Table 2.5-15
Plume Rise Sensitivity to Ambient Temperature

Temperature (K/m)	Plume Rise (m/s)
230	141.3
240	139.1
250	136.8
260	134.5
270	132.3
280	130.0
290	127.7

Plume rise calculations assume a wind speed of 1.0 m/s and a neutral temperature profile.

2.5.4.1 Mitigation

If and when an inversion causes the air quality in one of the open pits to exceed industrial hygiene levels, the hauling trucks and other equipment can be reassigned to different elevations and/or other pits to work (essentially shutting down the operation for that one pit). Electric mining equipment would be run in favour of equivalent diesel units, where and when available, and support equipment not essential to maintain production would be limited or removed from operating in the area.

It should be assumed that during the life of the project, cleaner burning diesel fuels and engines will became available, further reducing any potential air quality impact.

2.5.4.2 Residual Effects

The residual effects of the air quality of the open pits should be short term, especially on the health of any operators, due to the natural environmental processes that will dissipate a thermal inversion. The future capacity of renewable resources should not be affected by mobile emissions in the pit, and the long-term residual effects from these emissions should be negligible.

2.6 Climatology

Climate is a valued ecosystem component since climatic conditions determine the activities of most northern organisms and therefore provides the basis for ecosystem development. The severe climate of the southern Arctic may be viewed as a limiting factor to species abundance and diversity, affecting both biophysical and socioeconomic development.

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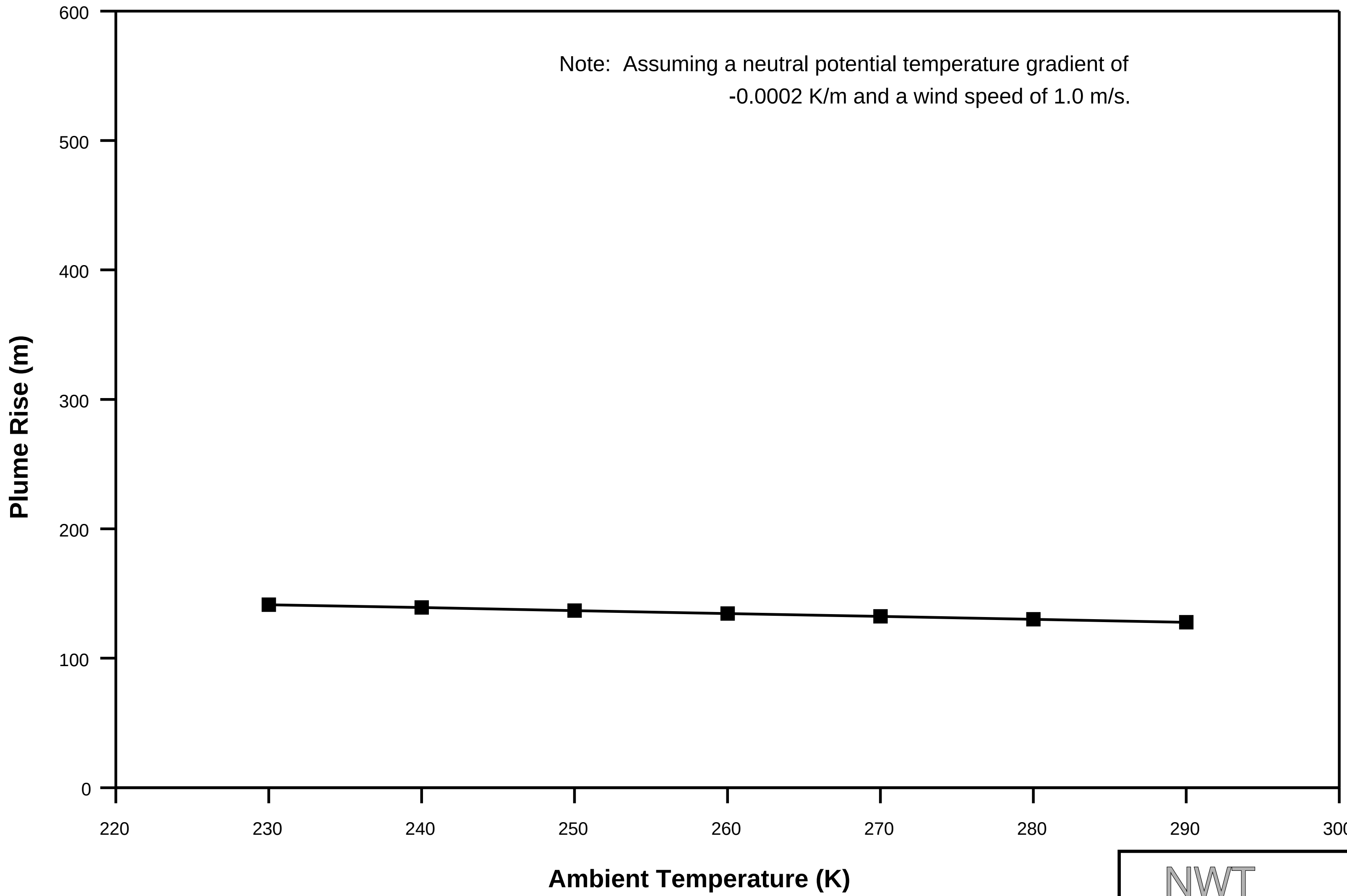


NWT DIAMONDS PROJECT

Figure 2.5-17
Plume Rise vs.
Ambient Temperature

Source: Rescan

Climatological variables that may be affected by project development include air temperature, relative humidity, wind regime and precipitation distribution. Project activities which could influence these variables consist largely of power generation, fuel combustion by haul trucks and landscape modification as a result of site infrastructure. These project activities may cause changes to surrounding microclimatic or macroclimatic regimes depending on the dispersion of local effects. Any potential climatic changes would take place largely during construction and operation periods.

2.6.1 "Heat Island" Effect

The generation of heat from diesel generators and fuel combustion will result in the formation of a local "heat island" at the NWT Diamonds Project site during periods of low wind velocity. A heat island is a microclimatological phenomenon that arises when energy is dissipated and contained within the local atmospheric environment. In essence, the immediate project area could be warmer than its surroundings. This phenomenon is generally associated with large cities where heat dissipation and changes to the radiative characteristics of the land surface may be sufficient to increase local air temperature.

The main sources of energy release at the project site will be the power plant, boilers and the surface equipment used in daily mining activities. According to annual fuel requirements estimates, surface mining equipment and gensets will account for most of the fuel consumption.

A heat island effect would likely be in the immediate camp area and within actively mined open pits. Effects would be temporary, as this climatic effect would disperse once atmospheric conditions become unstable.

2.6.1.1 Mitigation

There are no special mitigation measures specifically designed to reduce the effects of formation of a heat island because the environmental impact will be negligible and the geographic extent will be quite small.

2.6.1.2 Residual Effects

Overall, the significance of residual heat islands is deemed to be negligible, as this phenomenon will dissipate with unstable atmospheric conditions.

2.6.2 Wind Regime Modification

The local wind regime may be modified as a result of the alteration of landscape features during infrastructure construction. Project facilities such as buildings and waste rock dumps will project above local topography and will constitute obstacles to wind. This may alter wind patterns in the immediate vicinity of these features. Any wind alterations would persist throughout project operation.

The planned process plant facility and associated buildings will be constructed between Koala Lake and Kodiak Lake. Waste dumps will rise to a maximum height of 50 m above the surrounding topography in the vicinity of the open pits.

Altered wind patterns would change the distribution of snowfall during the winter. Snowdrifts may become established leeward of features projecting above local topography. This may result in secondary changes to the surface hydrologic regime during freshet.

2.6.2.1 Mitigation

There are no feasible mitigation measures to reduce the effects of site infrastructure on the wind regime during the operation of the project.

2.6.2.2 Residual Effects

During site decommissioning, all buildings will be removed. Waste dumps will be contoured and reclaimed and will continue to act as obstacles to wind movement. The overall effects of wind regime modification will be negligible except in the immediate vicinity of the dumps.

2.6.3 Climate Change

Fuel consumption at the NWT Diamonds Project site will produce greenhouse gas emissions. Anthropogenic sources of greenhouse gases are mainly from carbon dioxide (CO_2) emissions in the combustion of fossil fuels, and also include methane (CH_4), nitrous oxide (N_2O) and other gases. These emissions would be produced during exploration, construction and operation phases.

