August 20, 2014

DRILLING AND BLASTING DESIGN AND RELATED REGULATORY CONSIDERATIONS

Kiggavik Project

Submitted to:
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Report Number: 10-1345-0026 Task 3 REV 1

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REPORT

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Executive Summary

AREVA Resources Canada Inc.'s (AREVA's) Kiggavik property is situated approximately 80 km west of Baker Lake, Nunavut Territory. The Kiggavik Project can be divided into two main deposit areas: the Kiggavik area; and the Sissons area. Main, Centre and East Zone deposits are located within the Kiggavik area, while the Andrew Lake and End Grid deposits are located within the Sissons area, approximately 15 km to 17 km south of the Kiggavik area. AREVA has retained Golder Associates Ltd. (Golder) to assess drilling and blasting design for the proposed Kiggavik mining operations.

The study is intended to assess the potential to develop the Kiggavik Project by open pit mining at the Main, Centre and Andrew Lake deposits and underground mining at the End Grid deposit without incurring blasting related damage to the proposed infrastructure and local environment yet producing adequately fragmented rock. This document is a report of Golder's findings and is based on information provided to us by AREVA, published literature and Golder's experience from similar projects.

The original open pit blast designs proposed by AREVA used 150 mm diameter blastholes. Alternate blast designs have been proposed using 187 mm diameter blastholes. These are intended to reduce the cost of drilling and blasting while maintaining the impacts of blasting to below regulatory and non-regulatory limits. In order to limit the water damage to the explosive, which would result in poor blast performance and elevated nitrogen release levels, a doped emulsion of 70/30 (Emulsion/AN) blend is recommended. The potential impacts of blasting at the Kiggavik Project include ground vibrations, potential impact on fisheries, release of nitrogen compounds in mine water, flyrock and fragmentation size distribution produced by the proposed designs.

Golder understands that contract development mining will be retained for primary development and production ore mining at the End Grid underground operations. Therefore, design and implementation of the underground blasts are not included in this report. However, general comments are made regarding the potential for blast-induced impacts and potential methods to mitigate these, if necessary.

In general, there is little potential risk to the proposed infrastructure from vibrations induced by the proposed blast designs. Flyrock ranges and suggested clearance radii are less than the initially proposed clearance zone of 500 m. As well, the fragmentation size distribution is estimated to be greater than 95% passing for the maximum fragment size of 1.0 m.

The study indicates that the most obvious threats to the infrastructure are blast-induced ground vibrations at the Andrew Lake Dewatering Structure and the potential to exceed the Fisheries and Oceans Canada (DFO) limit (13 mm/s) if active spawning beds occur in the water bodies at locations nearest the pit crest. These threats are the highest as the blasting operations approach the proposed ultimate pit crest. As the blasting operations approach the ultimate pit crest, an increased collar and/or decking may be required to maintain vibrations below limits for the Andrew Lake Dewatering Structure and any active spawning beds which may occur near the shores of Andrew Lake closest to the dike.

It is important to remember that the analyses for ground vibrations, flyrock, instantaneous underwater overpressure and fragmentation presented in this report are based on empirical formulae which are commonly used in the blasting industry to assess these blasting effects. The models are intended as first approximations that should be calibrated to provide more refined estimates.

It is suggested that test programs be developed and conducted to calibrate and refine the ground vibration, flyrock, instantaneous water overpressure and fragmentation model parameters presented in this report. It is recommended that these be carried out during the initial phases of blasting at Kiggavik. A continued refinement of the models proposed is recommended in order to provide more accurate estimates and potentially allow for an optimization of blast designs as the blasting operations continue.

Mines are subject to regulations limiting ammonia, nitrate and nitrite levels in mine effluents released into the environment. In order to mitigate the potential impacts related to the loss of nitrogen compounds from the blasting operations, an effective explosives management system should be implemented as part of production start-up. This should be done for both the open pit and underground operations.

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1.0 INTRODUCTION

AREVA Resources Canada Inc. (AREVA) has retained Golder Associates Ltd. (Golder) to assess drilling and blasting design for the proposed Kiggavik Project in Nunavut Territory.

The Kiggavik property is situated approximately 80 km west of Baker Lake, Nunavut (Figure 1). The Kiggavik Project can be divided into two main deposit areas: the Kiggavik area; and the Sissons area. Main, Centre and East Zone deposits are located within the Kiggavik area, while the Andrew Lake and End Grid deposits are located within the Sissons area, approximately 15 km to 17 km south of the Kiggavik area, as shown on Figure 2.

The scope of work for this task is as follows:

- Review Golder's geotechnical database and summarize the existing geomechanical properties as they relate to blasting.
- Review AREVA's initially anticipated mine design parameters as well as available drilling and excavating equipment.
- Review the vibration, flyrock, fragmentation and water overpressure limitations set by regulatory agencies or internally by AREVA.
- Provide blast design criteria on the basis of the engineering geological model, available equipment, and required end-product from the blasting.
- Provide a comparative assessment of the available explosives (e.g. ANFO, Emulsion and Emulsion/AN blends). This will entail a trade-off assessment considering issues such as explosive and drilling costs as well as potential environmental impacts.
- Provide a review of issues related to the loss of nitrate, nitrite and ammonia associated blasting and provide a blast management plan intended to mitigate such losses.

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SCALE 1:7,500,000 KILOMETRES

Legend

- Community
- Proposed Kiggavik - Sissons Location

Reference
ESRI Canada Data
Atlas of Canada Data

PROJECT

AREVA

AREVA RESOURCES CANADA INC.
KIGGAVIK PROJECT

TITLE

GENERAL SITE LOCATION

Golder Associates
Sudbury, Ontario

PROJECT		10-1345-0026	FILE No.	
DESIGN	MD	09/10/09	SCALE AS SHOWN	REV. 0
GIS	RRD	07/02/11	**FIGURE: 1**	
CHECK	DC	Apr. 2011		
REVIEW	DS	Apr. 2011		

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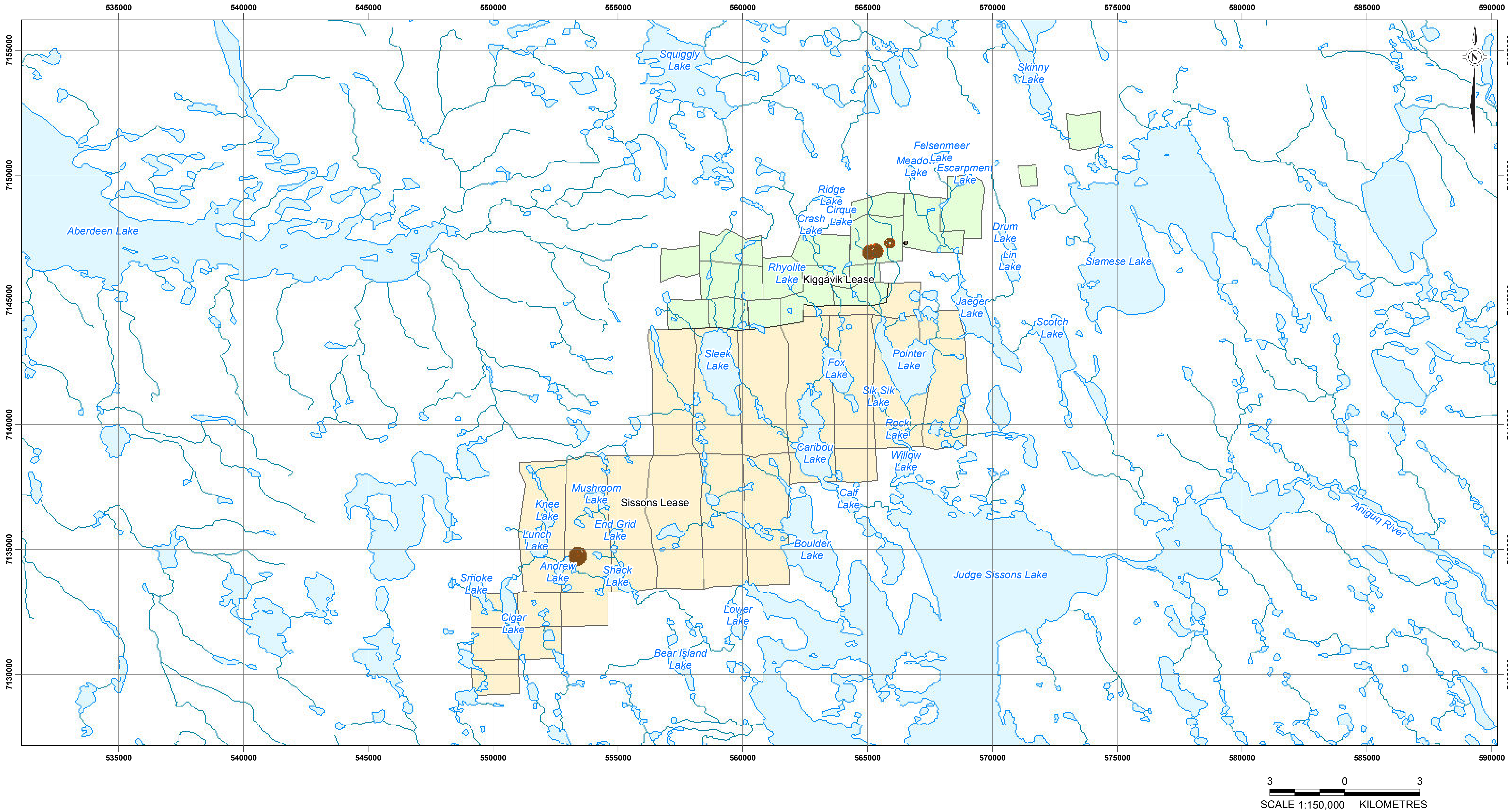


Legend

- Kiggavik Lease
- Sissons Lease

PROJECT

AREVA

AREVA RESOURCES CANADA INC.
KIGGAVIK PROJECT

TITLE

SITE MAP

Reference:
AREVA Resources Canada Inc.
NTS Mapsheets 56D, 66A, 66B
NAD 83 UTM Zone 14

Golder Associates
Sudbury, Ontario

PROJECT		10-1345-0026	FILE No.	
DESIGN	MD	14/10/09	SCALE AS SHOWN	REV. 0
GIS	RRD	07/02/11	FIGURE: 2	
CHECK	DC	Apr. 2011		
REVIEW	DS	Apr. 2011		

2.0 GEOTECHNICAL AND GEOMECHANICAL SUMMARY

2.1 General Geology

The Kiggavik Project is located within the Rae Province (AREVA, 2007), at the southwest end of the Archean Woodburn Group, and at the northeastern end of the Thelon Basin which formed after the Hudsonian Orogeny (Golder, 1989). The Woodburn group consists of metavolcanic and metasedimentary assemblages, which are in tectonic contact and structurally overlie Archean basement granitic to minor amphibolitic gneisses (AREVA, 2007), while the Thelon Sandstone unconformably overlies a series of geological units ranging from Archean Basement to Aphebian rocks of various metamorphic grades (Golder, 1989). A regional geological map is presented on Figure 3.

Overlying the Woodburn Group is the Meso-Proterozoic Dubwant Supergroup (AREVA, 2007). The Dubwant Supergroup can be subdivided into the Baker Lake, Wharton and Barrensland Groups, in ascending order. The Baker Lake Group consists of several sedimentary redbeds which are not exposed near the Kiggavik area, as well as the Christopher Island Formation, which may have intrusive equivalents present as syentic dikes within the Sissons area. The Wharton Group unconformably overlies the Baker Lake Group, and consists of the felsic volcanic Pitz Formation and fluorite-bearing granite (AREVA, 2007). The Pitz Formation is not present in the Sissons area, and the fluorite-bearing granite has been locally named the Lone Gull Granite. The Lone Gull Granite has been interpreted to be older than the Wharton Group. The Barrensland Group unconformably overlies the Wharton Group (AREVA, 2007). It mainly consists of the Thelon Formation, which is exposed to the north of the Sissons area, and the MacKenzie diabase dikes, which are the youngest rocks within the project area.

2.2 Kiggavik Area Deposits

The Kiggavik area is located between two regional fault zones (AREVA, 2007). The Thelon fault is located to the north, while the Sissons fault is located to the south. The Kiggavik deposits (Main, Centre and East Zones) follow a local 65° east-northeast trending shear zone (Figure 3). Basement host rocks are composed of metasediments (mainly metaarkoses and metapelites overlain by orthoquartzites), and to a lesser extent altered granite and intrusives. Despite their considerable metamorphic overprint, these rocks appear to be essentially flat lying with the foliation/bedding dipping north at 10° to 20° (Golder, 1989).

The lithology in the Main Zone deposit consists of granite and metasediments, with the near vertical fault serving as the contact between the two units. At Main Zone, a northwest-southeast trending dike of MacKenzie diabase cuts through the middle of the deposit, and is unmineralized (AREVA, 2007).

Main Zone consists of two parallel running major lenses, which are elongated along strike (AREVA, 2007) and are approximately 20 m to 30 m thick, as well as two minor lenses. The major lenses trend east-northeast with a plunge of approximately 25°, and are controlled by the intersection of the shear zone with a near vertical northeast trending fault. Generally, mineralization at Main Zone occurs to depth of approximately 150 m to 190 m below ground surface (mbgs). Mineralized zones are associated with an intensive alteration halo, characterized by desilicification and argillization with mainly illite and sericite.

Centre Zone is located approximately 600 m to the east of Main Zone, along strike of the shear zone (AREVA, 2007). Mineralization occurs in two lenses with a shallow depth, extending to a depth of approximately 100 m below ground surface. The footwall rock consists of an orthoquartzite horizon, which controls the dip of the mineralized lenses.

East Zone is located approximately 500 m to the east of Centre Zone, along strike of the shear zone (AREVA, 2007). Mineralization within the East Zone is similar to that of Centre Zone, and occurs up to 60 mbgs.

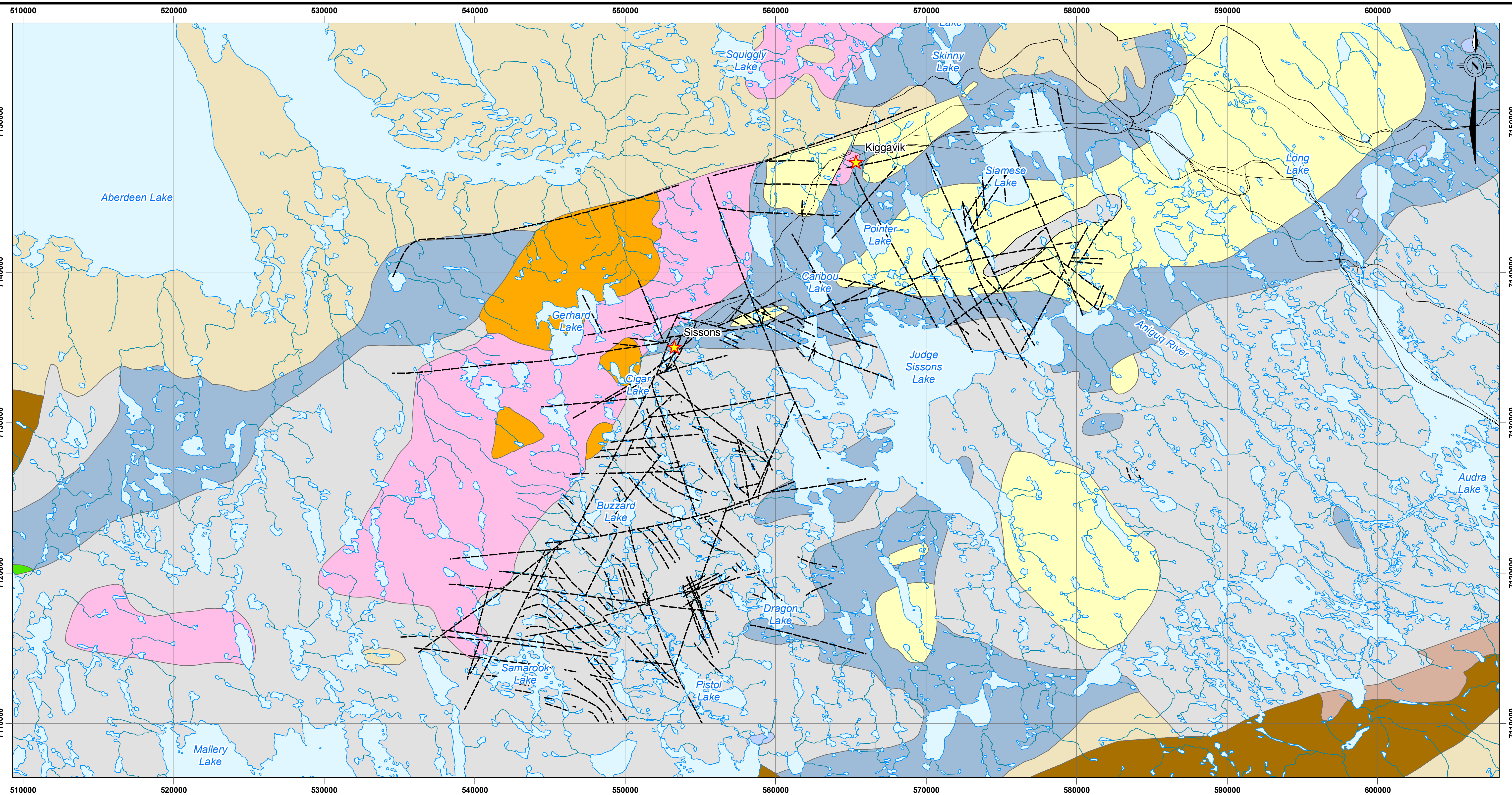
2.3 Sissons Area Deposits

The Sissons deposits are located in pelite and arenitic metasediments overlying granitic gneisses and granodiorites (AREVA, 2007). These formations have been strongly metamorphosed and altered, tectonised, and intruded by lamprophyres, syenites and granites. The rocks have gently dipping foliation, small scale recumbent folding and low angle thrusting. The area also consists of steeply dipping brittle deformation zones that trend east-northeast to north-northeast as a conjugate set. Three main faults (the Sissons North, Buzzard Lake and Andrew Lake) intersect the area.

The Andrew Lake deposit is located on a major east-northeast structure (AREVA, 2007) (Figure 3). This region has seen several episodes of hydraulic brecciation mainly within the granite and syenite rocks, and to a lesser extent in the metasediment units. The subvertical faulting associated with the Andrew Lake deposit governs the extension of the mineralization.

Three main mineralized lenses have been identified at Andrew Lake (AREVA, 2007). These are associated with strongly altered metasediments (metagreywackes and metapelites), altered paragneiss, and less altered metasediments. The lenses overlie each other, and are separated by a quartz breccia and paragneiss. Mineralization within the Andrew Lake area occurs between 70 m and 270 m below ground surface.

The End Grid deposit is located approximately 960 m northeast of the Andrew Lake deposit. Although the general geology is similar, the End Grid mineralization is located from 250 m to 450 m below surface. It has significantly poorer rock quality than the Andrew Lake deposit. Only underground mining methods are considered for the deposit.



Legend

Project Location	Felsic to intermediate volcanics and associated sediments	Nueltin Intrusive Suite
Fault Structure	Gneiss (undifferentiated)	Orthoquartzite
'other' Proterozoic sedimentary rocks	Gneiss, mostly granulites	Supracrustal rocks (undifferentiated)
Amer Group and equivalents, ca. 2.1 Ga	Granite (undivided)	Syenite
Baker Lake Group, ca. 1.84 Ga	Granitic rocks, granites, and granodiorites	Tonalites, diorites, and gabbros
Barrensland Group, ca. 1.72 Ga	Hurwitz Group and equivalents, ca. 2.1 Ga	Volcanics and sediments of the Prince Albert Group
Dolomitic limestone, sandstone, shale	Mafic volcanics and associated sediments	Wharton Group, ca. 1.75 Ga

5 0 5
SCALE 1:250,000 KILOMETRES

Reference:
Natural Resources Canada 2002
AREVA Resources Canada Inc.
NTS Mapsheets 56D, 66A, 66B
NAD83 UTM Zone 14

PROJECT
AREVA
AREVA RESOURCES CANADA INC.
KIGGAVIK PROJECT

TITLE
REGIONAL GEOLOGY AND STRUCTURE

Golder Associates
Sudbury, Ontario

PROJECT		10-1345-0026	FILE No.
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GIS	RRD	07/02/11	
CHECK	DC	Apr. 2011	**FIGURE: 3**
REVIEW	DS	Apr. 2011	

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2.4 Geotechnical Summary

2.4.1 Material Properties and Rock Mass Quality

In 2009, Golder carried out geotechnical and hydrogeological studies on the Kiggavik Project in order to develop geotechnical criteria for the purpose of open pit mine design (Golder, 2009). A summary of the geotechnical properties presented in that report are summarized in Table 1 and Table 2.

Table 1: Geotechnical Parameters for Kiggavik Main & Centre Zones

Rock Type	Alteration (ISRM)	UCS (MPa)	Youngs Modulus (GPa)	Density (g/cm^3)	Poissons Ratio	RMR (1976)
Metasediments	Highly Alt.	21.8	6.6	2.37	0.01	46 to 66 (fair to good)
	Fresh	98.4 +/- 26.1	44.6 +/- 6.3	2.69 +/- 0.10	0.17 +/- 0.02	62 to 71 (good)
Granite	Slightly to Moderately Alt.	55.9 +/- 27.0	23.9 +/- 18.2	2.42 +/- 0.22	0.10 +/- 0.03	62 to 76 (good)
	Fresh	112.3 +/- 28.5	45.1 +/- 3.4	2.64 +/- 0.05	0.15 +/- 0.01	

MPa = mega pascal, GPa = giga pascal, g/cm^3 = grams per cubic centimetre

Table 2: Geotechnical Parameters for Andrew Lake Zone

Rock Type	Alteration	UCS (MPa)	Youngs Modulus (GPa)	Density (g/cm^3)	Poissons Ratio	RMR (1976)
Metasediments < 200 m depth	Low to Mod. Alt.	29.9 +/- 13.2	11.3 +/- 6.5	2.46 +/- 0.17	0.08 +/- 0.04	42 to 62 (fair)
	Mod. to High Alt.	15.9 +/- 1.7	2.8 +/- 1.5	2.39 +/- 0.17	0.09 +/- 0.05	52 to 74 (fair to good)
Granite	Low to Mod. Alt.	66.5 +/- 20.4	22.4 +/- 2.5	2.53 +/- 0.10	0.15 +/- 0.02	52 to 65 (fair to good)
	Mod. to High Alt.	24.7	6.1	2.45	0.24	
Inferred Fault	Low to High Alt.	7.4 +/- 3.5	1.4 +/- 1.4	2.03 +/- 0.08	0.05 +/- 0.01	42 to 52 (poor to fair)
Quartz Breccia	Low Alt.	35.0	19.9	2.63	0.16	--

MPa = mega pascal, GPa = giga pascal, g/cm^3 = grams per cubic centimetre

The ore is found predominantly in the moderate to highly altered rock while most of the waste has been weakly to moderately altered.

2.4.2 Rock Mass Fabric

The rock mass structure for the Main and Centre Zones was interpreted to be comprised of 4 major sets (denoted B1, FO1, JN1 and FLT1). Set B1 (dip/dip direction: 05°/326°) is associated with bedding and foliation in the metasediments, but is also seen as a prominent joint set in the granitic rock units. Set FO1 (78°/190°) is also associated with foliation or veining both within the metasediments and granites, possibly related to a deformational event. Set FLT1 (78°/190°) is inclined to steeply dipping, trending near parallel to the main ENE trending shear zone associated with mineralization. Set JN1 (79°/233°) is an inferred persistent joint set, trending nearly orthogonal to the main shear zone.

The most dominant set for Andrew Lake (FO1A) is associated with the bedding/foliation with a dip/dip direction of 29°/093°. The other prominent set (JN1) could be related to the east-west trend fault structures cross-cutting the pit (46°/063°). There are also four predominant high angle joint sets and two shallow to inclined conjugate joint sets.

2.4.3 Faults and Shears

The faults and major shear zones identified to date at Main and Centre Zones are continuous enough to impact overall slope designs. The dominant fault systems are interpreted to strike to 065° and 095°. The 065° faults generally appear to dip steeply to the south, while the 095° system is inferred to dip at approximately 60° to the north. The intersection of these fault zones apparently controls the mineralization and linear shape of the orebodies. There is an apparent weakening and alteration of the rock mass up to several metres on either side of the inferred fault trace. Minor cross-cutting faults which dip steeply and trend NNW or NNE have also been observed.

At the Andrew Lake deposit, the regional Andrew Lake Fault is interpreted to lie within the footprint of the proposed pit. It is steeply dipping and trends northeast at 030°. Four dominant north-northeast trending fault features appear to control the lateral extents of the uranium mineralization at Andrew Lake, and strike in the same orientation as the mineralization.

2.4.4 Joint Spacing

The average joint spacings assumed for Main Zone and Centre Zone ranged from 0.7 m to 4.3 m. The average joint spacings estimated for Andrew Lake ranged between 0.5 m to 0.9 m (Golder, 2009).

2.4.5 Permafrost and Groundwater

Conclusions from our 2009 study indicated that the depth to permafrost at Andrew Lake is approximately 250 mbgs (-87 m above sea level (masl)), and approximately 210 mbgs (-30 masl) at Main Zone (Golder, 2009b).

Piezometer pressure readings documented and presented in Golder (2009c) indicate that artesian pressure conditions exist in the groundwater below both the Andrew Lake and Main Zone locations. This corresponds to the artesian conditions recorded in both 1989 by Golder and 2007/2008 by SRK.

