 and 1995, BHP engaged a consultant (Sandwell Inc.) to analyze the winter road for the potential effects of increased traffic on ice capacity, strength and condition. A continuous thickness survey of the entire winter road to Lac de Gras was undertaken, along with studies on ice durability, maintenance requirements, type of transportation equipment, vehicle speeds, frequency of loads and dynamic wave analysis. The results to date indicate that, with sufficient maintenance and planning, the winter road can safely support the additional anticipated traffic.

The following truck types are typical of those expected to be used on the winter road:

Truck Type	**Payload**
B-trains (decks)	33,500 to 35,000 kg
Super B (decks)	41,000 kg
Hi-boy (13.7 m)	22,500 kg
Temperature controlled van (13.7 m)	22,500 kg
Regular van (13.7 m)	22,500 kg
Low-boy (16 to 32 wheels)	to 60 t

The annual periods of winter road operation for the last decade are listed in Table 2.9-1.

Table 2.9-1
Historic Periods of Echo Bay Winter Road Availability

Year	First Truck	Last Truck
1995	25 January	13 April
1994	18 January	3 April
1993	3 February	1 April
1992	28 January	22 March
1991	23 January	13 March
1990	1 February	22 March
1989	14 February	7 April
1988	12 February	9 April
1986	14 January	1 April
1985	22 January	7 April
1984	30 January	8 April
1983	17 February	14 April

To minimize costs, B-train truck units will be used whenever possible for both dry and liquid haulage. Normal highway equipment clearances will be suitable for travelling the winter road and special high clearance rigs will not be required. B-train truck flatdecks are preferred over Super B-train trucks, which are subject to suspension problems (i.e., broken springs). Special loads exceeding the size or weight allowed on B-trains will be carried on 12 m to 13.7 m flatdecks, stepdecks or other types of trailers. Most small shipments will be transported in unheated 6 m or 12.2 m containers. Modules or pre-assembled units will be shipped on flatdeck or low-boy trailers.

Diesel fuel will be hauled to site by B-train tanker trucks, which can carry 42,000 L per trip under full load road conditions and 28,000 L per trip under reduced load conditions. Fuel hauling will generally commence as soon as the winter road is available; however, where possible, fuel deliveries will be scheduled during full load conditions.

All winter road transportation equipment must follow speed and load size restrictions imposed by Echo Bay road control/security and will be required to carry safety and cold weather survival equipment. These restrictions and requirements include the following:

- Maximum allowable cargo limits governed by Alberta and NWT highway regulations normally accepted for the Echo Bay winter road (dependent on weather conditions) are as follows:

  - 5 axle – 20 tonnes
  - 6 axle – 25 tonnes (trailer loads)
  - 7 axle – 32 tonnes (B-train loads)
  - 8 axle – 40 tonnes (Super B-trains)
  - 16 wheel low-boy – 36 tonnes
  - 32 wheel low-boy – 60 tonnes

  Special arrangements will be made for the shipment of heavy equipment components that exceed normal weight limitations of roads and bridges. Indications are that even the heaviest load of approximately 75.3 tonnes can be accommodated by special permit, subject to certain directives with regard to the type of carrying unit, time of travel, speed, pilot cars, etc. A study of ice road conditions has shown that sufficient ice thickness and strength can be expected toward the end of most winter road seasons to safely transport these loads.

- Weight restrictions apply to the Cameron River bridge (74,740 kg) at Tibbit Lake.

- Normal speeds are 30 km/h loaded on ice and 40 km/h empty. Portages are restricted to 5 km/h. These may vary depending on road conditions. Signs will be posted and/or security will advise of changes.

- Carriers will maintain spacing on the winter road as instructed by Echo Bay (usually 0.5 km to 1 km apart).

- Trucks will always travel in pairs.

- In the event of mechanical or other failure, the driver of the accompanying vehicle must pick up the operator of the disabled truck for drop-off at the next check point or camp. Under no circumstances can a driver remain with a disabled vehicle.

- Unless special authorization is obtained, truck will not be permitted to carry passengers.

- Drivers must take sufficient rest breaks and keep detailed log books. Echo Bay security will ensure that these directions are followed.

- In addition to standard equipment, all tractor operators must carry the following:

- CB radio
- rotary beacon
- sleeper
- fire extinguisher (1 to 5 lb ABC or 2 to 4 lb ABC)
- tire chains.

- All drivers must carry the following winter survival gear suitable for -50°C temperatures:

  - sleeping bag
  - winter boots (steel toes)
  - gloves and balaclava
  - winter coveralls or ski-doo suit
  - parka
  - emergency food rations (two days minimum).

Echo Bay security at Tibbit Lake will check to ensure that each driver possesses these items. Drivers who do not will be refused the right to proceed.

Routine studies will be undertaken annually in preparation for each year’s winter road program, taking into account the latest information on the availability of transport equipment and operators; dispatching of loads relative to site requirements; and travel constraints such as weather delays, ice thickness and condition and predicted duration of the season.

2.9.1.2 Edmonton to Yellowknife

Highway transport carriers equipped to provide all required services will be contracted to haul, with standard highway vehicles, from Edmonton to Yellowknife. The trailers will be suitable for haulage to Koala on the winter road without reloading. Although height and width problems are not anticipated, loads will usually be restricted to dimensions of 22.9 m long x 4.6 m high x 6.1 m wide. A number of reusable containers will be utilized for round-trip transportation of miscellaneous parts and goods requiring protection from weather or consolidation to avoid loss or damage in transit.

Specific restrictions enroute to Yellowknife include the limited capacities of the Mackenzie River ferry and ice bridge, Francs (French) Channel bridge (72,720 kg) and Yellowknife bridge (104,540 kg). Again, special arrangements will be made where required to ensure safe passage of heavily loaded project vehicles.

In addition to highway access, a 1,136 km long CN Rail line links Edmonton with Hay River. From Hay River, goods can be shipped 500 km by road to Yellowknife via Fort Providence and Rae-Edzo. Barge transportation from Hay River to Yellowknife is an available option.

2.9.1.3 Quantities of Materials Shipped by Road

Truck haulage requirements will be high during the construction phase of the project. An estimated 2,250 truckloads of equipment, materials, tools and consumables will be shipped to site over the two winter road seasons. The anticipated quantities of materials and number of loads required for construction of the project infrastructure are listed in Table 2.9-2.

Table 2.9-2
Anticipated Construction Quantities
and Truckloads Required (to Koala Plant Site)

	1996		1997	
Item	**Tonnes**	**No. of Loads**	**Tonnes**	**No. of Loads**
Diesel fuel	6,700	234	10,200	356
Construction materials	6,890	306	2,210	97
Building structures	3,045	132	--	--
Equipment	270	11	4,450	182
Fabricated platework	1,470	51	720	25
Construction camp	850	85	--	--
Permanent camp	2,620	115	--	--
Structural steel	12	1	3,520	140
Miscellaneous	5,250	207	7,375	291
Total	27,105	1,142	28,475	1,091

In addition, for the Proponent's preproduction phase activities, approximately 1,300 truckloads of equipment, materials, fuel and consumables will be shipped over the winter road. A breakdown of the estimated quantities of goods to be shipped by road during preproduction is given in Table 2.9-3.

To provide the annual quantities of supplies required during operations, approximately 1,950 truckloads will be shipped each year between 1998 and 2002; 2,090 truckloads each year between 2003 and 2006; and 2,815 truckloads each year from 2007 and thereafter until mine closure. The estimated quantities of goods to be shipped by road during operations are shown on Table 2.9-4.

2.9.2 Air Transport

2.9.2.1 Flight Requirements

Air transport will be an essential feature of project logistics. Chartered aircraft will be used to transport all personnel to and from the site, to bring foodstuffs and

Table 2.9-3
Anticipated Quantities of Road-shipped Supplies During Preproduction

Item	Year Shipped 1996	1997	1998
Mine			
Ammonium Nitrate (Contractor)	1,300 t		--
Ammonium Nitrate (Proponent)	250 t	3,460 t	--
Fuel for mobile equipment (Contractor)	5,000,000 L	--	--
Fuel for ANFO (Contractor)	90,000 L	--	--
Fuel for mobile equipment (Proponent)	1,050,000 L	10,976,000 L	--
Fuel for ANFO (Proponent)	55,000 L	521,000 L	--
Equipment mob/demob (Contractor)	1,000,000 kg	--	1,000,000 kg
Supplies (Contractor)	400,000 kg	--	--
Equipment mobilization (Proponent)	3,650,000 kg	1,490,000 kg	--
Consumables (Proponent)	27,000 kg	333,000 kg	--
Parts (Proponent)	23,000 kg	267,000 kg	--
Lube (Proponent)	24,000 L	285,000 L	--
Gensets & Boilers (Proponent)			
Fuel for gensets	3,800,000 L	8,075,000 L	--
Fuel for boilers	1,000,000 L	1,350,000 L	--
Lube	16,900 L	35,400 L	--
Consumables	14,400 kg	30,200 kg	--
Plant Start-up (Proponent)			
Initial supplies	--	250,000 kg	--
G & A (Proponent)			
Initial furnishings	120,000 kg	20,000 kg	--
Supplies	80,0000 kg	108,000 kg	--
Total			
Fuel	10,995,000 L	20,922,000 L	--
Truckloads (38,000 L/truckload)	289	550	--
Supplies	6,700 t	6,300 t	1,000 t
Truckloads (25,000 kg/truckload)	268	252	40

Table 2.9-4
Anticipated Annual Quantities
of Road-shipped Supplies During Operation

Item	Shipped Annually From Years 1-5 1998-2002	Years 6-7 2005-2006	Years 8-25 2007 Onwards
Surface Mining			
Ammonium Nitrate	10,000 t	9,500 t	10,500 t
Fuel for mobile equipment	27,000,000 L	26,000,000 L	29,000,000 L
Fuel for ANFO	1,200,000 L	1,100,000,L	1,200,000 L
Equipment mobilization	362 t	1,000 t	800 t
Mobile consumables	900 t	875 t	940 t
Mobile parts	690 t	675 t	750 t
Mobile lube	734,000 L	739,000 L	782,000 L
Underground Mining			
Explosives	--	320 t	385 t
Equipment mobilization and consumables	--	500 t	600 t
Power Plant and Boilers			
Fuel for gensets	22,000,000 L	26,750,000 L	45,000,000 L
Fuel for boilers	2,200,000 L	2,200,000 L	4,400,000 L
Lube	96,500 L	117,000 L	200,000 L
Consumables	82,000 kg	99,000 kg	169,000 kg
Process Plant			
Flocculant and heavy media	873 t	873 t	1746 t
Parts and consumables	472 t	472 t	944 t
G and & A Supplies	100 t	120 t	140 t
Total			
Fuel	52,400,000 L	56,000,000 L	79,600,000 L
Truckloads (38,000 L/truckload)	1,380	1,475	2,095
Supplies	14,300 t	15,290 t	17,956 t
Truckloads (25,000 kg/truckload)	572	612	718

other perishable or critical supplies to the site and to ship diamonds out from the site. At present there is no plan to use any project owned or operated aircraft. BHP’s existing Corporate Aviation Department will routinely audit the safety aspects of the project’s air transportation system, including the airstrip operation, the performance of all air carriers chartered by the project and the general suitability and safety statistics of all chartered aircraft.

The airstrip at the project site was specially designed to accommodate aircraft such as the Hercules C130 and Boeing 727/737 jets, which are the approximate size required for the numbers of personnel and the type and amount of supplies to be transported by air. Cessna Citation II or similar aircraft will be used for emergency Medivac flights. In addition, DC4 and Twin Otter flights will probably be required. The types of aircraft that are viable for access to the project site are listed below:

Aircraft Type	**Load**
Hercules C130	18,000 kg
Boeing 727 Combi-jet	passengers and freight (41,500 kg)
737 Combi-jet	passengers and freight (12,975 kg)
HS-748	passengers and freight (4,550 kg)
DC3	3,180 kg
DC4	9,091 kg
C46	7,727 kg
Twin Otter	18 passengers
Gulf Steam	24 passengers
Corporate Jet	6 to 8 passengers

Air transported supplies will be delivered predominantly from Yellowknife, but also from Edmonton at times, depending on aircraft availability, point of departure and whether or not the supplies are urgently needed.

Most personnel will be transported to and from Yellowknife in a large chartered jet. Smaller aircraft will be chartered to transport personnel to and from the surrounding communities. Project personnel will be expected to provide their own transportation from their homes to the designated pickup points. Air transportation arrangements for construction personnel will probably include chartered aircraft to and from other locations, such as Edmonton, depending on the availability of local experienced tradespeople required to properly staff the construction effort. The estimated number of aircraft trips that will be made to the site is listed in Table 2.9-5.