Generally, there is agreement within the scientific community that continued increases in atmospheric levels of greenhouse gases will increase the average temperature of the earth by “trapping” heat that is currently radiated from the earth’s surface to the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) concluded that a doubling in atmospheric CO_2 concentration could result in an increase in global mean surface temperature of 1.5°C to 4.5°C (IPCC 1992, cited by Canada 1994). The rate of increase may be between 0.2°C and 0.5°C per decade, which is slow by human standards but extremely rapid in geologic time.

The contribution of the NWT Diamonds Project to Canada’s greenhouse gas emissions through fossil fuel consumption and power generation was estimated by calculating project CO_2 emissions as a fraction of the CO_2 emissions of the NWT and Canada.

Fuel consumption by the project will peak at about 7.5×10^7 L, or approximately 70,000 tonnes annually. On average, fuel contains about 84.15% carbon by weight (Oldham 1995). Carbon dioxide emissions associated with the complete conversion to CO_2 of the contained carbon in 70,000 tonnes of fuel would therefore be 216,000 t/a, or 216 kilotonnes (kt).

Canadian emissions of CO_2 in 1990 totalled 460,393 kt (Canada 1994). The combined share of the Northwest and Yukon Territories was 1,892 kt. The estimated CO_2 emissions of the NWT Diamonds Project amount to approximately 11% of the total for the Territories, and about 0.047% of the 1990 total for Canada.

2.6.3.1 Mitigation

The contributions of the NWT Diamonds Project to global warming will be reduced by minimizing greenhouse gas (principally CO_2) emissions, by minimizing fuel consumption. Buildings will be insulated to minimize heating requirements, the design and siting of mine facilities will minimize haul distances (and therefore fuel consumption), and gensets and internal combustion engines will be maintained regularly to ensure efficient energy consumption.

2.6.3.2 Residual Effects

Although greenhouse gas emissions from the project will be produced over a period of 25 years, the time scale of potential impacts is unusually long, in the order of decades to centuries. The geographic extent of the residual effect is truly global. However, the effects directly attributable to the project are negligible, since the project will contribute a very small additional increase in Canada's total greenhouse gas emissions, which in turn account for a small fraction of worldwide emissions.

2.6.4 Acidic Deposition

Acidic deposition is the result of anthropogenic emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) reacting with oxygen and water in the atmosphere to form acids that can precipitate with rain, snow, sleet or dry particulates. The emissions may be carried long distances by prevailing winds before being deposited. The two most important constituents of acid deposition are nitric acid (HNO_3) and sulphuric acid (H_2SO_4). Together they account for approximately 98% of the free acidity found in acid rain (Likens 1978 in Cooper and Alley 1986). The main sources of SO_2 and NO_x emissions at the NWT Diamonds Project are the diesel power generating stations and the mobile mine equipment.

The acid neutralizing capacity of the atmosphere generally results from natural sources and includes chloride, sodium and calcium. Acid rain is a prominent issue in Eastern Canada and the U.S.A., because the lakes in this area lack the buffering capacity to neutralize the extra acid contribution from rainfall. Surface waters near the NWT Diamonds Project typically lack significant buffering capacity. A set of criteria has been proposed to assess the sensitivity to water to acidification. The criteria are based upon the levels of calcium, bicarbonate and conductance as summarized in Table 2.6-1.

Table 2.6-1
Categories of Water Sensitivity to Acidification

Sensitivity	Ca (mg/L)	HCO_3 (mg/L)	Conductance (µmho/cm)
Highly Sensitive	0 - 4	1 - 12	0 - 30
Moderately Sensitive	4 - 8	12 - 24	22 - 70
Least Sensitive	>8	>24	>60

Source: Altshuller and McBean 1980 in Shewchuk 1983.

Based upon the baseline water quality data collected for several lakes near the project, the total calcium concentrations are between 0.3 mg/L and 2.5 mg/L, the bicarbonate concentrations are between 2.0 mg/L and 9.5 mg/L, and the conductance is in the range of 9.0 µmhos/cm to 28.0 µmhos/cm. Hence, several of the lakes in the project area may be classified as highly sensitive to acidification. However, there is no threat of acidification of the lakes if there are no major sources of SO_2 and NO_x in the region.

Based on an annual diesel fuel consumption of 70,000 tonnes, it is estimated that the annual SO_2 emissions will be 70 tonnes, assuming the fuel contains 0.05 weight % sulphur. Thus, SO_2 emissions for the NWT Diamonds Project constitutes approximately 0.46% of the 1990 annual SO_2 emissions for NWT (15,157 t/a), and <0.01% of the total SO_2 emissions for Canada in 1990 (3,234,892 t/a).

Considering the mineral claim boundary for the NWT Diamonds Project encompasses approximately 344,000 ha, the sulphate deposition rate would be 0.10 kg/ha/a, well below the level necessary to protect the sensitive NWT ecosystem (7.0 kg/ha/a). This assumes that all of the sulphate is evenly deposited inside the mineral claim boundary. In reality, this may or may not be the case since deposition depends upon many factors such as particle size, wind speed and direction.

Based upon an inventory of NO_x emissions for Year 10 (2006), it is estimated that the annual NO_x emissions will be approximately 1,118 tonnes. The inventory included emissions from the permanent and Misery camp diesel gensets, boiler operation at the permanent camp, and mobile equipment operating in the Koala, Fox, Leslie and Misery pits. This accounts for approximately 13% of the annual NO_x emissions for the NWT (8,463 t/a) based on a 1990 inventory (NWT Renewable Resources 1995). The most up to date emissions inventory was for 1990, therefore, the contribution of NO_x emissions from the NWT Diamonds Project compared to the entire NWT will be less than 13%. On a nationwide scale the NO_x emissions from the NWT Diamonds Project account for only 0.055% of the annual Canadian NO_x emissions (2,026,110 t/a), based on a 1990 inventory.

The 1990 emissions inventory for NWT and Canada were based upon emission factors from the U.S. EPA Compilation of Air Pollutant Emission Factors (U.S. EPA 1985). This document is widely used to estimate air emissions rates and is commonly known as "AP-42." To allow direct comparison, the NO_x emission inventory for the NWT Diamonds Project was also based on the AP-42 emission factors. Another method of estimating emission rates is to obtain them directly from the equipment manufacturer. The emission rates for the air quality dispersion modelling (Section 2.5 Air Quality) were provided by the equipment manufacturers' and were different than the AP-42 emission rates used for the above comparison. The NO_x emission factors provided by the equipment manufacturer are more conservative (i.e., higher) than the AP-42 emission factors.

To assess the potential for acid rain problems in the Northwest Territories the ambient levels of SO_2 are being monitored. A Canadian Air and Precipitation Monitoring Network (CAPMoN) station was established in 1986 at the Snare Rapids hydro site approximately 150 km southwest of the NWT Diamonds Project. The station is operated by NWT Renewable Resources and Environment Canada. Rain and snow samples are collected on a daily basis and sent to the CAPMoN laboratory in Toronto for analysis.

Generally, the pH and other compounds measured at Snare Rapids show that there is negligible acid rain in precipitation. The levels are considered to be typical background levels associated with unpolluted areas. Sulphate deposition at Snare Rapids in 1992 was 0.96 kg/ha/a, well below the 7 kg/ha/a level considered to protect even the most sensitive ecosystems of the NWT. In Eastern Canada, where acid rain is a serious environmental problem, sulphate deposition is well in excess of 20 kg/ha/a (NWT Renewable Resources 1994).

2.6.4.1 Mitigation

The use of low sulphur diesel fuel along with frequent and scheduled maintenance of the diesel powered equipment will help to reduce sulphur emissions. The relatively low level of emissions, compared to Canada as a whole, along with the buffering capacity of the atmosphere (chloride, sodium, calcium) will ensure that the project has no impact on the climate of the region in the formation of acid rain.

2.6.4.2 Residual Effects

Due to the comparatively low level of SO_2 and NO_x emissions from the project, there will be no residual environmental effects from acid rain.

2.7 Noise

Noise levels that will result from the project have been predicted in order to identify and assess any adverse noise impact on workers, other individuals and wildlife. Baseline noise levels are very low due to the absence of human activity. The primary sources of noise associated with the project are expected to be aircraft, mobile and stationary mining equipment and blasting.