The significant conclusion is that the thick permafrost horizon acts as a confined aquifer. Water pressures, based on the installed vibrating wire piezometers, indicate that the piezometric head below the permafrost is at or above ground surface.

The Centre Pit is not expected to mine through the permafrost to expose this confined aquifer. The Andrew Lake and Main pits will be excavated to ultimate depths at or slightly below the current base of permafrost. Some inflow of water into the pits is likely to occur. Sources of water flows into pits in permafrost regions typically include:

- Seepage from melting of permafrost;
- Seepage from unfrozen zones through pit walls;
- Surface run-off and undiverted surface water; and
- Sub-permafrost water.

3.0 MINE DESIGN PARAMETERS

3.1 Open Pit Mining

3.1.1 Open Pit Parameters

Table 3 provides a summary of the mine design parameters currently proposed for the Kiggavik deposits. The pit sizes are based on the results of the 2007 Pre-feasibility Study and recent pit design studies.

Table 3: Mine Design Parameters for Kiggavik Deposits

Parameter	East Zone	Centre Zone	Main Zone	Andrew Lake
Pit Size (10^6 m^3)	2.7	6.9	28.7	38.4
Pit Maximum Depth (m)	~120	~110	~255	~275
Overall Pit Slope (^{o})	40	46 to 51	46 to 51	40 to 45
Bench Height (m)	12 (double bench)	12 (double bench)	12 (double bench)	12 (single bench)
Berm Width (m)	12	11 to 14	11 to 14	8
Bench Face Angle (^{o})	75	75	75	70 to 75
Ramp Width (m)	25	25	25	25

3.1.2 Drilling and Excavating Equipment

The following equipment is proposed for the drilling and blasting operations at Kiggavik:

- Rotary blasthole drill with the following parameters:
  - Diesel powered, self propelled, crawler mounted;
  - 187 mm diameter holes (a possible range of 150 mm to 229 mm);
  - Drill depths up to 45 m;

- Penetration rate estimated at 14.5 m/hr for 150 mm diameter holes;

- 18 m^3 hydraulic shovel for waste mining and a 10 m^3 backhoe for ore mining; and
- 140 tonne trucks for waste hauling and 91 tonne trucks for ore hauling.

3.2 Underground Mining

3.2.1 End Grid Mining Methods and Parameters

The End Grid mineralization is located from 250 m to 450 m below surface, and will be exploited using underground mining methods with the following key design criteria:

- The mining method used will be overhand drift-and-fill with cemented rock fill.
- Contract development mining will be retained for primary development and production ore mining.
- Drilling equipment will consist of electrohydraulic drill jumbos using small diameter holes (<75 mm).
- Explosives used will consist of ANFO and packaged emulsion.
- The dimensions of the panels will be 5 m high and 5 m wide with 3.5 m length rounds resulting in typical blast sizes of 200 tonnes.
- 6 m^3 loaders and 45-tonne trucks will muck and haul blasted material to surface.

4.0 COMPARATIVE ASSESSMENT OF EXPLOSIVES

As described in Section 2.4.5, mining will be carried out primarily in the permafrost, but the Andrew Lake and Main pits will be excavated to ultimate depths at or slightly below the current base of permafrost. Where pit wall development will be within permafrost (i.e. beneath the existing land surface), dry blasthole conditions may exist. Under these circumstances, a product having a lower resistance to water may be considered. However, some inflow of water into the pits is likely to occur. Consequently, the water resistance of the chosen explosive must be considered.

4.1 ANFO

Ammonium nitrate-fuel oil, or ANFO, is the least expensive explosive used by the mining industry. However, the water resistance of ANFO is poor, and it can be desensitized relatively easily even with low water contents. The effect of water on ANFO in the blasthole has been overcome by a number of methods. In the pits, dewatering equipment can be used to dewater the blastholes before loading. The ANFO is then loaded using dryliners, or polythene tubing sealed at the bottom and installed in the blasthole. Golder conducted tests at other open pit operations in arctic environments which indicate that this type of liner introduces significant logistic impediments, particularly in the extreme cold which exists for a large part of the year. For underground development blasting, holes can be dewatered using compressed air and then loaded directly with ANFO provided that the holes are not producing significant water and the charges are detonated within a few hours, usually at the end of the same shift.

4.2 Emulsion

Emulsions consist of an immiscible fuel mixed with a super saturated aqueous solution of ammonium nitrate (AN) (sometimes other oxidizing salts such as calcium nitrate or sodium nitrate are also used). The aqueous AN is in the form of droplets and the fuel forms a thin impervious film around them, thus resulting in a high level of water resistance. Bulk emulsions can provide excellent performance while being less resistant to contamination (by water and/or solid particles) than ANFO.

4.3 Emulsion/AN Mixtures

An alternative to ANFO that overcomes some of the problems associated with water resistance is an Emulsion/AN mixture. The amount of emulsion added to the mixture varies depending on the energy and water resistance requirements. The use of emulsion improves the bulk strength of the explosive and allows for an increase in breakage capacity. Since the AN can be surrounded by emulsion, the water resistance of the product is enhanced considerably from that of straight ANFO. Although the properties for each explosive vary, Table 4 shows the typical properties for Emulsion/AN blends.

Table 4: Typical Properties of Emulsion/AN Mixtures

Emulsion (%)	AN (%)	Density (g/cc)	Velocity of Detonation (m/s)	RWS/RBS	Water Resistance	Loading
100	0	1.3	5900	77/113	Excellent	Pump
70	30	1.3	5700	84/132	Excellent	Pump
50	50	1.3	5500	89/141	Good	Auger
30	70	1.2	4700	93/131	Poor	Auger
25	75	1.1	4600	94/127	Poor	Auger

Reference: Dyno Nobel Inc.

Notes: RWS is the Relative Weight Strength
RBS is the Relative Bulk Strength

In open pit mines, emulsion explosives are typically blended with prills of AN to increase the heave energy and water resistance of the explosive product. By adding a dry phase to an emulsion, the heave energy and, hence, muckpile looseness is increased. The emulsion phase surrounds the AN prills, thus providing water resistance to the product. A typical blend used in wet blastholes is 70% Emulsion and 30% AN (referred to as a 70/30 ratio). In order to avoid explosive dissolution in the potential wet areas of the pits, the use of a 70/30 Emulsion/AN blend is recommended. Explosive sleep times are increased with emulsion content within Emulsion/AN blends, providing improved production flexibility. Recommended sleep times for 70/30 Emulsion/AN blends are approximately 2 weeks. In areas of high water flow, it is often necessary to reduce sleep times below the recommended levels.

Blends are not commonly used underground for the following reasons:

- Good fragmentation is a higher priority in underground operations than muckpile looseness. Added AN would reduce the VOD and, thus, the fragmentation potential.

- To improve the explosive retention within upholes or breakthrough downholes, the viscosity of emulsions is increased by additional shearing at the loading truck. This shearing would destroy any AN prills that were added.
- Most operations, for logistical reasons, prefer to use a single emulsion type in underground operations (as opposed to using a combination of full emulsion and a blend).
- Blended explosives are not applicable to the smaller diameter holes that are typical in underground mines.
- Blends need to be fume classified for underground use before being used.

Thus, in wet conditions where ANFO cannot be used underground at the End Grid Mine, a 100% packaged emulsion explosive is recommended.

4.4 Explosive Costs

In general, the weight cost of ANFO, Emulsion and Emulsion/AN blends increases with the percent increase in Emulsion. However, it is difficult to quantify the difference without detailed knowledge of the manufacturer, the proposed plans for the site and the sources of components by a given manufacturer. Specific and relative costs vary based on geographic as well as infrastructure parameters such as:

- Sources for the products and/or components sourced; and
- Conditions that affect the costs of the explosives at the site including:
  - Transportation;
  - Storage;
  - Manufacturer and/or preparation; and
  - External market cost pressures for the raw materials.

Although each manufacturer may have different costs for the various explosives, estimated explosives costs are as follows:

- ANFO $72.50/100 kg
- 70/30 Emulsion/AN Blend $97.80/100 kg

Although, ANFO is generally the least expensive explosive product, the total cost of drilling and blasting must be considered when comparing options. This is because ANFO is also a less energetic explosive and requires a smaller blast pattern in order to achieve fragmentation results comparable to the denser, higher energy emulsion blends. Drilling costs are typically around 50% of total drill and blast costs. A cost comparison for the proposed blast designs is provided in Section 6.4.

4.5 Estimated Explosive Use over the Life of Mine

Based on the mine design work conducted by Golder in 2011, Table 5 summarizes the estimated explosive requirements for the Kiggavik and Andrew Lake open pits and the End Grid underground mine.

Table 5: Summary of Estimated Explosive Use by Year

Year	All Open Pits 70/30 Blend 1) (tonnes)	Underground Mine ANFO 2) (tonnes)
1	231	0
2	7,693	0
3	7,331	40
4	7,645	237
5	6,823	372
6	6,808	426
7	6,771	770
8	1,998	819
9	1,677	814
10	1,529	841
11	1,540	793
12	731	556
13	311	125
Total	**51,090**	**5,793**

We understand that the explosives supplier will provide the AN and emulsion components. They will be responsible for having it loaded on barges, transported to site and stored until required. The supplier will also supply mixing and delivery trucks. Typically, the supplier is also responsible for delivering the blasting agents to the blastholes. Mine personnel then charge the holes, place the detonators and primers and tie in the patterns.

The explosive supplier will be responsible for the design and construction of the ammonium nitrate storage area and emulsion plant. It is estimated that the facility will contain a 40,000 kg capacity explosives magazine (presplit powder and miscellaneous cartridge powder, primers and detonating cord), a magazine for blasting accessories (detonators, wire, etc.), bulk storage silos or buildings (4,800 tonnes capacity) and a garage to house explosives delivery vehicles.

4.6 Potential Environmental Impacts

Emulsion/AN blends are often used to address wet conditions in blastholes. Manufacturers provide technical data sheets to provide water resistance assessment, but are typically given as qualitative evaluations such as “fair”, “good”, or “excellent”. Schettler and Brashear (1996) conducted a study designed to assess the performance of various Emulsion/AN blends in the presence of water. The study results can be summarized by the following:

- Products with an Emulsion/AN ratio of 20/80 performed no better than straight ANFO;

- A 60/40 blend is necessary for a product to be considered “water resistant”;
- Acceptable performance was not achieved until a 50/50 ratio of Emulsion/AN was used; and
- A 50/50 ratio is likely necessary to ensure that a product is “waterproof”.

Figure 4 shows the estimated leach rates for Emulsion/AN blends. There is less than 0.5% difference in leach rate above a 60/40 Emulsion/AN ratio (“water resistant” blend).

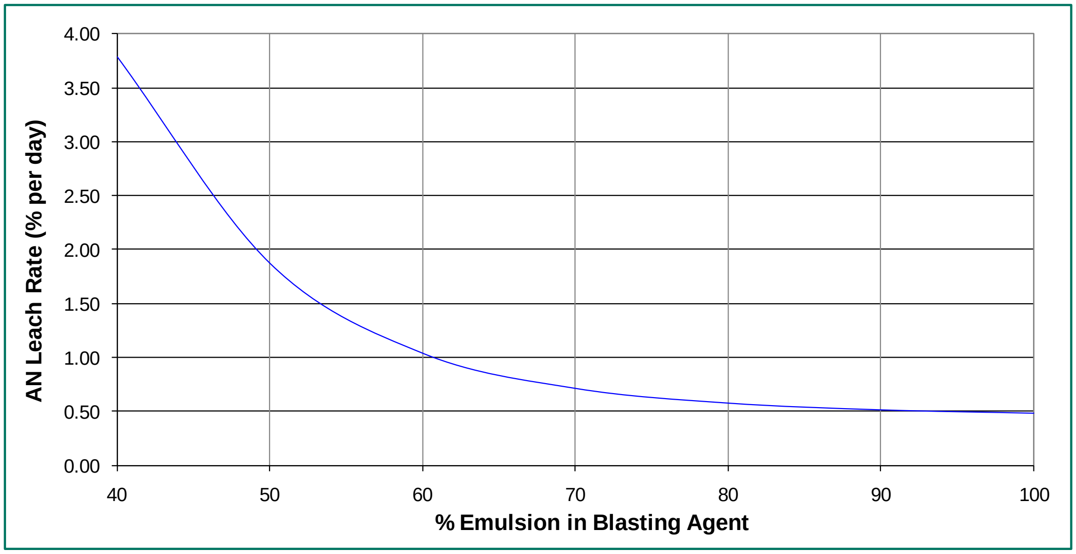


Figure 4: Leaching Rates of Doped Emulsion Blends

Pumpable blends have better water resistance than augerable blends which tend to lose their water resistance as the percentage of emulsion decreases. In order to limit the water damage to the explosive, which would result in poor blast performance, a doped emulsion of 70/30 (Emulsion/AN) blend is recommended.

5.0 BLAST IMPACT LIMITATIONS

5.1 Regulatory Limits

5.1.1 Explosives Regulations

The Canadian Regulations for the storage, possession, transportation, destruction and sale of blasting explosives and initiation systems is contained in Appendix A. The following is an excerpt from Section 2.2 of that document entitled Magazine Location:

A magazine should be situated so that the accidental explosion of its contents is not likely to cause any serious damage to other buildings or injury to persons. The minimum distances by which a magazine must be separated from other buildings or places are dependent on the maximum quantity of explosives stored in the magazine at any one time. In Canada, the Quantity-Distance Table, compiled from a study *of the effects of recorded explosions, are taken as a guide in approving the site for a magazine containing given amounts and types of explosives.*

It is emphasized that these are minimum distances. Greater distances should be observed wherever possible and greater distances in specific cases may be mandatory. Refer to Appendix A for a summary of the Quantity-Distance Table.

When it is impractical or uneconomical to store all the explosives in one magazine sited in accordance with the Quantity-Distance Table for blasting explosives, judicious selection, siting, and barricading of magazines might provide the solution by establishing a magazine area that may be shared by different construction companies and may accommodate a much larger weight of explosives in a number of magazines.

The purpose of a barricade is to protect the magazine adjacent to it from direct missile attack emanating from another magazine or a nearby explosion. However, to ensure that the explosives will not be initiated by sympathetic detonation or flash from an explosion, magazines must be separated by at least the distance given in the Quantity-Distance Table for barricaded magazines (D2).

A plot of the data contained in the table is shown on Figure 5.

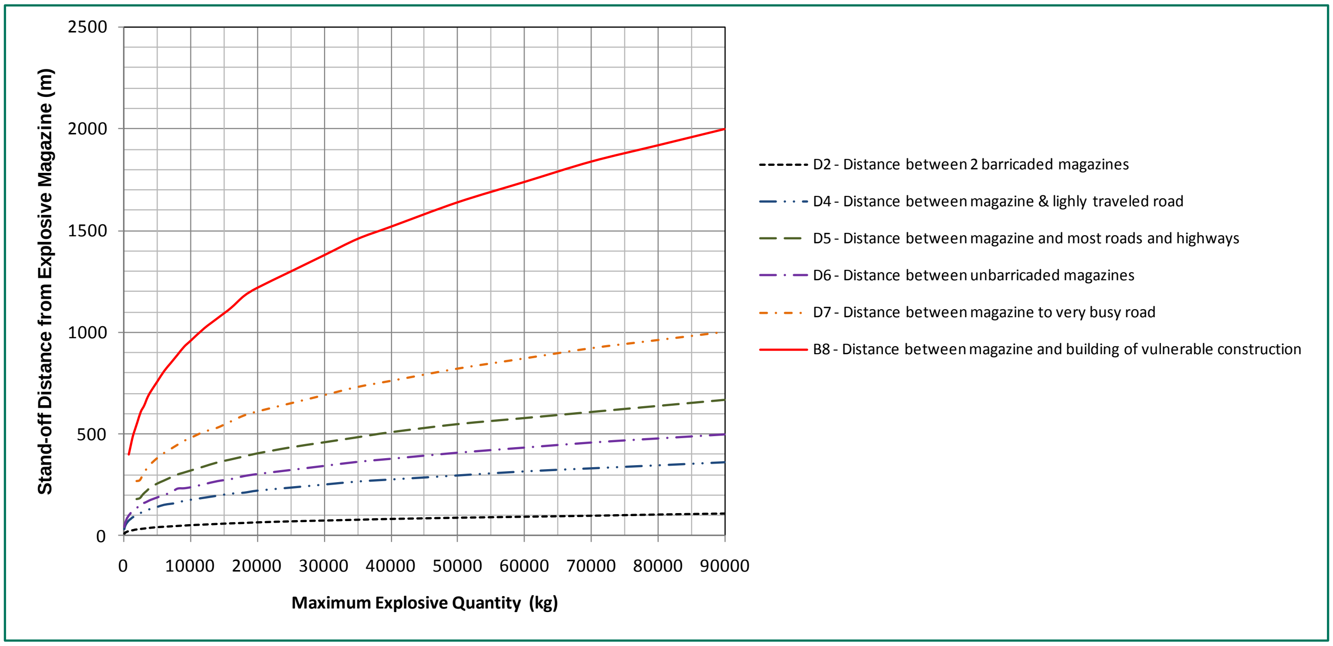


Figure 5: Quantity-Distance Plot for Storing Explosives

The following extended notes are provided in the regulations:

- D1 and D3 – since these apply primarily to factory operations, they have not been shown here.
- D2 – This is the distance that is required to separate two magazines, provided there is an effective barricade between them.

- D4 – This is the required distance between a magazine and a very lightly traveled road (from 20 to 500 vehicles per day; provincially numbered highways do not qualify as lightly traveled roads).
- D5 – This is the distance required from a magazine to most roads and highways (from 500 to 5,000 vehicles per day). Note that there is an overriding minimum distance of 180 m.
- D6 – This is the distance between unbarricaded magazines.
- D7 – This column is called Inhabited Building Distance. It applies to very busy roads (more than 5,000 vehicles in a 24-hour period) and to buildings where people may assemble. Note that there are minimum distances: 270 m for up to 20 people and 400 m for more than 20 people.
- D8 – This is the distance from a magazine to a building of vulnerable construction. Vulnerable construction includes highrises, schools, hospitals, etc. Note that this is twice the normal Inhabited Building Distance found in D7. There is an overriding distance of 400 m.

A copy of the Nunavut Mine Health Safety Regulations is contained in Appendix B. Section 14.06 states that:

Overhead power lines supplying electricity to a magazine or area where explosives are prepared shall

a) be protected against power surges and lighting; and

b) be terminated in a cable a minimum of 60 m horizontal distance from the magazine.

Section 14.08, subsection 2) states:

The ground surrounding a magazine must be kept free of all brush, timber or other combustible material for a distance of not less than 20 m from the magazine (R-026-99, s.56).

5.1.2 Impact on Fisheries

Fisheries and Oceans Canada (DFO) has established a set of guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky, 1998). These guidelines set out that "No explosive may be used that produces or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during egg incubation". Under conditions where these guidelines cannot be met, the proponent is required to prepare a mitigation plan outlining additional procedures for protecting fish and their habitat. It is worth noting that this guideline limit only applies during spawning season and only at spawning beds. The DFO guidelines also set out an underwater overpressure limit of 100 kPa at fish habitat. The underwater overpressure limit only tends to become a measurable indicator when blasting or explosives are used within the water body itself. No blasting is expected to occur in any body of water on or around the Kiggavik Project site.

5.1.3 Nitrogen Compounds in Mine Effluent

Mines are subject to regulations limiting ammonia, nitrate and nitrite levels in mine effluents released into the environment. Discharge limits are typically defined in consultation with the regulators based on legislated water quality guidelines where they exist (e.g. metal mining effluent regulations (MMER), drinking water, aquatic life, etc).

The ammonia limits in mine effluent in Nunavut are set by the water board in consultation with the proponent (AREVA). The effluent limits are intended to allow the proponent to meet Canadian Environmental Quality Guidelines (CCME) aquatic life guidelines in the receiving environment at a pre-determined location. The receiving guidelines are as follows:

- Total unionized ammonia 0.019 mg/L (this is dependent on water temperature); and
- Total NO_3-N = 13 mg/L.

The MMER does not have ammonia guidelines but states the undiluted effluent cannot be acutely toxic.

The preparation of an Ammonia Management Plan is typically part of the permitting process in Nunavut. This plan would outline the measures that will be taken to minimize the release of Nitrogen compounds in effluent and meet the suggested discharge limits.

5.2 Non-Regulatory Limits

5.2.1 Ground Vibrations

The intensity of ground vibrations, which is an elastic effect measured in units of PPV, is defined as the speed of excitation of particles within the ground resulting from vibratory motion. For the purposes of this report, PPV is measured in mm/s.

While ground vibration is an elastic effect, one must also consider the plastic or non-elastic effect produced locally by each detonation when assessing the effects on the bedrock strata and local water wells. The detonation of an explosive produces a very rapid and dramatic increase in volume due to the conversion of the explosive from a solid to a gaseous state. When this occurs within the confines of a borehole, it has the following effects:

- The bedrock in the area immediately adjacent to the explosive product is crushed.
- As the energy from the detonation radiates outward from the borehole, the bedrock between the borehole and quarried face becomes fragmented and is displaced while there is minimal fracturing of the bedrock behind the borehole.
- Energy not used in the fracturing and displacement of the bedrock dissipates in the form of ground vibrations, sound and airblast. This energy attenuates rapidly from the blast site due to geometric spreading and natural damping.

Ground vibration guidelines are typically established for blasting sites to prevent damage to adjacent facilities or infrastructure. Exceeding these levels does not in itself imply that damage has occurred but only increases the potential that damage might occur. Siskind and Stagg (1993) suggested a PPV limit for Class B or better steel pipelines (or Class 6 or better PVC pipelines) at 127 mm/s. However, many pipeline companies in Canada (including TransCanada Pipelines and Union Gas) impose a more conservative limit of 50 mm/s. Ground vibration limits for stronger materials, such as concrete, may be set as high as 150 to 200 mm/s, while peak ground vibration levels of 300 to 600 mm/s are required to create micro-cracks or open existing discontinuities in bedrock (Keil et al., 1977). Richards and Moore (2007) provided a review of the damage potential from blast-induced vibrations from open pit coal mines. Table 6 provides a summary of PPV limits proposed for a variety of infrastructure types.

Table 6: Vibration Limits for Various Infrastructure Types

Infrastructure Type	PPV Limit (mm/s)	Comments
Power Transmission Towers *	100	Concrete footings
Wooden Hydro Poles *	240	
Electrical Sub-stations *	10 – 30	Depending on switch type. Manufacturer should be consulted.
Railway Tracks *	100	
Buried Pipelines **	127	
Underground Fibre Optics Line *	100	
Concrete and grout <72 hours from placement ***	10	
Mine Plant and Industrial Buildings *	100	Unoccupied structures of reinforced concrete or steel construction

* Suggested by Richards and Moore (2007)

** Siskind and Stagg (1993)

*** OPSS 120

Charlie et al. (1987) suggested the following criteria for blasting near dams (Table 7), based on liquefaction potential.

Table 7: General Guidelines to Vibration Damage Thresholds for Blasting Near Dams

Dam Construction	PPV Limit (mm/s)
Dams constructed of or having foundation materials consisting of loose sand or silts that are sensitive to vibration.	25
Dams having medium dense sand or silts within the dam or foundation materials	50
Dams having materials insensitive to vibrations in the dam or foundation materials	100

* From Charlie et al. (1987)

The information presented in the above tables can be used as general guidelines for assessing the potential for blast vibration damage to structures. Due to the inherent variability in site conditions, caution must be exercised when assessing the potential damage from blast-induced vibration. Actual vibrations will need to be monitored during construction and operations.

Minimum setback distances based on a maximum PPV of 50 mm/s, representing the situation of a dam having medium dense sands or silts in the dam or foundations, have been calculated for the various values of confinement, ‘k’, and for three potential charge weights per delay. The actual velocities will need to be determined during a vibration monitoring program that will be required in order to measure the response of the de-watering dikes and tailings dike to pit blasting. Depending on the actual velocities experienced by the dikes, charge weights may need to be modified during operations. The threshold value of 50 mm/s may be modified once more detailed information is obtained relating to the foundation materials beneath the dikes.

5.2.2 Flyrock

Flyrock causes the most injuries and damage in reported blasting incidents at surface mines. It can be considered as the ejection of rock fragments through the air or along the ground beyond the blast zone. It also occurs when the explosive within the blasthole is either excessive or poorly confined and high pressure gas propels broken rock fragments. Flyrock generally results from a mismatch between the available energy and the work to be done. This results from either too much energy for a fixed burden or insufficient burden for a fixed charge. Flyrock results from three key mechanisms (face bursting, cratering and rifling) which result from the lack of confinement of the energy from the explosive column.

Flyrock should be limited from endangering the mine personnel as well as impacting the mine infrastructure. The previously proposed blast clearance zone for the Kiggavik Project has been set at 500 m from final pit crest.

5.2.3 Fragmentation

In addition to designing blasts that minimize potential damage to the nearby structures, the design must also ensure that the resulting blasted rock has a size distribution that complies with the mine's requirements and downstream processes such as crushing. We understand that the maximum fragmentation size for the Kiggavik open pits is 1,000 mm. This is the assumed feed size to the crusher (i.e. ROM ore). Anything larger than this will be caught in a grizzly and reduced with a rock breaker.