2.9.2.2 Site Airstrip

The 1,950 m long airstrip at the project site was built to accommodate the aircraft described above. Parking, loading and service areas, as well as a road and aircraft control building, will be constructed near the north end of the strip, adjacent to the access road from the winter road. The building will serve as the control terminal for the airstrip and the reporting centre for incoming road traffic. Aviation fuel for emergency aircraft refuelling will be available at the site.

Runway lighting and navigational aid systems to permit Instrument Flight Rules (IFR) non-precision approaches by aircraft equipped with global positioning system (GPS) and/or automatic directional finder (ADF) equipment will be

Table 2.9-5
Anticipated Number of Aircraft Trips to Site

Aircraft	Trips
Construction Period (Contractors)	
Hercules C130	109
727/737 Combi-jet	148
DC4/DC3/HS 748/C46 Prop. Cargo	149
Twin Otter	14
Gulf Stream	72
Preproduction Period	
727/737 Combi-jet	170
727/737 Cargo jet	20
DC4/DC3/HS 748/C46 Prop. Cargo	48
Twin Otter	172
Hercules C130	20
Operations Period (1998-2006 – Years 1 to 9)	
727/737 Combi-jet	208
727/737 Cargo jet	15
DC4/DC3/HS 748/C46 Prop. Cargo	52
Twin Otter	208
Small jets	26
(2007-Onwards – Years 10 to 25)	
727/737 Combi-jet	260
727/737 Cargo jet	20
DC4/DC3/HS 748/C46 Prop. Cargo	72
Twin Otter	292
Small jets	26

provided. The Proponent and its consultants have worked with Transport Canada in establishing the most appropriate and modern lighting and navigation systems. These systems are described below.

Runway and Approach Lighting System

- two high intensity, variable brightness, 732 m approach light systems with runway alignment indicator lights (AN/SSALR)
- two precision approach path slope indicator systems (PAPI)
- two 100 W red/green runway threshold indicator light systems

- high intensity 100 W runway edge lighting on 762 mm extensions
- medium intensity blue taxiway lights, yellow turn-off lights and apron demarcation lights as required
- floodlight system for aircraft parking and loading area
- central operator control system for all the above.

Radio Aids to Facilitate IFR Non-precision Approaches

- one 125 W solid state, crystal controlled non-directional radio beacon transmitter
- one Transport Canada-designed and approved GPS, IFR non-precision approach procedure requiring aircraft-based GPS equipment, but no ground installations
- one VHF fixed base radio transmitter/receiver now installed at Koala with two “Icom” hand-held backup radios.

Weather Observation and Recording Equipment

- Wizard II weather station now installed at Koala
- two wind indicators, one near each end of the runway
- two lighted windsock towers, one at each end of the runway
- vertical visibility range detector
- horizontal visibility range detector.

2.9.3 Transport Logistics

The objective of the traffic plan is to ensure safe, expedient and economical transport of all personnel and materials to and from the NWT Diamonds Project by either air or road. While all initial transport logistics will be coordinated out of the Proponent’s offices in Yellowknife and Vancouver, this responsibility will be transferred to personnel on site as the project infrastructure becomes established.

Traffic logistics during the construction of the project infrastructure will be coordinated similarly by the EPCM contractor out of its base office and temporary project offices.

A marshalling and storage area will be established in Yellowknife to ensure that winter road use and traffic dispatch are managed efficiently. In addition, a temporary or contracted marshalling and storage area will be established in Edmonton to ensure that truck transport is optimized between Edmonton and

Yellowknife during the construction and preproduction periods of the project. Edmonton is a prime location for these facilities because of its strategic connections to the main road and rail network to manufacturing and fabrication centres in both Canada and the U.S.

The Proponent and the EPCM contractor will set up logistics groups to monitor vendor transport schedules and coordinate documentation and routing with freight forwarders and carriers. Traffic coordinators, with appropriate support staff, will be located at the Yellowknife and temporary Edmonton marshalling yards to coordinate the traffic and logistics functions for each winter road campaign.

Responding to site requirements for equipment, supplies, food, fuels and personnel, these groups will plan, schedule and expedite the following air and ground transport activities:

- delivery to the Yellowknife and/or Edmonton marshalling area, including inspection and acceptance
- delivery to site direct from source
- delivery to Yellowknife from Edmonton and other sources
- consolidation of loads at source, at the temporary Edmonton marshalling area and at Yellowknife
- delivery to Yellowknife from Edmonton by highway vehicles, and from Yellowknife to site by specially equipped trucks
- fabrication or pre-assembly of components to reduce field work and expedite shipping
- coordination with Echo Bay of winter road traffic plans to ensure that safety and traffic control requirements are met
- inspection of winter road haulers, vehicles and communications equipment to ensure they are fit for use and carry the appropriate safety and cold weather emergency equipment, insurance and permits, and that operators obey road rules and safety instructions.

2.10 Human Resources

The Human Resources Program for the NWT Diamonds Project will reflect the best practices that have emerged from BHP's experience as a global employer. The Human Resources Program will be designed to do the following:

- address the unique personnel issues inherent to the environment in which the project is located
- create a long-term work system
- promote a culture that focuses on safety, creativity and productivity
- provide a satisfying working environment for all employees.

Contemporary human resource practices and principles will be incorporated into the program.

The NWT Diamonds Project will operate as a performance based organization incorporating a team concept of individual involvement, accountability and optimum performance. The recruitment of personnel and orientation, training and education at all levels of the work force will be central to achieving a good performance organization.

The following sections describe the various project human resource activities planned for this project.

2.10.1 The Labour Standards Act

The *Labour Standards Act*, adopted by the NWT Legislative Assembly, is a statute that serves as the legislation for employment standards in the NWT. The Act sets out the general rights and responsibilities, basic requirements and fundamental principles of labour standards in the NWT.

The areas governed by the *Labour Standards Act* and Regulations include

- hours of work
- minimum wages
- termination of employment
- annual vacations
- general holidays
- pregnancy and parental leave
- inspections
- the Labour Standards Board
- payroll records

- payment of wages
- offences and punishment.

Other applicable NWT worker-related legislation includes the *Safety Act*, the *Mining Safety Act* and the *Workers' Compensation Act*. All hiring and employment policies and practices for the NWT Diamonds Project will comply with the requirements of the NWT legislation, various federal acts and other applicable legislation.

2.10.2 Human Resources Policy

Established human resources policies, and those under development, will ensure that high standards of safety, efficiency and consistency are met. All employees will be required to comply with all policies implemented by BHP as the Operator of the project. Policies will be reviewed on a regular basis to ensure they reflect the Operator's directives, employee needs and contemporary human resource practices. The Operator will implement the following human resources policy for the project.

2.10.2.1 Equal Opportunity/Hiring Preference

The Operator will be an equal opportunity employer and employ people based on skills, regardless of race, gender, colour, religious affiliation or disabilities.

The Operator, however, is committed to giving employment preference, dependent on the applicant's skill level, to Aboriginal people from the Northwest Territories, then to non-Aboriginal Northwest Territories residents, and then to other Canadians.

In addition, a limited number of non-Canadian expatriates will be seconded to the project to provide specialist advice periodically or as part of that individual's career development in accordance with BHP's global Career Development Program.

The Operator will appoint an officer who will have responsibility to ensure compliance with equal opportunity and hiring policies.

2.10.2.2 Sexual Harassment

The Operator will implement a sexual harassment policy to promote the establishment of a workplace free of harassment. The policy will be in accordance with standards set out in any appropriate legislation and will be amended from time to time to reflect any changes made to that legislation (Appendix I-B2).

2.10.2.3 AIDS and HIV

The Operator will put in place an AIDS (Acquired Immune Deficiency Syndrome) and HIV (Human Immunodeficiency Virus) policy that incorporates provisions for AIDS education programs and procedures to effectively handle AIDS/HIV related personnel issues in a sensitive and confidential manner (Appendix I-B3).

2.10.2.4 Drugs and Alcohol

The Operator has a drugs and alcohol policy in place that bans the use of controlled substances and alcohol in all areas of this operation, including the permanent camp. Employees are advised of this policy and are required to comply with it.

2.10.2.5 Firearms

The Operator has a "no firearms" policy for the mine and in the camp. No employees will be allowed to bring firearms into the project area. Security arrangements with respect to the policy will be enforced.

2.10.2.6 No Smoking Policy

A non-smoking policy has been implemented in all confined areas including offices, lunch rooms, kitchen and bedrooms. Designated smoking rooms are provided for people who wish to smoke and, because of weather conditions, cannot do so outdoors.

2.10.2.7 Medical Examination

As part of the recruitment process, all job offers will be contingent on the pre-employment examinations. The purposes of this medical examination are to

- ensure compliance with legislation
- identify medical conditions that preclude employment or work ability
- identify medical conditions that could be aggravated by exposure at the project
- identify any condition that can be accommodated.

Based on the examination results, employees will be apprised on the state of their health. Regular medical evaluations will be conducted for employees. These will include chest X-rays, lung function tests, and hearing and vision testing.

2.10.2.8 Security/Confidentiality

Due to the nature of the project, each employee will be required to comply with security and confidentiality provisions. All employees, contractors and visitors are required to sign a "Confidential Information, Security and Drug Testing Agreement" (Appendix I-B4). Security arrangements will vary depending on the area in which the employee is working. Security will be very stringent in key areas. Employees may be required to undergo searches, including that of the body and of personal belongings.

2.10.3 Recruitment

Personnel for the NWT Diamonds Project will be recruited from communities within the NWT and other Canadian provinces.

2.10.3.1 Preference

As outlined above, hiring preference will be given to NWT Aboriginal people and other NWT residents who have the skills required to work at the mine. It will be necessary to recruit from other Canadian provinces as well. Labour studies for the project have indicated that NWT residents alone will not be able to meet all the personnel requirements for the mine, particularly in the professional and skilled areas. Details of the project skills mix required and the available skills in the NWT are contained in Volume IV, Section 4. Appendix I-B5 describes the employee selection philosophy and recruitment process.

2.10.3.2 Recruitment Process

The recruitment procedure for hiring will be based on a standard interview process. Before this process is introduced for the hiring of Aboriginal people, discussions will take place within Aboriginal communities to ensure the process is adapted or, if necessary, modified to ensure potential Aboriginal applicants understand and are comfortable participating in the process. Aboriginal people will be trained in the use of this interview process and will form part of the interview teams.

2.10.3.3 Point of Hire

The Proponent has designated Yellowknife as the principal point of hire. Employees will be flown to and from Yellowknife and the mine at the completion of their shift rotation free of charge. In addition, air service will be provided for employees in smaller communities that do not have year-round road access to Yellowknife. These communities include Snare Lake, Rae Lakes, Wha Ti, Lutsel K'e and Coppermine. The air service, like that for Yellowknife point of hires, will be provided to these communities at no cost to the employees. Again, these employees will be picked up at each community and returned there at the completion of their rotation. This practice will assist in ensuring the community retains some benefit from the increased wage economy that will be generated by the project.

2.10.4 Training/Education

Training for all employees can be categorized into five stages:

- pre-employment training
- orientation
- initial job training
- certification
- continuing development.

A brief description of each stage is provided below.

2.10.4.1 Pre-Employment Training

In order to maximize employment opportunities for Aboriginal people and NWT residents, pre-employment programs will be developed to provide potential employees with the opportunity to gain skills they currently do not have. These programs will be developed using a mix of existing courses, new programs and on-the-job experiences.

The Proponent, in conjunction with Yellowknife-based mining companies (Con, Miramar and Royal Oak) and the Department of Safety and Public Services, has worked with Arctic College in developing a pre-employment mine training program. The first graduating class completed the program on June 30, 1995. In addition, the Proponent will work with a training consultant to develop a mine-specific competency-based training program. These programs are described further in Appendix I-B6.

2.10.4.2 Orientation

The following orientation programs will be implemented:

- site and working conditions
- safety and health
- environmental protection

- quality control
- training modules, including cross-cultural training.

All employees will be required to go through the orientation program before commencing their duties. Prior to the actual start of duties, employees will be required to attend a job-specific orientation.

2.10.4.3 Initial Job Training

The initial job training for the majority of new employees will be

- competency-based
- on-the-job
- multi-media training.

The Operator will develop a suite of competency-based training plans for most of the jobs at the mine.

2.10.4.4 Certification

The Operator will issue certification to each employee who successfully demonstrates competence in any training program they undertake. Each employee will have a training plan, which will be reviewed at regular intervals to ensure that legislative requirements are met and that the employee maintains his or her level of skill.

2.10.4.5 Continuing Development

A range of training and education programs will be available to employees on a continual basis. Some of the traditional programs are the following:

- competency-based training programs
- computer training/skill upgrade
- cross-cultural training (this program will form part of the orientation program as well)
- apprenticeship/youth training
- external training
- vendor training (new equipment or plant)

- continuing education at the college level, i.e., fees, text books, tutorials, etc. (This usually consists of the Operator paying for up to 75% of the student's costs if a course is completed successfully.)
- team work
- meeting participation
- train the trainer courses
- management training.