Project activity, and hence noise levels, will vary almost continuously throughout the duration of the project. The spatial boundaries are shown in Figure 2.7-1. The project claim boundary has been designated as the spatial boundary for the assessment of noise impacts as this area is restricted to project activities. Therefore, the only practical approach for quantifying noise levels is to define representative levels of activity during selected periods of time within various noise producing areas. Since the number of scenarios analyzed must be limited, at least some of them have been selected to represent near worst-case conditions. The scenarios analyzed are as follows:

- airport operation during year 1997 and beyond assuming the use of B727 aircraft
- airport operation during year 1998 and beyond assuming the use of B737 aircraft
- mining operations in vicinity of Panda pit during year 1998 (summer and winter)
- mining operations in vicinity of Koala and Panda pits during year 2000 (summer and winter)
- mining operations in vicinity of Misery pit during year 1999 (summer and winter)
- mining operations in vicinity of Misery pit during year 2001 (summer and winter)
- blasting within any of the proposed pits during operations phase of project
- haul trucks travelling between Misery pit and the process plant.

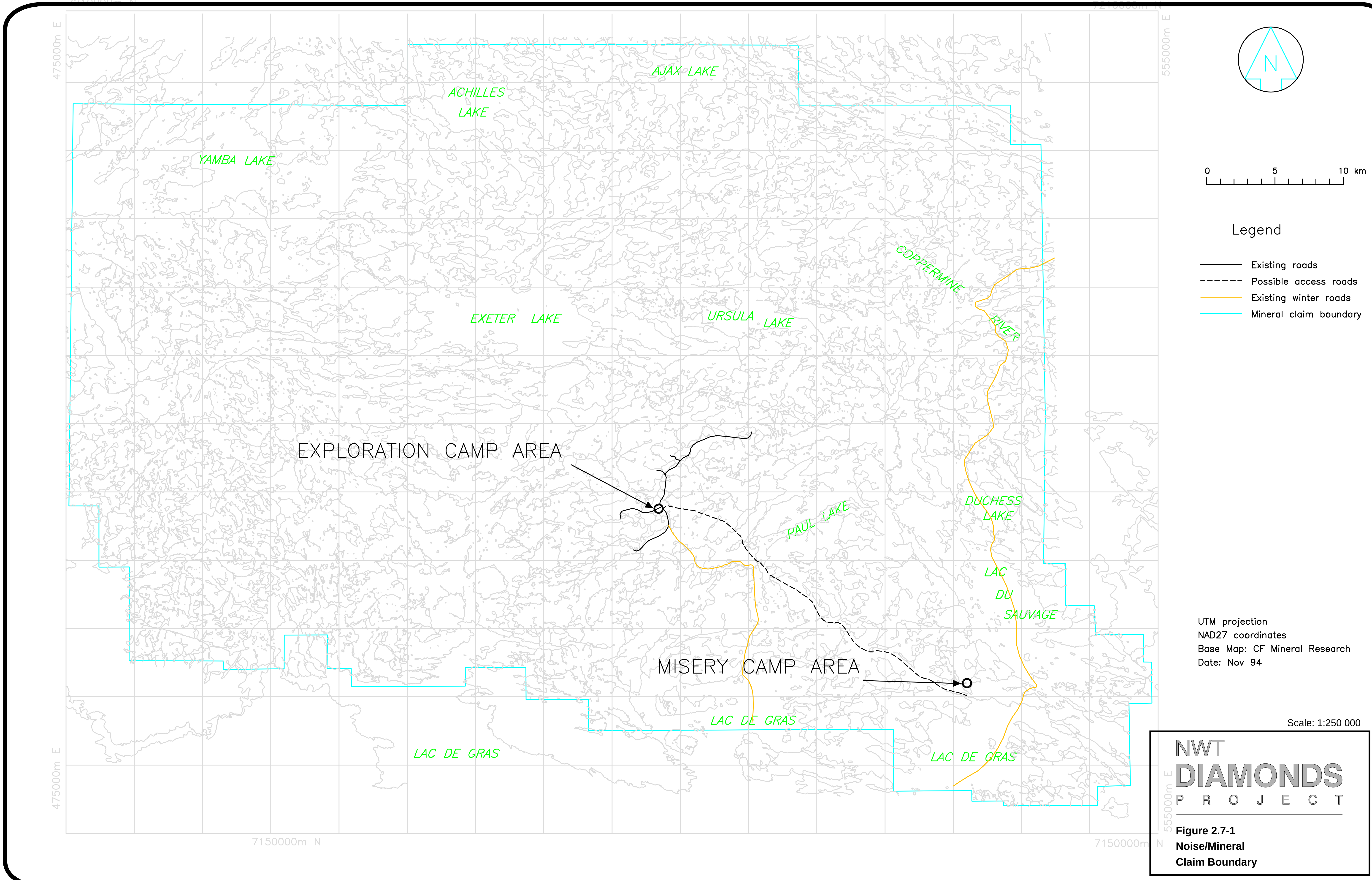


Figure 2.7-1
Noise/Mineral Claim Boundary

Source: Rescan

Noise levels during the construction phase of the project have not been specifically addressed, since they will generally be less intense and will occur over relatively brief periods of time in comparison with noise levels produced during the operations phase of the project.

Although the majority of noise issues are dealt with in this section of the EIS, hearing damage risk associated with occupational noise exposure is discussed in Volume II, Section 2.11.9, which deals with Occupational Health and Safety. As noted in that section, the NWT Diamonds Project will comply with all occupational noise regulations. Potential noise impacts on wildlife are discussed in Section 3.3.

2.7.1 Acoustical Concepts and Terminology

Environmental noise resulting from almost any type of industrial or transportation project generally involves a number of individual sources, some of which may produce noise levels that vary with time and others that may be non-continuous. Therefore, the long-term impact of environmental noise is generally assessed on the basis of long-term "energy average" noise levels. Although the term "average" usually implies a mid-point between low and high values, this is not the case when dealing with noise levels expressed in decibels (dB). To illustrate, if one considers a hypothetical noise source that produces 50 dB for one hour, 60 dB for one hour and 70 dB for one hour, the energy average of these sound levels is not 60 dB, but 66 dB. Energy averages are established primarily by the loudest events as these events contain so much more sound energy than the majority of the noise events. For example, in the case cited above, the 70 dB source contains ten times more sound energy than the 60 dB source and 100 times more energy than the 50 dB source.

The metric energy average used in this study for mobile and stationary mining equipment is the Equivalent Sound Level, abbreviated as Leq. It is defined as the steady sound level that would contain the same amount of sound energy as the actual time varying sound level. It is calculated for any given receiver location by combining the predicted sound energy from all significant noise sources and averaging over the time period of interest, for example a year. Research conducted over the past 25 years has been reasonably consistent in demonstrating a relationship between energy average sound levels such as the Leq and various effects on humans.

Although aircraft noise can be described in terms of Leq, Transport Canada and Canada Mortgage and Housing Corporation (CMHC) employ a different energy average, the Noise Exposure Forecast, abbreviated as NEF. Therefore, in order to permit comparison of airport noise levels with Transport Canada and CMHC guidelines, NEF has been employed in this study. However, airport noise has also been predicted in terms of Leq so that it can be directly compared against the Equivalent Sound Levels predicted for stationary and mobile mining equipment.

Notwithstanding the advantages of energy averages for environmental noise assessment, there are some situations where the assessment of noise levels produced by single events is appropriate. For example, the effects of noise on wildlife are most often assessed using single event noise metrics such as the maximum A-Weighted Level, primarily because most of the wildlife effects data collected over the years have used this relatively simple metric. “A-Weighting” is a frequency weighting network that is available in most sound level meters to simulate the frequency response of human hearing by electronically attenuating the low and high frequencies. Although the hearing response of different animals varies by species, the hearing characteristics of many mammals are comparable with that of humans (Heffner and Heffner 1985), and, therefore, in the absence of any more appropriate weighting network, it is acceptable to use A-Weighted noise levels for assessing effects on wildlife. In view of these considerations, maximum A-Weighted levels have been predicted for a few selected noise sources, such as trucks travelling along haul roads and helicopters flying over the study area.

Single event noise metrics are also appropriate for predicting human sleep disturbance. For example, the probability of noise from an individual aircraft awakening someone in the camp buildings next to the airstrip can best be predicted using the A-Weighted Sound Exposure Level (SEL) that results from an individual aircraft arrival or departure. The SEL is an indication of the total sound energy produced by a given event.