6.0 BLAST DESIGN

The selection of an appropriate blasthole diameter is important in terms of fragmentation and cost. Ideally, it is desirable to obtain the maximum fragmentation at a minimum cost. The cost of drilling and explosives decreases as the diameter of the blasthole increases. Other factors must be considered such as bench height, rock structure and rock hardness. Smaller diameter blastholes are more suited to strongly jointed rocks as the decreased spacing results in fewer joints between holes. This will tend to reduce the amount of oversize and result in better fragmentation. Blasthole sampling is another consideration when selecting the blasthole size. Depending on the resource block model and type of mineralization, a tighter blasthole spacing can provide additional sampling data for ore grade control. Some operations will use smaller diameter holes in ore blasts and larger diameter holes in waste blasts.

As discussed in Section 3.1.2, the blasthole diameter considered in the 2007 PFS was 150 mm (6 in.) with the capability of drilling larger diameter blastholes. Alternative designs are presented here for larger blastholes of 187 mm (9 in.) diameter.

The underground blast designs for the End Grid deposit are not discussed in this section. Both underground development and production blasting will be done by contract crews using typical drift development blasting methods. Blast parameters such as hole size, cut design, hole spacing and trim blasting are expected to be developed by the contractor.

6.1 Blast Design Assumptions

The production blast design criteria were formulated on the basis of the engineering geological models for the deposits. Basic assumptions used for the process were:

- A doped emulsion will be used (70/30, Emulsion/AN) to address potentially wet blasting conditions.
- The operating bench height will be 12 m.
- The available equipment will be capable of drilling blasthole diameters ranging from 150 mm up to 229 mm. The earlier studies based costs on a 150 mm diameter blasthole. We also propose an alternate blasthole of 187 mm diameter in order reduce the number of blastholes required. This would result in less drills, fewer drillers and lower costs.
- A staggered pattern using millisecond delays and en echelon firing sequence, initiated from a corner, is assumed. The inter-hole and inter-row are designed to provide an upright muckpile which is appropriate for the limited mobility and good breakout force and reach of a hydraulic shovel (JMRC, 1996).
- The length of the blasted block will be a minimum of twice the width, which will be between three and five rows for production blasts.
- The bench face angles will generally be steep, approximately 75°, and hence vertical blastholes have been assumed. According to Hagan and Bulow (2000), a vertical back row will usually be satisfactory where the designed final face is steeply dipping (>70°). Inclined blastholes could improve the consistency of the burden and the efficiency of fragmentation; however, accuracy of drilling angled holes is difficult to achieve, particularly with smaller diameter blastholes.

6.2 Production Blast Design

Table 8 summarizes the blast designs considered for the Kiggavik open pits and are based on the geotechnical properties for the Kiggavik site (Table 1). Table 9 shows the proposed charge tables for the proposed blast designs.

Table 8: Blast Design Parameters for the Kiggavik Open Pits

Parameter	Values	
Hole Diameter (mm)	**150**	**187**
Bench Height (m)	12.0	12.0
Bench Face Angle (^{o})	75	75
Hole Inclination (^{o})	90	90
Sub-drill (m)	1.5	1.8
Hole Depth (m)	13.3	13.8
Drill Pattern	Staggered	Staggered
Sequence	En-echelon	En-echelon
Spacing-burden Ratio	1:1.15	1:1.15
Number of rows	5	5
Number of holes/row	10	10
Inter-hole Delays (ms)	25	42
Inter-row Delays (ms)	67	84
Stemming Material	Crushed Stone	Crushed Stone

Table 9: Charge Table for 150 mm and 187 mm Diameter Holes *

Parameter	150 mm Hole (70/30 blend)	187 mm Hole (70/30 blend)	187 mm Hole (ANFO)
Burden (m)	5.0	5.9	5.4
Spacing (m)	5.8	6.8	6.3
Stemming Length (m)	4.1	4.9	4.3
Explosive Charge Length (m)	9.4	8.9	9.2
Explosive Type (Emulsion/AN)	70/30	70/30	100% ANFO
Explosive Density (g/cc)	1.3	1.3	0.86
Linear Charge Density (kg/m)	23.0	35.8	23.6
Explosive VOD (m/sec)	5,700	5,700	3900
Explosive Rel. Weight Strength (%)	84	84	100
Explosives Per Hole (kg)	216	318	217
Powder Factor (kg/m^3)	0.62	0.66	0.53
Powder Factor (kg/tonne)	0.25	0.27	0.20

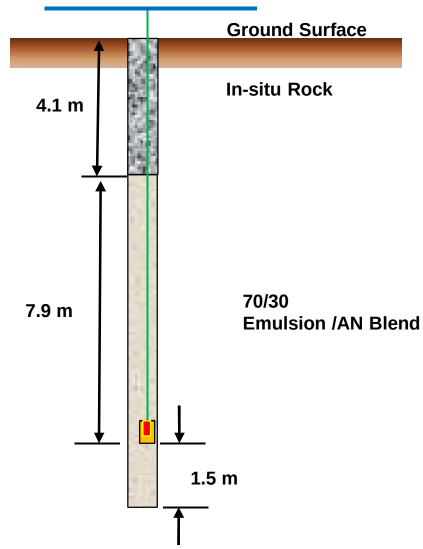
*****_Assuming holes are loaded with a 70/30 (Emulsion/AN) blend._

The blast designs for the proposed production blasts are shown on Figure 6 and Figure 7.

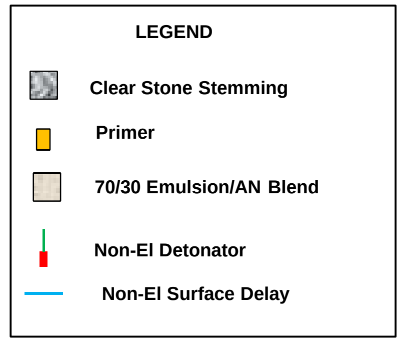
Kiggavik Project Open Pits Production Blast Design for 150 mm Diameter Holes and 70/30 Emulsion/AN Blend

FIGURE 6

LOADING

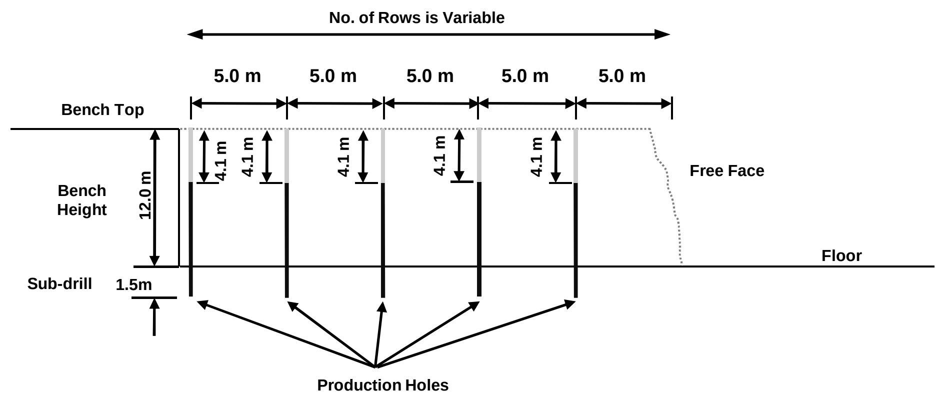


Designs shown are for 150 mm diameter blastholes loaded with a 70/30 Emulsion/AN blend. See text for design parameters details.



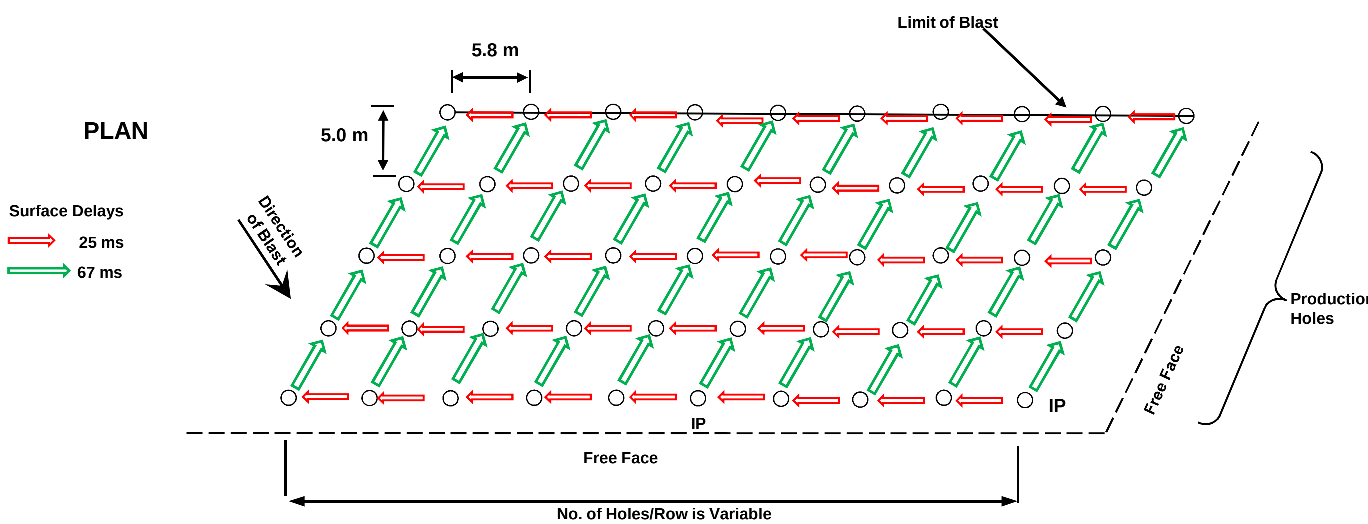
SECTION

This design assumes a 12.0 m bench



The timing shown is an example only. The actual sequencing will depend on the requirements of the operation.

PLAN



SHEMATIC ONLY
Not to Scale

DATE: February 2011
PROJECT: 10-1325-0026 Task 3

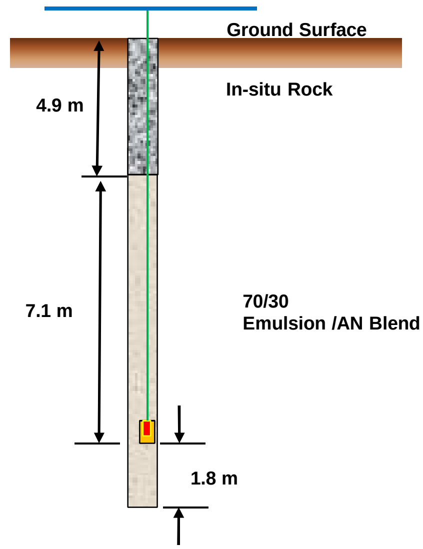
Golder Associates

DRAWN: DJC
CHKD: DLS

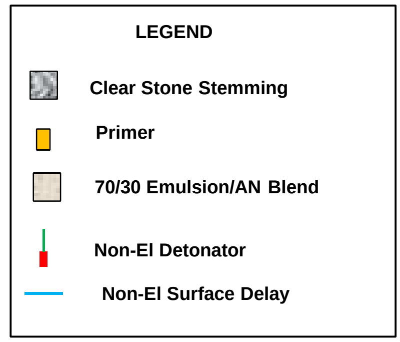
Kiggavik Project Open Pits Proposed Production Blast Design for 187 mm Diameter Holes and 70/30 Emulsion/AN Blend

FIGURE 7

LOADING

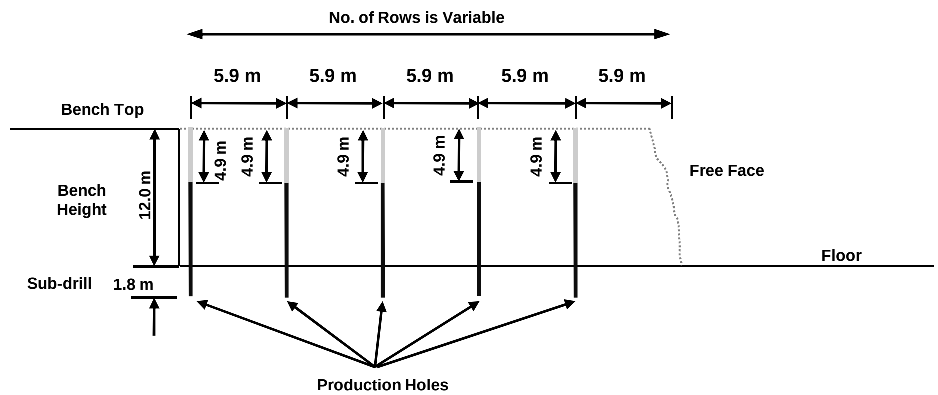


Designs shown are for 187 mm diameter blastholes loaded with a 70/30 Emulsion/AN blend. See text for design parameters details.



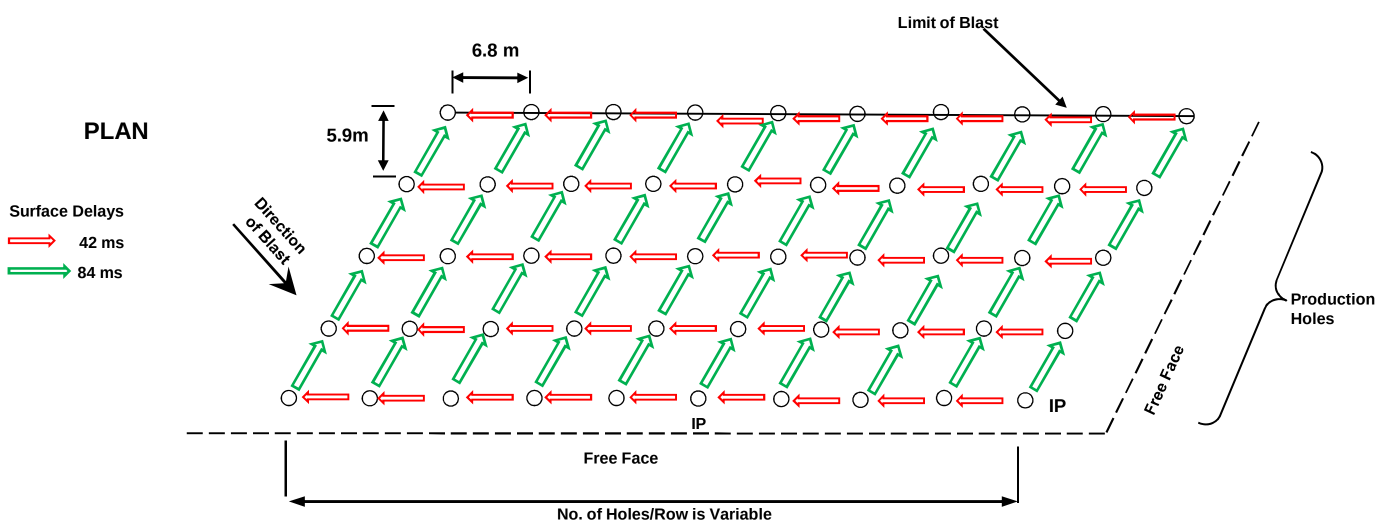
SECTION

This design assumes a 12.0 m bench



The timing shown is an example only. The actual sequencing will depend on the requirements of the operation.

PLAN



SHEMATIC ONLY
Not to Scale

DATE: February 2011
PROJECT: 10-1325-0026 Task 3

Golder Associates

DRAWN: DJC
CHKD: DLS

6.3 Controlled Blasting for Final Walls

Wall blasts are intended to reduce the extent and degree of damage in the rock mass of the remaining pit walls. The most effective technique is to use presplit holes in conjunction with trim blasts.

6.3.1 Presplitting

Presplitting involves drilling a row of closely spaced blastholes along the design excavation limit. These blastholes are very lightly charged and then detonated simultaneously or in groups separated by short (i.e. 17 ms) surface delays. The presplit blastholes can be fired either as a separate shot or with the production blast. In the latter case, the presplit should detonate about 50 ms before the earliest firing production blasthole(s). Firing of the presplit charges splits the rock just along the design excavation limit, creating an internal surface to which the production blast can then break. Firing of the presplit charges will itself create overbreak if the presplit blastholes are too close together or charged too heavily.

Presplitting can give more spectacular results (especially in strong massive rocks), but is generally more costly than postsplit blasting. Presplitting rarely gives impressive results in highly fissured ground where, in cases of overcharging, it can be quite detrimental. The spacing between presplit blastholes normally increases with the blasthole diameter. The initial presplit hole spacing for the proposed blasthole diameters are as follows (after Hagan and Bulow, 2000):

- 150 mm – 1.80 m, 1.1 kg/m; and
- 187 mm – 2.51 m, 2.0 kg/m.

These hole spacings can then be adjusted according to actual field results.

6.3.2 Trim Blasting

Trim blasts are located between the production blasts and the presplit blasts and possess the following characteristics:

- Narrow width of blast, typically consisting of a maximum of 4 rows of blastholes parallel to the pit wall;
- Length of the blast is typically greater than several times the width;
- Clean free face that is not overburdened so that the rock can easily and quickly be moved forward; and
- Reduced charge weight in blastholes, especially those drilled closest to the pit.

According to Hagan and Bulow (2000), the charge weight for the final row is commonly reduced by about 45% and both the burden and spacing are reduced by approximately 25%. The distance between the buffer row and the pit limit or presplit line is critical to ensure the toe of the bench is achieved but the pit wall is not damaged. The standoff of the final row from the presplit is approximately 45% to 50% of the production row burden. Table 10 shows the proposed charge tables for a typical final row of a trim blast.

Table 10: Charge Table – Kiggavik Open Pits Trim Blasts

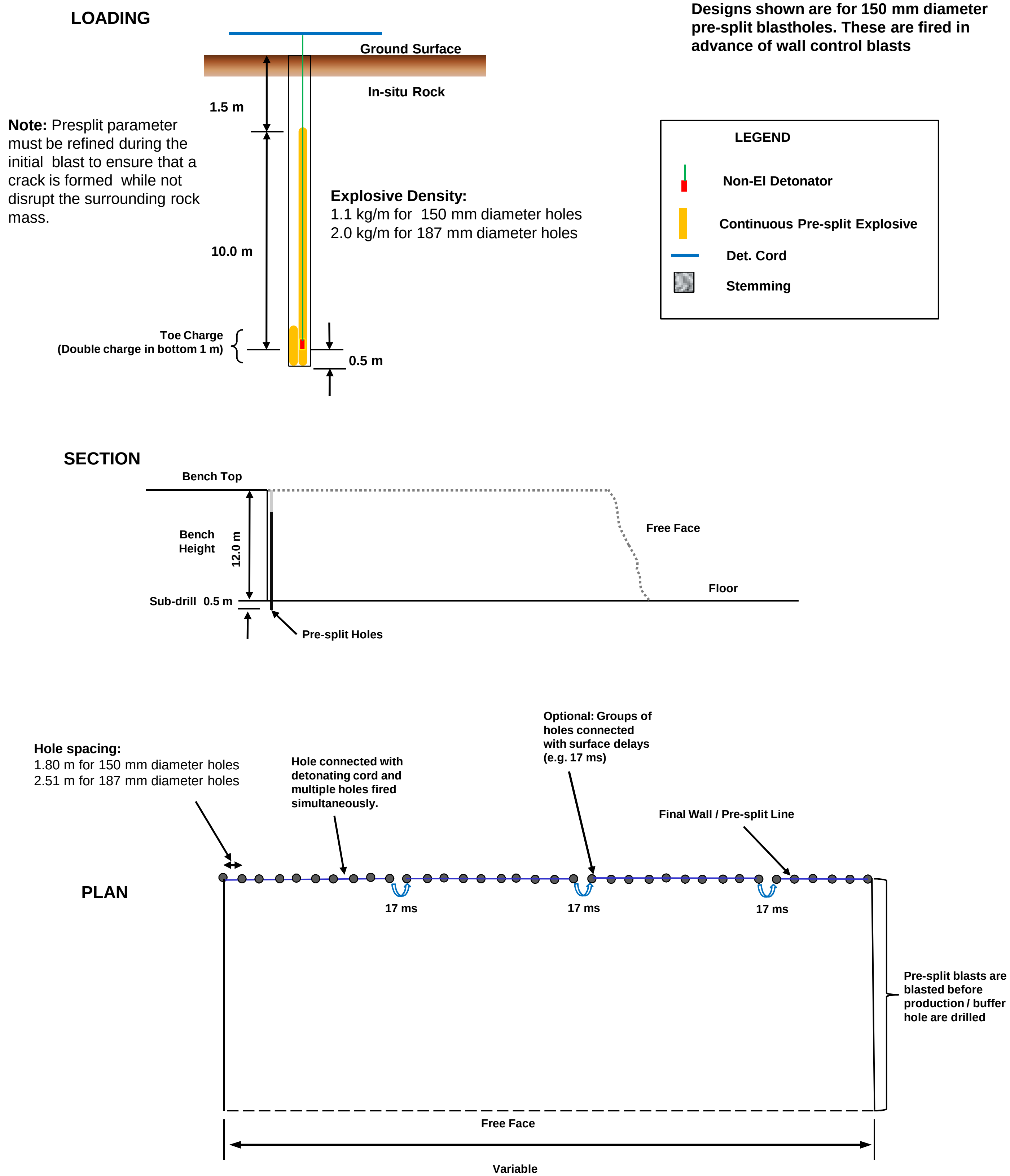
Parameter	150 mm Hole	187 mm Hole
Burden (m)	3.6	4.4
Spacing (m)	4.0	5.0
Stemming Length (m)	8.2	8.8
Final to Presplit Row Distance (m)	2.5	3.0
Explosive Charge Length (m)	4.9	4.8
Explosive Type (Emulsion/AN)	70/30	70/30
Explosive Density (g/cc)	1.30	1.30
Linear Charge Density (kg/m)	23.0	35.8
Explosive VOD (m/sec)	5,700	5,700
Explosive Rel. Weight Strength (%)	84	84
Explosives Per Hole (kg)	110	170
Powder Factor (kg/m^3)	0.63	0.64
Powder Factor (kg/tonne)	0.24	0.25
Stemming Material	Crushed Stone	Crushed Stone

Assuming an Emulsion/AN ration of 70/30 and a 12 m bench.

The final selected design will need to be optimized through a series of engineered field trials. The proposed designs for the production, presplit and trim blasts are shown on Figure 8, Figure 9 and Figure 10.

Kiggavik Project Open Pits
Proposed Presplit Blast Design

FIGURE 8



SHEMATIC ONLY
Not to Scale

DATE: February 2011
PROJECT: 10-1325-0026 Task 3

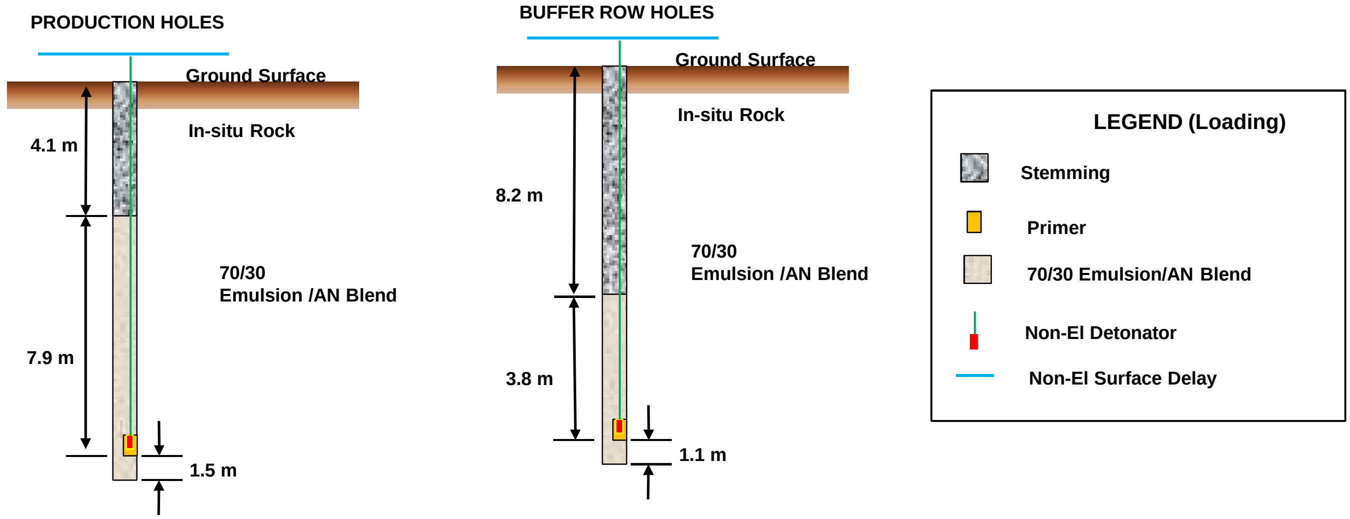
Golder Associates

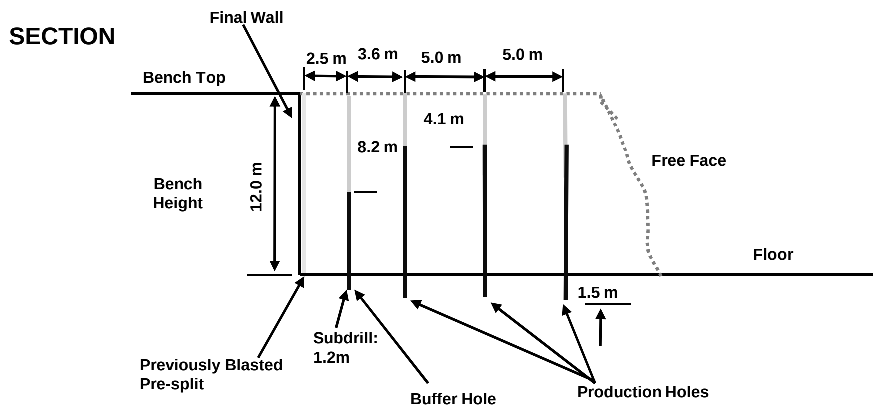
DRAWN: DJC
CHKD: DLS

Kiggavik Project Open Pits Trim Blast for 150 mm Diameter Holes and 70/30 Emulsion/AN Blend

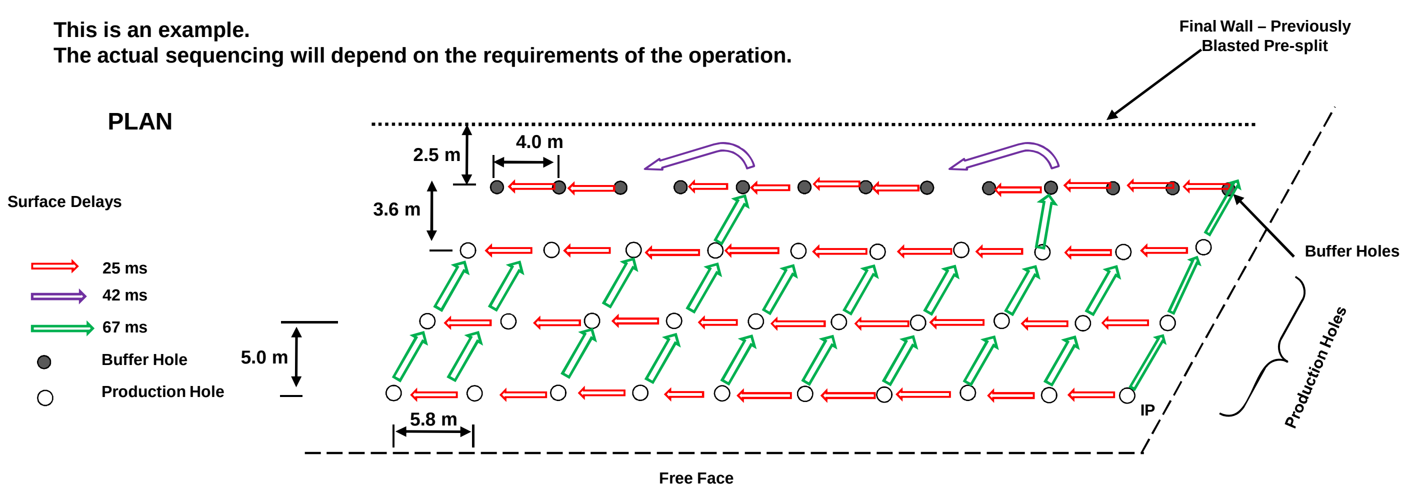
FIGURE 9

LOADING Designs shown are for 150 mm diameter blastholes loaded with a 70/30 Emulsion/AN blend.