Because of the dynamics of training and educational needs, programs will be added or modified as the job and employee requirements evolve over time.

2.10.5 Labour Relations

Efforts will be taken to establish good labour relations with employees through sound and fair employment and management practices.

2.10.5.1 Employment Contracts

It is intended that employees will have an employment contract with the Operator of the NWT Diamonds Project that provides the following details:

- remuneration and benefits package
- shift schedule and rotation
- probation period
- camp accommodation details
- transport/travel arrangements
- pre-employment medical examination requirements
- security, confidentiality, drug/alcohol free requirements.

Individual contracts may have additional features because of the nature of the work (security requirements), the length of the contract (a specialist job with a specific timeframe) or cultural requirements (Aboriginal traditions). Employment contracts will be extended to potential employees allowing a reasonable amount of time for consideration of the contract before agreeing to or rejecting the offer. Contracts will be reviewed on a regular basis with all employees.

2.10.5.2 Grievance Procedure

A grievance procedure will be developed to allow employees to raise concerns and have their issues handled in a systematic fashion. The procedure will encourage employees to raise issues that affect them and guarantees willing responses to the issues in an environment free of threat or retaliation. Elements of the procedure can be developed with employees as the mine develops.

2.10.5.3 Discipline Procedure

A discipline procedure will be developed to provide a consistent and established mechanism to handle disciplinary matters. Employees will be made aware of this procedure as part of the orientation training; employees and supervisors will receive written documentation setting out the procedure. Training programs will be established for those who may be required to deal with discipline issues.

2.10.5.4 Unions

The Operator is aware of relevant laws with respect to union and employee rights. Employees may decide whether or not they wish to join a union. BHP works effectively with unions in many of its operations around the world.

2.10.5.5 Shift Schedule

The mine is expected to operate 24 h/d for 365 days of the year. Under the current favoured shift schedule scheme, the majority of the work force will work a 2 weeks on/2 weeks off rotation. The operation work force would consist of four crews, working two 12-hour shifts per day on a rotation basis. Support functions would work one day-shift per day (12 hours), but will be available for emergency backup. A limited number of management personnel will work 4 days on/3 days off. A permit application for the proposed work schedule will be submitted to NWT authorities under the *Labour Standards Act*.

2.10.6 Employee Benefits

The Operator will offer all employees a range of benefits designed to assist them and their families in both the short- and long-term stages of the project.

2.10.6.1 Pension Plan

The Operator will offer a pension plan for both full and part-time employees. The plan will include a defined contribution level, likely to be between 3% to 5% of the employee's pensionable income and subject to variation once a year. The plan will also contain an employer contribution scale, vesting/locking in provisions and benefits on termination, retirement or death, and will provide member options for retirement age.

The plan will be managed by a joint employer/member retirement committee. A preliminary pension plan design is provided in Appendix I-B7.

2.10.6.2 Health Care Plan

The Operator will offer a health care package for its employees.

Medicals

As mentioned previously, new employees must complete a pre-employment medical. In addition, an annual medical examination procedure will be established to monitor the employee's level of health and fitness. Employees will be advised by a medical practitioner of the need for follow-up health care if the annual screening finds any abnormality. The Operator will work with Aboriginal communities with respect to health care to ensure that traditional health care practices within those communities are respected and utilized as a part of the health care plan.

Extended Health Care

The Operator will offer an extended health care plan that includes such items as hospital room coverage, paramedic coverage (with upper limits), vision care (with upper limits) and dental care with some upper limits (e.g., orthodontic work).

2.10.6.3 Work Clothing and Safety Equipment

All employees will be provided with the work clothing and safety equipment necessary to carry out their job. This will include safety helmets, safety glasses, specialist equipment such as welding vests and goggles, steel toe capped safety boots/shoes and any specialist clothing required for extreme weather conditions. Basic arctic survival training courses will be provided for all employees.

2.10.6.4 Employee Assistance Programs

The Operator will participate in an Employee Assistance Program (EAP) that will provide advice and assistance for employees on a range of issues, including financial management, drug/alcohol dependency and work-related stress management.

The program will include Aboriginal community-based counselors to assist employees from those communities. All programs will respect the individual's confidentiality.

2.10.6.5 Vacation Leave

The Operator will provide vacation leave for all employees. Vacation leave provisions will be in accordance with appropriate NWT legislation. Employees will be encouraged to take regular, annual vacation leave.

2.10.6.6 Salary

Each employee will be paid a competitive salary, with payments made every two weeks. Whenever possible, paycheques will be deposited directly into employee bank accounts, or other, similar arrangements will be made.

2.10.6.7 Allowances

An annual allowance will be provided to each employee to offset the cost of living in NWT, which is high compared to other areas of Canada. Employees recruited from outside the NWT or from communities within the NWT not provided with project-supported transport may elect to use this allowance to offset travel costs to and from their town or communities at the start and finish of their shift rotation.

2.10.7 Organizational Design

The project will be structured to conform with BHP Minerals' organizational philosophy and structure. The project's Critical Organization Specification will serve as the foundation to meet its high performance oriented goals, as follows:

- safety aware and committed – environmentally pro-active
- participative and team-based
- learning and career development oriented
- team viewed as a critical function
- employee responsibility and accountability for results
- employee ownership of common goals and culture
- integrity-based, promoting employee dignity and self-esteem.

2.10.7.1 Organizational Structure

The organizational design will be based around a team culture and structure. The proposed structure will be designed to support good performance through

- a flatter and more flexible design
- fewer levels than traditional organizations
- team-based job and team leadership structure that facilitate team performance.

Business Unit Leaders such as Superintendents and Coordinators will serve roles analogous to Department Managers and will have responsibility for the overall operation of a business unit (e.g., lab technical services, plant operations, etc.). They will serve as technical resources to the teams in facilitating team productivity.

Coordinators/Group Leaders will also serve technical/professional roles and function as resources to teams. Their objective will be to facilitate and assist teams as necessary to ensure success. Group Leaders will focus particularly on team development, facilitation and coaching through both daily interactions, on-the-job training and formalized classroom training.

Skilled labour will be team members and leaders and form the focus of the organization. Team members will be equipped with the skills necessary to operate effectively and will have an understanding of the importance of quality, service and organizational goals. Team members will be encouraged to make decisions that directly affect their work, and will be accountable for individual and team results. Team members will also participate in selecting team leaders.

As team members develop the necessary skills, team performance will become increasingly more self-directed over a number of years and will require less reliance on supervisory assistance. The degree of team autonomy will be dependent on the training and development levels of the team members, as well as the nature of the work being performed. Varying levels of leadership direction will be provided to each team as needed to ensure the most effective functioning of team members.

Figure 2.10-1 illustrates the critical inter-relationships between organizational levels, operational units and the support functions. The relationships between business units, work groups and teams emphasize the supportive team culture. The structure is characterized by inter-dependent linkages that promote the effectiveness of a high performance team-based culture. For example, the resource functions within the organization (i.e., administration, human resources, etc.) are focused on servicing internal "customers" or business units. Similarly, team resources (i.e., trainers, planners, etc.) are also dedicated to servicing their internal customers such as the work groups.

2.10.8 Community Programs

The Proponent has become involved in several community programs, particularly with Aboriginal and other organizations. Examples are outlined below.

◎ Table of Contents

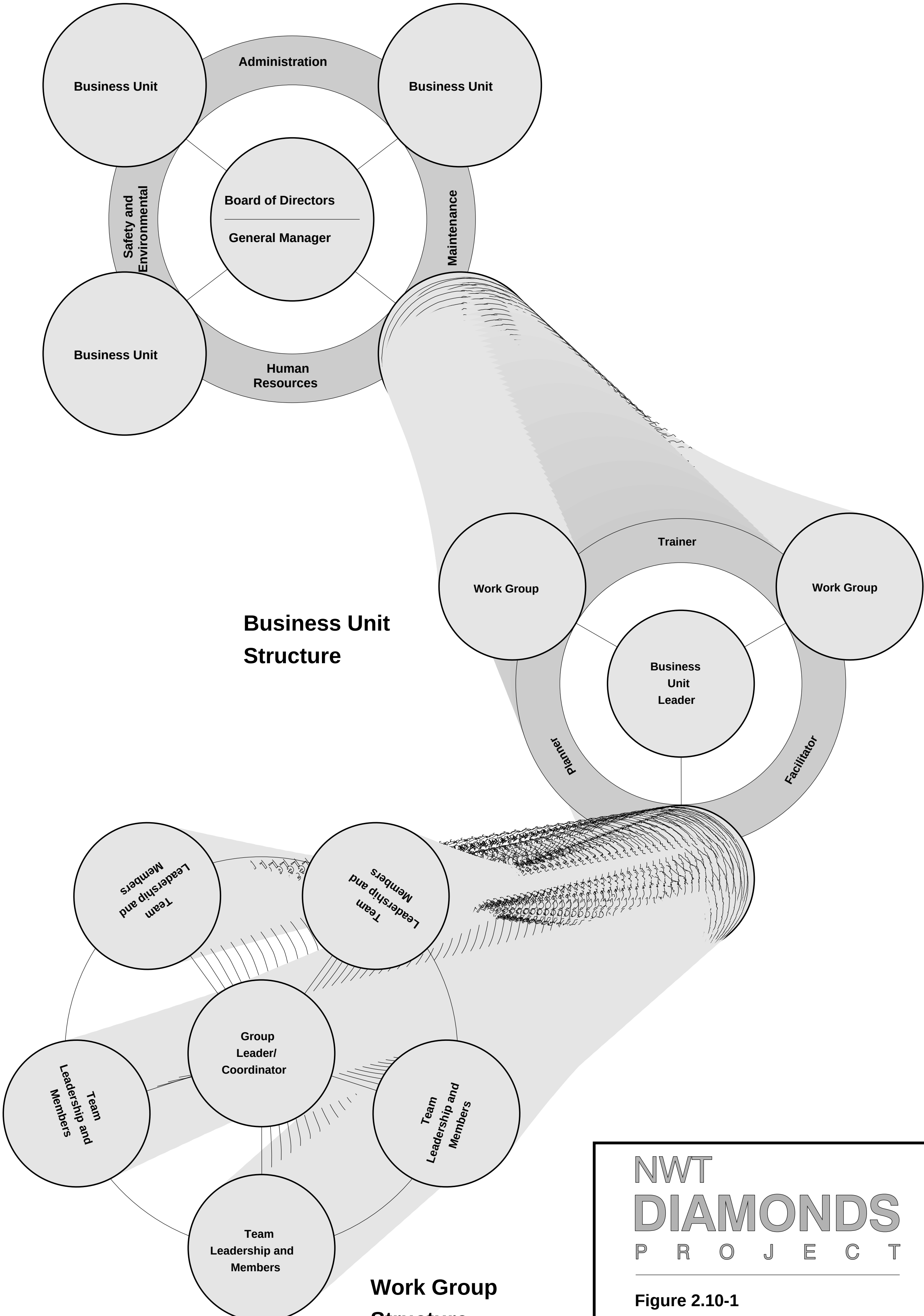


Figure 2.10-1
Business Unit Inter-Relationship Structure

Source: BHP

2.10.8.1 Scholarships

The Proponent has already established a scholarship program with the Treaty 11 Dogrib. This program includes a scholarship for university undergraduates ($5,000 per year) and a number of scholarships for Grades 11 and 12 high school students (ten scholarships at $500/scholarship). As the mine develops toward full production, these scholarship programs will be extended to other communities.

2.10.8.2 Schools

The Proponent has made visits to the various schools in the region to assist in providing career advice to school children wishing to pursue a career in mining. Programs will focus on encouraging children to stay in school until Grade 12 and then continue their studies at college or university.

2.10.8.3 Pre-Employment Training

The Proponent will work with Aboriginal communities to introduce pre-employment training/programs designed for the mining industry. The Proponent will also work with these communities to provide advice and training for job interviews to people within those communities.

2.10.8.4 Community Communication

As part of its lead-up to project permitting, the Proponent has sponsored a series of community information sessions and public meetings. These activities will continue after the project commences operations. Visits to the mine site by non-employee community members will be initiated so that family members become familiar with the work environment in which their spouse and/or family are working.

2.10.9 Accommodation

Mine site accommodation will be provided for all employees whose job requires them to work at the mine. Normally, the accommodation will be on the basis of one person to a room, with private washroom, toilet and cupboards. Accommodation will be provided free of charge to mine employees. All meals will be provided for employees free of charge. Menus will be varied and will cater for dietary requirements of employees, particularly those of Aboriginal employees.

Accommodations will not be provided for non-mine employees with the exception of a small group of senior managers whose contracts require them to be based in Yellowknife and to be provided with accommodation assistance, and the occasional company visitor.