Noise from blasting can be assessed in terms of SEL (unweighted, since blast noise contains primarily low frequencies) or the unweighted peak instantaneous sound pressure level that results from an individual blast. The rationale for assessing blast noise in terms of single event metrics is that such events are usually infrequent, of very short duration and very high in level. As a result of these unique characteristics, the relationship between long-term energy average levels and effects that has been established for other types of noise cannot be directly applied to blast noise.

2.7.2 Aircraft Noise

The issue of aircraft noise encompasses noise in the vicinity of Koala airstrip, noise from fixed wing aircraft remote from the airstrip, and noise from helicopters. Airstrip noise is a concern for project personnel living and working in the immediate vicinity, whereas noise from individual aircraft beyond the immediate vicinity is more likely to affect wildlife and people engaged in wilderness tourism activities.

Total numbers and types of aircraft expected to visit the site airstrip various stages of the project are summarized in Table 2.7-1. For the purpose of this study, maximum daily flights were used to conservatively estimate noise impacts. During the construction period, the heaviest usage will be during the summer months (mid-May to mid-September) when the hours of daylight are long and the runway is free of snow. On the average summer day, the airstrip may receive about six flights. Only three flights per week are expected throughout the winter months during construction. During the operations period, air flights will be more consistent year-round, with up to eight flights per day and an average of approximately three flights per day.

For the purpose of predicting airport noise contours, the aircraft types and numbers indicated in Table 2.7-1 for years 2006 and beyond have been assumed as they represent a worst case scenario. The type of large jet (Boeing 727 or Boeing 737) used will depend upon the carrier contracted to serve the airport. As the 737 is significantly quieter than the 727, two sets of contours have been prepared, one for each type of jet. In both cases, it has been assumed that Runway 02 (for a plane arriving in a northerly direction) will be designated as the preferred runway for arrivals and Runway 20 (for a plane departing in a southerly direction or the same runway) will be designated as the preferred runway for departures.

NEF contours were prepared using Transport Canada's NEF computer program. NEFs are used primarily for land use planning around airports and, since sleep disturbance is a potential consequence of airport noise, the NEF computation procedure applies a penalty to nighttime aircraft movements such that each nighttime movement is effectively equal to 16.67 daytime movements, which reflects a 12.2 dB penalty. Although nighttime is normally considered to be from 10:00 p.m. to 7:00 a.m., some workers will be sleeping at any given time throughout the day at the camp buildings and therefore, for this project, the nighttime penalty has been applied to all aircraft movements. In this regard, the NEF contours for this project are somewhat non-standard and are unusually large for this size of facility.

Leq and SEL contours were prepared using the U.S. Federal Aviation Administration, Integrated Noise Model (INM). The Equivalent Sound Level, Leq, indicates the energy average sound level that will result from airstrip operations. The purpose of presenting airstrip noise in terms of Leq is to permit direct comparison of airstrip noise with noise produced by stationary and mobile mining equipment and also to permit comparison of airstrip noise with occupational noise limits. SEL contours for individual airstrip operations have been generated to illustrate the relative differences in noise produced by various aircraft and to permit an assessment to be made of sleep disturbance at both the NWT Diamonds Project exploration camp and at the permanent camp, both of which are located in close proximity to the runway.

Table 2.7-1
Anticipated Numbers of Aircraft Trips to Site

Aircraft	Annual Trips
B727 or B737 Combi-Jet	148
Hercules C130	109
DC4/DC3/HS748/C46 Prop Cargo	149
Twin Otter, etc.	14
Gulf Stream	72
Total for Construction Period	**492**
Preproduction Period	
B727 or B737 Combi Jet	170
B727 or B737 Cargo Jet	20
Hercules C130	20
DC4/DC3/HS748/C46 Prop Cargo	48
Twin Otter, etc.	172
Total for Preproduction Period	**430**
Operations Period (1998 to 2006 - Years 1 to 9)	
B727 or B737 Combi Jet	208
B727 or B737 Cargo Jet	15
DC4/DC3/HS748/C46 Prop Cargo	52
Twin Otter, etc.	208
Small Jets	26
Total for Years 1 to 9	**509**
(2007-Onwards - Years 10 to 25)	
B727 or B737 Combi Jet	260
B727 or B737 Cargo Jet	20
DC4/DC3/HS748/C46 Prop Cargo	72
Twin Otter, etc.	292
Small Jets	26
Total for Years 10 to 25	**670**

All of the assumptions and input data used to produce NEF, Leq and SEL contours are described more completely in Appendix IV-B. NEF contours are presented at a scale of 1:25,000 in Figure 2.7-2 and show the location of the proposed permanent camp building in relationship to the NEF contours for both the B727 and B737s.

Housing located between the NEF 30 and 35 contours generally requires special sound insulation and areas inside the NEF 35 contour are normally considered to be unsuitable for residential construction (CMHC 1981) because even if interior levels could be adequately attenuated, outdoor recreation space would remain excessively noisy. As indicated in Figure 2.7-2, the permanent camp building will be located on the NEF 40 contour if B727s are used or the NEF 35 contour if B737s are used. Hence, without any mitigation in terms of special sound insulating construction, there would appear to be some adverse noise impact on this facility. However, comparison of predicted NEFs at the permanent camp against these standard criteria may not be totally appropriate, since application of the nighttime weighting penalty throughout the entire day has resulted in significantly higher NEF values even though nighttime weighting is not particularly relevant to residents while they are outside of the building.

The NWT Diamonds Project exploration camp is within 200 m of the runway. Consequently, noise levels at this temporary location will be much higher than at the permanent camp. Although NEF contours are not normally computed, and may not be valid, in such close proximity to a runway it is estimated that the NEF at the exploration camp would likely exceed 45. By normal standards for permanent housing, NEFs in this range would be considered unacceptable.

Equivalent sound level (Leq) contours for both arrivals and departures of B727 aircraft are presented in Figure 2.7-3 in relation to the project boundaries. The SEL contours are presented in Appendix IV-B.

It can be concluded both from the Leq contours and the SEL contours that there would be no risk of hearing damage for the occupants of either the exploration camp or the proposed permanent camp. Interference with communication would be likely within the exploration camp during aircraft noise events.

As noted previously, NEF contours are used primarily for land use planning around airports. Sleep disturbance can be assessed more directly by considering the predicted SELs for individual aircraft events. A very large scale field study on sleep disturbance near four U.K. airports was recently reported by Ollerhead *et al.* (1993). The study involved 400 subjects monitored for a total of 5,742 subject-nights and 4,823 separate aircraft noise events with maximum A-weighted noise levels ranging from 60 dBA to over 100 dBA. Both wrist actimeters and sleep-EEGs were used to detect sleep disturbance; it was found that about 40% of the actimetric disturbances represented awakenings of 10 to 15 seconds or more. The