This is an example.
The actual sequencing will depend on the requirements of the operation.



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DATE: February 2011
PROJECT: 10-1325-0026 Task 3

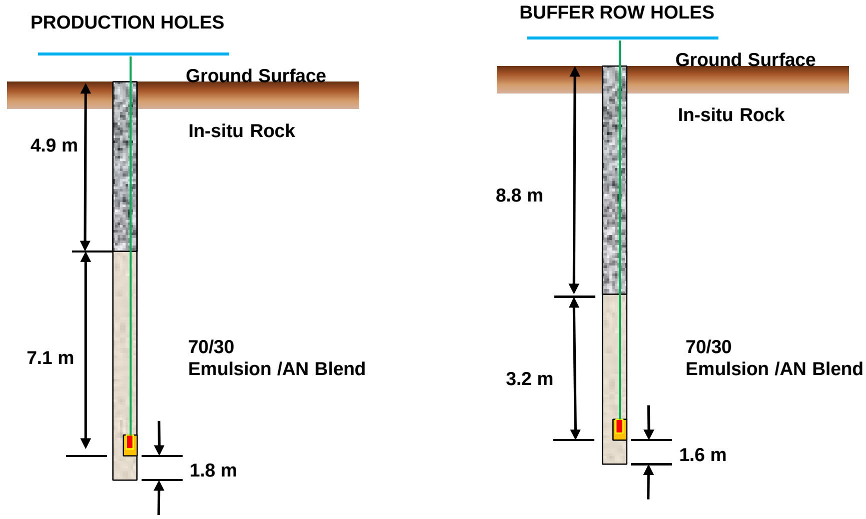
Golder Associates

DRAWN: DJC
CHKD: DLS

Kiggavik Project Open Pits Trim Blast for 187 mm Diameter Holes and 70/30 Emulsion/AN Blend

FIGURE 10

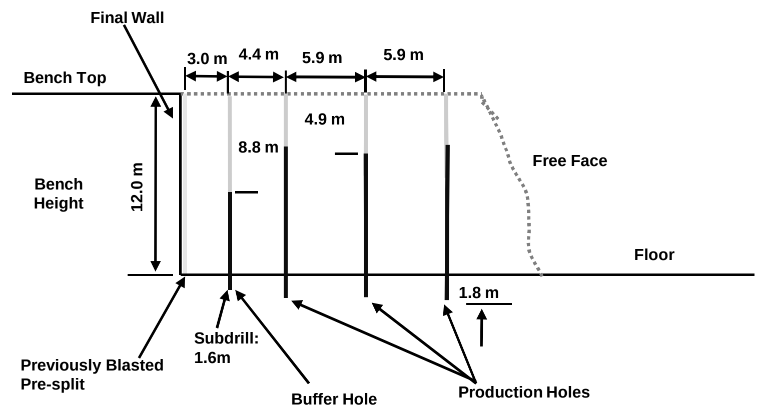
LOADING Designs shown are for 187 mm diameter blastholes loaded with a 70/30 Emulsion/AN blend.



LEGEND (Loading)

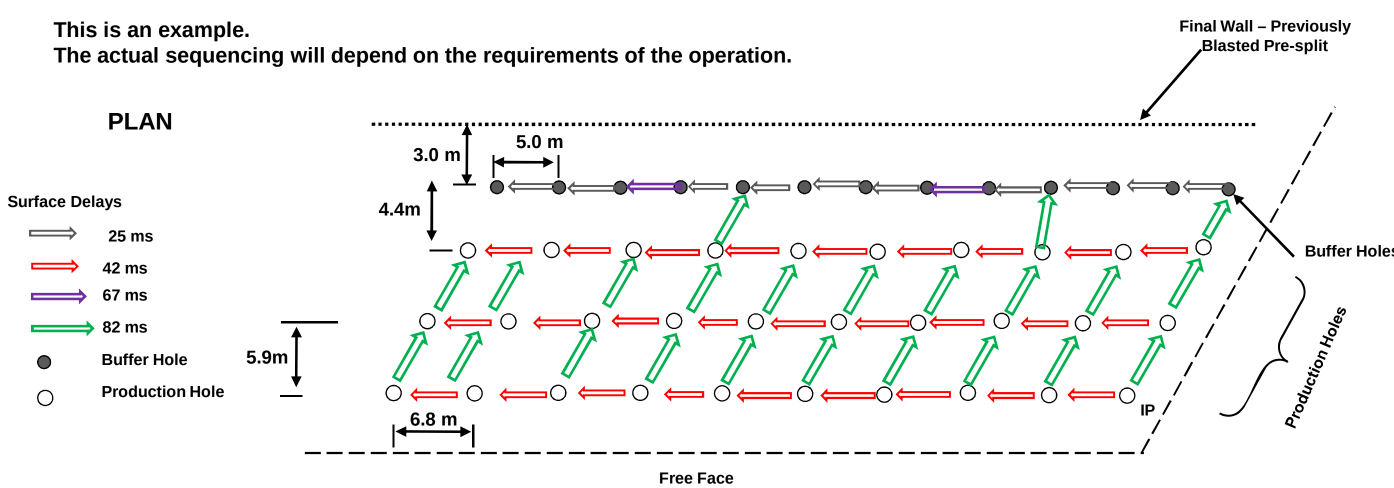
- Stemming
- Primer
- 70/30 Emulsion/AN Blend
- Non-El Detonator
- Non-El Surface Delay

SECTION



This is an example.
The actual sequencing will depend on the requirements of the operation.

PLAN



SHEMATIC ONLY
Not to Scale

DATE: February 2011
PROJECT: 10-1325-0026 Task 3

Golder Associates

DRAWN: DJC
CHKD: DLS

6.4 Fragmentation

The most commonly used system to predict rock fragmentation in bench blasting with a single free face is the Kuz-Ram fragmentation model. The Kuz-Ram model is an empirically derived predictor of size distribution for blasting hard rock and does not include further breakdown during subsequent handling. The approach has been found to provide a reliable estimate of the coarse end of the size distribution, but tends to underestimate the proportion of fines at the smaller particle end of the distribution. The Kuz-Ram model takes into account the blast layout, rock type, and the explosive used, although it does not allow for changes in the blast timing. It incorporates the effects of burden, spacing, blasthole diameter, charge length and type, square or staggered patterns, rock jointing and rock strength. Two key drawbacks to the Kuz-Ram Model are its poor predictive capability in the fines range and upper limit cut-off to block sizes.

Because the Kuz-Ram model was developed based on empirical data, it provides guidelines and trends for fragmentation prediction results but should not be considered as a precise predictor. Calibration of the model is typically achieved by image analysis, which provides a quantitative measure of fragmentation based on image analysis of muckpiles, run of mine (ROM) and crusher product.

The predicted fragmentation assumes a ratio of actual to theoretical VOD of 0.85, although this ratio could be as high as 0.95 if the bulk product is well mixed. Plots of the estimated fragmentation size distributions for the blast designs presented in Table 8 are displayed on Figure 11 and Figure 12. Since most of the blasts will be in waste rock, the analyses were conducted for the waste blast designs at the two locations.

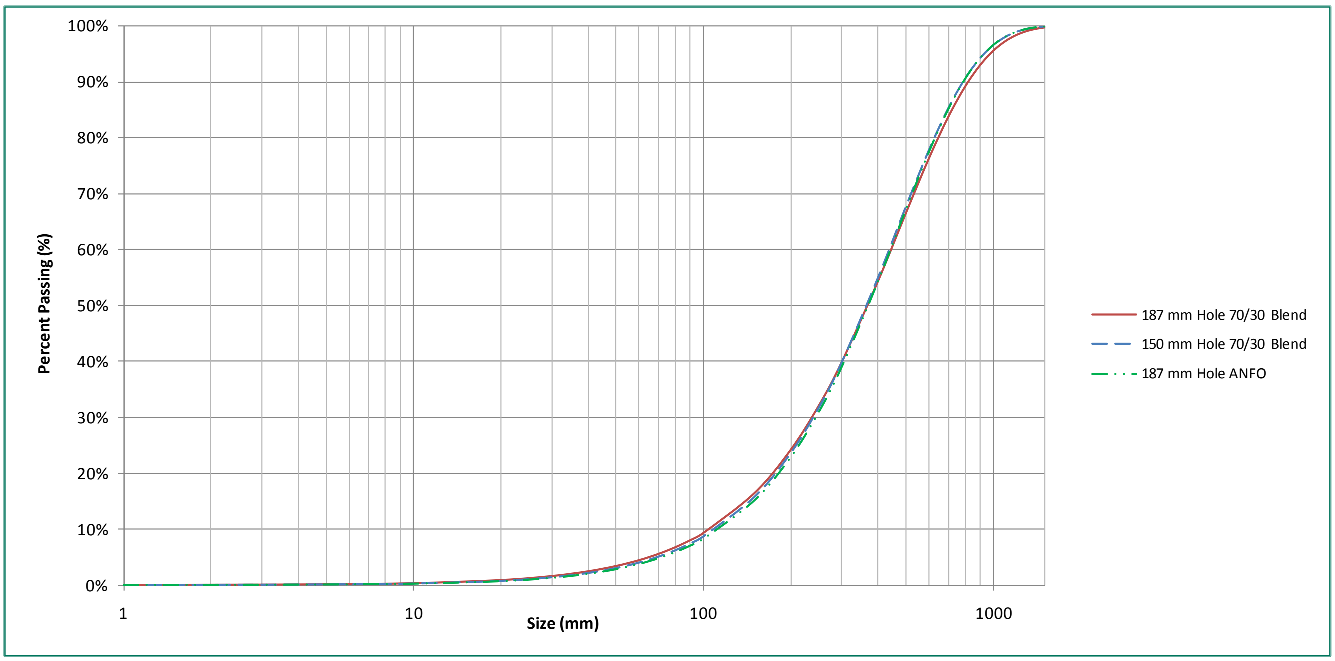


Figure 11: Fragmentation Size Distribution for the Kiggavik Main and Centre Pits

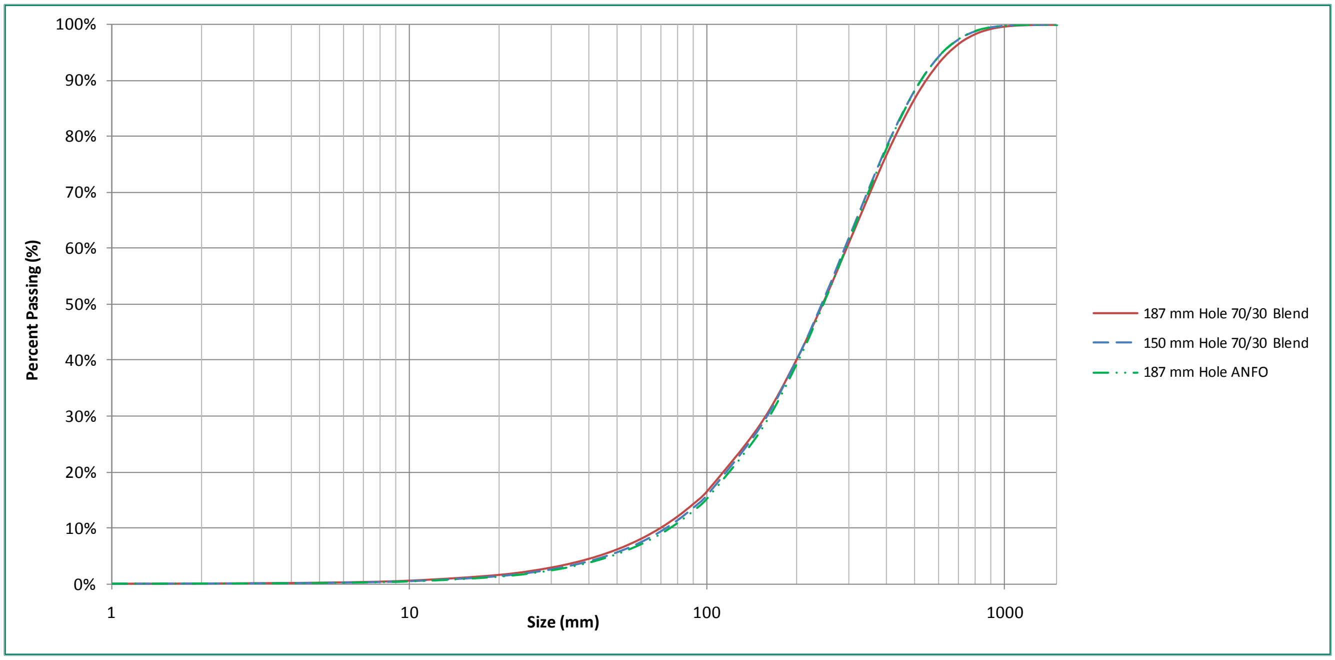


Figure 12: Fragmentation Size Distribution for the Kiggavik Andrew Lake Pit

Our analyses suggest that the proposed blast designs will produce greater than 95% passing for the required upper size limit of 1,000 mm diameter. Table 11 summarize the predicted rock fragmentation size distributions for the preceding design criteria at the Main and Centre Zones and Andrew Lake, respectively. They both assume a 5-row blast pattern with 10 holes per row. The analyses suggest that the proposed designs will produce greater than 95% passing for the required upper size limit of 1,000 mm diameter.

Table 11: Kiggavik Fragmentation Size Assessment (Emulsion/AN - 70/30)

Location	Hole Diam. (mm)	50% Passing (mm)	80% Passing (mm)	% Passing at 1,000 mm	X_c (mm)*
Main - Centre	187	369	647	95	471
	150	366	627	96	463
Andrew Lake	187	244	428	100	312
	150	242	421	100	308

* X_c is the characteristic size in mm

Fragmentation is expected to be finer at Andrew Lake due to the decreased joint spacing and reduced rock strength. The rock factor, a key parameter in the fragmentation analysis, is determined from the joint parameters, in situ block size, rock density, rock strength and Young's Modulus. The results displayed in Table 10 suggest that there should be potential to expand the blasthole pattern at Andrew Lake while continuing to provide adequately fragmented rock.

6.5 Impact of Blast Design Variations on Costs

Based on the estimated drilling and blasting operating costs provided by AREVA in 2010, an order of magnitude estimate of the cost impact resulting from changes to the explosives, blasthole diameter and blast patterns can be made. The typical assumptions used for such estimates include the following:

- Total drill and blast costs are normalized to the base case of 187 mm diameter holes and a 70/30 Emulsion/AN blend;
- The drilling cost per metre is the same as for the base case (e.g. possible variances due to penetration rate are ignored);
- Blast accessory costs are the same per hole (detonators, primers, trunkline, etc.); and
- The fragmentation has been normalized to the base case by adjusting the drill pattern.

A comparison of the costs associated with current production blast design (187 mm diameter holes with the 70/30 blend) with the two alternate designs is displayed on Figure 13 and summarized in Table 12:

a) 70/30 blend in 150 mm diameter holes (proposed in Section 6.2); and

b) ANFO in 187 mm diameter holes using a design normalized to the fragmentation of the 70/30 blend.

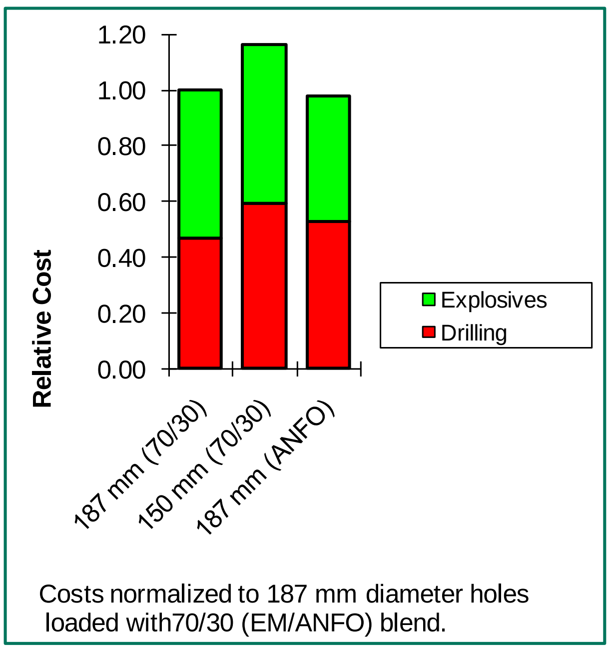


Figure 13: Blast Cost Comparison for Three Production Blast Designs

Figure 13 demonstrates that for the two 70/30 blend options, the explosive cost remains near constant due to tightening of the drill pattern with a 150 mm diameter hole so as to maintain a similar powder factor. The drilling cost, however, is lower for the larger 187 mm diameter hole since fewer holes are needed on the expanded pattern. In addition, fewer blastholes means that less drills and drillers are also needed. Figure 13 also demonstrates that the overall cost when using the less expensive ANFO is similar to the 70/30 blend option (187 mm hole) due to less drilling required with the more energetic explosive.

Table 12: Relative Drill and Blast Costs

Hole Diameter.	Explosive	Relative Drill and Blast Cost [1)]
187 mm Hole [2)]	70/30 (Emulsion/AN)	1.00
150 mm Hole	70/30 (Emulsion/AN)	1.19
187 mm Hole	ANFO	0.98

1) Costs are normalized to the fragmentation of the Base Case blast design.
2) Base Case blast design.

Table 12 shows that the overall cost for implementing the 187 mm diameter holes is significantly less than for the 150 mm diameter holes when using a 70/30 blend and about the same as using ANFO

7.0 IMPACT ASSESSMENT

7.1 Vibration Attenuation Models

The effect of blast vibrations on active spawning bed and structures is related to both the amplitude and dominant frequency of the vibration as well as the type and configuration of the structure. The PPV is the most commonly used measure of the intensity of the ground vibration due to blasts. Two of the most important variables that affect the PPV from a blast are the distance from the source (seismic waves attenuate with distance) and the maximum explosive charge weight per delay period. The most common method of normalizing these two factors is by means of plotting the scaled distance (distance divided by the square root of the charge weight per delay) against the PPV. The PPV is given by the following equation:

$$PPV = K\left(\frac{D}{\sqrt{W}}\right)^{e}$$

where PPV is the Peak Particle Velocity (mm/sec)

D is the distance between the charge and the point of measurements (m)

W is the effective mass charge per delay (kg)

$\mathrm{K, e}$ are site constants

A plot of the 95% confidence line provides a means to predict the maximum vibration for a given explosive charge weight per delay and given distance from the source to the target location.

Numerous studies have been conducted over the years and have yielded predictive formulas for various types of blasting operations. Additionally, Golder has collected data from various blasts sites and environments. In the absence of site-specific data, estimates of the constants may be obtained from these studies and the limited information concerning the site. Because of the level of uncertainty associated with such estimates, the constants may be more conservative than site-specific constants derived from a regression analysis of actual data from monitored blasts at the site. The use of such literature derived constants should only be used until actual data for the site and the type of blasting are obtained. Commonly cited attenuation results, as well as those collected by Golder, are plotted on Figure 14.

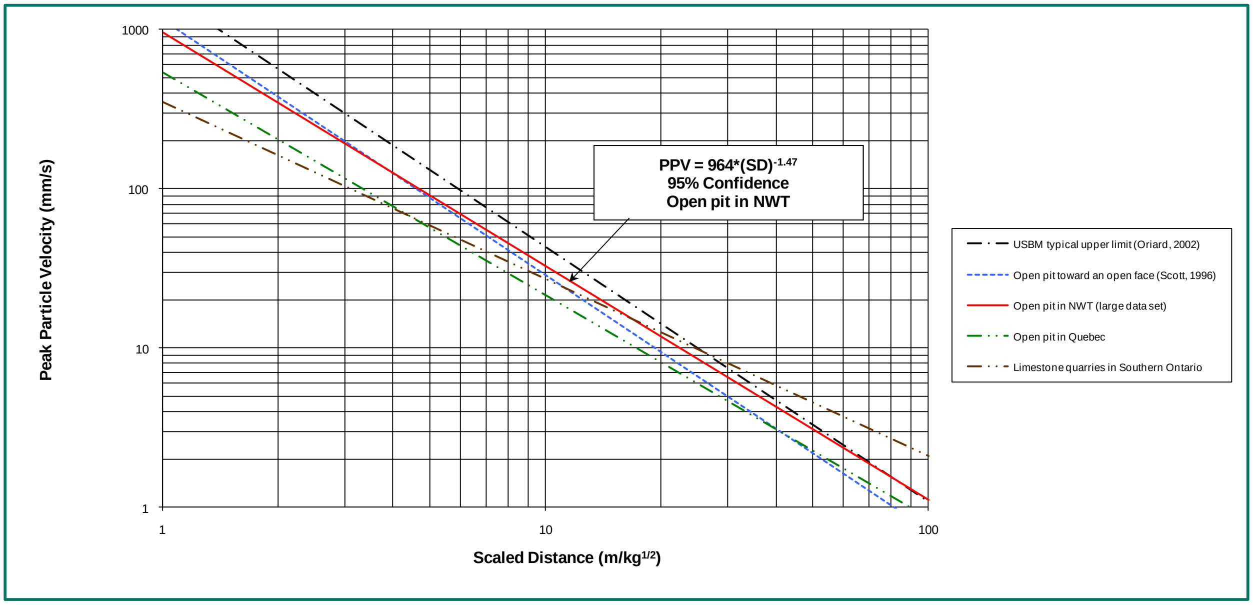


Figure 14: Ground Vibration Attenuation Results from Various Studies

Based on the initial information we have regarding the Kiggavik sites, the constants from the open pit in the NWT (K value of 964 and an e value of -1.47) have been chosen until further substantial data from the site are recorded. Figure 15 shows the estimated vibration amplitudes for the proposed designs using 150 mm and 187 mm diameter blastholes (70/30 Emulsion/AN blend).