2.10.9.1 Camp Rules

A comprehensive set of rules for camp behaviour will be established. All camp residents, including contractors and visitors, will be required to comply with those rules. Alcohol, controlled substances and firearms will be strictly forbidden. People found in possession of any of the above will be flown out of camp. In the event that the person involved is an employee, he or she may be dismissed.

2.11 Occupational Health and Safety

BHP has earned a global reputation as a responsible and fair employer. Employee safety is a priority within NWT Diamonds Project and has captured a high profile throughout the ranks of management, employees and the Board of Directors. Heightened safety awareness and major safety initiatives are underway to protect the health and safety of the NWT Diamonds Project's employees.

2.11.1 BHP Occupational Health and Safety Policy Overview

BHP's Occupational Health and Safety Policy (OH&S) (Appendix I-B8) is a statement of the company's commitment "to the highest standard of occupational health and safety performance throughout its businesses as an integral part of efficient and profitable business management." The company strives to protect the health and safety of its employees, contractors and visitors from undue risks arising from activities at all its operations, and will do so at the NWT Diamonds Project.

BHP is seeking to continuously improve safety and develop ways to bolster this improvement. Management systems are being implemented to identify, evaluate and control workplace hazards. In combination with these management systems, employees are given the necessary training and tools to work safely. All employees, including skilled labour, supervisors and management, are held accountable for their personal safety and that of their fellow workers.

BHP also requires its operations to

- comply with all applicable laws, regulations, codes and standards
- monitor developing trends and state of knowledge regarding occupational health and safety worldwide
- contribute to development of relevant occupational health and safety legislation, regulations and policy
- take into account evolving community expectations, management practices, scientific knowledge, technology and supporting relevant research

- maintain open communication with employees, government and the community

- adopt practices and systems to address and manage priority safety and health issues and risks.

Guidance Notes, which are currently being revised, are provided to BHP management to assist with the interpretation and implementation of the OH&S Policy. A copy of the Guidance Notes can be found in Appendix I-B8.

2.11.2 BHP Minerals "Benchmarking Safety"

In an effort to seek continuous improvement in its safety performance, BHP Minerals embarked on a "Benchmarking Safety" study in 1994/1995 to determine the key success factors that contribute to world-class safety performance. Based on the results of internal and external site visits by the BHP Minerals Benchmarking Team, Benchmarking Safety will serve as a catalyst to accelerate BHP Minerals' safety improvement at the group, division and operational levels. BHP Minerals is now engaged in supporting standards of performance and a demanding audit system group-wide, based on the recommendations of the Benchmarking Team. BHP Minerals is also enhancing management commitment and leadership and advancing the partnership with employees in a number of areas. These include developing safety and job skills, recognizing safety performance improvements and clearly supporting the employees' obligations to intervene in unsafe acts and conditions. These key safety factors will be integral to all BHP safety programs, with the goal of all employees contributing toward world-class safety performance within BHP Minerals.

The NWT Diamonds Project safety and health program, as well as that of other BHP Minerals operations worldwide, will build upon these initial benchmarking results.

2.11.3 BHP Minerals Safety Management Framework

In concert with the Benchmarking Safety study, BHP Minerals adopted the National Occupational Safety Association (NOSA) system group-wide for all its operations in 1994. A safety program developed in South Africa, NOSA is being implemented at many of the mines visited during BHP's Benchmarking Safety study. When construction commences, the NWT Diamonds Project will also be included in the program.

BHP Minerals uses the NOSA "Five-Star Safety and Health Management System" as the framework for its safety and health program. The NOSA program is designed to protect employees from injury and illness that may result from their employment. NOSA focuses on good safety practices, safety awareness, risk management, employee involvement and management commitment. This is accomplished by

- identifying possible causes of accidents
- setting standards of practice and procedures
- setting standards of accountability
- measuring performance against standards
- evaluating compliance with standards
- correcting deficiencies and non-conformance.

The NOSA program involves all employees, from the Chief Executive Officer (CEO) to the newest hire. All employees will participate in extensive training to ensure their own safety and the safety of fellow employees. The intensive training component is discussed further in Section 2.11.9.2.

The implementation process reached its initial formal evaluation phase on March 27, 1995, when the first NOSA inspections were conducted at BHP Australia Coal mines in Queensland, Australia. These inspections will continue at the other operations through August 1995.

To measure the success of the program, NOSA inspectors conduct annual audits based on 73 safety and health criteria and a one- to five-star rating system. Additional audits are conducted by both internal and external safety professionals.

A tentative timetable for the implementation of NOSA at the NWT Diamonds Project, following project approval, is as follows:

- *Year 1*: baseline NOSA site assessment and initiate NOSA training of work force
- *Year 2*: continue NOSA training of work force, develop site-specific safety standards and begin internal audits and inspections
- *Year 3*: first NOSA grading of the operation; continue training
- *Year 4 and beyond*: annual NOSA audit and rating; continue training.

2.11.4 BHP Minerals Safety Reporting

BHP Minerals has a safety reporting system that requires notification of the BHP Minerals Executive General Manager (EGM) and Division Group General Manager (GGM) in the event of a fatality or serious accident within 24 hours of the incident. If a fatality occurs, the Operations Manager and the GGM are required to appear before the Managing Director in Melbourne or by video conference to explain the incident, the cause(s) and factor(s) contributing to the incident and the action/abatement plan to prevent a recurrence. All employees are informed of the incident. The relevant authorities are also informed of a fatality in conformance with regulatory requirements.

All lost-time accidents are also reported to the Operations Manager and Division GGM within 24 hours of the incident. A detailed accident investigation is completed with the assistance of a joint safety and health committee or accident review board. The Workers' Compensation Board and/or insurance carrier are also notified within the required timeframe for reporting. Follow-up reports are provided-upon request.

Each operation, including offices, is responsible for submitting a monthly safety report (Appendix I-B9) with information regarding number of employees, total hours worked, number of fatalities, permanently disabling injuries, number of lost-time injuries, number of total injuries, number of near misses and property damage accidents for employees and contractors. Narratives are included for lost-time accidents and other significant incidents, as well as safety achievements and initiatives.

The information provided is then consolidated for Division and Group level safety reports, which are distributed to the EGM, GGMs, Operations/Mine Managers and Safety and Health Managers/Coordinators throughout BHP Minerals. The Minerals Group Safety Report is also included in the Monthly Group Business Performance Report that is submitted to the Managing Director and Board of Directors.

The improvement realized to date can be attributed to a management commitment to safety, focused safety and health programs and initiatives, and increased safety awareness throughout BHP Minerals among management, operations, employees, unions and contractors.

The 1994 safety experience for the NWT Diamonds Advanced Exploration Program, in comparison with other NWT mines, is provided in Table 2.11-1. The frequency rate for the program was 3.9 compared with frequency rates ranging from a low of 2.9 to a high of 18.7 at other NWT mines. The severity rate for the NWT Diamonds Advanced Exploration Program was 25.6, resulting in 65 days lost. In comparison, all other NWT mines had greater numbers of days lost from 91 to 508 and severity rates from 57.4 to 426.1.

As required by the Mining Safety Regulations of the *NWT Mining Safety Act*, monthly accident summary reports on mine safety are submitted to the Mining Inspector on form B.

Table 2.11-1
Accident Statistics – Mines in the Northwest Territories – 1994

Operation	Work Hours	Frequency	Days Lost	Severity
Mine 1	645,819	5.0	501	155.2
Mine 2	566,375	3.5	275	97.1
Mine 3	895,552	2.9	327	73.0
Mine 4	428,110	9.3	508	237.3
Mine 5	535,061	2.99	246	92.0
Mine 6	42,716	18.7	91	426.1
Mine 7	327,363	3.7	94	57.4
NWT Diamonds Advanced Exploration *	508,631	3.9	65	25.6
Average	493,703	4.4	263	106.7

* Employees and contractors combined.
Source: NWT Chamber of Mines, April 1995.

A copy of the *BHP Minerals Safety Bulletin*, April 1995 edition, can be found in Appendix I-B10. The Bulletin provides a brief overview of the overall Minerals Group Safety Program and initiatives discussed previously.

2.11.5 NWT Diamonds OH&S Program Overview

Safety has been and will continue to be the top priority at the NWT Diamonds Project. The OH&S program for the project will be based on the foundation provided by the BHP Occupational Health and Safety Policy and Management Guidance Notes, Minerals Group Safety Framework, "Benchmarking Safety" and safety reporting systems discussed previously. NWT Diamonds will also build upon the safety and health program implemented during the advanced exploration phase and past/current experiences working in the remote arctic environment of this and other similar projects. OH&S laws and regulations, primarily the *NWT Mining Safety Act* and others discussed in Section 1.4.3, that govern project operations, products and services will also shape the OH&S program.

The project will focus on establishing employee involvement, good safety practices, continuous safety awareness and risk management as integral components of its OH&S Program.

The Proponent currently has procedures and practices in place at the project site. These include safety orientation and training, safe work practices, health and safety programs, health and safety committees, as well as emergency response and contingency plans. Project employees will be expected to comply with this OH&S program as a condition of their employment, and contractors and visitors are expected to comply as well. The Proponent takes into account its responsibility and duty to all employees, contractors and visitors to provide safe operations, conditions, premises, equipment and systems. In return, project management expects all employees, contractors and visitors to conduct their work in a skillful, safe and competent manner and to exercise reasonable care with respect to themselves, fellow workers and the environment. This philosophy will continue to be followed.

Before arrival on site, employees will be given a preplacement medical examination to ensure they will be able to perform all aspects of their work in the unique environment of the project without undue stress on their mental or physical health. Likewise, contractors are required to provide evidence attesting to the good health of their employees prior to assignment to the project.

The Proponent has identified potential occupational health and safety hazards; these are discussed in Sections 2.11.7 and 2.11.8.

Monitoring programs and management systems will be developed to address potential exposures, concerns and issues arising from the health and safety hazards that are inherent to mining, mineral processing and operations in the arctic environment. Protective and cost-effective solutions, including engineering, personal protective equipment and administrative controls, will be used to minimize workplace hazards.

The Proponent will seek to participate in the formulation of effective policies, legislation and regulations as they relate to occupational health and safety. Consultation and communication with government, management and skilled labour will be important components of the OH&S program.

2.11.6 OH&S Communications

2.11.6.1 Employees

Effective communication channels, involving all employees in matters of health and safety, will be developed to foster individual commitment to safety and responsible attitudes, behaviour and practices in the workplace. All personnel arriving for the first time at the project site, or when significant procedural changes occur, will receive a thorough orientation into the rules and procedures in effect at the site. These will include individual responsibility and accountability, emergency procedures, environmental awareness, company policies and procedures, and health and safety requirements. A written copy of this orientation will be provided to each individual.

Commencing with the orientation, relevant occupational health and safety training will be provided as an integral part of developing each employee’s job competency. Instructions will be provided to employees in the safe performance of duties. Specific OH&S training is discussed in further detail in Section 2.11.9.

Potential loss of life and property due to fire are considerably greater in a remote camp situated in the severe climate and arctic environment than elsewhere. Therefore, proper preventive and response training of each individual is paramount. Emergency response, evacuation procedures, arctic survival, incident reporting and drills will be integrated into site orientation and communicated to all personnel.

At every level, employees will be encouraged to maintain a strong interest in health and safety improvement through participation in activities such as regular safety meetings, OH&S committees, training, health promotion, hazard reduction programs, dispute resolution and workplace design and improvements.

Project site managers and supervisors will be responsible for ensuring that safety is of paramount concern, that lines of communication are maintained and that effective management systems are in place to protect employees and support policy objectives. OH&S management systems are discussed in Section 2.11.9.

2.11.6.2 Contractors, Suppliers and Visitors

The selection and retention of contractors and suppliers will be based in part on their demonstrated commitment to occupational health and safety excellence. Past OH&S performance of project contractors will be assessed and reviewed. Contractors will be required to provide evidence attesting to the acceptable medical status of their employees prior to assignment at the NWT Diamonds Project.

Before commencement of any contract, and prior to operating on site, contractors will be required to provide documentation of their health and safety programs, develop and submit plans necessary for safe completion of the scope of work and demonstrate a company commitment to safety. Project management will work with contractors to ensure compliance with policies, procedures and programs. When unsafe or unhealthy contractor work practices or conditions arise, the contractor will be obliged to correct the situation in a timely manner to the satisfaction of project management, OH&S staff and/or the OH&S committee. BHP and NWT Diamonds Project standards will serve as the guideposts for performance.

Purchasers and suppliers must ensure that goods and services conform to legal requirements, accepted standards and project specifications. Any hazard associated with these goods and services will be identified, documented and communicated to project management prior to delivery and in conformance with NWT Mine Hazardous Materials Identification System (MHMIS) requirements.