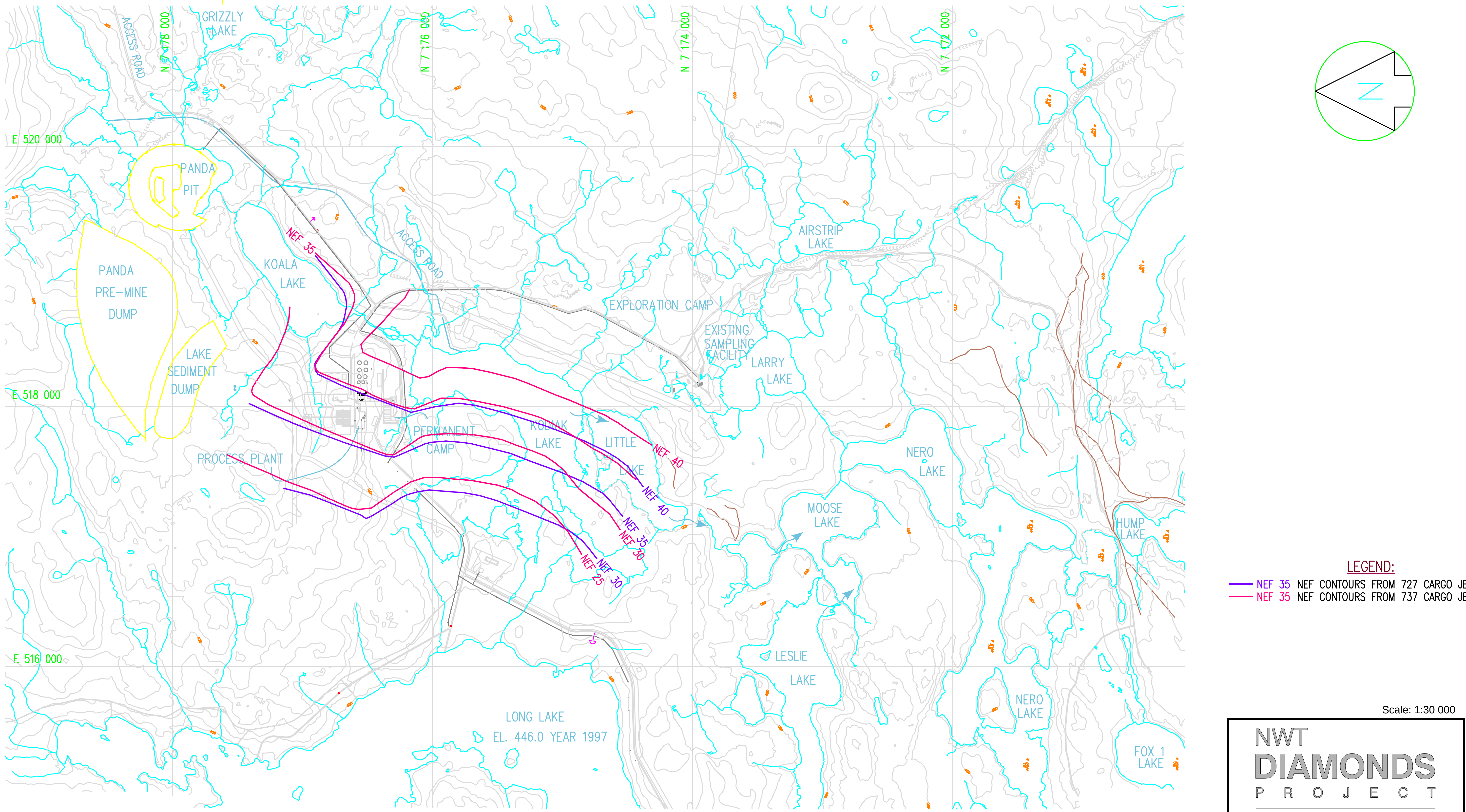
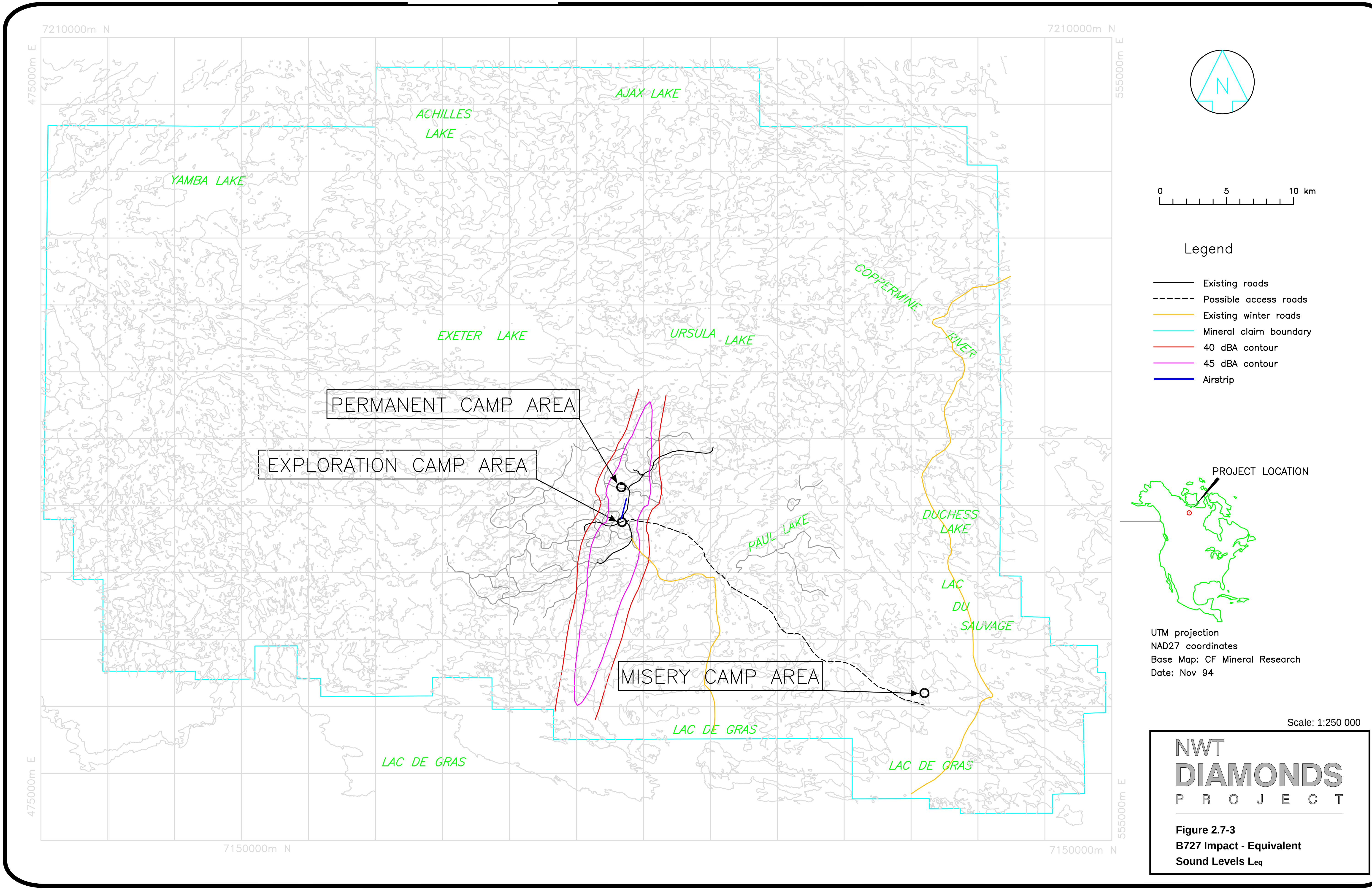


Figure 2.7-2
Noise Exposure Forecast Contours

Source: Rescan



Source: Rescan

main conclusion of the study was that "...once asleep, very few people living near airports are at risk of any substantial sleep disturbance due to aircraft noise, even at the highest event noise levels." At outdoor event levels below 90 dBA, average sleep disturbance rates are unlikely to be affected by aircraft noise. The authors also point out that "...variations about the average are substantial; the most susceptible 2% to 3% of people are over 60% more sensitive than average; some may be twice as sensitive to noise disturbance."

For arrivals on Runway 02 and departures on Runway 20, outdoor SELs at the exploration camp and at the proposed permanent camp will be as indicated in Table 2.7-2.

Table 2.7-2
Sound Exposure Levels at Camps due to Individual Aircraft

	Permanent Camp		Exploration Camp	
Aircraft Type	**Arrivals on Runway 02**	**Departures on Runway 20**	**Arrivals on Runway 02**	**Departures on Runway 20**
B727	<80 dBA	100 dBA	92 dBA	>>100 dBA
B737	<80 dBA	93 dBA	92 dBA	>>100 dBA
DC3	<80 dBA	80 dBA	90 dBA	97 dBA
Twin Otter	<80 dBA	< 80 dBA	88 dBA	85 dBA
Gulfstream	<80 dBA	97 dBA	92 dBA	>>100 dBA

Based on the conclusions from the Ollerhead study and assuming normal building construction, there would appear to be a significant risk of sleep disturbance at the permanent camp only for jet aircraft departures. For the exploration camp, SELs for arrivals on Runway 02 would appear to be marginally unacceptable, particularly considering that the temporary buildings used for worker accommodation can be expected to provide relatively poor insulation from exterior noise. For departures on Runway 20, the SELs predicted for the exploration camp are well above the SEL 90 criterion for all but the quietest aircraft. These results would be essentially the same for arrivals on 20 and departures on 02.

The extent of influence (area of impact) of airstrip noise, if B727 aircraft are used, measured as equivalent noise levels (Leq), is 36 km^2 at/or above 45 decibels and 78 km^2 at/or above 40 decibels. Utilization of B737 aircraft decreases those areas to 16 km^2 and 36 km^2, respectively. There are no recognized criteria that can be used to judge the acceptability of these zones of influence. However, it is unlikely that the long-term baseline levels would have been much below Leq 40. Figure 2.7-3 illustrates the area of impact for the B727 aircraft in relation to the project spatial boundaries.