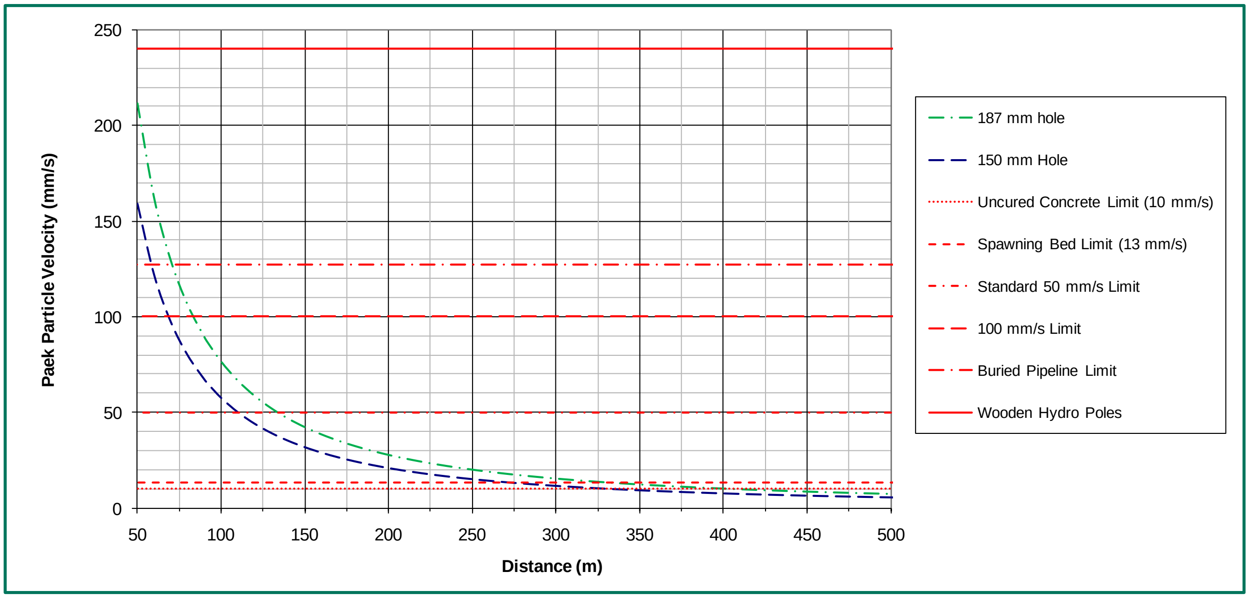


Figure 15: Estimated PPV at a Given Distance for 150 mm and 187 mm Diameter Holes and Showing Various Vibration Limits

7.2 Impact on Canadian Fisheries Waters

7.2.1 Blast Induced PPV and Spawning Beds

Based on the ground vibration attenuation rates discussed previously in Section 7.1, the peak ground vibration levels are expected to fall below the DFO guideline limit of 13 mm/s beyond a distance of about 70 m from the blasting operations. The closest water bodies to the proposed blasting operations are well within this range. The large distances from the water bodies and the small explosive charge loads mean that the ground vibration induced by the underground operations at the End Grid deposit should not impact any spawning beds at the closest water bodies. The estimated PPV levels for these two locations are shown in Table 13.

Table 13: Estimated PPV for Water Bodies near the Proposed Kiggavik Pits

Location	Point of Concern	Distance (m)	Est. Maximum PPV (mm/s)	
			150 mm Holes	187 mm Holes
Pond east of Main Zone Pit	Pit centre to shoreline	500	5.4	7.2
	Pit crest to shoreline	200	**20.7**	**27.6**
Andrew Lake	Pit centre to shoreline	490	5.7	7.7
	Pit crest to shoreline	120	**40.7**	**55.1**

Notes: Distances are measured from approximate location of last production blast, not final trim blast.
Values of PPV that exceed 13 mm/sec are shown in bold.

Estimates shown in Table 13 suggest that blast-induced PPV levels should be below the 13 mm/s limit at the pit centres while blasts conducted near the pit crests may exceed that limit. Therefore, if spawning activity does occur in these water bodies, maintaining compliance with the DFO guidelines will require modifications to blast designs at the pit crests.

It is anticipated that a reduction in the maximum explosive weight detonated per delay period will be required when blasting approaches the following distances to the water bodies active during the spawning season:

- 330 m for 187 mm diameter blastholes; and
- 270 m for 150 mm diameter blastholes.

Early calibration of the vibration attenuation models will indicate whether refinements to the blast designs are needed. The estimates of PPV will also change as a result of further changes to the mine plan, pit optimization, dike alignment optimization, blast design optimization, and calibration of the vibration attenuation model. Any one, or combination, of the following design modifications would reduce the maximum charge weight per delay and consequently the estimated PPV:

1. Reduce the borehole diameter with a corresponding reduction in the drill pattern.
2. Use ANFO with a corresponding reduction in drill pattern if water conditions permit.
3. Introduce decked charges within each borehole.
4. Reduce the borehole length (depth) by reducing the bench height.

7.2.2 Instantaneous Overpressure

The DFO guidelines also set out an underwater overpressure limit of 100 kPa at fish habitat (Wright and Hopky, 1998). However, in a letter from the DFO (addressed January 24, 2011), it is stated that the threshold is inadequate to protect fish and that 50 kPa limit should be used instead. A copy of this letter is attached in Appendix C. The underwater overpressure limit only tends to become a measurable indicator when blasting or explosives are used within the water body itself. No blasting is expected to occur in any body of water on or around the mine site; however, the methodology to estimate the required setback distance for confined explosives to achieve the 50 kPa and 100 kPa guidelines provided by Wright and Hopky (1998) is reviewed below.

The relationship between acoustic impedance and the density and velocity of the medium through which the compression wave travels is given by:

$Z_w/Z_r = (D_w*C_w)/(D_r*C_r)$

where: D_w = density of water = 1 g/cm^3

D_r = density of the substrate, g/cm^3

C_w = compression wave velocity in water = 146,300 cm/s

C_r = compression wave velocity in substrate, cm/s

Z_w = acoustic impedance of water

Z_r = acoustic impedance of substrate

Typical values used for D_r and C_r for various substrates are shown in Table 14.

Table 14: Typical Values for Substrate Density and Compression Wave Velocity

Substrate	D_r (g/cm^3)	C_r (cm/s)
Rock	2.64	457,200
Frozen Soil	1.92	304,800
Ice	0.98	304,800
Saturated Soil	2.08	146,300
Unsaturated Soil	1.92	45,700

Reference: Wright and Hopky (1998)

The transfer of shock pressure from the substrate to the water can be estimated from:

$P_w = (2*(Z_w/Z_r)*P_r)/(1+(Z_w/Z_r))$

where: P_w = pressure (kPa) in water

P_r = pressure (kPa) in substrate

Z_w = acoustic impedance of water

Z_r = acoustic impedance of substrate

The equation can be re-written to solve for the pressure in the substrate (P_r), as:

$P_r = (P_w*(1+(Z_w/Z_r)))/(2*(Z_w/Z_r))$

The equation is solved by setting the value of P_w to the 100 kPa guideline to determine the pressure in the substrate, P_r, which is required to produce this detonation overpressure in the water. The resulting value for P_r is used to determine the PPV (cm/s) in the rock for the given conditions based on the following:

$PPV = (2*P_r)/(D_r*C_r)$

The relationship between PPV, charge weight, and distance was described in Section 7.2 and is given by:

$PPV = k * (R/W^{0.5})^{-b}$

Equating the two equations for PPV, and solving for distance, R, for a given charge weight, W, gives the minimum setback distance from fish habitat required so as not to exceed the 100 kPa overpressure guideline.

The properties shown in Table 15 were used to assess the minimum setback distance.

Table 15: Properties Used to Assess Setback Distance for Instantaneous Overpressure

Medium	Density (g/cm^3)	Compressional Wave Velocity (cm/s)
Water	1.0	146,300 [1)]
Rock	2.6	457,200 [1)]

1) Wright and Hopky (1998)

Based on the above properties, the range of potential charge weights, and the range in confinement value, k, the following minimum setback distances, below which the 50 kPa and 100 kPa overpressure guidelines will not be exceeded, are estimated in Table 16. (Charge weights assume a 70/30 Emulsion/AN blend explosives.)

Table 16: Minimum Setback Distance for Instantaneous Overpressure Guideline

Hole Diam. (mm)	Max. Charge Wt/Delay (kg)	Min. Setback Distance (m)	
		50 kPa Limit	100 kPa Limit
150	215	131	82
187	318	160	100

Note: Assuming k=964 and b=1.47

The minimum suggested setback distances are less than the distances from the proposed pit crest to the nearest shoreline for the Main Zone pit, but are greater than the proposed pit crest for the Andrew Lake pit. The relationship between charge weight per delay and minimum setback distance to achieve both the 50 kPa and 100 kPa guidelines for instantaneous overpressure is shown on Figure 16. The figure can be used as a guide to the development of alternative blast designs in areas that may be affected by instantaneous overpressures greater than 50 kPa.

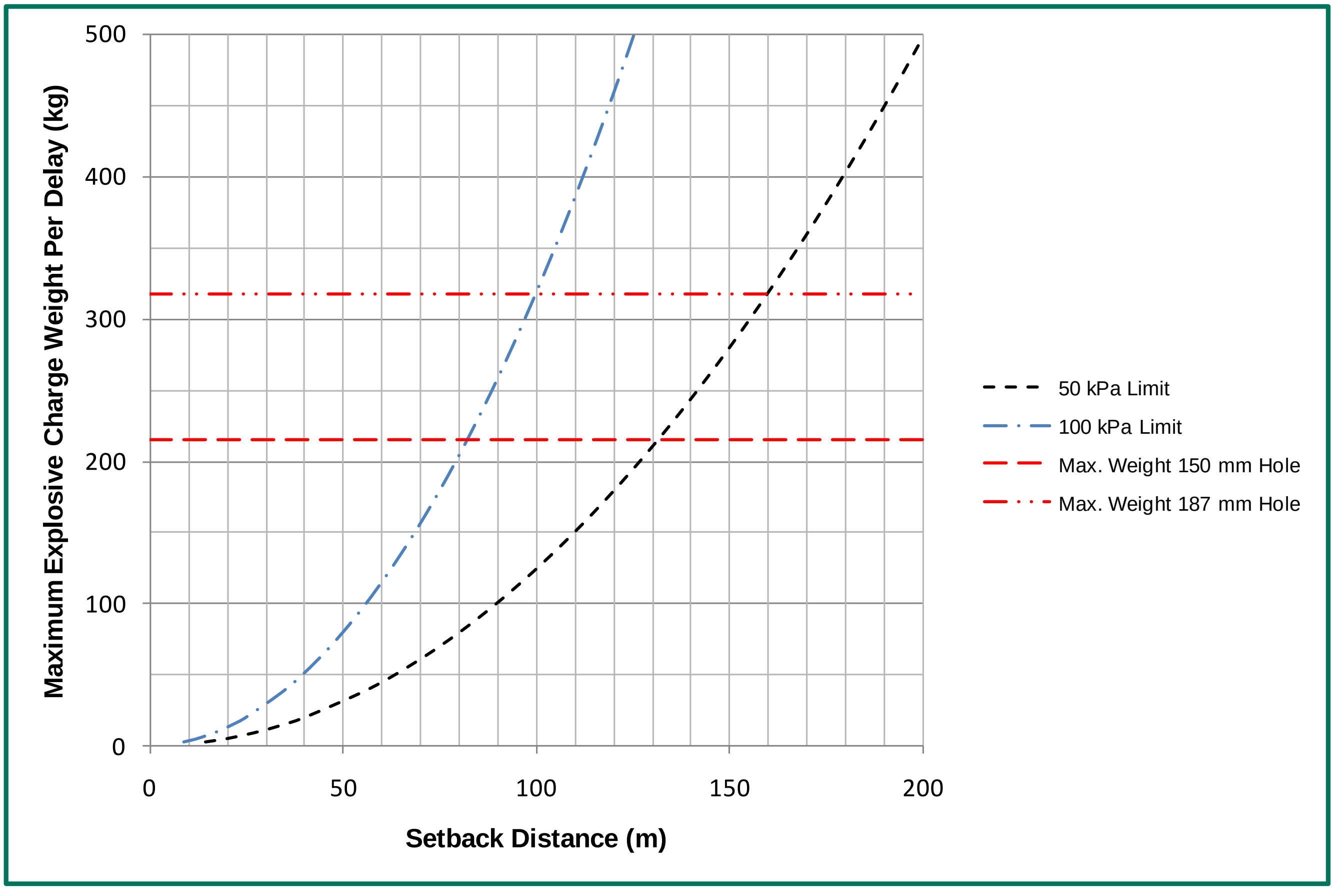


Figure 16: Charge Weight versus Setback Distance for Instantaneous Water Overpressure

As mentioned above, the underwater overpressure limit only tends to become a measurable indicator when blasting or explosives are used within the water body itself. Monitoring of the instantaneous overpressure from test blasts is recommended to provide site-specific data. In areas of concern, mitigative procedures to discourage fish habitat development could be adopted, and might include the use of a bubble curtain.

The large distance from the water bodies and the small explosive charge loads used in the underground operations mean that the instantaneous overpressure induced by the blasts at the End Grid deposit should not impact local fisheries.

7.3 Ground Vibration Impact

7.3.1 Estimated PPV at Proposed Infrastructure Locations

To estimate the vibration levels at various proposed structures at the Kiggavik Project site, the currently available surface site plans were used to measure the distances of the facilities to the pit blasts. These site plans, which were provided by AREVA, can be found in Appendix D. The estimated distances from the blasts to the various surface and sub-surface facilities are shown in Table 17 and Table 18. Blast designs in this section assume the 70/30 Emulsion/AN blend is used.

Table 17: Estimated PPV at Selected Infrastructure Facilities Induced by Main, Centre and East Zone Blasts

Facility	Distance (m)	187 mm Diam. Blasthole		150 mm Diam. Blasthole	
		SD ($m/kg^{1/2}$)	PPV (mm/s)	SD ($m/kg^{1/2}$)	PPV (mm/s)
Acid Plant	505	28.32	7.1	34.44	5.3
Incinerator	520	29.16	6.8	35.46	5.1
Mill	593	33.25	5.6	40.44	4.7
Explosive Area	850	47.67	3.3	57.97	2.5
Tank Farm	646	36.23	4.9	44.06	3.7
Power House	693	38.86	4.4	47.26	3.3
Shop Area	800	44.86	3.6	54.56	2.7
Administration	812	45.53	3.5	55.38	2.6
Security Gate House	930	52.16	2.9	63.43	2.2
Accommodation Complex	1,115	62.53	2.2	76.04	1.7
Construction Camp	1,330	74.58	1.7	90.71	1.3

Table 18: Estimated PPV at Selected Infrastructure Facilities Induced by Andrew Lake Zone Blasts

Facility	Distance (m)	187 Diam. Blasthole		150 mm Diam. Blasthole	
		SD ($m/kg^{1/2}$)	PPV (mm/s)	SD ($m/kg^{1/2}$)	PPV (mm/s)
Magazine	380	21.31	10.7	26.16	7.9
Container Yard	320	17.94	13.8	22.03	10.2
Tank Farm	450	25.23	8.4	30.98	6.2
Sediment Pond	435	24.39	8.8	29.95	6.5
Water Treatment Area 1)	600	33.65	5.5	41.31	4.1
Camp	850	47.67	3.3	58.52	2.4
Decline	1,180	66.17	2.0	81.23	1.5
Batch Plant	1,320	74.02	1.7	90.87	1.3
Exhaust	1,380	77.39	1.6	95.00	1.2

1) Water Treatment, Mine Shop, Power House and Incinerator

The estimated PPV at the proposed infrastructure locations are below the appropriate blast vibration limits. The monitoring of vibrations from the initial blasts at the proposed open pits will facilitate the refining of the estimated attenuation parameters. The estimated PPV at the Andrew Lake Dewatering Structure is shown in Table 19.

Table 19: Estimated PPV at the Andrew Lake Dewatering Structure

Location	Blast Location	Distance (m)	Est. Maximum PPV (mm/s)	
			150 mm Hole	187 mm Hole
Andrew Lake Dike	Pit center	490	5.5	7.4
	Pit crest	120	43.3	**58.5**

Estimates shown in Table 19 suggest that blast-induced PPV levels should be below the 50 mm/s limit at the pit centre while blasts conducted near the pit crests may exceed that limit for blasts using 187 mm diameter holes. The estimates of PPV amplitude are likely to change resulting from changes to the mine plan, pit optimization, dike alignment optimization, blast design optimization, and calibration of the vibration attenuation model. Ongoing blast monitoring will provide guidance as to when, if at all, blast designs should be altered to accommodate vibration levels at the dike. The smaller diameter holes (150 mm) could also be used for the initial waste stripping at Andrew Lake.

Ground vibrations induced by the underground operations at the End Grid deposit should not impact the local infrastructure due to the relatively large distances from the closest structures and small explosive charge loads.

7.4 Flyrock Range

Numerous studies of flyrock projection have been conducted and studied. These include Lundborg (1981), Roth (1981), Workman and Calder (1994), St. George and Gibson (2001), Richard and Moore (2004 and 2005), Little (2007), and McKenzie (2009). In general, these are based on kinematic equations to describe the motion of rock fragments after ejection. McKenzie (2009) developed and presented equations to predict maximum flyrock range and the size of particle achieving the maximum range for blasts of varying rock density, blasthole diameter, explosive density and the state of confinement. The publication also presented guidelines to establish personnel clearance distances as a function of charge design and implementation. The maximum flyrock range is given by:

$$R_{max} = 11 * SDB_m{}^{-2.167} \left(\frac{\emptyset}{F_s}\right)^{0.667}$$

where R_{max} is the flyrock range (m)

SDB_m is the Scaled Distance of Burial (metric)

$\emptyset$ is the hole diameter (mm)

F_s is the shape factor (usually between 1.1 to 1.3 describes most flyrock fragments well)

SDB_m is given by the following:

$$SDB_m = \frac{St + 0.0005m\emptyset}{0.00923(m\emptyset^3\rho_{exp})^{0.333}}$$

where St is the stemming length (m)

m is the charge length as multiple of hole diameter. Max of 8 for holes <100 mm, max 10 for holes >=100 mm

$\emptyset$ is the blasthole diameter (mm)

ρ_{exp} is the explosive density (g/cc)

The equation to estimate the size of particle capable of achieving maximum projection distance is given by:

$$x_f = 2.82 * \frac{2.6}{\rho_r} SDB_m{}^{-2.167} \emptyset^{0.667} F_s{}^{0.333}$$

where x_f particle size (m)

ρ_r is the rock density (g/cc)

Normal blasthole charging operations incur error and variability in the length of stemming columns. The stemming length used in the above equations should use at least a 95% value of the stemming length (i.e. 95% of the stemming columns exceed this length). This is given by the following:

$$St_{95} = St_{avg} - 1.64\sigma_{St}$$

where St_{avg} is the average stemming length (m)

σ_{St} is the standard deviation of the stemming length (m)

St_{95} is the 95% value of the stemming length (m)

A normal degree of variability in stemming length would be around 10% (McKenzie, 2009). A minimum personnel distance is based on a factor of safety of 1.5 times the maximum estimated flyrock range. The results of the flyrock analysis using McKenzie's model are summarized in Table 20.

Table 20: Summary of Flyrock Ranges for Proposed Production Blast Designs

Hole Diam. (mm)	St_{95} (m)	Particle Size (mm)	R_{max} (m)	Clearance (m)
150	3.43	48	154	231
187	4.10	60	192	289

Assuming: a) 70/30 (Emulsion/AN) ratio explosive.

b) The bench top is at the same elevation as the final destination.

The flyrock analysis indicates that for a blast using a 150 mm diameter blasthole with the proposed blast parameters has maximum flyrock range of 154 m and a suggested personnel clearance of 231 m. A blast using a 187 mm diameter blasthole with the proposed blast parameters is likely to have a maximum flyrock range of

192 m and a suggested personnel clearance of 289 m. The flyrock estimates for the proposed blast operations are well below the proposed 500 m clearance.

The ability to control face burdens will provide greater control over flyrock from the blast face and assist in limiting overbreak. The use of face mapping tools (e.g. laser contouring) is suggested to control face burdens.

With the exception of the initial portal entrance blasts, the underground blasting operations at the End Grid will not present any flyrock risks. Flyrock from the portal entrance blasts can be limited by the use of blasting mats or other cover.

7.5 Nitrate Loss Mitigation

7.5.1 Nitrate Loss Mechanisms

Mines are subject to regulations limiting ammonia, nitrate and nitrite levels in mine effluents released into the environment. The primary source of these nitrogen compounds is typically explosive used in blasting operations, as AN remains a significant component of most explosives used in the mining industry. The amount of AN entering a local water drainage system is related to site conditions, explosives used, explosive handling and blast efficiency.

The key mechanisms by which AN is lost to the water drainage system are as follows:

- Spillage during blasthole loading or transportation to the blast site;
- Dissolution by standing or flowing water through the blasthole;
- Erosion of explosive from high flowing water through the blasthole; and
- Leaching of undetonated explosive from the blasted muck, including both ore and waste rock.

Although the majority of explosives used will be from the surface open pits, the End Grid underground mine is also a likely source of nitrate loss. Losses at underground operations can be significant but are often ignored because of the relatively small volume of explosives used there. The ability to achieve good blast efficiency and performance is also related to the mining method used and the blast design employed.

An important factor often related to underground blasting operations is the high use of ANFO. Key issues are as follows:

- Spillage of ANFO often occurs as a result of blowback during the pneumatic loading of blastholes and moving the hose from hole-to-hole. ANFO has no water resistance and will dissolve readily in water.
- The direct release of nitrates into water in wet areas. Loading wet blastholes with ANFO can result in a significant AN loss through dissolution.

Photos 7.1 through 7.4 show typical blasting environments for both open pit and underground situations that are likely to result in AN loss to the environment.

Surface and Underground Blast Loading

Photos 7.1 – 7.4

Photo 7.1: Emulsion spillage during transfer of loading hose from one pit hole to another

Photo 7.2: Emulsion loaded in a wet pit hole. A film residue is visible on the surface of the water.

Photo 7.3: ANFO spillage during underground loading

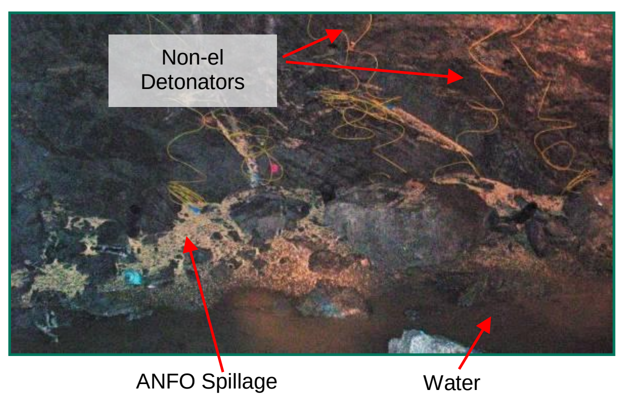


Photo 7.4: Detail of ANFO spillage from pneumatic blowback while underground loading.

7.5.2 Estimated Nitrogen Loss

Following the detonation of AN-based explosive, some residual nitrogen compounds (namely Ammonia, NH_3; Nitrite, NO_2; and Nitrate, NO_3) are left on the surface of the soils, the rock, the pit walls, etc., and can subsequently be washed out by surface run-off. Based on field studies at mining operations, Pommen (1983) and Ferguson and Leask (1988) reported the following factors for expressing the residual nitrogen remaining after the detonation of AN-based explosives:

- Nitrogen loss factor for ANFO: 1% (1% of the mass of nitrogen initially present).
- Nitrogen loss factor for the Emulsion: 5-6% (5 to 6% of the mass of nitrogen initially present).

The steps required for the calculation of the nitrogen loss during blasting is as follows:

- Compute the quantities of explosives (tonnes per year) to be used;
- Compute, from the tonnage of explosives at year "*i*", the initial content (tonnes per year) of nitrogen present in the explosive before use.
- Compute, from the tonnage of nitrogen initially present in the explosives at year "*i*", the residual load of Nitrogen (tonnes per year) left on-site after use of the explosive.
- Transform the total residual load of nitrogen on-site at year "*i*" into tonnes per year of each of NO_3, NH_3 and NO_2 (expressed as N-NO_3, N-NH_3, N-NO_2).

The variables used in the calculation of nitrogen loss during the use of explosives are as follows:

- % Emulsion in the explosive – 70% (0% for the End Grid);
- % ANFO in the explosive – 30% (100% for the End Grid);
- % N in Emulsion – 25%;
- % N in ANFO – 33%;
- % Residual N from Emulsion left after detonation – 5%;
- % Residual N from Emulsion left after detonation – 1%;
- % N as N-NO_3 – 87%;
- % N as N-NH_3 – 10%; and
- % N as N-NO_2 – 3%.

Based on the estimated explosive use during the life of the project, an estimate of the nitrogen loss was calculated for the three main operating areas: Kiggavik, Andrew Lake and End Grid. This was broken down into the respective nitrogen contributions from the three primary compounds noted. Figure 17 shows a summary of the annual nitrogen for the three operations. Table 21, Table 22 and Table 23 tabulate the annual nitrogen loss from the total explosive use at the Kiggavik, Andrew Lake and End Grid operations, respectively.