Visitors to the project site will be informed of the relevant OH&S policy-related and site-specific requirements. They will be advised that they are to comply with these and other requirements as a condition of entry and presence on the project property. Following safety orientation, visitors, contractors and employees will be required to sign documentation of their orientation and the confidential information, security and drug testing agreement. The project will develop additional systems and procedures to protect non-employees from hazards while they are on site.

2.11.6.3 Occupational Health and Safety Committee

In accordance with regulations of the *NWT Mining Safety Act*, an Occupational Health and Safety committee has been established on site for the Advanced Exploration phase. This committee will be expanded during the operations phase to comprise a cross-section of employees who will be empowered to ensure that workplace practices comply with the provisions of the *NWT Mining Safety Act*. Issues related to the promotion of safe and health work practices will also be under the purview of the committee. The OH&S committee will accomplish these objectives by conducting monthly site-wide inspections, in the presence of employees from the particular work area. Issues and hazards will be recorded and follow-up actions will be assigned by the committee.

The OH&S committee will hold bi-weekly crew information and safety meetings with all employees. Each employee will be encouraged to contribute to the success of the safety meetings. Minutes of safety meetings will be posted for review. The requirement for individual responsibility and accountability for safe work practices will be clearly defined to every employee. This participation will form the basis of all site work programs.

Safety systems will define line management and committee responsibilities as well as the procedures for appropriate investigation, recording and reporting of incidents/ accidents. Significant and high potential events, as well as near misses, will be identified and investigated promptly. The essential causes and corrective actions will be documented for review and/or subsequent management inspection.

The committee will also provide input into emergency preparedness and response plans as well as training to achieve the appropriate level of competency.

In instances where “serious” occupational safety and health issues arise, the NWT Mines Inspectorate may require the formation of a tripartite (government, management and labour) committee to review, evaluate and provide decision-making on these matters. Assistance from the OH&S committee will be important to this process.

2.11.7 Safety Hazards

The Proponent will identify and address specific safety hazards, some of which are inherent to typical mining and mineral processing operations, while others are unique to the arctic location and environment of the project.

2.11.7.1 Arctic Safety

Remote Site

The vast distance of the NWT Diamonds Project from significant support facilities and the lack of existing transport and emergency care infrastructure in the area will be addressed by providing on-site emergency facilities and by maintaining a 1,950 m airstrip to ensure the availability of transportation to and from the site.

Climate

Winter temperatures in the project area drop below -40°C. Coupled with a strong northwest wind, these extreme temperatures pose a major safety challenge for operations personnel. Proper winter clothing and gear that maintain a comfortable body temperature and shield against wind exposure are required from approximately the beginning of October to mid-May. In addition, severe windstorms and snowfalls can create occasional white-out conditions, which can last from several hours to several days. White-out conditions can reduce visibility to 1 m.

Because of the risks of personnel becoming injured, lost or stranded in these white-outs, overexposure to the severe cold, frostbite and hypothermia are significant safety hazards. Road travel and equipment operation are impossible under these extreme conditions. Therefore, emergency clothing, food caches and refuge stations will be provided near work locations for workers who are left stranded in vehicles and in remote, free-standing job site structures not connected to the utilidor grid.

Wildlife

Grizzly bears, wolverines, wolves and foxes are among the wildlife that can pose a potential threat to unprotected and unaware field workers and camp residents. All employees will be required to attend mandatory training on wildlife encounters and appropriate measures to avoid attacks.

Aerial and land sightings of wildlife will be logged and reported. Employees, contractors and visitors will be warned of the presence of wildlife in the project area and informed of the animals' seasonal habits and habitats and of other wildlife-related activities. Precautions and prevention measures, as well as a "sightings and encounters policy and action plan", are part of operational planning.

Communications

The primary communications link to Yellowknife and other major centres will be via contracted satellite service. This system is reliable, but technical problems may arise in severe weather or when the dish is misaligned. In this event, a backup communications systems using short-wave radio will be available for sending communication transmissions from the mine site to receiving stations in Yellowknife.

VHF (FM) radios, mounted in all vehicles and equipment, and hand-held radio units for field personnel and supervisors will be used for local communications throughout the mine site and surrounding claims. All personnel will be trained in the proper use of this equipment. Communications between the mine site and aircraft will be through pre-determined VHF channels established by trained and licensed personnel.

Transportation

Charter aircraft will be used to transport mine personnel to and from Yellowknife and the mine site. This reliance on air charters demands strict and continuous involvement by BHP aviation personnel to ensure that charter operators, aircraft and crews meet the highest safety standards.

Operators will be selected based on availability of required aircraft types and qualified, competent crews. Only aircraft types and companies approved by BHP's Corporate Aviation Department will be used for personnel transportation. The Aviation Department will also conduct strict operational and maintenance audits of charter operators to ensure compliance with the following requirements:

- dispatcher policy and responsibility
- IFR equipment installation and maintenance
- pre-takeoff safety briefings
- Transport Canada approved operating limits
- pilot and ground crew post-accident training
- aircraft report logging
- industry-standard maintenance programs and record keeping.

Prior to each flight, a thorough safety briefing by the aircraft pilot/flight attendant will be made to passengers detailing the locations of emergency equipment and procedures to be followed.

Airstrip operation procedures will be based on Transport Canada regulations for incoming and departing aircraft. Personnel boarding and disembarking from aircraft will be directed by the airstrip coordinator. Manifests will account for all passengers travelling by air before each departure.

Employees transported in and working around helicopters will be briefed on the hazards posed by helicopter operations, as well as proper signalling and communication techniques.

Vehicles

A seat belt policy will be enforced at the project. The policy and circumstances when seat belts are required will be discussed with all employees, contractors and visitors at the safety orientation.

Given the extreme climatic and ground conditions, injuries resulting from vehicular accidents are potentially serious and/or life threatening. Additional preventive measures will be taken to address these site-specific concerns, especially for vehicle operation on ice. Light duty vehicles and mobile equipment training, inspections and proper operating procedures will be clearly outlined. For example, the existing Procedures Manual for the NWT Diamonds Project has specific rules, regulations and/or instructions on “Mobile Equipment Pre-Operation Check List”, “Small Vehicles Travelers Course” and “Procedures for Hauling to Bulk Sample Plant from Portal.”

Ice roads are built each winter on frozen lakes and rivers to allow the haulage of heavy equipment and bulk supplies into the site and vehicular traffic between exploration sites and camp/plant facilities; these areas are otherwise inaccessible during the summer. At present, an ice monitoring program is conducted from November to May of each year to ensure the ice thickness is sufficient for vehicular traffic, permissible loads and maximum safe driving speeds. In the event that ice is unsafe, recommendations are issued and travel restricted where appropriate.

2.11.7.2 Open Pit Mining

Pit Slope Failure

Minor rock slippages will be contained by safety berms, typically 11 m wide, established in pit slopes at 30 m intervals. These berms may require periodic cleaning to clear fallen debris. Although detailed geotechnical studies and design will minimize the chance of instability, the risk of major failure cannot be dismissed. Pit slope deterioration is generally evident in advance of failure so that risk to personnel is low and sufficient time is available for mitigative measures to be taken. Ongoing comprehensive slope monitoring will be conducted as required and will be an integral part of the operations criteria.

In the event of a major pit slope failure during any mining phase of the open pits, additional engineering analysis work will be necessary to determine methods for stabilizing the slope. Pit slopes have been designed to ensure, where practical, that no such slippage takes place.

Fire

The potential for fire in the pit is limited, given the open operating conditions. Fire, if it happens, most probably will involve a piece of mobile equipment or an electrical substation. Mobile equipment will be equipped with on-board engine fire suppression systems and fire extinguishers. In the event of a fire, workers will initiate the emergency response plan. The emergency response fire-fighting team will be contacted by radio and will assume fire-fighting duties with appropriate equipment.

Blasting

Blasting will be scheduled regularly, often on a daily basis. The primary blasting agent will be bulk ammonium nitrate/fuel oil (ANFO). The rules for safe use, handling and storage, which are stipulated for mining operations in the NWT Mining Safety Regulations, will be followed.

The primary potential hazard arising from open pit blasting is damage by flyrock. The anticipated zone of flyrock contact will be clearly defined prior to each blast, and all personnel and equipment will be removed from the area.

2.11.7.3 Underground Mining

Ventilation

Underground ventilation will be provided by main and auxiliary fans and ducts for fresh air intakes. As discussed in Section 2.4, the ventilation equipment will also remove air contaminants generated by equipment exhaust emissions, blasting and drilling operations.

Failure of one or all main fans, or major short-circuiting of fresh or exhaust air, would be a significant event and could result in unacceptable and high concentrations of air contaminants from engine exhaust and airborne dust. All the main fans will be permanently monitored. In the case of mechanical or electrical failure of one or all, an alarm system will be triggered, which will emit a signal to alert all underground personnel to evacuate.

Preventive maintenance and automatic standby generators will ensure that such failures are rare. One complete main fan and spare parts inventory will be kept on site to facilitate repairs in the event of a major breakdown.

Any short-circuiting of exhaust air into the fresh air streams will contaminate the air supply. A well-designed ventilation system will ensure that higher air pressure is maintained in fresh air supply areas and ducts than in the exhaust air areas and ducts, preventing any egress from the fresh air side to the exhaust side. Regular monitoring of all areas will provide early detection of short-circuiting. If short-circuiting is detected, the ventilation system will be repaired immediately.

In addition to the main ventilation system, auxiliary ventilation will supply adequate air flows to areas of the mine that are off the main circuit. Stringent operating procedures for auxiliary ventilation will be established. Employees will not be permitted to begin working in areas before adequate ventilation has been established.

Routine and frequent monitoring of air flows and air contaminant levels is critical in detecting system malfunction or poor air quality. In the event that the ventilation system proves inadequate or performs incorrectly, operations will be completely or partially suspended until an adequate solution is implemented.

Following restoration of ventilation and/or after blasting operations, work in the underground mine will be allowed to resume only after an adequate time has passed to allow underground air quality to return to normal operating quality.

Roof Falls

Good support design and installation and continuous monitoring of conditions will limit the hazard of roof falls. The structural strength and integrity of the granite wall rock have been evaluated and are discussed in Section 2.3. It has been confirmed that the rock will allow large, stable openings to be mined with a minimum of support, although in some areas a variety of additional roof support measures will be taken as required to ensure stability, including spot bolting, screening and strapping, and/or use of shotcrete (grouting).

In the event that a roof fall should occur, the access ramps, the production/service shaft and the ventilation raise will provide escape routes, thus minimizing the potential for entrapment. The Mine Rescue Team will be also be trained to assist in freeing trapped personnel and providing emergency medical treatment until the injured can be transported to the site hospital and medically evacuated, if necessary.

Fire

Mobile and electrical equipment pose the greatest potential fire hazards. Although on-board fire suppression systems on mobile equipment and the availability of fire extinguishing equipment reduce the risk of fire, the smoke and gases resulting from an underground fire would be a serious hazard to worker safety.

In the event of a serious fire, a general alarm will be activated using the common fire/ventilation alarm system, and underground personnel will be advised to evacuate the mine. Self rescuers, provided to all personnel before their descent underground, will be used. Unless blocked by fire, the best method of egress will be the main shaft. If the main shaft is blocked, personnel will be advised to use the alternative exit of the refuge station equipped with a fresh air line.

Regular drills of mine rescue, evacuation techniques and use of self rescue apparatus are critical to ensuring that correct and effective procedures are followed in the event of an underground fire.

Mine rescue teams will enter the mine only if safe to do so.

Water Inflow

Estimating water inflows into underground mines involves complex hydrogeological analysis, application of engineering judgment and experience, and consideration of the permafrost ground conditions. Actual versus estimated water inflow volumes and direction will be compared and assessed to determine the adequacy and capacity of the required pumping system.

Information gained from the underground exploration bulk sampling program has allowed procedures to be developed for mitigation of water inflows into the Panda and Koala underground mines. Little inflow is anticipated during shaft sinking, as most of the ground in that area is in permafrost. Where ground conditions transit from frozen to unfrozen, or perched water tables are encountered, inflows could be significant. The presence of water-filled structures will be detected and controlled by drilling one long hole in advance of the heading. If substantial water is encountered, additional holes may be drilled. The intercepted water will flow to a central sump and be pumped to the surface.

The capacity of the pumping system can be increased if greater-than-predicted water flows are encountered. Initial response to the larger flows will utilize the designed surplus pumping capacity. If this is insufficient, it will be necessary to either seal with grouting or allow partial flooding of the mine until additional pumping capacity is installed.

While sudden, unexpected and uncontrollable water flows are extremely unlikely, emergency planning will include contingencies for situations such as a large volume in-rush or mechanical and/or electrical failure of the pumping systems. As in the case of fire or loss of ventilation, personnel will be advised to evacuate the mine.