Individual aircraft could be clearly audible to people on the ground at distances well beyond the airstrip but most individuals are not likely to perceive such noise events as objectionable. For example, at the southern claim boundary, which is approximately 30 km south of the airstrip, maximum A-weighted noise levels received on the ground, directly beneath the aircraft, will be as indicated in Table 2.7-3.

Table 2.7-3
Noise Levels of Individual Aircraft at 30 km from Airstrip

	Arrivals		Departures	
Aircraft Type	**Altitude (m)**	**Maximum Noise Level (dBA)**	**Altitude (m)**	**Maximum Noise Level (dBA)**
B727	1,500	61	3,800	74
B737	1,500	62	3,800	73
DC3	1,500	57	3,000	60
Twin Otter	1,500	58	4,000	53
Gulfstream	1,500	56	4,000	71

The altitudes indicated in Table 2.7-3 for arrivals assume a 3° glide slope. The altitudes for departures were obtained from the Integrated Noise Model computer program. Maximum noise levels for each type of aircraft at the indicated altitudes were determined using a computer data base, “Omega 10.8”, developed by Armstrong Aerospace Medical Research Laboratory at Wright-Patterson Air Force Base, Ohio, U.S.A.

There will be a limited amount of helicopter traffic associated with exploration activities at the site. It is estimated that, on average, about 4 h/d will be required and these flights will normally be within the perimeter of the claim boundaries. The most common helicopters used are likely to be Bell models 205 and 206. Flight altitudes are generally <150 m above ground level. Maximum noise levels on the ground will depend upon many factors including the helicopter type and operating conditions as well as the altitude of the helicopter and the lateral distance from the helicopter flight track and the observer on the ground. Helicopter noise level data reported in the technical literature is rather incomplete and often inconsistent. The predicted values indicated in Table 2.7-4 have been derived from partial information contained in several of these references (Transport Canada 1985, Newman *et al.* 1982, and Broderson and Edwards 1976) and, although they represent the best data available they provide only an approximate indication of noise levels to be expected.

Table 2.7-4
Helicopter Noise Levels

Helicopter Model	Helicopter at 75 m Altitude			Helicopter at 150 m Altitude		
	Receiver on Flight Track	150 m off Flight Track	500 m off Flight Track	Receiver on Flight Track	150 m off Flight Track	500 m off Flight Track
Bell 206	86 dBA	79 dBA	60 dBA	80 dBA	77 dBA	65 dBA
Bell 205	93 dBA	86 dBA	68 dBA	87 dBA	84 dBA	72 dBA

The values shown in Table 2.7-4 illustrate the fact that as a helicopter decreases to a lower altitude, noise levels on the ground directly beneath it will increase but noise levels beyond a certain lateral distance from the flight track will actually decrease. This occurs because sound passing over the ground at a "grazing" angle of incidence is subject to additional "ground attenuation" that does not occur when the helicopter is directly or almost directly overhead.

Noise from helicopter operations will occur almost entirely within the claim boundaries of the project and at most locations it will occur very infrequently. The predicted levels are unlikely to be considered objectionable by most humans. Potential effects on wildlife are discussed in Section 3.3.

2.7.2.1 Mitigation

At the proposed permanent camp, noise from jet aircraft departures could result in some sleep disturbance which will be mitigated through the design and construction of the building to attenuate aircraft noise. Such measures would likely include the provision of improved windows and insulated cladding on the building exterior. Although the detailed camp design has yet to be carried out, the types of measures described above are capable of providing the additional attenuation that would be necessary to prevent sleep disturbance for most individuals.

At the existing exploration camp and to a lesser extent the construction camp, noise from jet aircraft departures will be well above the threshold at which sleep disturbance is to be expected. Since the housing consists of temporary structures, and feasible means of mitigating this adverse impact or relocating the people to the permanent or construction camp would be likely. Given the short-term nature of the construction period, with predominantly dayshift work and daytime flights, the impacts are considered negligable.

Noise from aircraft beyond the immediate vicinity of the airstrip will be audible on the ground, but the predicted levels, which range from 53 dBA to 74 dBA, are unlikely to be annoying to most people. If small aircraft noise is found to adversely affect wilderness tourism activities in particular areas, it may be possible to mitigate any such impact by requesting pilots to avoid these particular areas. Similarly, in the case of low flying helicopters, any predicted impacts on wildlife could be mitigated by establishing minimum altitudes or avoiding particular areas altogether during sensitive periods. Further details were provided in the air traffic management plan (Volume III, Section 6.3).

2.7.2.2 Residual Impact

Residual impacts of aircraft noise are expected to be negligible, with the implementation of necessary mitigative measures.

2.7.3 Noise from Mining Operations

Noise from mining activity will be ongoing into the areas adjacent to the pits and to the process plant. The day-to-day noise levels produced will vary depending on the extent and location of the equipment that is operating. To assess the noise produced by the mine, four scenarios were developed. The scenarios were selected at two general locations: one at the Panda pit, which incorporated both the equipment working this pit and equipment working at the process plant, and the other at the Misery pit. The scenarios were selected based on the following concepts:

- At the early stages of development of each pit, the equipment will be working at or near ground surface and the noise will not be attenuated by the pit walls. However, at the later stages of development, a significant proportion of the equipment will be operating in the pit, and the pit walls will offer substantial shielding to horizontal sound propagation.
- The early production stage of each pit will involve the most equipment.
- Infrastructure noise sources such as the process plant and power plant will be relatively constant throughout the life of the project.
- Winter and summer noise propagation will vary significantly due to the seasonal variation in atmospheric thermal gradients.

For each of the scenarios, probable haul roads were established for both waste and ore. The equipment was distributed throughout the site, and noise levels were assigned to each piece of equipment based on its duty cycle. In the case of trucks on the haul roads, the vehicles were modelled based on a statistical distribution along the length of each road. The noise levels that were used for various types of equipment are listed in Table 2.7-5. Complete details of the modelling process as well as the detailed input data for the computer modelling are contained in Appendix IV-B.

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Table 2.7-5
Noise Source Frequency Spectra Used for Prediction of Stationary and Mobile Mining Equipment

Equipment	Model	Data source	Noise Levels at 15m Octave Band Centre Frequency Spectra Used for Prediction of Stationary and Mobile Mining Equipment 63	125	250	500	1000	2000	4000	A-Weighted Level (dBA)
Mine Production Equipment										
2160 HP Haul Truck	CAT 793	A, B, C, D	85	86	83	84	83	80	78	88
920 HP Haul Aux. Truck	CAT 777C	A, B, C, D	82	83	80	81	80	77	75	85
10K Gallon Water Truck	CAT 769C	A, B, C, D	82	83	80	81	80	77	75	85
Highway Haul Truck	various	B, K	80	82	81	80	79	73	67	83
Rubber Tired Loader	CAT 994	B, C, D	80	83	81	77	80	80	70	85
Excavator/Backhoe	CAT 330L	D, G, H	80	82	77	74	74	69	65	78
Track Dozer	CAT D10L	B, D, F, H	85	88	82	86	82	82	80	89
Rubber Tired Dozer	CAT 834B	B, D, F, H	79	82	76	80	76	76	74	83
Grader	CAT 16G	D, H	84	86	81	78	78	73	69	82
Air-Track Pneumatic Drill	small dia.	E	91	87	88	95	89	89	87	96
Diesel Rotary Drill	BE 49R/47R	B, D, F, H	85	88	82	86	82	82	80	89
Hydraulic Shovel	P&H 1550/2250	B, D, F, H	81	82	79	80	79	76	74	84
Gyrating (Primary) Crusher	Fuller 42"x65"	A, J	90	90	87	93	89	82	74	93
Mine Support Equipment										
Main Powerplant	(4) CAT 3616	D	95	74	67	70	74	76	75	81
Powerplant at Misery	(2) CAT 3516	D, I	60	54	57	59	64	65	65	70
Excavator	CAT 375	D, G, H	80	82	77	74	74	69	65	78
Track Dozer	CAT D6H	B, D, F, H	79	82	76	80	76	76	74	83
Loader	CAT 966F	B, C, D	73	76	74	70	73	73	63	78

A: Barron Kennedy Lyzun & Associates Ltd. in-house measurement data from Revelstoke Dam construction site.
B: field data from Bolt Beranek and Newman Inc., "Noise Control for Buildings and Manufacturing Plants", 1981.
C: Barron Kennedy Lyzun & Associates Ltd. in-house measurement data from open pit mine Sparwood, B.C.
D: manufacturer's data from Finning Ltd.
E: measurement by Barron Kennedy Lyzun & Associates Ltd. near Keenleyside Dam.
F: EPA, "Noise from Construction Equipment and Operations, Building Equipment, and Home Appliances", 1971, pg.11.
G: M. Koyasu, "Evaluation and Control of Construction Noise: The State-of Art", Internoise 84, pg. 773 to 776.
H: K. Mugikura, *et al,* "A Simplified Prediction Method for Noise Propagation at Construction Sites", Internoise 84, pg. 777 to 782.
I: Estimate by Enclosure Manufacturer, Sonic Barrier Ltd.
J: Estimate by manufacturer (Fuller).
K: Maximum noise level permitted by Transport Canada for new heavy duty trucks under maximum acceleration is 83 dBA.