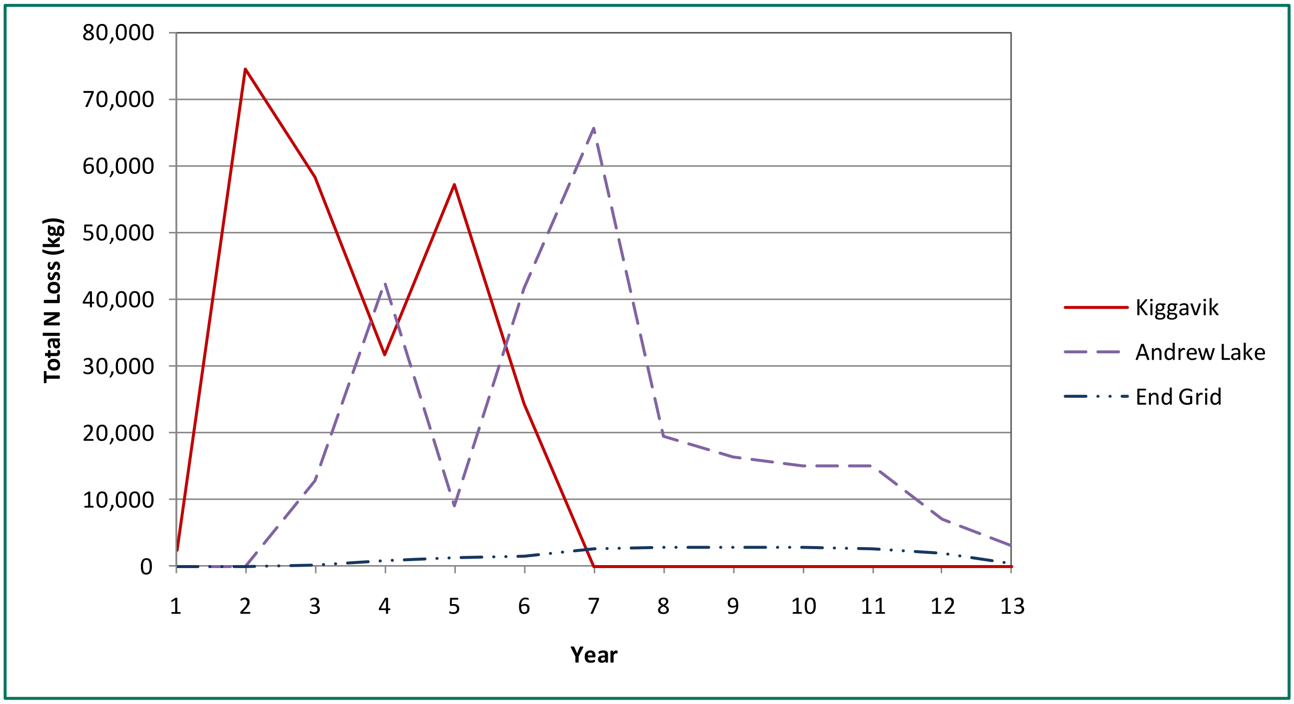


Figure 17: Estimated Yearly Nitrogen Loss for Kiggavik, Andrew Lake and End Grid

Table 21: Summary of Estimated Nitrogen Loss for Kiggavik

Year	Total N Loss (kg)*	N Loss by Compound (kg)*		
		NO_3	NH_3	NO_2
1**	2,244	1,952	224	67
2	74,587	64,890	7,459	2,238
3	58,281	50,704	5,828	1,748
4	31,649	27,534	3,165	949
5	57,172	49,739	5,717	1,715
6	24,390	21,219	2,439	732
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
Total	**248,321**	**216,040**	**24,832**	**7,450**

* *Based on assumptions and estimated from Ferguson and Leask (1988)*

** *Blasting in Year 1 is for the purpose-built pit excavation only.*

Table 22: Summary of Estimated Nitrogen Loss for Andrew Lake

Year	Total N Loss (kg)	N Loss by Compound (kg)		
		NO_3	NH_3	NO_2
1	0	0	0	0
2	0	0	0	0
3	12,789	11,127	1,279	384
4	42,473	36,952	4,247	1,274
5	8,981	7,814	898	269
6	41,616	36,206	4,162	1,248
7	65,641	57,107	6,564	1,969
8	19,374	16,855	1,937	581
9	16,263	14,149	1,626	488
10	15,018	13,066	1,502	451
11	14,928	12,988	1,493	448
12	7,084	6,163	708	213
13	3,018	2,625	302	91
Total	**247,185**	**215,051**	**24,718**	**7,416**

Table 23: Summary of Estimated Nitrogen Loss for End Grid

Year	Total N Loss (kg)	N Loss by Compound (kg)		
		NO_3	NH_3	NO_2
1	0	0	0	0
2	0	0	0	0
3	132	115	13	4
4	782	680	78	23
5	1,228	1,068	123	37
6	1,406	1,223	141	42
7	2,541	2,211	254	76
8	2,703	2,351	270	81
9	2,686	2,337	269	81
10	2,775	2,415	278	83
11	2,617	2,277	262	79
12	1,835	1,596	183	55
13	413	359	41	12
Total	**19,117**	**16,632**	**1,912**	**574**

7.5.3 Mitigation Strategies

In order to minimize any potential impacts an effective explosives management system should be implemented as part of production start-up. The management strategy should include the following:

- An education program for all production employees that outlines the potential problem and appropriate mitigation techniques;
- A spill handling procedure;
- A monitoring program that is integrated with baseline water quality information; and
- A review of blasting operations early in production to determine efficiency levels.

7.5.4 Observed Ammonia Concentrations

Table 24 summarizes the total ammonia concentrations in mine water from various case studies at surface and underground mines. This information is from Wiber et al. (1991), Royal Oak Mines (1997), Pommen (1983), Golder (2006) and Cameron et al. (2007). The table also notes the control measures implemented to reduce the total nitrogen levels, and, for a few cases, the levels after these actions were taken. It is evident from this data that in many cases the implementation of more effective blast management procedures, or a change to explosive type, resulted in significant reductions to measured ammonia concentrations.

Table 24: Total Ammonia Concentrations in Mine Water from Case Studies

Project	Type	Explosives	Conc. (mg/l)	Modifications	Conc. (mg/l)	Comments
Falconbridge Thayer-Lindsley	Underground -Shaft Sinking	Water Gel	2			
Falconbridge Thayer-Lindsley	Underground -Drifting	ANFO	60	ANFO management procedures established and implemented	10-30	Could not meet standards
Falconbridge Thayer-Lindsley	Underground -Drifting	ANFO/ Watergel	<10			
Placer Dome Inc. Dome Mine	Underground - Stope & drift	ANFO	12	Changed handling practices, education of operations personnel	1	Did not change explosives
Hemlo Gold Mines Golden Giant Mine	Underground -Drifting	ANFO	10-15	Changed handling practices, education and training	<4	Follow-up of training important
Elliot Lake Uranium Mines	Underground -Stope & drift	ANFO	60-350	Changed handling practices and reduced water source, recycled water and diverted surface water flow		Often did not meet standards
Royal Oak Mines Giant Mine	Underground -Stope & drift	ANFO/Slurry	15.3	Reduced wastage of explosives	12.3	
Brenda Mines	Open pit	ANFO/Slurry	15-30			7-8 tons/year nitrogen and 825 tons total nitrogen
Cyprus Anvil Faro Mine	Open pit	ANFO				
McIntyre Mines Ltd. Grande Cache	Open pit	ANFO	2-23			
Fording Coal Ltd.	Open Pit	Slurry	0.1-5.0*			
Diavik Diamond Mine	Open Pit	Em/AN**	2-37	Increased Em/AN ratio from 65/35 to 80/20 and reduced explosive sleep time		Reduced the number and amplitude of spikes

* Typically 0.1-0.5 mg/l – in 1977/78 recorded up to 5.0 mg/l that is believed to be related to specific discharges from an explosives plant

** Em/AN – Emulsion/AN blend

8.0 CONCLUSIONS AND RECOMMENDATIONS

Production and wall control blast designs have been presented for the proposed open pits at the Kiggavik Project. The blast designs have been based on standard design methods applied to the specific rock types and structure that is known to exist in the deposit areas. Designs for two open pit blasthole sizes have been presented, 187 mm and 150 mm. The use of 150 mm diameter holes would result in the need to drill more blastholes due to the reduction in spacing and burden and, therefore, increase costs.

Where the development of the pit walls is beneath the de-watered lakes (Andrew Lake Zone), wet blasthole conditions can be expected. Where the walls are developed within permafrost beneath the existing land mass (Main and Centre Zones), drier blasthole conditions may be encountered, although actual conditions will remain unknown until the blasting operations commence. In order to limit the water damage to the explosive, which would result in poor blast performance, a doped emulsion of 70/30 (Emulsion/AN) blend is recommended. A charge table has been presented for the two blasthole diameters using a 70/30 blend. Although ANFO is a less expensive explosive product, its lower energy requires a higher drilling density thereby increasing overall drill and blast costs.

The following is a summary of the findings of our study and recommendations for further work:

- Blast layout designs have been presented for the open pit blasting at the Main, Centre and Andrew Lake Zones. With input from the AREVA and eventual operating experience, other designs may be considered more appropriate for the mine and should be subjected to analysis using the presented flyrock, vibration and fragmentation models (or calibrated versions of them).

- Proposed blast designs are likely to produce acceptable results for the following:

  - Fragmentation;

  - Vibration levels at the existing and proposed infrastructure; and

  - Flyrock ranges and suggested clearance radii. (These are within the initially proposed clearance zone of 500 m).

- 187 mm diameter blastholes may induce PPV amplitudes that exceed the initially proposed limit of 50 mm/s for the Andrew Lake Dewatering Structure as blasts approach the pit crest. The threshold value of 50 mm/s may be modified once more detailed information is obtained relating to the foundation materials beneath the dikes. Ongoing blast monitoring will provide guidance as to when, if at all, blast designs should be altered to accommodate vibration limits at the dike.

- The proposed blast designs are unlikely to induce underwater overpressure levels that are harmful to fish in the adjacent water bodies. Analyses indicate that blasts are likely to induce PPV levels that are below the 13 mm/s limit (for active spawning beds) at the pit centres, while blasts conducted near the pit crests may exceed that limit. If spawning activity does occur along these reaches of the above-mentioned water bodies, maintaining compliance with the DFO guidelines is necessary.

- Recently updated data on the estimated drill penetration rates, estimated drilling and explosives unit costs and the cost of accessories were used to provide an order of magnitude estimate of the cost impact resulting from changes to the explosives, blasthole diameter and blast patterns. The base case design of 187 mm diameter holes using a 70/30 Emulsion/AN blend provides a lowest cost option that can be used routinely in all conditions, wet or dry, without modifying drilling patterns or blast procedures.

- The ground vibration, flyrock, fragmentation, and instantaneous underwater overpressure analyses presented in this report are based on empirical formulae which are commonly used in the blasting industry to assess these effects from blasting. The models are intended to provide initial approximations only and they should be calibrated with actual site data to provide refined estimates. It is suggested that monitoring programs be developed and conducted to calibrate and refine the ground vibration, flyrock and fragmentation models presented in this report. These could be initiated in advance of the main blasting at the Kiggavik open pits, possibly as test blasts when early waste stripping commences.

- The use of face mapping tools (e.g. laser contouring) is suggested to ensure that face burdens are controlled. This will provide greater control over flyrock from the blast face and assist in limiting overbreak.

- Contract development mining will be retained for primary development and production ore mining at the End Grid underground operation. The limited size of the blasts and charge weights, as well as the large distances from the proposed infrastructure and lakes, will limit the potential impact by vibration and instantaneous water overpressure. Flyrock will only be a concern for the portal construction. The use of blasting mats or other cover should mitigate this risk. In order to limit the loss of nitrogen compounds to the environment, the use of packaged Emulsion explosives could be considered. This will also help to maintain good blast performance and efficiency.

- The annual total nitrogen loss, as well as that for the three primary nitrogen compounds, has been estimated for the life of mine. The total annual estimated nitrogen loss ranges from 2,244 kg (Year 1) to 74,904 kg (Year 4) and a total life of mine nitrogen loss estimated at approximately 514,600 kg.

- In order to mitigate the potential impacts of AN loss from the blasting operations, an effective explosives management system should be implemented as part of production start-up. This should be done for both the open pit and underground operations.

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APPENDIX A

Canadian Explosives Regulations

Natural Resources Canada
Ressources naturelles Canada

Blasting Explosives and Initiation Systems

Storage, Possession, Transportation, Destruction and Sale

Explosives Regulatory Division
Explosives Safety and Security Branch
Minerals and Metals Sector

March 2008

Canada

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Please consult our web site regularly to obtain more information and documentations on the Explosives Regulatory Division, such as:

- The *Explosives Act* and Regulations;
- Full Quantity-Distance Tables along with recent rulings;
- Bulletins and directives letters on:
  - Zone licences for blasting explosives;
  - Restricted usage of Type 6 magazines for stand-alone, overnight and unattended storage;
- Application Form 10 to obtain a magazine licence; and
- Other explosives-related information.

1. INTRODUCTION

All explosives are DANGEROUS. While some are more dangerous than others, most will explode; will cause serious physical harm, including death; and will cause significant damage unless stored and handled properly.

Proper storage serves two purposes. The first is SAFETY. The storage of explosives has a much deeper relationship to safety in their use than is commonly realized. Improper storage of blasting explosives, detonating cord, and initiation systems (detonators, fuse and igniters) can be the cause of misfires, incomplete detonation, and of charges burning in the borehole.

The second purpose is SECURITY. Every effort must be made by means of substantial construction and strong locks to prevent access to the interior of magazines and to discourage, as much as possible, those persons seeking explosives for criminal purposes.

This booklet reviews the basic principles of the storage and handling of blasting explosives, detonators, initiation systems, and related explosive accessories. It also summarizes some of the legal aspects of their storage and sale. These principles and the law are detailed in Canada's *Explosives Act*, which, by a system of licences and permits, controls the authorization, manufacture, importation, sale, and storage of all explosives, as well as some aspects of their transportation by road. This Act is enforced by Inspectors of Explosives with the assistance of the appropriate police forces. This booklet is intended primarily for use by blasters in giving a general overview of explosives regulations and standards.

It is wise to consult the Explosives Regulatory Division during the early planning stages, and definitely before purchasing or constructing a magazine or establishing a magazine area, since buildings and sites not meeting the established norms will be UNACCEPTABLE for licensing and use.

2. MAGAZINE SITE

2.1 Surveillance

In practical terms, it is impossible to design a magazine that is completely impregnable to determined thieves with modern tools and equipment, given sufficient time. Therefore, the aim must be to survey magazines sufficiently frequently to deny thieves this opportunity.

All storage sites should have some form of regular and recorded surveillance, unless the magazines are empty. The surveillance could be daily site visits at irregular times, the alternative being some form of electronic surveillance. Records of time and date of site visits should be available to inspectors and the police. Directive letter #61 outlines these requirements.

Any magazine site that suffers a break-in or attempted break-in must increase surveillance. Additionally, if criminal activity in the area increases, as indicated by nearby magazine break-ins or police information, then the surveillance level must be increased.

2.2 Magazine Location

A magazine should be situated so that the accidental explosion of its contents is not likely to cause any serious damage to other buildings or injury to persons. The minimum distances by which a magazine must be separated from other buildings or places are dependent on the maximum quantity of explosives stored in the magazine at any one time. In Canada, the Quantity-Distance Table, compiled from a study of the effects of recorded explosions, are taken as a guide in approving the site for a magazine containing given amounts and types of explosives.

It is emphasized that these are minimum distances. Greater distances should be observed wherever possible and greater distances in specific cases may be mandatory. Refer to Appendix A for a summary of the Quantity-Distance Table.

When it is impractical or uneconomical to store all the explosives in one magazine sited in accordance with the Quantity-Distance Table for blasting explosives, judicious selection, siting, and barricading of magazines might provide the solution by establishing a magazine area that may be shared by different construction companies and may accommodate a much larger weight of explosives in a number of magazines.

The purpose of a barricade is to protect the magazine adjacent to it from direct missile attack emanating from another magazine or a nearby explosion. However, to ensure that the explosives will not be initiated by sympathetic detonation or flash from an explosion, magazines must be separated by at least the distance given in the Quantity-Distance Table for barricaded magazines (D2).

2.3 Environmental Considerations

If any magazine is situated within 30 metres (m) of a body of water, an environmental assessment of the site is required. Therefore, contact an Inspector of Explosives for further details.

2.4 Ammonium Nitrate

When stored with or adjacent to other explosives, half the weight of ammonium nitrate must be treated as an explosive and be included in the licence limits for the magazine. For example, if 250 kilograms (kg) of ammonium nitrate is stored along with 25 kg of dynamite, the total quantity of 150 kg must be considered as blasting explosives for the assessment of quantity-distances.

It should be noted that the mixing of ammonium nitrate and fuel oil (ANFO) to form an explosive is legal only if the user has a valid factory licence or manufacturing certificate. Contact ERD to obtain application forms.

2.5 Initiation Systems Magazine

When initiation systems are kept in a magazine, no other blasting explosive shall be kept in that magazine. The term “initiation systems” includes the different types of electric, non-electric, and electronic detonators, with or without the fuse, shock tube or detonating cord attached, as well as detonating relays and electric squibs for fuse starters.

Since the initiation system is the trigger needed to release the energy of blasting explosives and is the key to their use for criminal purposes, every effort must be made to prevent unlawful access.

If local conditions necessitate locating the initiation system magazine close to the blasting explosives magazine, it should be at least 50 m from it. This distance may be reduced at the discretion of an Inspector if the quantity of detonators stored is small. Type 9 magazines (two-compartment magazines) may be authorized by an Inspector.

2.6 Detonating Cord and Boosters

Since detonating cord and boosters contain PETN, TNT, or similar high explosives, their explosive potential must always be borne in mind. They must always be stored in a blasting explosives magazine (never with detonators) and kept in closed cases. Cut ends of detonating cords should be sealed with masking or other suitable tape to prevent loss of explosives.

2.7 Other Materials and Equipment

Only materials and equipment, such as pallet movers, that do not increase the risk of fire or explosion and that are needed for handling explosives in the magazine or for the operation of the magazine may be brought into the magazine.

2.8 Fuse Lighters, Igniter Cord, and Connectors

Fuse lighters, igniter cord, and igniter cord connectors are explosives, but present more of a fire hazard than an explosion risk. For this reason, these items must not be stored in either a blasting explosives or an initiation system magazine but, rather, in a separate, dry, secure location.

2.9 Protection Against Lightning

Locating a magazine at the base of a high bank will reduce the possibility of it being struck by lightning. Grounding the magazine is advisable in areas subject to severe electrical storms. Upon the approach of thunderstorms, the magazine must be closed and all personnel must be evacuated from the immediate area.

2.10 Proximity to Electrical Transmission Lines

All overhead cables should stop at least 15 m from the magazine in order to divert a potential lightning strike and then proceed underground to the exterior of the magazine.

For power lines exceeding 15 kilovolts (kV) or that serve a national grid or are otherwise vital, consult the *Quantity-Distance Principles User's Manual*.

For the installation of any electrical equipment on the outside or inside of a magazine, including communication devices or alarm systems, consult the *Storage Standards for Industrial Explosives* or an Inspector.

2.11 Wireless Communication Devices

Wireless communication devices such as cellular phones, mobile radios, pagers, GPS units, etc., must not be brought inside an initiating system magazine. A good practice is to leave such items outside all magazines.

2.12 Portable Electrical Devices

All portable electrical devices used in magazines, including bar code readers, calculators and lighting, must be watertight, dust tight, and impact resistant.

2.13 Protection Against External Fires

Fire is a hazard that must always be borne in mind when considering explosives storage. To guard against it, the grounds surrounding a magazine must be maintained free from bush, weeds, dry grass, and other combustible material for a distance of at least 8 m. A magazine built of concrete blocks or clad in fire-resistant material affords added fire protection.

All material used to raise a magazine above ground level (to facilitate truck offloading, for example) must be of non-combustible materials.

2.14 Signs

Suitable signs must be posted at all explosives storage sites so that the public is warned of the hazard. Ideally, the signs should not be posted in a manner that would attract undue attention.

Conditions vary from location to location and the following is suggested as a guideline:

WALK-IN TYPE MAGAZINES

A warning sign that is readable at a distance of 8 m must be posted on each usual approach to the magazine. The sign must be positioned so that it does not attract unwanted attention and minimizes the possibility that a bullet shot in the direction of the sign would hit the magazine.

The following words or words to the same effect must appear on the warning sign:

EXPLOSIVES
Authorized Personnel Only
No Smoking
Violators will be charged under the *Explosives Act*

PORTABLE MAGAZINES

Portable magazines located on logging sites, construction sites, or within city limits may require warning signs. Depending on the area where the portable magazines are located, signage requirements may depend on local and provincial/territorial regulations. Contact your regional inspectors for details and guidance.

2.15 Entrance Gate

The entrance to any site storing a large quantity of explosives should be protected by a sturdy, lockable barrier that will effectively prevent vehicular access. It must be closed at all times and locked whenever the site is unattended.

3. MAGAZINES

3.1 Construction

Magazines for blasting explosives and initiation systems must be built to conform to the *Storage Standards for Industrial Explosives, May 2001*, or the most recent version.

Note: In addition to the Canada Explosives Act and Regulations, for any storage, transport, and sale of explosives in the province of Quebec, please consult the Explosives Act and Regulations of Quebec administered and applied by the Sûreté du Québec.

3.2 Heating

Heating of magazines may be permitted. Details on the installation of heating systems can by found in the *Storage Standards for Industrial Explosives*.

3.3 Housekeeping

Regular follow-up by magazine operators must be made to ensure the following:

- Observance of the "No Smoking - No Matches" rule;
- Magazine reserved exclusively for the storage of explosives;
- Magazine kept scrupulously clean and orderly;
- Habitual use of brooms, mats, and dust pans;
- Proper stacking of explosives below the stacking line; and
- Packaging of explosives properly identified with its ownership identification.

It is important to keep a magazine clean because grit, sand, or abrasive materials can make explosives more sensitive.

There are normally many varieties of initiating systems stored in a magazine, e.g., electric and non-electric detonators, not only of different periods, but of different lengths as well. For this reason, a system of shelves on which each variety can be stored in their original containers and be readily seen and selected is recommended.

3.4 Opening Cases or Packages

Cases of explosives should not be opened in a magazine. The case must be properly closed before returning it to the magazine. Under no circumstance should there be open cases or loose cartridges in a magazine. Whenever possible, a cartridge must be replaced in its original case.

3.5 Empty Cases or Packages

Empty cases or other combustible material must not be allowed to accumulate inside or in proximity to a magazine. All empty explosives packages and packing material must be carefully collected and destroyed because they constitute a potential explosive and fire hazard.

Any packaging or container that is clean and in good condition when it is emptied, and that did not contain nitroglycerine or any other liquid explosive, may be re-used for the same purpose. All markings must be kept accurate for its content.

3.6 Stacking Height

On the interior of the wall of the magazine, a “stacking line” must be painted or otherwise permanently marked with a red line 10 millimetres (mm) wide at a distance at least 15 centimetres (cm) below the height of the bullet-resistant material. This is to prevent a bullet shot from an elevated point from impacting the explosives.

Cases should never be piled too high and never be above the stacking line. A person standing on the floor should be able to handle the top case without difficulty.

3.7 Turnover of Stock

Attention must always be paid to the turnover of stock. The older stock must be used first since most explosives deteriorate with time. Care must be taken not to leave old stock at the back of the magazine when a new supply is brought in.

The presence of corrosion on the metal shells of detonators indicates that deterioration may be advanced and the detonators should be destroyed with care. Damaged detonators should not be used.

In many instances when deteriorated explosives have been found in magazines, the cause has been traced to the return of the explosives to the magazine after they had been temporarily held under unfavourable conditions. This also applies to the return by customers of leftover explosives. Therefore, any person in charge of a magazine must carefully scrutinize all returned explosives.

3.8 Instruction Sheet

Instruction sheets for blasting explosives and initiation systems magazines are available on request. The appropriate sheets must be posted inside each magazine. These sheets should be reviewed frequently by the magazine keeper.

4. LICENSING AND POSSESSION

All explosives magazines, other than at a military establishment and those under provincial control on mine or quarry sites, come under the jurisdiction of Canada’s *Explosives Act*.

However, a magazine on a mine or quarry site making sales or using the explosives off the site also comes under federal jurisdiction for those activities. Under the *Explosives Act*, storage falls into two categories:

> STORAGE AND POSSESSION FOR USE
>
> The storage and possession of any quantities of blasting explosives and detonators must be covered by a magazine licence (Form 10 - Magazine Licence application). The licence is the permit to possess the quantity of explosives listed in the licence. The licence allows storage, but also possession, even if there is no magazine, for example, for daily deliveries and pickups.
>
> STORAGE FOR SALE
>
> The storage of any quantity of blasting explosives or detonators for sale, as well as any quantity on consignment, must be covered by a vendor's licence (Form 10 - Magazine Licence application). It is an offence under the *Explosives Act* for any person to sell, give away, or otherwise distribute blasting explosives or detonators unless licensed to do so. The licence is also the permit to possess the quantity of explosives listed in the licence.

The annual fee for licences is set by regulation. Issuance of a licence is conditional upon the security and safety afforded to the public by the magazines and on their continual upkeep and state of repair. Anyone desiring to establish magazines and to obtain a licence should apply to the Explosives Regulatory Division indicating the type of magazines proposed, their location, and the maximum quantity to be stored in each one.

When issued, a licence must be retained at the site with the magazines for further inspection by an inspector or police officer. The licence may be kept at the main magazine or in an office near it.

4.1 Classification of Explosives

All explosives have an assigned United Nations (UN) number of four digits, a two-digit Transport of Dangerous Goods class number, and a compatibility group letter. A blasting explosive may be designated by UN 0332, Class 1.5D. The compatibility group indicates which explosives can be transported and stored together. Note that it is prohibited to store explosives of compatibility groups B (mostly detonators) and D (mostly blasting explosives) together.

4.2 Non-Explosive Blasting Accessories

Non-explosive blasting accessories such as connecting wire, blasting machines or exploders, circuit testers, and cap crimpers must not be stored in a magazine containing explosives.

4.3 Local Laws or By-Laws

Prior to storing explosives, it is recommended that local authorities be consulted as the *Explosives Act* does not relieve any person of the obligation to comply with the requirements of any provincial/territorial or municipal law regarding explosives.

4.4 Inventories

A careful inventory must be kept of all receipts of blasting explosives and initiation systems to a magazine and of every issue from it. Care must be taken to ensure that stocks do not exceed the licence limits for the magazine as the law provides for a penalty when limits are exceeded. A sample of inventory control sheets is shown in Appendix B. One inventory sheet per product is recommended.

A magazine keeper who issues explosives to shot firers, blasters, or powdermen/women must keep a record of the amount of blasting explosives and detonators issued. "Returns" must also be carefully recorded. Every precaution must be taken to ensure that no explosives have been "mislaid" or lost as they may be the cause of subsequent accidents. A signature must be obtained for every issue or return of explosives.