Loss of Power to Pumps and Fans

The site power plant will contain several diesel generating units plus auxiliary standby diesel operating units, which will limit the possibility of a general electrical outage. In case of general power failure, the underground mine will be evacuated, since both the ventilation and dewatering systems are dependent on electrical supply.

Once power is available again, it will be supplied on a priority basis to the pumps and fans underground. In the case of partial power failure or limited power availability at the mine site, pumps will be started first. Starting fans will have a second priority and production equipment will have the last priority.

Personnel will not be allowed to enter the underground mine unless safe to do so.

Oil and Fuel Oil Spills

Minor spills will be cleaned up immediately. In the case of a major spill, oil will eventually flow to a catchment sump or site sediment catchment pond. The sump or pond will be designed to facilitate oil recovery by pumping it with a portable pump into a portable tank. The emergency response team will be notified of the spill, and the contingency plan, as discussed in Volume III, Section 5.2, will be activated. Appropriate reporting measures will be undertaken. The spill area will be accessible to the emergency response team only.

2.11.7.4 Other Safety Hazards

Slips, Trips and Falls

Common to all industrial activities, slips, trips and falls are major safety hazards. Given the icy and slippery ground conditions on the surface during the winter, and wet conditions underground and in the mineral processing plant, employees will be reminded to take special care and footing. Safety instructions and training will emphasize the slip, trip and fall hazards.

Fall protection, including the use of safety harnesses, will be provided for work at heights. Emphasis will be placed on precautions while working at heights, on ladders, on scaffolding and while ascending and descending mobile equipment and plant steps.

Manual Handling

Manual handling of materials increases the potential for back injuries and muscle strain. Lifting, especially when done alone and improperly, may result in injuries that accrue lost work days and require physician consultation, therapy and use of medications. In the worst case, hospitalization, surgery, disability evaluation and rehabilitation may be necessary.

Lifting and back protection programs will be incorporated into employee training, especially in the high-risk occupations, to minimize the potential for injuries. Mechanical devices such as hydraulic lifts, trolleys and materials handling equipment will be purchased and used.

Cardiac Events

Given the remoteness of the project site and distance to emergency services, preparedness for cardiac events will be significant. Mine rescue teams will be well-trained in providing rapid response and cardio-pulmonary resuscitation. Nurses at the site hospital will have the necessary equipment, skills and experience to evaluate, triage and stabilize the injured in preparation for medical evacuation. Further discussion on resources available for first aid/medical evacuation can be found in Section 2.11.9.8.

Drowning

Drowning is a significant hazard to anyone travelling or working on open water or frozen lakes and rivers. Accidental immersion in cold water can quickly precipitate the onset of hypothermia, drowning and, in the worst case, death. As described previously, ice monitoring will be done to assess ice thickness and ensure safe conditions.

Treatment of hypothermia, cold water survival techniques and drown-proofing, as well as the provision and use of personal flotation devices, will be fundamental components of the safety program at NWT Diamonds Project to protect workers, contractors and visitors from drowning.

2.11.8 Occupational Hygiene Issues

A number of potential occupational hygiene issues associated with the project mining, mineral processing and maintenance activities have been identified. An Occupational Hygiene Program for the NWT Diamonds Project is under development.

2.11.8.1 Kimberlite

Several literature searches were conducted on kimberlite and health effects; no relevant information was found.

The characteristics of kimberlite are discussed in Section 2.3. The material is typically soft, clayey and hygroscopic and exhibits a wide range of characteristics. As stated in the NWT publication, *Diamonds and the Northwest Territories, Canada*, and indicated from analytical results, kimberlite contains very little alpha (a)-quartz. Bulk analyses of kimberlite samples indicate 0.17% and 0.23% a-quartz (Table 2.11-2).

Table 2.11-2
Free Silica Analysis of Granite and Kimberlite

	Free Silica (x SiO_2 %)	
Sample Identification	**Analysis**	**Duplicate Analysis**
Fox - Granite	17.0	17.2
Panda - Granite	17.7	17.7
Fox Granite - Grab Sample #46A (face)	4.09	4.04
Fox Granite - Grab Sample #46B (face)	0.53	0.43
Fox Granite - Grab Sample #47A (face)	1.71	1.67
Fox Granite - Grab Sample #47B (face)	1.86	1.90
Panda - Kimberlite	0.23	0.17

Notes:
1. Analysis done by X-RAL, Don Mills, Ontario, May 19, 1995.
2. Analysis for free silica, or a-quartz, by X-ray diffraction techniques.
3. Samples analyzed as received (wet).

Mudstones of the crater facies are composed of mainly clay, serpentine, calcite and phlogopite. The matrix of the diatreme facies of the kimberlite pipes is typically made up of microcrystalline serpentine, phlogopite and calcite in a soft, clayey mass. Microscopic analysis was performed to determine the presence of chrysotile asbestos in the serpentine-containing kimberlite. The results (Table 2.11-3) indicate <1% asbestos in all the kimberlite samples that were submitted for analysis.

Table 2.11-3
Asbestos Analysis of Kimberlite

Sample Identification	Asbestos (%) Analysis	Method
Fox Pipe (round 96)	ND	PCM[2]
Panda Pipe	ND	PCM[2]
Misery Pipe	<1	SEM[3]
Koala Pipe	<1	SEM
Fox Pipe (No. 3)	<1	SEM
Panda Pipe (No. 4)	<1	SEM
Fox Pipe (round 46)	<1	SEM
Fox Pipe (round 47)	<1	SEM

Notes:
1. ND = Not Detected.
2. Analysis done by PCM, Phase Contrast Microscopy, Lockhart Risk Management, Vancouver, B.C.
3. Analysis done by SEM, Scanning Electron Microscopy, University of British Columbia.

During the bulk sampling program, drilling through this material did not generate much dust. The kimberlite material to be processed will generate some dust within the plant. The ore will typically be frozen in the winter; in the summer, the kimberlite will be thawed and sticky. Primary crushing and stockpiling as well as HPGR crushing and X-ray sorting in the plant will create dust at times.

Dust suppression methods, including dust collecting fabric filters and/or scrubbers will be used to control respirable dust, quartz and fugitive dust emissions. These additional protection measures will also minimize workers' exposure to kimberlite.

OH&S staff will monitor the literature for new findings, if any, on the health effects of kimberlite.

2.11.8.2 Asbestos

The lack of asbestos in the serpentine-containing kimberlite has been discussed previously. Serpentine is not found in the granitic host rock.

In the past, asbestos has been used extensively in brake and clutch systems in heavy mine equipment. However, with specifications for asbestos-free systems and current restrictions on asbestos in products, it is not likely to be present in the new equipment procured for the project. The presence or absence of asbestos in brake and clutch systems will be confirmed.

In the event that asbestos is present, an asbestos registry, air monitoring and control measures will be implemented. If necessary, medical surveillance will be taken in compliance with the law and good medical practice.

2.11.8.3 Quartz

The predominant host rock type for the five kimberlite pipes is granite. The quartz content of the granitic rock varies in the geologic areas surrounding the pipes. Based on bulk analysis via X-ray diffraction, a-quartz in granite ranged from 0.53% to 17.2% for Fox granite and grab samples. The Panda granite sample contained 17.7% a-quartz. The respirable fraction of the quartz will be determined with further air monitoring under operational conditions. Table 2.11-2 presents the analytical results for crystalline free silica in bulk samples from Fox and Panda granite and in Panda kimberlite. Samples and duplicate analyses, via X-ray diffraction, were performed by X-RAL, Don Mills, Ontario.

Given the presence of quartz in the host rock, engineering controls, ventilation, pressurized cabs, personal protection and dust capturing and suppression systems will be used to prevent exposures to respirable crystalline silica. Pre-stripping, drilling and mining will release airborne concentrations of quartz. Water will be used during drilling, and water sprays will be used to suppress the dust areas after blasting. Effective control measures will prevent workers from developing silicosis, a debilitating, chronic lung disease.

Abrasive sand blasting media may contain a variety of materials, from zinc slag to silica sand. The silica content in blasting agents will be assessed before abrasive blasting is conducted. The product of choice is non-silica-containing. Abrasive sand blasting helmets, respiratory equipment, protective clothing and worker isolation will ensure that exposures are minimized.

Personal quartz and dust monitoring will be conducted to ensure that the permissible exposure limit for quartz is not exceeded and to evaluate the effectiveness of controls. The NWT 8-hour Occupational Exposure Limit is 0.1 mg/m^3 for respirable mass and 0.3 mg/m^3 for total mass. Silicosis medical surveillance, through lung function tests and chest X-rays, will also be conducted.

2.11.8.4 Diesel Emissions, Exhaust Particulates and Gases

The major air contaminants from diesel engine exhaust emissions are particulates, respirable combustible dust (RCD), carbon dioxide (CO_2), carbon monoxide (CO), oxides of nitrogen (NO_x), sulphur dioxide (SO_2), ammonia (NH_3), aldehydes and polynuclear aromatic hydrocarbons (PAHs). These emissions generally generate complaints about irritant and respiratory effects; however, the carcinogenic PAHs are also of concern. With the exception of diesel exhaust particulates, established air monitoring protocols and threshold limit values (TLVs) are available.

Potential occupational exposure to diesel exhaust air contaminants may occur during open pit and underground mining operations and during maintenance of vehicles in enclosed buildings. However, air monitoring, along with the use of engineering controls, personal protective equipment and administrative controls, will minimize occupational exposures and improve general air quality.

The potential for atmospheric inversions in the open pit has been recognized. Air modelling, taking into consideration the emissions generated by diesel equipment in the pit, has been completed and is discussed in Volume III, Section 2.1. These events will be limited, but when they do occur, elevated airborne concentrations of diesel-generated air contaminants may reach the permissible worker exposure limits. Operational procedures will be established to ensure OH&S is maintained and that respective TLVs are not exceeded. Mobile equipment operators who remain in their pressurized cabs will not be affected by air quality as much as personnel working partly or entirely in the open air. These workers will include mechanics, electricians, assistants and supervisory personnel. Therefore, control measures will include operational adjustments from decreasing emissions to relocation and shutdown of diesel equipment for short durations.

Occupational exposures underground will depend greatly on the amount of ventilation, quality of air, exhaust controls on equipment, equipment maintenance and fuel quality. Efforts will be taken in all these areas to determine the mix of controls that will be most effective in maintaining exposures below the TLVs. BHP’s experience in the use and control of underground diesel equipment at its Minerals and Steel Collieries operations will be applied. At present, the proposed plan for the underground ventilation system will ensure a constant supply of fresh air at a rate of approximately 123 m^3/s down a shaft to the bottom haulage, where it cycles through the working areas and is exhausted to the surface up another shaft.

Diesel exhaust emissions and CO/NO_x levels will be monitored and controlled in the maintenance shop to ensure good air quality. A continuous monitor will be installed in the maintenance shop. Offices located above sections of the maintenance shop will have proper ventilation systems to avoid the intake of maintenance shop air.

Without adequate ventilation, there is potential for atmospheric inversions to occur in the shop. Because of the cold weather, ventilation systems within the shop will be designed to supply adequate air flow and volume for general dilution of exhaust. Extraction devices will be installed and used for the exhaust emissions control at the source before the contaminants are distributed throughout the shop air. Additionally, vehicle operations inside the maintenance shop will be restricted.

2.11.8.5 Blasting By-products

Ammonium nitrate/fuel oil (ANFO) mixtures will be the primary explosives used during open pit and underground mining. Occupational exposures will be minimized by establishing controls during mixing and following blasting.

Where possible, automated explosives mixing equipment and personal protective equipment will be used. Also, a minimum clearance and re-entry time will be instituted after blasting to allow for dispersement of air contaminants in both open pit and underground mining operations.

2.11.8.6 Atmospheric Inversion

Atmospheric (thermal) inversions may occur in the deep open pits, especially in the absence of wind in the winter season. A prolonged thermal inversion can trap exhaust gases and emissions during operations at the lower levels of the pit. This could lead to employee exposure to high concentrations of gaseous and particulate contaminants.

Most mobile equipment, drills and light duty vehicles will be equipped with pressurized cabs. Also, equipment using low sulphur diesel fuel will have exhaust filter systems to control particulate emissions. However, the movements and work of a number of maintenance personnel will be outside the cabs in the open pit.

Frequent monitoring of occupational and environmental airborne concentrations of contaminants during thermal inversions will ensure that personnel are removed from these areas prior to excessive exposure above the permissible TLV-time weighted averages. Alternate air supplies, in the form of self-contained breathing apparatus (SCBA), will be available at predetermined locations. Workers will be alerted to the availability and locations of this equipment and will be trained in its use.

Air modelling will provide an estimate of the potential extent, conditions and frequency for thermal inversion events. Volume III, Section 2.1, details the air quality management plan for the open pit.