Information on wind and thermal conditions was developed from an analysis of data contained in Section 2.6. Reference was also made to the frequency and duration of extremely stable events described in Section 2.5.

Panda Pit Scenario 1 was developed based on the year 1998. Although this will be a production year, it was selected because it will be the first complete year of operation for which data are available. Operation of the process plant and the power plant have also been included in this scenario.

Panda Pit Scenario 2 includes the Koala pit and was developed based on the year 2000. This year represents a combination of production mining in Panda pit and initial clearing of overburden in Koala pit. Operation of the process plant and the power plant have also been included in this scenario.

Misery Pit Scenario 1 was developed based on the year 1999, representing early development at Misery with equipment operating at or near the surface.

Misery Pit Scenario 2 was developed based on the year 2001, representing an early year of full production at the pit.

The resulting Leq contours for the worst case scenarios for the Panda/Koala area and the Misery area are shown in Figure 2.7-4. The contours have been developed for 35 dBA and 40 dBA. A review of the contours leads to the following observations:

- The contours for the Panda/Koala pits cover a significantly larger area than those for the Misery pit. This is due to two factors. First, the Panda/Koala contours include noise from the process plant and power plant. Second, the Misery pit is to be mined using smaller (and therefore less noisy) equipment than the Panda/Koala pits.

- For all scenarios, the winter contours are larger than the summer contours. This is due to the increased rate and duration of temperature inversions in the winter season, which promotes efficient propagation of sound by refracting (bending) sound waves back down towards the ground.

Since the 24 hour Leq without any project activity would almost always be at least 30 dBA, the 35 dBA contours in Figure 2.7-4 represent the extent to which mining noise may exceed the pre-project ambient levels by up to 5 dBA. For purposes of assessing environmental noise impacts, increases of <5 dBA relative to pre-project conditions are often considered to be of questionable significance. Therefore, the 35 dBA contours presented in these figures provide an approximate indication of the zone of influence of mining noise. These zones of influence are all well inside the NWT Diamonds Project claim boundary and generally extend less than a few kilometres from the actual mining activity. Consequently, it is

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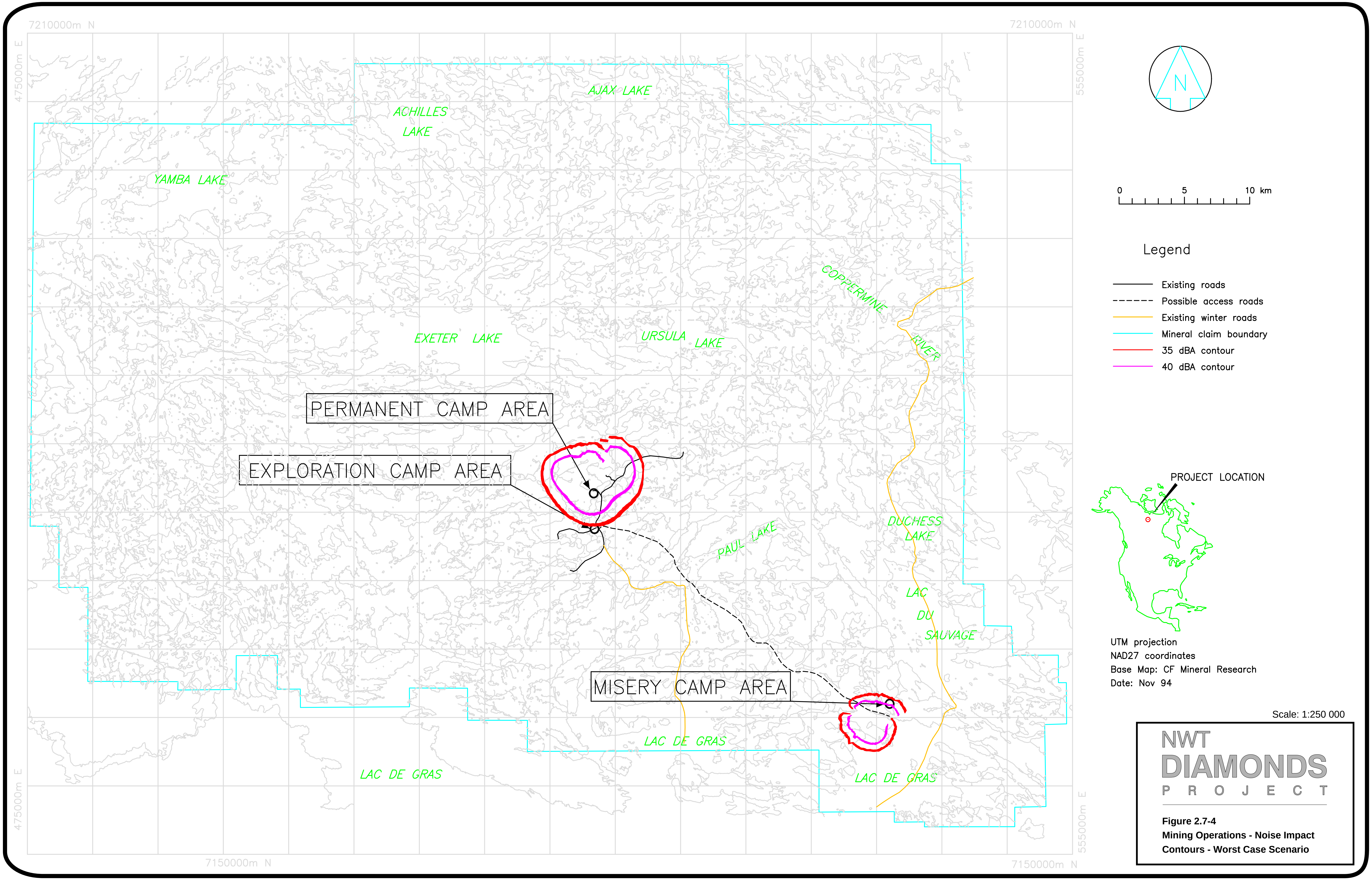

Figure 2.7-4
Mining Operations - Noise Impact Contours - Worst Case Scenario

Source: Rescan

unlikely that any non-project personnel will be within these areas and, as a result, no adverse noise impact on humans is anticipated.

In addition to the mining noise discussed above, highway trucks hauling ore along Misery road will also contribute to the noise environment. Along the majority of the road, trucks are likely to be the predominant and often the only audible source of project noise. Since new highway trucks will be purchased specifically for the project, it is assumed that these trucks will comply with Transport Canada noise limits for new heavy duty trucks. The Transport Canada limit is 83 dBA measured at 15 m from the truck as it passes under maximum acceleration (i.e., under the noisiest operating condition). The rate at which this truck noise will attenuate with distance will depend to some extent on ground cover and atmospheric conditions. However, during conditions that promote efficient sound propagation, for example during inversions, the maximum noise level from trucks will attenuate approximately 6 dB per doubling of source-to-receiver distance. Assuming a maximum noise level of 83 dBA at 15 m from the road, maximum noise levels at distances beyond 15 m would be as indicated in Table 2.7-6.

Table 2.7-6
Maximum Passby Noise Levels for Trucks on Misery Haul Road

Distance from Road (m)	15	30	60	120	240	480	1,000
Max. Noise Level (dBA)	83	77	71	65	59	53	47

During the production years for Misery pit, a daily average of 1,500 tonnes of ore will be hauled by truck to the process plant. Assuming that 50 tonne trucks will be used, there would be approximately 30 round trips per day between Misery pit and the process plant. Therefore, any given location along the road could experience 60 truck passbys per day, which averages about one every 25 minutes.