A record must be kept of every explosive that is put into and taken out of storage. The record must be retained for at least three years after the date the explosive is taken out of storage.

All stock must be counted at least monthly. Results of the stock counts must be recorded in the inventory book. Unresolved discrepancies must be reported to police and the Explosives Regulatory Division.

Records must be kept in a secure location to preclude loss of records in the event of a theft.

4.5 Explosives Sales Register

In addition to a stock inventory, vendors of explosives are required to maintain a record of all sales. Records of all sales must be retained for at least three years after the date the explosives have been sold.

In these days where explosives are the means of choice to carry out threats, it is important that vendors do not deliver or sell explosives to anyone they do not know, who cannot identify themselves, or who does not have a valid magazine licence.

4.6 Ownership Identification

To assist police forces in the apprehension and conviction of criminals, it is imperative that every outer package or case of blasting explosives or detonators be properly and permanently marked to indicate ownership. It should be realized that in criminal proceedings for theft, proof of latest ownership must be established beyond a reasonable doubt before a conviction can be obtained.

The legal responsibility rests with the vendor of the explosives to mark the case in the next sequentially available rectangle in the identification ladder prior to shipment with one of the following:

- User's magazine licence number; or
- Vendor's magazine licence number when sale is to another vendor; or
- Provincial or territorial magazine licence/permit number.

If a shipment of blasting explosives or detonators arrives at its destination without any marking or with an improper one, the person receiving it is requested either to refuse delivery or to mark it correctly and deal directly with the shipper for any inconvenience or expense incurred.

When full cases of detonators, detonating cords, and boosters are purchased, the shipper is required to mark only the outer case. It is the responsibility of the person opening such a case to mark the inner cartons or spools immediately with the appropriate magazine licence number.

4.7 Reporting of Theft

Every instance of theft of explosives, whether actual, suspected or attempted, must be reported as quickly as possible to both the local police and to the Explosives Regulatory Division; the latter report must be in writing (Form 34 - Eplosives Incident Report). The information should include:

- Place, date and time;
- Magazine information, such as type and tag number;
- Nature, quantity and ownership identification number on explosives stolen;
- Method of entry and property damage; and
- Other pertinent details.

5. TRANSPORT OF EXPLOSIVES

The day-to-day transportation of explosives by dealers, common carriers, construction crews, and individuals in private motorcars is primarily under the jurisdiction of the *Transportation of Dangerous Goods Act*. Transport by rail, marine, and aircraft is also subject to the *Transport of Dangerous Goods Act* and other regulatory acts. Canada's *Explosives Act* also sets some regulations that relate to the transport of explosives.

Every vehicle used to transport explosives must be in sound mechanical condition and capable of safely transporting explosives. The following requirements should be met:

- Equipped with two fire extinguishers readily available for use;
- Electric wiring is insulated and firmly secured;
- Fuel tanks and fuel lines have no leaks;
- Chassis and engine body are clean and free of excess oil and grease;
- Brakes and steering are in good condition;
- Tires are not worn or visibly defective; and
- Explosives Vehicle Certificate if more than 2000 kg are transported.

The portion of a vehicle containing explosives must be kept free of grit, combustible or abrasive material, matches, any spark-producing or flame-producing device, and any substance that could ignite spontaneously.

Detonators must be kept separate from other explosives in a vehicle so that the explosion of one or more detonators will not ignite any of the other explosives. The detonators must be in a completely enclosed container or compartment that protects them from detonation in the case of fire for at least one hour. There must be no access to the detonators from inside the cargo compartment of the vehicle.

A driver of a vehicle must be a minimum of 18 years old, and 21 years old if more than 2000 kg is transported. Two drivers must accompany a vehicle if explosives are to be transported for a period of more than 10 consecutive hours. A vehicle should be equipped with a tracking and communication system to allow the company to locate every vehicle at any time.

Four orange Transport of Dangerous Goods placards are to be displayed on each side of a vehicle while it contains explosives. All explosives of the same compatibility group may be transported together without separation regardless of the hazard division. Consult the Transportation of Dangerous Goods Directorate for specific rules for placarding mixed loads of explosives of different hazard divisions, compatibility groups, and others.

6. DESTRUCTION OF EXPLOSIVES

It is sometimes necessary to destroy explosives. These explosives may be fresh material from containers that have been broken during transportation, usable material for which there is no further use on a job, or may consist of material that has deteriorated or become unfit for use through damage. Deteriorated explosives can be much more hazardous than those in good condition, and hence require special care in handling and disposal.

It is always preferable to contact the manufacturer or vendor of explosives prior to destroying explosives. Manufacturers are in a better position to determine the appropriate destruction methods.

Members of the public who discover abandoned explosives should not attempt to dispose of them, but should contact their local police forces.

The safe methods recommended in the *Guidelines for Disposal of Industrial Explosives* are intended for the use of experienced and competent people, such as technicians or blasters. If large quantities of blasting explosives must be destroyed, and if experienced or competent people are not available to perform the work, or if there is any question about the safety of the undertaking, the handling and destruction of the explosives should be deferred. Consult with a representative of the manufacturer of the explosive or the Explosives Regulatory Division for advice.

Scrap or deteriorated explosives must be packaged according to the Transportation of Dangerous Goods Regulations for transportation to a destruction site.

Since the destruction of explosives may contribute to pollution, particularly when ammonium-nitrate based and watergel explosives are involved, it is advisable to consult the local agency responsible for the environment before proceeding.

6.1 Dynamite and Nitroglycerine Contamination

Nitroglycerine (NG)-based blasting explosives, such as the dynamites, are liable to “sweat.” This sweating may be the exudation of nitroglycerine and, although it is greatly increased by storage in a hot, moist atmosphere, it can occur even under good storage conditions. Sweating increases their sensitivity to friction.

Beads of nitroglycerine form on the outside and ends of cartridges, and after a time the exuded nitroglycerine will soak into the bottom and lower sides of the cases, staining them noticeably. The sweating may be observed earlier on cartridges in open cases. In either event, the cartridges in all packages should be examined and, if still serviceable, taken for early use. They should be issued only if the person receiving them understands their condition. If the sweating observed is so great that the cartridges are unserviceable, they should be destroyed by burning.

The authorization of an Inspector of Explosives must be obtained prior to the transportation of degraded NG explosives. These explosives can be very sensitive to shock and friction, and specific procedures must be followed for packaging and transportation.

Where nitroglycerine exudation has occurred to such an extent that the liquid has seeped from the cases to the floor, special decontamination must be performed. Contaminated wooden battens, duckboards and false floors should be removed from the magazine and burned. CAUTION: Such contaminated wood can explode. Any free, liquid nitroglycerin must be removed with sawdust or absorbent. The contaminated absorbent must then be burnt.

When removal of contaminated articles is impossible, the stain must be thoroughly cleaned with a special preparation that neutralizes nitroglycerine. NG destroyer may be made by dissolving 500 grams (g) of caustic soda (NaOH) in about 1 litre (L) of water and adding 6.5 L of wood alcohol (CH_3OH) or methylated spirits (a stronger solution is obtainable through your explosives distributor). **Do not spread NG destroyer on free liquid nitroglycerin because it could cause a hazardous chemical reaction.**

Hands and eyes should be protected when this solution is used. Apply generously and allow the solution to remain on the contaminated area for half an hour or longer. Then remove it by washing the floor thoroughly with clean water. All cloths and mops used should be allowed to dry and then be burned. Be sure the floor is perfectly dry before storing other explosives on it.

6.2 Emulsion, Watergel, and Ammonium Nitrate-Based Explosives

These types of explosives are much less sensitive to shock and friction than nitroglycerine explosives. Nevertheless, they are every bit as powerful and all the safety rules must be applied. Any spillage of explosives must be carefully collected and destroyed.

On watergel, wetness on the outside of a film cartridge or segregation of the ingredients indicates that syneresis (gel breakdown) has occurred; therefore, the product will likely fail to shoot. Likewise, an emulsion that has become stiff or crusty, rather than feeling smooth and pliable, has probably become insensitive.

If ANFO is kept too long, fuel oil may leak through the plastic bags and contaminate the magazine. This creates a fire hazard and, if the condition is severe, it may be necessary to replace any contaminated floor sections. If ANFO bags are kept for a long time, these should be rotated or turned over in order to reduce the oil migration through the material to the bottom of the packaging.

Leakage of explosives through their packaging may contaminate the magazine. Spills must be picked up properly, and attention must be paid where spilled emulsion and ANFO could have left an oily residue, which creates a fire hazard. If all explosives cannot be cleaned up (e.g., spills in cracks, porous materials), it may be necessary to replace contaminated flor sections.

6.3 Destruction by Detonation

Often the best method of destruction is to detonate explosives in a blast hole as part of a production blast by introducing them in the borehole under the collar or stemming.

If the explosives are still in good condition to be transported to an agreeable client, small quantities of explosives can be added in the blast hole.

Special care must be taken to not mix different types of explosives to avoid contamination or incompatibility between the explosives to be blasted and the explosives to be destroyed. It is important to discuss the intention of doing the destruction with the client, vendor, or blaster.

6.4 Destruction by Combustion

Burning is one method of destruction. It must be assumed that there is always the chance of an explosion during burning; consequently, a remote location must be chosen so that no damage to property or injury to people will result.

Every precaution must be taken to make certain that only one type of explosive is destroyed at a time. Dynamite, detonating cord, cast boosters, and safety fuses must be examined carefully to ensure that no detonators of any kind are among the explosives to be burned. The presence of only one detonator or of a metallic object will probably lead to detonation. Therefore, initiation devices must never be burned; they should be destroyed separately by being detonated at a carefully selected place.

6.5 Abandoning Explosives

It is a serious offence under the *Explosives Act* to abandon explosives. The explosives involved may have been lost or forgotten, deliberately abandoned, or improperly kept by their owners. Accidents under such circumstances border on criminal negligence for which severe penalties are provided by the Criminal Code, over and above any consequences resulting from an accident. The consequences of a child finding explosives can be disastrous.

6.6 Burying Explosives

Explosives must never be buried. Explosives may retain their properties for a very long time, e.g., nitroglycerine, a component of dynamite, does not degrade with time. Many instances have occurred in which lives have been lost through the explosion of nitroglycerine that had lain for more than twenty (20) years in the ground, in crevices between the rocks, or even under water. Similarly, TNT, often used as an ingredient of some slurry and other blasting explosives, and some other explosives do not lose their explosive force with time.

The Explosives Regulatory Division's main priorities are the security and safety of workers and the public. If you have any questions on or concerns about the storage, possession transportation, destruction, sale, or other aspects of explosives, please do not hesitate to contact ERD headquarters or any of its regional offices listed on page v.

Appendix A

QUANTITY-DISTANCE TABLE
FOR STORING BLASTING EXPLOSIVES

The Explosives Regulatory Division has introduced the Quantity-Distance (Q-D) criteria. Any licence, and any zone licence in which the magazine is moved to a new location, must follow the Q-D principles.

USING THE TABLE

Columns D1 to D8

D1 and D3 As these apply primarily to factory operations, they have been deleted here.

D2 This is the distance that is required to separate two magazines, provided there is an effective barricade between them.

D4 This is the required distance between a magazine and a very lightly traveled road (from 20 to 500 vehicles per day; provincially numbered highways do not qualify as lightly traveled roads).

D5 This is the distance required from a magazine to most roads and highways (from 500 to 5000 vehicles per day). Note that there is an overriding minimum distance of 180 m.

D6 This is the distance between unbarricaded magazines.

D7 This column is called Inhabited Building Distance. It applies to very busy roads (more than 5000 vehicles in a 24-hour period) and to buildings where people may assemble. Note that there are minimum distances: 270 m for up to 20 people and 400 m for more than 20 people.

D8 This is the distance from a magazine to a building of vulnerable construction. Vulnerable construction includes highrises, schools, hospitals, etc. Note that this is twice the normal Inhabited Building Distance found in D7. There is an overriding distance of 400 m.

UN CLASSIFICATION SYSTEM FOR BLASTING EXPLOSIVES

Under the United Nations classification system, blasting explosives are either Hazard Division 1.1 or 1.5 (detonator sensitive or booster sensitive). The Table treats them both the same. For quantities larger than 90 000 kg, contact your regional inspector.

Example 1: You want to store 5500 kg. Since there is no entry for 5500 kg, choose the next highest quantity (6000 kg) and find the required storage distances for storing 6000 kg. There is no interpolation for intermediate values.

Example 2: You have measured 500 m to the nearest house and you want to know how much you can store. Since there is no entry for 500 m under D7, find the next lowest distance value, 480 m (480 m allows 10 000 kg if there is no other limiting factor).

DAYTIME STORAGE

The Table does not apply to daytime storage under the jurisdiction of a provincial or territorial Occupational Health and Safety authority.

ABRIDGED TABLE FOR HAZARD DIVISIONS 1.1 AND 1.5

	Quantity Distance Metres					
NEQ (kg)	D2	D4	D5	D6	D7	D8
50	10	30	180	45	270	400
60	10	32		45		
70	10	33		46		
80	11	35		48		
90	11	36		50		
100	12	38		53		
120	12	40		55		
140	13	42		60		
160	14	44		63		
180	14	46		65		
200	15	47		65		
250	16	51		70		
300	17	54		75		
350	17	57		80		
400	18	59		83		
450	19	62		88		
500	20	64		90		
600	21	68		95		
700	22	72		100		400
800	23	75		105		415
900	24	78		108		430
1000	24	80		113		445
1200	26	86		120		475
1400	27	90		125		500
1600	29	94		130		520
1800	30	98		135		540
2000	31	105	180	140	270	560
2500	33	110	185	163	275	610
3000	35	120	205	163	305	640
3500	37	125	220	170	330	680
4000	39	130	235	178	350	710
5000	42	140	255	190	380	760
6000	44	150	270	203	405	810
7000	46	155	285	213	425	850
8000	48	160	300	233	445	890
9000	50	170	310	235	465	930
10000	52	175	320	240	480	960
12000	55	185	340	255	510	1020
14000	58	195	360	270	510	1080
16000	61	205	375	280	560	1120
18000	63	210	390	295	590	1180
20000	66	220	405	305	610	1220
25000	71	235	435	325	650	1300
30000	75	250	460	345	690	1380
35000	79	265	485	365	730	1460
40000	83	275	510	380	760	1520
50000	89	295	550	410	820	1640
60000	94	315	580	435	870	1740
70000	99	330	610	460	920	1840
80000	105	345	640	480	960	1920
90000	110	360	670	500	1000	2000

Appendix B

SAMPLE FORM OF INVENTORY CONTROL SHEET

EXPLOSIVES INVENTORY

MAGAZINE TAG NO.:

PRODUCT DESCRIPTION*:

DATE	Shipped To/ Received From	STOCK			SIGNATURE
		IN	OUT	BALANCE	

*** Product description, such as brand name, strength, size of cartridge, detonator type, length and period, etc.**

APPENDIX B

Nunavut Mine Health Safety Regulations

MINE HEALTH AND SAFETY ACT

LOI SUR LA SANTÉ ET LA SÉCURITÉ DANS LES MINES

CONSOLIDATION OF MINE HEALTH AND SAFETY REGULATIONS
R-125-95

CODIFICATION ADMINISTRATIVE DU RÈGLEMENT SUR LA SANTÉ ET LA SÉCURITÉ DANS LES MINES
R-125-95

AS AMENDED BY
R-026-97
R-106-97
R-041-98
R-026-99

MODIFIÉ PAR
R-026-97
R-106-97
R-041-98
R-026-99

This consolidation is not an official statement of the law. It is an office consolidation prepared for convenience of reference only. The authoritative text of regulations can be ascertained from the *Revised Regulations of the Northwest Territories, 1990* and the monthly publication of Part II of the *Northwest Territories Gazette* (for regulations made before April 1, 1999) and Part II of the Nunavut Gazette (for regulations made on or after April 1, 1999).

La presénte codification administrative ne constitue pas le texte officiel de la loi; elle n'est établie qu'à titre documentaire. Seuls les règlements contenus dans les *Règlements révisés des Territoires du Nord-Ouest (1990*) et dans les parutions mensuelles de la Partie II de la *Gazette des Territoires du Nord-Ouest* (dans le cas des règlements pris avant le 1er avril 1999) et de la Partie II de la Gazette du Nunavut (dans le cas des règlements pris depuis le 1er avril 1999) ont force de loi.

R-026-99,s.52.

gel ou tout autre explosif au nitrate d'ammonium relativement insensible. (*blasting agent*)

«trou de sautage» S'entend d'un trou foré dans le but d'y placer et d'y faire sauter des explosifs. (*blasthole*) R-026-99, art. 52.

MAGAZINES

Explosive Magazines

14.02. The manager shall

(a) obtain an explosives magazine permit from the chief inspector before a magazine is located, erected, built and put into service or modified;

(b) ensure that a magazine is not put into service until an explosives magazine permit has been issued;

(c) ensure that a copy of the explosives magazine permit is posted inside the magazine; and

(d) ensure that the magazine meets the requirements of regulations and standards made under the *Explosives Act* (Canada), as amended from time to time. R-026-99,s.53.

Surface Magazines

14.03. (1) Subject to subsection (2), the site for a surface magazine shall be selected in accordance with the Quantity-Distance Table For Blasting Explosives.

(2) The manager may apply to the chief inspector for a variance where it is not possible to comply with the Quantity-Distance Table For Blasting Explosives.

(3) The manager shall ensure that a surface magazine ceases to be used if the conditions under which the explosives magazine permit was issued no longer exist.

(4) The manager shall ensure that "NO SMOKING OR OPEN FLAME" signs are posted at all approaches to a magazine.

(5) No person shall smoke, take an open flame or

DÉPÔTS

Dépôts d'explosifs

14.02. Le directeur :

a) reçoit un permis de dépôt d'explosifs de l'inspecteur en chef avant que le dépôt ne soit localisé, érigé, construit et mis en service ou modifié;

b) fait en sorte que le dépôt ne soit mis en service avant la délivrance du permis de dépôt d'explosifs;

c) fait en sorte qu'une copie du permis de dépôt d'explosifs soit affichée à l'intérieur du dépôt;

d) fait en sorte que le dépôt respecte les exigences des règlements et normes pris en vertu de la *Loi sur les explosifs* (Canada), dans sa version la plus récente. R-026-99, art. 53.

Dépôts en surface

14.03. (1) Sous réserve du paragraphe (2), le lieu d'un dépôt en surface doit être choisi en conformité avec le tableau des distances en fonction des quantités d'explosifs.

(2) Le directeur peut demander une dérogation à l'inspecteur en chef s'il n'est pas possible de se conformer au tableau des distances en fonction des quantités d'explosifs.

(3) Le directeur fait en sorte que le dépôt en surface cesse d'être utilisé si les conditions en vertu desquelles le permis de dépôt d'explosifs a été délivré ne sont plus remplies.

(4) Le directeur fait en sorte que des panneaux "NE PAS FUMER OU PAS DE FLAMME NUE" soient affichées à tous les accès d'un dépôt.

(5) Nul ne fume, ne tient une flamme nue ou ne

produce sparks within 20 m of any place where explosives are stored or handled.

(6) Explosives stored on the surface shall be kept in a magazine with "DANGER EXPLOSIVES" signs conspicuously posted at all approaches to the magazine and on each side of the magazine.

(7) Magazines shall be kept securely locked at all times except when an authorized person is present. R-026-99.s.54.

Electrical, Heating and Lighting

14.04. In each magazine or area where explosives are prepared,

(a) electrical equipment and wiring shall meet the requirements of CSA Standard CAN/CSA M421-93, *Use of Electricity in Mines*;

(b) electrical wiring shall be installed in metal armour or rigid metal conduit having screwed, waterproof joints; and

(c) cable armouring and conduit shall be permanently grounded. R-026-99,s.55.

14.05. Where a magazine or area where explosives are prepared is electrically heated, lighted or provided with a telephone,

(a) electrical fuses or circuit breakers shall be installed in a locked fireproof cabinet located outside the room in which explosives are stored;

(b) electrical fuses or circuit breakers for heating circuits shall interrupt the current where it is 25% over the normal load;

(c) where a liquid is used as a heating medium, the radiation pipes shall be effectively grounded;

(d) electrical fuses for lighting circuits shall not be rated at more than 10A; and

(e) lighting fixtures shall be suitable for Class II, Division 2 locations.

14.06. Overhead power lines supplying electricity to a magazine or area where explosives are prepared shall

(a) be protected against power surges and lightning; and

produit d'étincelles à moins de 20 m de tout endroit où sont stockés ou manipulés des explosifs.

(6) Les explosifs stockés à la surface doivent l'être dans un dépôt sur lequel et aux accès duquel sont affichés bien en vue des panneaux indiquant «DANGER EXPLOSIFS».

(7) Les dépôts sont tenus fermés sécuritairement en tout temps sauf en présence d'une personne autorisée. R-026-99, art. 54.

Électricité, chauffage et éclairage

14.04. Dans tout dépôt ou tout lieu où sont préparés des explosifs :

a) l'équipement et les canalisations électriques respectent les exigences de la norme CAN/CSA M421-93 intitulée *Utilisation de l'électricité dans les mines*;

b) les canalisations électriques sont installées dans une armature ou un conduit en métal avec des joints vissés étanches;

c) l'armature et le conduit des câbles sont enterrés de façon permanente. R-026-99, art. 55.

14.05. Lorqu'un dépôt ou un lieu de préparation des explosifs est chauffé électriquement, éclairé ou pourvu d'un téléphone :

a) des fusibles électriques doivent être installés dans un coffret fermé à l'épreuve du feu à l'extérieur de la pièce dans laquelle sont stockés les explosifs;

b) les fusibles ou les coupes circuits des circuits de chauffage doivent couper le courant lorsque celui-ci est 25 % au-dessus de la normale;

c) lorsque le chauffage s'effectue par liquide, les tuyaux de chauffage doivent être enterrés efficacement;

d) les fusibles des circuits électriques ne doivent pas être supérieurs à 10A;

e) les accessoires d'éclairage sont adaptés à des endroits de type classe 2, division 2.

14.06. Les lignes aériennes d'électricité approvisionnant le dépôt ou le lieu de préparation des explosifs en électricité :

a) sont protégées contre les surtensions et la

(b) be terminated in a cable a minimum of 60 m horizontal distance from the magazine.

foudre;

b) sont terminées dans un câble situé à une distance horizontale minimum de 60 m du dépôt.

14.07. All metal parts of a magazine or area where explosives are prepared such as framing, cladding, piping, cable armour and any electrical components shall be permanently bonded to ground in accordance with the requirements of CSA Standard C22.1-94, *Canadian Electrical Code, Part I.*

14.07. Toutes les parties métalliques du dépôt ou le lieu de préparation des explosifs telles que la charpente, le gainage, le tubage, l'armature des câbles et tous les composants électriques sont attachés au sol de façon permanente en conformité avec les exigences de la Première partie du *Code canadien de l'électricité* (C22.1-94).

Magazine Care and Use

14.08. (1) Each magazine shall be operated and maintained in accordance with the following rules:

(a) the magazine shall be in the charge of an authorized person who shall carry out a weekly inspection of the magazine and record the results in a log-book;

(b) at a mine site, a record shall be kept of all explosives issued and received and of the inventory of the surface magazine in a log-book, and all entries shall be signed by the authorized person;

(c) the magazine shall be kept clean, dry, and free from grit at all times and any spillage shall be cleaned up immediately;

(d) where necessary, the shelves and floors shall be treated with a suitable neutralizing agent to remove all traces of explosive substances;

(e) the contents, including any explosives returned from a work place, shall be arranged in a tidy and organized manner;

(f) the magazine shall not contain any exposed iron or steel except in fixtures;

(g) an authorized person shall ensure that the stock of explosives is rotated so that the oldest stock of each type and size of explosive is used first.

(2) The ground surrounding a magazine must be kept free of all brush, timber or other combustible material for a distance of not less than 20 m from the magazine. R-026-99,s.56.

Entretien et utilisation du dépôt

14.08. (1) Tout dépôt est exploité et entretenu en conformité avec les règles suivantes :

a) il est placé sous le contrôle d'une personne autorisée qui effectue une inspection hebdomadaire du dépôt dont elle enregistre les résultats dans un registre;

b) dans un chantier minier, un relevé de tous les explosifs distribués et reçus ainsi que l'inventaire du contenu du dépôt de surface est tenu dans un registre et toutes les entrées sont signées par la personne autorisée;

c) il est tenu propre, sec et sans grenaille en tout temps et tout deversement est immédiatement nettoyé;

d) lorsque nécessaire, les étagères et le sol sont traités avec un agent neutralisant adapté pour enlever toute trace de substances explosives;

e) ce qui s'y trouve est rangé de manière organisée y compris les explosifs retournés d'un lieu de travail;

f) il ne contient aucun fer ou acier nu sauf dans les élements fixes;

g) une personne autorisée s'assure de la rotation du stock de manière à ce que le stock le plus vieux pour chaque type et chaque taille d'explosif soit utilisé en premier.

(2) Le sol entourant le dépôt doit être libre de tous copeaux, grumes ou autres matériaux combustibles dans un rayon d'au moins 20 m. R-026-99, art. 56.

UNDERGROUND STORAGE

Explosives

14.09. Explosives underground in a mine shall be stored in a magazine, on day benches or in suitable shift boxes. R-026-99,s.57.

14.10. Detonators underground in a mine shall be stored in a magazine or in suitable shift containers. R-026-99,s.58.

Permits

14.11. (1) The manager shall apply to the chief inspector for a permit to store more than 300 kg of explosives in an underground magazine.