2.11.8.7 Ferrosilicon

A slurry of fine ferrosilicon and water will be used in the heavy medium separation process to separate high density particles, including diamonds, from low density, non-diamond material in a conventional separating cyclone.

Ferrosilicon is non-flammable, non-reactive and poses a low health hazard. The Material Safety Data Sheet (MSDS) for “Duramet (Ferrosilicon)”, manufactured by Washington Mill Electro Minerals Corporation, can be found in Appendix I-

B11. The toxicity characteristics of Duramet do not meet federal Workplace Hazardous Material Information System (WHMIS) criteria for carcinogenicity, reproductive effect, teratogenicity and mutagenicity; however, coughing, shortness of breath and irritation of the nose and throat could result from overexposure to the dust.

Fine dust may be generated when the bags containing the product are discharged into the dry storage bin. Therefore a dust extraction system will be used to capture and redeposit the fine ferrosilicon particles in the storage bin. A dry-element-type baghouse will be used; a reverse air pulse system will clean the filter elements.

No specific TLV has been established for ferrosilicon. Based on its extremely low toxicity, the nuisance particulate standard of 10 mg/m^3 for total dust will be applied.

2.11.8.8 Cold

Frostbite and hypothermia are significant potential hazards associated with working at the NWT Diamonds Project. Hypothermia, caused by overexposure to a cold environment, results in lowering of the internal body-core temperature. Frostbite can lead to damaged tissues, loss of extremities and infection. Unless proper precautions are taken, the onset of frostbite and hypothermia can occur quickly.

Frostbite and hypothermia result from chilling by cold wind and air temperatures or cold water. The most common cause on land is a combination of low temperature and wind chill, associated physical exertion and inadequate clothing.

Specific rules and procedures will be enforced at the project, including the requirement that employees wear winter gear (snow parkas, pants, steel-toe snowboots) and travel with emergency packs while in vehicles. Additional measures include training on the prevention, signs and symptoms, and treatment of frostbite and hypothermia. Also, fully equipped refuge stations will be provided in case of white-out conditions, extreme cold weather and/or occasions when workers could become stranded or lost.

2.11.8.9 Noise

Heavy equipment operation, blasting, drilling and mineral processing will generate noise levels that may pose a potential occupational hazard to workers. Both area and personal dosimetry will be conducted to

- identify high noise sources
- monitor the occupational exposures to noise

- determine the octave-band frequencies of noise sources to assist in the selection of controls
- evaluate effectiveness of modifications and controls
- assist in the selection of proper and effective hearing protection
- document noise assessments
- support worker training.

Occupational noise is regulated by the *NWT Mining Safety Act*. Provisions for a hearing conservation program include noise control, hearing protection, baseline and annual audiometric testing and training. A written Hearing Conservation Program will be developed.

Noise control is required when steady-state noise exposures exceed 85 decibels (dBA) over 8 hours or equivalent. These rules are currently being revised. Therefore, the NWT Diamonds Project will keep abreast of potential revisions to the TLVs, noise control criteria and elements of the noise control/audiometric programs.

Noise specifications of heavy equipment and other noise sources will be evaluated to determine and estimate the potential noise levels and frequencies at the project site. BHP Minerals' experience in dealing with noise sources at other operations will be used.

A number of alternatives are available and will be used to minimize noise exposures, including noise isolation, noise reduction and engineering controls, hearing protection and administrative controls.

2.11.8.10 Radioactive Materials

Due to reported radon occurrences in diamond mines in Russia and other underground mines, analyses were conducted to measure levels for the NWT Diamonds Project. Radioactivity tests conducted to date on kimberlite ore suggest that radon gas emissions are very low for the ore and overburden. Test results, reported in Becquerels per gram (B/g), are provided in Table 2.11-4. Also, radiation levels, as detected in a water sample, showed 0.010 B/g Ra 226 and <0.010 B/g Th 228.

Table 2.11-4
Radioactivity Test Results

Area	Location	Radium 226	Thorium 228
Panda	(Unlabelled)	0.110	0.060
Misery	(M38 28-28.5)	0.0500	0.030
	(M33 11-15)	2.000	1.300
Koala	(K8-15-71E)	0.0300	0.030
	(K8-15-71E)	0.0400	<0.010
Leslie	(L-15-4-18)	0.0700	0.080
	(L-15-9(41-45)	0.0200	<0.010
Fox	(F-7-295)	3.500	2.000
	(F-7-295)	0.0400	<0.020

As mining progresses in the open pit and underground, periodic radon monitoring will be conducted to confirm low radon concentration. Ventilation will minimize radon gas emissions, if any, in the underground mining operations.

Fixed radiation sources will be used for nuclear densimeters, levelling gauges in chutes and containers and the X-ray sorting machines for diamond recovery. All of these instruments will contain the radiation in sealed sources and will not emit radiation in excess of the regulatory limits imposed by the Radiation Protection Bureau under the mandate of the *Radiation Emitting Devices (RED) Act* and Regulations (Schedule II, Part XV). The X-radiation warning sign will be affixed to fixed sources by the manufacturer.

NWT Diamonds will purchase equipment, which must be labelled as a radiation source, from manufacturers, importers or vendors who have complied with the requirements of the *RED Act* and Regulations. These instruments are categorized as “cabinet X-ray devices” and must meet the X-ray emission regulatory limit of a maximum of 0.5 milliroentgen per hour (mR/h) at 5 cm from the surface. This limit is the same as that for television sets or other consumer products.

The specific type of X-ray diamond recovery machine to be used at the project has not yet been chosen, but will likely be similar to that currently in use at the BHP Minerals Testing Laboratory in Reno, Nevada. Therefore, based on the sorter operation at the Reno lab, an assessment by Health Canada was made on the environmental and health concerns. P. Dvorak, Head of the X-ray Section for the Radiation Protection Bureau, Health Canada, stated the following in a March 15, 1995, correspondence to C. David, Environmental Health Assessment Office:

> The device in question operates with a low X-ray tube voltage (35 kV), resulting in an X-ray beam substantially less penetrating

> than are beams commonly used in equipment such as dental X-ray machines or Baggage Inspection X-ray Units. The X-ray is confined to an enclosure during equipment operation and there is no reason for any environmental concern. As you are well aware, radiation is produced only when the X-ray tube is energized, and X-ray exposure at low photon energies leaves no residual radioactivity.

From screening of the radiation exposures of Reno lab personnel, it is anticipated that occupational radiation exposures from the fixed sources at the project, including the X-ray sorter machine(s), will be negligible. The personal employee data collected to date for current and cumulative external dose (millirem) for calendar quarters, calendar years and lifetime were reported as “not detectable” (ND), “not required” (NR) or close to the analytical level of detection. The maximum allowable cumulative dose per year is 5 rem or 5,000 millirem (deep dose tissue), and 50 rem or 50,000 millirem (shallow dose tissue).

Occupational exposure to airborne concentrations of ionizing radiation and/or radon daughters at the project will be monitored to ensure compliance with the permissible exposure limit of the NWT Radiation Hazard Regulations. The regulations specify a maximum permissible dose of 5 rem per year. A Radiation Exposure Control Code of Practice, including monitoring plan, worker training and recording, will be developed and submitted for approval by the Chief Mines Inspector.

2.11.8.11 Vibration

Hand-arm vibration affects the nervous and cardiovascular system in the hands and fingers. Whole-body vibration delivered through the buttocks or feet can result in internal organ damage. Occupations at high risk include mechanics, truck drivers, heavy equipment operators and miners exposed to whole-body vibration.

Worker exposures through hand-arm and/or whole-body vibration will be evaluated and controlled. This will include efforts to

- establish criteria for vibration-dampened equipment purchases
- educate workers on risks of hand-arm and whole-body vibration and available control options
- provide vibration-dampened seats in heavy equipment
- monitor and establish baseline assessments of vibration exposures and follow-up controls and monitoring.

2.11.8.12 Welding

Control of worker exposures to welding fumes, including metal fumes, flux products and welding gases, will be implemented in conjunction with a monitoring program for airborne contaminants (CO, CO_2, ozone, welding fume/metals, chromium, nickel). Worker protection, including welding shield, goggles, gloves, apron and respiratory equipment, will be provided.

In areas such as the welding shop or other fixed location of welding activity, the primary control of exposure will be through local ventilation. Local exhaust collection hoods or extraction systems will be designed and installed. Welding performed in other locations, such as confined spaces, will require additional monitoring, supplied air respirators and effective contaminant extraction.

Exposures to the various contaminants will be minimized to comply with the TLVs.

2.11.8.13 Chemicals

In accordance with NWT Mine Hazardous Materials Information System (MHMIS) regulations, MSDSs for all hazardous chemicals will be available on site for inventory, review and training prior to their use. A MHMIS system, commencing with approved purchases and MSDS, will assist in determining the potential health and physical hazards associated with the product. The system also provides information on monitoring and control measures and medical treatment.

A controlled chemicals list and MSDS registry for products will be updated regularly. All employees will have access to MSDS and their training will be documented.

Products containing carcinogens or suspected carcinogens will not be purchased and used on site, unless substitutes cannot be located. These products will be restricted, with additional protection measures applied.

Ferrosilicon will be the primary chemical agent used in the processing plant. This has been discussed previously in Section 2.11.8.7.

Other potential chemical exposures include paints, battery acids, resins, vulcanizing chemicals, solvents and cleaners and other maintenance-type products. Because of their varied health effects and exposure limits, appropriate training, monitoring and control measures will be evaluated on a case-by-case basis.

2.11.8.14 Confined Space

Confined space entry requires a signed work permit and prior authorization. Stringent work entry procedures will ensure that site preparation, adequate ventilation, air contaminant testing, standby worker, emergency rescue and all safety procedures are reviewed and discussed. Self-contained breathing apparatus (SCBAs) will be available if needed for confined space entry. Workers will be alerted to the availability and locations of SCBAs and will be declared medically fit to use SCBAs by a physician. Training on the use of SCBAs will be provided.

Special considerations will be given to confined space activities, including welding and cutting on shovels, inspection and maintenance work on rear-end housing (axle boxes) of open pit equipment, storage tank entry and solvent use.

The acceptable airborne concentrations for confined space entry are as follows:

- oxygen: 18% to 23%
- flammable gas or vapour: 20% of lower explosive limit (LEL) for normal work and 10% of LEL for hot work.

Confined space entry procedures for the site and an inventory of potential confined space locations will be developed.

2.11.8.15 Bloodborne Pathogens

A Bloodborne Pathogens Program has been implemented at the project site to address potential exposure of personnel to bloodborne pathogens during the Advanced Exploration phase. Bloodborne pathogens include AIDS (Acquired Immune Deficiency Syndrome), HIV (Human Immunodeficiency Virus) and Hepatitis B.

Training to protect all mine rescue workers and first aid responders from bloodborne pathogens is an important component of the program. Training elements include

- instructions on the proper use of protective gloves, masks and goggles
- procedures on avoiding contact with blood during rescue attempts
- first aid and medical treatment
- proper cleanup and disposal techniques.

Immunization for Hepatitis B will be offered to members of the mine rescue team and first aid responders. In the event of exposure, testing for HIV/Hepatitis B will be provided.

2.11.8.16 Indoor Air Quality

Indoor air quality is an issue of personal comfort, health and aesthetics. The camp facility, maintenance shop and offices are the main areas where good air quality will need to be assured. Common occupant complaints can include odour, headache, eye irritation, sore throat, shortness of breath and fatigue. In all cases, establishing acceptable indoor air quality is critical. This is especially important at the project given the extreme climatic conditions and close living/working quarters.

A no smoking policy has been implemented and will continue to be followed. Smoking will be permitted only in designated areas, with separate ventilation, that are not normally used by non-smokers. Other measures to ensure good air quality will include effective ventilation and heating systems, stringent maintenance and cleaning procedures and control of noxious cleaning/chemical products.

Established guidelines for indoor air quality will be followed. These include air testing for carbon monoxide, carbon dioxide, temperature, humidity, air flow/volume and chemical/biological contaminants (bacteria and fungi).

2.11.9 OH&S Management Systems

2.11.9.1 Procedures Manual

The NWT Diamonds Project Procedures Manual, which has been in effect since February 1994, specifies procedures to ensure compliance with established OH&S policy, rules, regulations and/or instructions for the following areas of operation**:**

- mechanical rules / mine and plant
- heavy medium separation plant start-up
- heavy medium separation shutdown
- tools
- safe work and confined space permits
- conveyors
- welding

- emergency code
- electrical
- lockout
- mobile equipment pre-operation checklist
- handling remnants of explosives contained in ore processed through the plant
- hauling from portal to plant
- small vehicles operation
- starting and operation recommendation for cold weather
- operation policy during white-out conditions
- fire
- working alone underground
- propane handling
- emergency generator start-up
- radioactive material incident
- snowmobile safety
- ice road.