The noise levels presented in Table 2.7-6 are the maximum levels that are expected during any individual truck passby. These maximum levels might persist for only a few seconds at locations close to the road and for perhaps as long as a minute at locations more distant from the road. Long-term average levels due to traffic along Misery haul road would be extremely low due to the brief duration of each noise event.

2.7.3.1 Mitigation

No mitigation measures are deemed necessary in the areas around the pits and process plant.

2.7.3.2 Residual Effects

In summary, the impact of noise on people as a result of mobile and stationary mining equipment is predicted to be negligible. Potential impacts on wildlife are discussed in Section 3.3.

2.7.4 Noise from Blasting

Blasting will be employed at all of the proposed pits to dislodge rock. Blasts will typically take place once per day and will utilize sequential delay systems. These delay systems typically allow for between 10 and 100 sequential delays that subdivide the overall blast into many smaller blasts, each separated by sequential time delays ranging anywhere from 10 to 100 m/s. The overall duration of each blast for this project will typically be in the 1 to 2 second range.

As discussed previously, noise from blasting is usually assessed on the basis of single noise events rather than long-term averages, because blast noise is typically infrequent and of short duration but with relatively high peak levels. Although SEL have been used by some authorities to assess blasting noise, the peak instantaneous noise level (unweighted) is still widely used and forms the basis of many blast noise criteria. Peak noise from blasting is occasionally expressed in terms of peak overpressures (Pa/m^2) but more often in decibels (dB).

Caution must be exercised in comparing peak instantaneous noise levels (in dB) for impulsive noise against A-weighted maximum noise levels (in dBA) for non-impulsive noise. Subjectively, noise from an impulsive event such as blasting will be perceived to be much quieter than its unweighted peak level might suggest. In other words, a blast producing a peak level of 100 dB would be perceived as being much quieter than a non-impulsive event, such as an aircraft flyover, which produces an A-weighted maximum level of 100 dBA. For this reason, it is recommended that blast noise predictions be assessed relative to blast noise criteria rather than by comparison with the noise levels predicted for other types of noise.

Blast noise is predominantly low frequency sound and for that reason it is quite omni-directional. Although localized “shadow zones” will occur behind topographic features such as waste dumps, low frequency sound will readily refract/bend around any such obstacles such that the noise levels beyond the “shadow zone” will be much the same as they would have been without any barrier. Consequently, predicted levels of blast noise for this project have simply been computed in terms of peak noise levels at various distances from the source.

During the initial development of each pit, blasts will be close to the original elevation of the ground. However, as the pits become deeper, the perimeter edges of the pit will act as barriers to sound, with the result that blast noise beyond the perimeter of the pit will be attenuated by an amount that will depend upon the depth of the pit. The pits will be developed in a series of benches, each approximately 15 m high. According to one previous study (Griffiths and Oates 1978), the additional attenuation to be expected for blast noise originating on the first, second and third bench below original ground level would be approximately 2 dB, 6 dB and 13 dB, respectively. It is unlikely that the additional attenuation would ever exceed 15 or 20 dB, even for very deep pits, because of reflection of sound off the far side of the pit.

Peak unweighted noise levels for this project have been predicted at distances up to 2 km from the blast using the following empirical formula reported by Fidell *et al.* (1983):

$$AB = 0.162(D/W^{1/3})^{-0.794}$$

where AB is the air blast overpressure in pounds per square inch (psi), D is the distance in feet and W is the maximum charge per delay (weight of explosive detonated at any one instant) in pounds. The overpressure in psi is then converted to peak noise level in dB using the relationship

$$SPL - 20\log(AB) + 170.75$$

where SPL is sound pressure level (i.e., peak noise level) in dB and AB is the air blast overpressure in psi.

As a check on the empirical formula, reference was made to noise measurement data obtained from a number of blasts monitored by BHP at Island Copper, an open pit mine near Port Hardy, B.C. The Island Copper blast noise data were measured at distances ranging from 60 m to 300 m, and the charges per delay ranged from 45 kg to 360 kg. The type of blasts carried out at Island Copper are directly comparable to those proposed for the NWT Diamonds Project. Comparison of the Island Copper data with results that would have been obtained using the prediction formula showed reasonably good consistency.

The attenuation of blast noise with increasing distance beyond 2 km has been predicted using data reported by Schomer and Luz (1994). The Schomer and Luz data address two different atmospheric conditions. The first condition is one that results in very efficient sound propagation. It typically exists when the receiver is downwind of the source or when a temperature inversion occurs. The second condition is one that results on most other occasions, for example, when the receiver is upwind of the source, during calm wind conditions or when neutral or lapse temperature gradients exist. Hence, these two conditions provide an indication of blast noise propagation during both “normal” and “worst case” conditions.

Table 2.7-7 shows predicted peak noise levels for two different weights of explosive per delay and assuming the two different types of propagation conditions as discussed above. The levels presented in the table assume no acoustic shielding by the perimeter of the pit. For blasts significantly below the elevation of the edge of the pit, peak noise levels could be as much as 15 to 20 dB lower than the values shown in Table 2.7-7.

Table 2.7-7
Predicted Peak Noise Levels due to Blasting

Distance from Blast (km)	45 kg (100 lb) per Delay "Normal" Propagation	45 kg (100 lb) per Delay "Efficient" Propagation	400 kg (900 lb) per Delay "Normal" Propagation	400 kg (900 lb) per Delay "Efficient" Propagation
0.5	115	115	120	120
1	110	110	115	115
2	105	105	110	110
4	87	99	93	104
6	77	95	82	100
8	70	92	75	97
10	64	90	69	95
20	47	84	52	89
30	36	73	41	78

Criteria for judging the acceptability of blast noise in terms of unweighted peak noise levels have been suggested by several authorities (Taylor *et al.* 1975; Pater 1975; Kamperman 1980). Such criteria have generally been developed in response to complaint data or surveys carried out among residents living in close proximity to quarries or artillery ranges. Taylor *et al.* (1974) report that no significant public reaction is apparent during day or night for peak levels below 128 dB, whereas Pater (1975) reports a low risk of noise complaints for peak levels below 115 dB. Kamperman (1980) reports that, based on sonic boom data, roughly 10% of the population would be "highly annoyed" by peak levels of 128 dB whereas few, if any, would be "highly annoyed" by peak levels below 122 dB. Taking all of these into account, a conservative criterion would appear to be 115 dB for avoidance of complaints.

As indicated in Table 2.7-7, predicted peak levels from blasting are all well below 115 dB except immediately adjacent to the mining pits. However, it is conceivable that the mere audibility of blast noise might be considered objectionable by some individuals involved in wilderness tourism activities. Therefore, it would be desirable to know the extent of audibility for blast noise. Unfortunately, considering the variability to be expected in source levels, sound attenuation over distance and background noise levels at receiver locations, it is only possible to estimate a range of audibilities to be expected under most conditions.

Based on the predicted peak levels presented in Table 2.7-7 and expected background levels of 25 to 40 dBA at locations remote from project activity, the extent of blast noise audibility is estimated to be in the order of 8 km during "normal" atmospheric conditions and 30 km during temperature inversions or downwind conditions. The only outfitter's camp known to be located within 30 km of any mine pit is approximately 22 km east-southeast of the Misery pit. As noted previously, the unweighted peak levels presented in Table 2.7-7 will be perceived to be much quieter than steady, A-weighted levels having the same decibel values, and this has been taken into account in estimating the extent of audibility of blast noise. Once several benches have been established in the mining pits, the additional "barrier" attenuation that will reduce the extent of audibility to as little as 4 km during "normal" atmospheric conditions and 10 km during temperature inversions or downwind conditions.

2.7.4.1 Mitigation

Peak noise levels from blasting will be below the 115 dB criterion of acceptability at both the exploration and permanent camps, but many blasts will be clearly audible at these locations. However, blasts will generally be scheduled at approximately the same time each day, which will help to habituate workers to this daily noise event, thereby minimizing any startle or annoyance. Although no studies have been conducted on the subject to date, it is reasonable to assume that the regular timing of blasts might also help to habituate wildlife within the audible range of blast noise. Through the use of control blasting techniques, peak noise can be reduced by using longer detonator delay periods and lowering the explosive weight per delay.

2.7.4.2 Residual Effects

In summary, the impact of blasting on humans is anticipated to be negligible. Persons involved in wilderness tourism activities may hear blast noise on some occasions if they are within roughly 30 km of a mine pit. There should be negligible impact at or beyond the spatial boundary (claim boundary) for this project.