Copies of the manual are available at each work station and in every office at the site. The Procedures Manual will be updated to conform to NOSA requirements and incorporate procedures relevant to new system operations and project start-up activities.

2.11.9.2 Training

In addition to safety induction, numerous training programs will address regulatory requirements, job competency and BHP Minerals/NWT Diamonds Project standards of performance. The involvement of OH&S representatives/committee, employees and mine rescue/emergency response teams in ongoing communication, training and exercises will be encouraged.

Commencing with safety inductions, each employee will receive task training relevant to the particulars of the job as well as the necessary safety and health precautions.

Additional training will be conducted on arctic survival and ice travel, wildlife safety, emergency/drill and evacuation procedures, use of personal protective equipment, MHMIS, occupational health hazards, motor vehicle safety and fire preparedness.

The potential loss of life and property due to fire is a major concern. Therefore, all camp residents will be provided with essential fire preparedness training. This will include regular on-site training on the locations, types and proper use of fire extinguishing equipment and fire drills.

All personnel currently employed at the operation receive ongoing annual NWT Mine Hazardous Material Information System (MHMIS) training as required by the NWT Mines Department and Federal Department of Labour. This program educates each individual at the site about the elements of the project's MHMIS program, how to identify hazardous products and read a Material Safety Data Sheet, as well as the proper use, handling, storage and disposal of the products and first aid procedures. Mandatory training as prescribed by the NWT Mining Safety Regulations will continue to be conducted during all phases of the project.

Mine rescue teams will be provided with ongoing training, as required by the *NWT Mining Safety Act* and Regulations. Mine rescue teams, as well as emergency response units, will be given the minimum four 8-hour sessions per year of training and additional training as deemed necessary. Medical personnel will be included in these training sessions.

NOSA training, as discussed in Section 2.11.3, will be conducted once NOSA implementation is initiated at the NWT Diamonds Project. NOSA training courses targeting various employee, supervisor, management levels and OH&S staff/committee members will be conducted. NOSA courses will heighten awareness regarding OH&S and improving OH&S skills and competencies. The training courses available through NOSA include the following:

- employee health and safety training
- general health and safety training
- accident investigator course
- safety management technology
- instructional techniques in safety

- NOSA five-star system coaching
- auditor's course
- health and safety representative course.

All training will be documented.

2.11.9.3 Hazard Assessment/Job Safety Analysis

The hazards associated with each workplace will be identified and maintained in a hazard register, which will also set out action plans as a part of the overall risk reduction program. Hazards associated with the operations, materials, processes, work practices and climate/environment of the project will be initially identified by NWT Diamonds Project Health and Safety Department staff using job safety analysis. In such analysis, the nature and degree of hazard are assessed, and these identified hazards then form the basis for procedures for the worker to accomplish the job without undue risk.

Efforts will be taken to install appropriate engineering controls and safety systems to minimize potential health and safety hazards. These efforts will be made in the design, installation, commissioning and operation of the new plant and equipment, processes and work procedures. Following installation, testing will be done to evaluate the effectiveness of controls in protecting worker health. For example, velometers will be used to monitor air movements in fume hoods, extraction and ventilation systems and to ensure safe operating parameters are met.

All equipment will be inspected, especially pre-shift, with the use of inspection checklists. Work practices and operating procedures will also be evaluated for potential health and safety hazards. Corrective actions and operating plans will be developed to control and/or minimize worker exposure.

2.11.9.4 Work Permit Program

A Work Permit Program has been implemented to ensure that safe work practices and protection are employed in special types of work/tasks prior to the employee performing the work. Authorization and the work permit will be granted to the worker by the general foreman/superintendent after types of hazards and precautions have been reviewed.

The permit is valid for one day only, must be posted at the job and is to be returned to the foreman at shift end or on the completion of the job.

The Work Permit Program covers confined space work, hot work and other potentially hazardous conditions such as height, radioactivity, sandblasting, flammable materials, fumes, high pressure and chemicals. Precautions that may be required include atmospheric testing, cleaning, ventilation, fire/explosion protection, isolation, special clothing and equipment, respiratory protection, training, standby person and work area precautions. A copy of the Work Permit is provided in Appendix I-B12.

2.11.9.5 Workplace Monitoring and Control

An Occupational Hygiene Monitoring Program is currently being developed for the NWT Diamonds Project. The objectives of the program are to

- identify sources of contamination and hazardous areas
- assess occupational exposures to biological, chemical and physical hazards associated with or arising from the project
- establish baselines and trends in changes to the workplace environment
- determine compliance with TLVs or other recommended guidelines
- trigger additional protective measures, if necessary, to keep workers healthy
- assist in the evaluation of the effectiveness of the design, work practices and safe work procedures
- evaluate the need for and effectiveness of personal protective equipment
- evaluate the need for and effectiveness of engineering controls
- evaluate the need for medical monitoring and surveillance
- develop job exposure profiles
- document workplace exposures and controls in workers' compensation claims
- train workers and increase awareness.

Monitoring has been discussed previously in relevant sections. A comprehensive monitoring program will be implemented for air contaminants, noise, vibration, radiation, asbestos, respirable quartz and confined space. Elements of the sampling program, including occupational hygienist qualifications, monitoring equipment, area/personal samples, contaminants, frequency and statistical analysis, will be developed and outlined in the Occupational Hygiene Monitoring Program.

2.11.9.6 Protection Programs

Control measures to protect worker health, in order of priority, are engineering controls, administrative controls and personal protective equipment. Monitoring will be conducted to determine the need for these control measures.

Engineering controls will be integrated into the design of the mine, process plant and facilities/infrastructure. These are logically the most effective in controlling the hazard at the source, transmission path or receiver. Engineering controls have been discussed previously in relevant sections. Targeted methods available, depending on the circumstances, include substitution, changing the process, isolation/enclosure, local exhaust or general/dilution ventilation, dust suppression and equipment redesign.

Administrative controls may be required to reduce overall worker exposure by adjusting work schedules, rotating job assignment, shifting work to other areas and written work procedures for hazardous jobs and hazardous material handling. Administrative controls may be necessary in the open pit during atmospheric inversions.

Personal protective equipment (PPE) includes hearing protection, respirators, eye protection, hand protection, emergency eyewash facilities and emergency showers, protective clothing, emergency cleanup equipment and standard safety equipment such as safety glasses, hard hats and steel-toe boots.

The project will implement a systematic personal protective equipment program that meets the criteria established by regulations, consensus organizations (Canadian Standards Association and American National Standards Institute) and advisory bodies. The program will focus on the proper selection and fit, use and maintenance, PPE inspection, worker training and “PPE Required” postings in hazardous areas. The limitations on use and medical clearance/fit testing for respirator use are also essential components of the program.

Protection programs to control the occurrence and spread of water-borne, food-borne and/or vector-borne diseases will be implemented. This will include water quality monitoring of potable water, good hygienic practices of the catering crew and necessary precautions to ward off potential vectors.

2.11.9.7 Medical Surveillance Programs

Medical examinations were briefly discussed in Section 2.10. The Medical Program will have three elements:

- the baseline medical condition of the employee as determined during the preplacement examination

- the periodic surveillance examination that tracks employee health during the course of employment

- injury and illness care and status assessment post-injury, including determination of disability and rehabilitation program elements.

Specific medical examination protocols will be developed by an occupational physician for each type of examination. Additional medical testing and provisions unique to the remote environment will be incorporated into the preplacement and the surveillance examinations, as follows:

- immunization program to include immunization history, tetanus booster, Hepatitis B vaccine for mine rescue teams and first aid crews, and flu shot program annually

- drug screening at preplacement, periodically and following accidents for cause.

Additional medical screening will be required for the contracted catering crew. Food handling and hygiene are critical in preventing the transmission of food-borne communicable diseases. Screening will include proof of a clinical examination of potential communicable disease sites, including the skin, ears, upper respiratory tract and gastro-intestinal tract. Medical history, especially for infectious disease experience, will be taken. The catering crew should be pre-vaccinated for both Hepatitis A and Hepatitis B. They should be routinely screened for tuberculosis (mantoux test). Chest X-rays will be required if a member of the catering crew is suspected of being a disease carrier.

The Medical Program will be established and conducted in accordance with the regulations of the *NWT Mining Safety Act* and Regulations pertaining to medical certificates and medical monitoring.

2.11.9.8 Emergency Response Plan

Emergency preparedness and response are and will continue to be critical functions at the NWT Diamonds Project. Given the remote site, many emergency services will be relegated to the Mine Rescue Teams. These will include first aid/ emergency medical services, mine rescue, fire-fighting and response to situations unique to the project such as travel on frozen lakes and rivers, hypothermia and bear and wildlife encounters.

Systems for emergency preparedness will revolve around the Emergency Response Plan, training and drills. These systems will

- ensure effective interaction with crisis and emergency management activities

- assist project management in identifying potential emergencies
- minimize the potential for emergencies to arise
- ensure that emergency procedures are implemented at the earliest possible stage.

The Emergency Response Plan at the NWT Diamonds Project site will include first aid, fire-fighting, mine rescue teams, emergency response crews and contingency planning.

For the expected work force, four emergency response units of six employees each will be maintained at all times to comply with the Mines Department requirements. Emergency response/mine rescue teams and nursing personnel will be trained to respond to head, neck, back and spinal cord injuries. Equipment such as backboards and neck braces will be available to provide proper stabilization prior to evacuation of the injured.

The *NWT Public Health Act* requires that a hospital with at least four beds and an adequate staff of qualified nurses be provided on site in light of the remoteness of the project. The hospital will be equipped with medications, dressings, medical and surgical supplies for all reasonable requirements equivalent to public hospitals of similar size. A fully-outfitted ambulance is already based on site for emergency transport.

First aid requirements are established by the *NWT Occupational Health and Safety Act*. First aid training is required for all supervisors, mine rescue personnel and 10% of the work force. Emergency first aid facilities and supplies will be located throughout the mine site.

Additional training specific to responding to fires, spill response and other emergencies will also be provided.

All fire-fighting systems will comply with the National Fire Protection Association Codes. The project will require a "quick-attack" fire-fighting unit equipped with a designated fire truck capable of meeting all fixed and mobile fire-fighting requirements, particularly fuel fires. Other emergency response equipment will be stored in emergency response vehicles. A complete set of cold-weather fire-fighting turnout gear will be maintained and stored for easy access near the fire and emergency response vehicles.

All fire-fighting or emergency response units will be comprised of mine site employees from various work areas. A dedicated system of radio communications will be in place to alert personnel to an emergency. The number of fire-fighting personnel on site will always be maintained at six, regardless of shift rotation. emergency response teams will be fully trained in fire-fighting, hazardous materials, mine rescue and first aid.

The Spill Contingency Plan is discussed in further detail in Volume III, Section 4.2. Predetermined lines of response, plans for action/response, equipment and training exercises are components of the plan.

2.11.9.9 Inspections and Audits

Site inspections will be conducted by the Mines Safety Division of NWT Mines Department. All site areas will be inspected with a cross-section of employees in attendance. The Mines Inspector will prepare a report noting any issues/hazards/ work practices requiring abatement. All items in this report will be corrected and addressed within the allotted timeframe by site management and OH&S Department staff.

Periodic inspections of the site facilities by a representative of the fire marshall’s office will be conducted to identify existing, potential or perceived fire hazards. These hazards will be addressed within the timeframe allotted.

Property inspections will also be conducted periodically by other governmental agencies, including but not limited to the NWT Mines Safety Branch, Environment Canada and the Department of Labour. Inspection reports and recommendations made by these agencies will require project management action.

NOSA inspections and audits will be conducted by external NOSA inspectors and/or internal auditors trained in the NOSA system and audit procedures.

Frequent site inspections by GNWT personnel, with the site OH&S committee in attendance, and periodic Group and Division level audits by BHP representatives will be conducted to ensure compliance with governmental regulations, BHP and project procedures and work practices. Information from these inspections and audits will provide a positive, non-punitive approach for site managers to improve OH&S associated with work operations and practices in their areas of responsibility. The OH&S committee will review the recommendations and follow up to ensure that corrective actions are taken.

2.11.9.10 Incident/Accident Investigation and Reporting

Recordkeeping of inspection reports, monitoring and testing data and accident investigations will be maintained. The information will be provided to the NWT Mines Inspection Branch, the site OH&S committee and workers on site. Where appropriate, the information will also be distributed within BHP Minerals according to the reporting structure/mechanism discussed in Section 2.11.4.

The records will provide historical data on the activities and improvements made within the workplace safety system. These statistics are also useful as a diagnostic tool to identify trends and problem areas.

Potentially serious events that occur will be investigated to determine contributing factors, essential causes and mitigative actions. These will be reviewed by project management for implementation and subsequent inspection.