(2) The application shall contain a plan of the location and the specification of the magazine.

(3) Where the chief inspector is satisfied with the plan of the location, the chief inspector may issue a permit to the applicant.

(4) Explosives shall be stored in a magazine in accordance with the requirements established by the chief inspector.

(5) Where explosives loading operations are conducted continuously over successive shifts, the quantity of explosives required for the completion of the operation may be stored near the loading site without a permit. R-026-99,s.59.

Storage of Detonators Underground

14.12. (1) The manager shall apply to the chief inspector for a permit to store detonators in a magazine.

(2) **Repealed, R-026-99,s.60.**

(3) The application for a permit to store detonators shall contain a plan of the location and the specifications of the construction of the magazine.

(4) Detonators shall be stored in a magazine in accordance with requirements established by the chief inspector.

STOCKAGE SOUTERRAIN

Explosifs

14.09. Les explosifs souterrains, dans une mine, sont stockés dans un dépôt, des coffres journaliers ou dans des boîtes de poste qui conviennent. R-026-99, art.57.

14.10. Les détonateurs souterrains, dans une mine, sont stockés dans un dépôt ou dans des contenants de poste adaptés. R-026-99, art. 58.

Permis

14.11. (1) Le directeur demande un permis à l'inspecteur en chef pour stocker plus de 300 kg d'explosifs dans un dépôt souterrain.

(2) La demande contient un plan des lieux et les caractéristiques du dépôt.

(3) L'inspecteur en chef qui est satisfait du plan des lieux peut délivrer un permis au demandeur.

(4) Les explosifs sont stockés dans un dépôt en conformité avec les exigences mises en place par l'inspecteur en chef.

(5) Lorsque des opérations de chargement d'explosifs se poursuivent pendant plusieurs postes consécutifs, la quantité d'explosifs nécessaire à la réalisation complète de l'opération de chargement peut être stockée près du lieu de chargement sans permis. R-026-99, art. 59.

Stockage souterrain des détonateurs

14.12. (1) Le directeur demande un permis à l'inspecteur en chef pour stocker des détonateurs dans un dépôt.

(2) **Abrogé, R-026-99, art. 60.**

(3) La demande comprend un plan du lieu et les caractéristiques de la construction du dépôt.

(4) Les détonateurs stockés dans un dépôt sont stockés en conformité avec les exigences mises en place par l'inspecteur en chef.

(5) The magazine shall not be within 20 m of any location where other explosives are stored.

(6) Where the chief inspector is satisfied with the plan of the location and the specifications of the construction, the chief inspector may issue a permit to the applicant. R-026-99,s.60.

Location of Explosives Storage

14.13. A magazine, day bench, shift box or shift container shall be
(a) located at least 60 m from a shaft, hoist room, refuge station, transformer vault, electrical substation or fuel storage area;
(b) provided with conspicuous signs marked "EXPLOSIVES" in letters at least 150 mm in height; and
(c) provided with conspicuous "NO SMOKING OR OPEN FLAME" signs visible from all approaches and placed not less than 20 m from the magazine, day bench, shift box or shift container. R-026-99,s.61.

Day Bench or Shift Box Location

14.14. (1) A day bench or shift box shall be located in an area that is acceptable to an inspector, free of water, and free from risk of any train, car or haulage colliding with the explosives.

(2) A day bench or shift box shall be constructed or placed at least 1 m above floor level where the surrounding strata is adequately secured and shall, where necessary, have floors and walls lined with non-sparking material.

Weekly Inspection

14.15. The manager shall authorize and require one or more qualified persons to make a thorough weekly inspection of all magazines, day benches, shift boxes or shift containers used for storing explosives or detonators and to report, in writing, to the manager stating that the required inspection has been made and indicating the conditions found. R-026-99,s.62.

(5) Le dépôt ne doit pas se trouver à moins de 20 m de tout lieu où sont stockés d'autres explosifs.

(6) L'inspecteur en chef qui est satisfait du plan des lieux et des caractéristiques de la construction peut délivrer un permis au demandeur. R-026-99, art.60.

Lieu de stockage des explosifs

14.13. Un dépôt, un coffre journalier, une boîte de poste ou un contenant de poste doit être :
a) situé à 60 m au moins d'un puit, d'une salle de machine d'extraction, d'un abri, d'une chambre de transformateur, d'une sous-station électrique ou d'un dépôt de fuel;
b) pourvu de panneaux bien en vue sur lesquels sont inscrits «EXPLOSIFS» en lettres d'une taille non inférieure à 150 mm;
c) pourvu de de panneaux visibles de tous les abords sur lesquels sont inscrits «NE PAS FUMER OU PAS DE FLAMME NUE» dans un rayon de 20 m autour d'un dépôt, d'un coffre journalier, d'une boîte ou d'un contenant de poste. R-026-99, art. 61.

Emplacement du coffre journalier ou de la boîte de poste

14.14. (1) Le coffre journalier ou la boîte de poste doivent être situés dans un lieu sec acceptable par un inspecteur, et sans risque de collision de train, de berline ou de transport avec les explosifs.

(2) Le coffre journalier ou la boîte de poste doivent être construits ou placés au moins 1 m au dessus du sol où les strates environnantes sont protégées adéquatement et, lorsque nécessaire, dont les sols et les murs sont doublés de matériau qui ne provoque pas d'étincelles.

Inspection hebdomadaire

14.15. Le directeur autorise une ou plusieurs personnes qualifiées à procéder à une inspection hebdomadaire de tous les dépôts, coffres journaliers, boîtes de poste ou contenants de poste utilisés pour stocker des explosifs ou des détonateurs et de rapporter au directeur en précisant que l'inspection exigée a été faite et l'état dans lequel ils se trouvent. R-026-99, art. 62.

Blasting Certificate

14.16. (1) No person shall prepare or conduct or be allowed to prepare or conduct a blasting operation in or about a mine unless that person holds a blasting certificate issued by the chief inspector or a provisional blasting certificate issued by the manager.

(2) Notwithstanding subsection (1), a person who is not the holder of a blasting certificate may assist in the preparation and firing of charges if he or she does so under the immediate direction and supervision of a person who holds a blasting certificate.

(3) The blaster shall deliver his or her blasting certificate to the manager when he or she commences employment as a blaster at the mine, and the manager shall, unless the certificate has been suspended, return it to the blaster when his or her employment is terminated.

Fume Class

14.17. (1) Subject to subsection (2), explosives used in an underground mine shall be of Fume Class I rating as established by the Explosives Branch of the Department of Natural Resources, (Canada).

(2) Before explosives other than explosives of Fume Class I rating are used in an underground mine, the manager shall apply to the chief inspector for permission to use such explosives, and the application shall contain details of the procedures to be taken to ensure that no person is exposed to fumes and gases that endanger his or her health.

(3) The manager shall give a copy of an application under subsection (2) to the Committee.

(4) Where the chief inspector is satisfied that the procedures to be taken to ensure that no person is exposed to fumes and gases that may endanger health, the chief inspector may give permission to use explosives other than explosives of Fume Class I rating in an underground mine.

Prohibitions

14.18. No person shall possess any explosives or detonators except as required in the performance of his or

Certificat de sautage

14.16. (1) Nul ne peut préparer, conduire ou être autorisé à préparer ou diriger un travail de sautage dans ou près d'une mine à moins d'être titulaire d'un certificat de sautage delivré par l'inspecteur en chef ou d'un certificat de sautage provisoire délivré par le directeur.

(2) Par dérogation au paragraphe (1), une personne qui n'est pas titulaire d'un certificat de sautage peut aider à la préparation et à la mise à feu des charges si elle le fait sous la direction et le contrôle d'une personne titulaire d'un certificat de sautage.

(3) Le boutefeu dépose son certificat de sautage auprès du directeur lorsqu'il commence son travail en tant que boutefeu à la mine et le directeur, à moins que le certificat n'ait été suspendu, le lui rend lorsque son emploi est terminé.

Catégorie de fumée

14.17. (1) Sous réserve du paragraphe (2), les explosifs utilisés dans une mine souterraine doivent être notés fumée de classe I par la direction des explosifs du ministère de l'Énergie, des mines et des ressources du Canada.

(2) Avant de pouvoir utiliser dans une mine souterraine d'autres explosifs que ceux notés fumée de classe I, le directeur demande l'autorisation d'utiliser de tels explosifs à l'inspecteur en chef. La demande doit contenir les détails de la marche à suivre devant être prise afin de faire en sorte que personne ne soit exposée à des fumées ou des gaz qui peuvent menacer sa santé.

(3) Le directeur donne au comité une copie de la demande faite en vertu du paragraphe (2).

(4) Lorsque l'inspecteur en chef est satisfait des marches à suivre devant être prises afin de faire en sorte que personne ne soit exposée à des fumées ou des gaz qui peuvent menacer la santé, il peut donner l'autorisation d'utiliser dans une mine souterraine d'autres explosifs que ceux notés fumée de classe I. R-026-97, art. 11.

Interdiction

14.18. Il est interdit d'être en possession d'explosifs ou de détonateurs en dehors de l'exercice de ses fonctions à la her duties at the mine.

14.19. No person shall remove, or be permitted to remove, explosives or detonators from a mine without a specific written authorization given by the manager in respect of each occurrence.

Frozen Explosives

14.20. Frozen explosives shall only be thawed in accordance with a procedure established by the manager in accordance with the manufacturer's recommendations.

Careless Acts

14.21. (1) No person shall commit a careless act with explosives or detonators.

(2) A person who discovers that a careless act has been committed involving explosives or detonators shall report the incident without delay to his or her shift boss, who shall report the matter without delay to his or her supervisor.

(3) A supervisor who receives a report of a careless act involving explosives or detonators shall, without delay, report the incident to the manager.

(4) A manager who receives a report of a careless act involving explosives or detonators shall make an initial verbal report without delay to the chief inspector and the Committee, and shall provide a written report within 24 hours of the incident.

Opening of Containers

14.22. Only implements made of non-sparking material shall be used to open boxes containing nitro-glycerine based explosives.

Defective Explosives

14.23. (1) A person who discovers explosives he or she believes to be defective shall not use them and shall, without delay, report to the shift boss or supervisor.

(2) The shift boss or supervisor shall, without delay, report the defective explosives to the manager.

(3) The manager shall

mine.

14.19. Il est interdit de sortir ou d'être autorisée à sortir des explosifs ou des détonateurs de la mine sans autorisation expresse écrite du directeur à chaque fois que nécessaire.

Explosifs congelés

14.20. Les explosifs congelés sont seulement dégelés en conformité avec la marche à suivre mise en place par le directeur selon les recommandations du fabricant.

Actes négligents

14.21. (1) Il est interdit de commettre des actes négligents avec des explosifs ou des détonateurs.

(2) Toute personne qui découvre qu'un acte négligent avec des explosifs ou des détonateurs a été commis doit le rapporter immédiatement à son chef de poste qui rapporte le problème à son surveillant.

(3) Le surveillant qui reçoit un rapport d'un acte négligent avec des explosifs ou des détonateurs en rapporte les détails au directeur.

(4) Le directeur qui reçoit un rapport d'un acte négligent avec des explosifs ou des détonateurs rapporte celui-ci à l'inspecteur en chef et au comité, verbalement tout d'abord, puis par écrit dans les 24 heures.

Ouverture des contenants

14.22. Les caisses contenant des explosifs à base de nitroglycérine doivent être ouvertes avec des outils faits de matériaux qui ne produisent pas d'étincelles.

Explosifs défectueux

14.23. (1) La personne qui découvre tout explosif qu'elle croit défectueux ne doit pas les utiliser et en rapporte immédiatement au chef de poste ou au surveillant.

(2) Le chef de poste ou le surveillant en rapporte au directeur sans délai.

(3) Le directeur :

(a) report the matter to an inspector and to the manufacturer of the explosives, with as much batch identification data as is available; and
(b) ensure that the explosives are removed and destroyed in a safe manner in accordance with the manufacturer's recommendations.

R-026-99,s.63.

Cartridge Wrapper

14.24. Cartridge explosives, other than water-gel or emulsion explosives that are to be used for blasting oversize rock or bringing down hung-up material, shall not be removed from their wrappers.

Prohibition

14.25. (1) No person shall use safety fuse, otherwise known as tape fuse, in any blasting operations at a mine.

(2) The manager shall ensure that safety fuse is not present at a mine.

Transporting Explosives

14.26. Explosives and detonators at a mine shall be carried or transported in accordance with these regulations.

14.27. Repealed, R-026-99,s.64.

14.28. Detonators, if not used, shall be returned to the detonator magazine or shift box or shift container but the number of detonators in a shift box or shift container must not exceed 50. R-026-99,s.65.

Transportation of Explosives and Detonators

14.29. Mobile equipment used for transporting explosives on the surface shall

(a) be kept in sound mechanical condition;
(b) when carrying explosives, be provided with orange diamond-shaped placards and with clearly visible signs marked "EXPLOSIVES" in letters not less than 150 mm in height;

a) rapporte le problème à un inspecteur et au fabricant des explosifs accompagné du maximum de renseignements disponibles sur le lot;
b) fait en sorte que les explosifs soient retirés et détruits en toute sécurité en conformité avec les recommandations du fabricant.

R-026-99, art. 63.

Emballage des cartouches

14.24. Les cartouches d'explosif, autre que les explosifs en bouillie ou les émulsions explosives utilisées pour le sautage des roches de grandes dimensions ou pour faire descendre les produits d'abattage bloqués, ne doivent pas être retirées de leur emballage d'origine.

Interdiction

14.25. (1) Il est interdit d'utiliser des mèches de sûreté également connues sous le nom de mèche plate, pour les travaux de sautage dans une mine.

(2) Le directeur fait en sorte qu'aucune mèche de sûreté ne soit présente dans la mine.

Transport des explosifs

14.26. Les explosifs et les détonateurs dans une mine doivent être portés ou transportés en conformité avec le présent règlement.

14.27. Abrogé, R-026-99, art. 64.

14.28. Les détonateurs non utilisés doivent être retournés au dépôt de détonateurs, dans la boîte de poste ou le contenant de poste mais le nombre de détonateurs contenus dans la boîte de poste ou dans le contenant de poste ne doit pas être supérieur à 50. R-026-99, art. 65.

Transport des explosifs et des détonateurs

14.29. Un équipement mobile, de transport des explosifs en surface dans une mine :

a) doit être tenu en bon état mécanique;
b) doit être équipé de plaques de danger en forme de diamant de couleur orange et de panneaux indiquant de manière clairement visible «EXPLOSIFS» en lettre n'ayant pas moins de 150 mm de hauteur;

(c) have all metal parts that could come in contact with containers of explosives covered with wood, tarpaulin or similar non-sparking material;
(d) not be used to transport other goods or materials at the same time as explosives are transported;
(e) be equipped with a type 20-ABC fire extinguisher;
(f) not be loaded with explosives in excess of 80% of its rated carrying capacity;
(g) have explosives secured or fastened so as to prevent any part of the load from becoming dislodged;
(h) transport detonators with other explosives only if the detonators are
  (i) packed in their original containers and placed in a wooden box with a snugly fitting lid that is separated from other explosives by a solid partition of wood at least 150 mm thick and that extends at least 150 mm above the highest level to which the explosives are packed in the vehicle, and
  (ii) 5,000 or fewer in number;
(i) only be operated by an authorized person who is in attendance at all times;
(j) carry only those persons necessary for handling explosives;
(k) not be refuelled if explosives or detonators are on board except where the mobile equipment is designed and used solely for the transportation of bulk blasting agents; and
(l) have its engine shut off and its park brake on while loading or unloading explosives, except where the vehicle uses an engine-powered device for loading and unloading the explosives. R-026-99,s.66.

c) doit avoir toutes les parties métalliques qui pourraient venir en contact avec les conteneurs d'explosifs couverts de bois, d'une bâche ou de tout autre matériau qui ne produit pas d'étincelles;
d) ne doit pas être utilisé pour transporter d'autres biens ou matériels en même temps que des explosifs;
e) doit être équipé d'un extincteur de type 20-ABC;
f) ne doit pas être chargé avec des explosifs à plus de 80 % de sa masse brute maximale;
g) doit avoir les explosifs arrimés ou attachés afin d'éviter que toute partie du chargement ne se détache;
h) ne doit transporter des détonateurs avec d'autres explosifs que si les détonateurs sont :
  (i) emballés dans leur contenant d'origine et rangés dans une boîte en bois au couvercle parfaitement adapté, séparée des autres explosifs par une cloison de bois épaisse d'au moins 150 mm et qui dépasse de 150 mm au moins le point le plus haut auquel les explosifs sont chargés dans le véhicule,
  (ii) moins de 5 000 en nombre;
i) ne peut être conduit que par une personne autorisée et qui doit être présente en tout temps;
j) ne peut transporter que les personnes nécessaires à la manutention des explosifs;
k) ne doit pas être ravitaillé en carburant lorsqu’il porte des explosifs ou des détonateurs sauf s’il s’agit d’un équipement mobile conçu et utilisé exclusivement au transport de substances explosives en vrac;
l) doit avoir son moteur arrêté et son frein à main serré pendant le chargement et le déchargement des explosifs sauf lorsque le véhicule utilise un dispositif, dont l'énergie vient du moteur, pour charger et décharger les explosifs. R-026-99, art. 66.

14.30. (1) The transfer of explosives or detonators from an explosives magazine shall be so arranged that no delay occurs between the time the explosives or detonators leave the magazine and the time they are properly stored in designated underground magazines or distributed to points of use.

14.30. (1) Le transport d'explosifs ou de détonateurs d'un dépôt d'explosifs doit être préparé de façon à ce qu'aucun retard n'intervienne entre le moment où les explosifs ou les détonateurs quittent le dépôt et le moment où ils sont stockés dans les dépôts souterrains ou distribués aux endroits d'utilisation.

(2) Explosives shall not be left at any level station or near the collar or other entrance to the mine, but shall be transferred to designated magazines or points of use without delay.

(3) At no time shall explosives be left unattended during transportation. R-026-99,s.67.

14.31. (1) When explosives are to be transported in a conveyance, the authorized person in charge of the operation shall give notice of that fact to the hoist operator and, as applicable, to the shaft supervisor and cage tender.

(2) Explosives shall not be loaded into, transported in or unloaded from a conveyance unless there is an authorized person in charge.

(3) No materials shall be carried in the same conveyance as explosives.

(4) No persons shall be transported in a conveyance while explosives are being transported in the same shaft, except that persons may be transported in the conveyance for the sole purpose of handling the explosives.

(5) Explosives that have been delivered to a head frame or portal shall be transported underground immediately on the approach of an electrical storm.

(6) Explosives shall not be transported in a shaft during an electrical storm.

14.32. Where explosives or detonators are transported underground on a train,

- (a) the locomotive shall be maintained on the forward end of the train, and no explosives or detonators shall be carried on the locomotive;
- (b) a car carrying explosives or detonators shall be
  - (i) separated from the locomotive by an empty car or a spacer of equivalent length, and
  - (ii) protected from hazards related to the presence of trolley wires;
- (c) the explosives and detonators shall be in

(2) Les explosifs ne doivent être laissés à aucune recette de niveau ni près de l'orifice du puit mais doivent être transportés sans retard aux dépôts désignés ou aux endroits d'utilisation.

(3) À aucun moment durant le transport, les explosifs ne doivent rester sans surveillance. R-026-99, art. 67.

14.31. (1) Lorsque des explosifs doivent être transportés dans un transporteur, la personne autorisée chargée de l'opération en avise le machiniste d'extraction et, selon le cas, le surveillant du puit et le préposé à la cage.

(2) Les explosifs ne doivent pas être chargés ou transportés dans un transporteur ou déchargés d'un transporteur sans la présence d'une personne autorisée chargée de l'opération.

(3) Il est interdit de transporter dans un même transporteur des explosifs et des matériaux.

(4) Il est interdit de transporter des personnes dans un transporteur alors que des explosifs sont transportés en même temps dans le même puits, à l'exception des personnes nécessaires à la manutention des explosifs.

(5) Tous les explosifs qui ont été délivrés à un chevalement ou une entrée de galerie doivent être transportés sous terre immédiatement à l'approche d'un orage électrique.

(6) Il est interdit de transporter des explosifs dans un puits lors d'un orage électrique.

14.32. Lorsque le transport des explosifs ou des détonateurs sous terre s'effectue sur un train :

- a) la locomotive doit rester à l'avant du convoi et ne doit pas transporter d'explosifs ou de détonateurs;
- b) la berline qui transporte les explosifs :
  - (i) doit être séparée de la locomotive par une berline vide ou une barre d'espacement de longueur équivalente;
  - (ii) être adéquatement protégée contre les dangers liés à la présence de fils de contact;
- c) les explosifs et les détonateurs doivent être placés dans des contenants acceptables par

containers that are acceptable to the chief inspector and that prevent the explosives and detonators from coming into contact with any metal that could produce a spark; and

(d) a train carrying explosives or detonators
   (i) shall only comprise the locomotive, the empty car or spacer and the explosive cars, and
   (ii) shall not proceed at a speed exceeding 10 km/h.

14.33. Where explosives or detonators are transported underground by means of trackless mobile equipment,

(a) the mobile equipment shall not proceed at a speed exceeding 10 km/h;
(b) the explosives and detonators shall be in containers that are acceptable to the chief inspector and that prevent the explosives and detonators from coming into contact with any metal that could produce a spark;
(c) the explosives and detonators shall be so loaded that they cannot fall from the mobile equipment;
(d) the mobile equipment shall, when carrying explosives, be provided with conspicuous signs marked "EXPLOSIVES" in letters at least 150 mm in height;
(e) the mobile equipment shall have its engine shut off and park brake on while loading or unloading explosives or detonators except where the vehicle uses an engine-powered device for loading and unloading the explosives or detonators;
(f) the mobile equipment shall not be refuelled with explosives or detonators aboard, except for mobile equipment designed and used solely for the transportation of bulk blasting agents;
(g) no person shall smoke or have an open flame within 20 m of a vehicle transporting explosives;
(h) the mobile equipment shall not be used to transport other materials at the same time as the explosives or detonators; and
(i) the mobile equipment shall not carry persons other than those handling the explosives and detonators.

l'inspecteur en chef afin de prévenir tout contact entre les explosifs ou les détonateurs et tout métal qui pourrait produire une étincelle;

d) le convoi transportant des explosifs ou des détonateurs ne doit être composé que d'une locomotive, d'une berline vide ou de la berline d'espacement et des berlines transportant les explosifs et sa vitesse ne doit pas dépasser 10 km par heure.

14.33. Lorsque le transport souterrain des explosifs ou des détonateurs s'effectue par engin mobile ne se déplaçant pas sur des rails,

a) la vitesse de l'engin mobile ne doit pas dépasser 10 km par heure;
b) les explosifs et les détonateurs doivent être placés dans des contenants acceptables par l'inspecteur en chef afin de prévenir tout contact entre les explosifs ou les détonateurs et tout métal qui pourrait produire une étincelle;
c) les explosifs et les détonateurs doivent être chargés de manière à ne pas tomber de l'engin mobile;
d) lorsqu'il transporte des explosifs, l'engin mobile doit porter des panneaux indiquant de manière clairement visible «EXPLOSIFS» en lettre n'ayant pas moins de 150 mm de hauteur;
e) l'engin mobile doit avoir son moteur arrêté et son frein à main serré pendant le chargement et le déchargement des explosifs ou des détonateurs sauf lorsque celui-ci utilise un dispositif, dont l'énergie vient du moteur, pour charger et décharger les explosifs;
f) l'engin mobile ne doit pas être ravitaillé en carburant lorsqu'il porte des explosifs ou des détonateurs sauf s'il s'agit d'un engin mobile étudié et utilisé exclusivement au transport de substances explosives en vrac;
g) il est interdit de fumer ou de porter une flamme nue à moins de 20 m d'un véhicule qui transporte des explosifs;
h) l'engin mobile ne doit pas transporter d'autres matériaux en même temps que des explosifs ou des détonateurs;
i) il est interdit de transporter sur l'équipement

d'autres personnes que celles chargées de la manutention des explosifs ou des détonateurs.

Loading and Priming Procedures

14.34. (1) Explosives shall not be loaded into a blasthole
- (a) of insufficient size or in which there is an obstruction; or
- (b) by hitting, pounding, ramming or applying undue pressure.

(2) Explosives shall only be loaded into a blasthole by means of a loading tool made of non-sparking material.

(3) Primers shall only be made up at the blast site as required and shall not be transported.

(4) When priming nitro-glycerine type explosives, only a non-sparking implement shall be used to punch a hole in the explosive.

(5) Every primed explosive shall
- (a) contain a properly placed detonating device sufficient to efficiently initiate the explosion;
- (b) in the case of a cartridge explosive, have the detonator inserted into the cartridge in such a manner that it cannot be separated or pulled out of the cartridge during the loading operation; and
- (c) be detonated at the time for blasting except where a procedure for doing otherwise has been established by the manager, given to the Committee and approved by the chief inspector.

(6) Where detonating cord is used,
- (a) loading shall be completed in all holes;
- (b) all equipment not required for the loading operation shall be removed from the blast site before
  - (i) cords are interconnected between holes or attached to trunk line circuits, and
  - (ii) delay devices or initiating detonators are attached to trunk line circuits; and

Marches à suivre pour le chargement et l'amorçage

14.34. (1) Il est interdit de charger d'explosifs un trou de mine qui :
- a) soit est de taille trop petite ou est obstrué;
- b) soit doit l'être en frappant, bourrant, martelant ou en applicant une pression excessive.

(2) Les explosifs ne doivent être chargés dans un trou de mine qu'à l'aide d'outils de chargement fait en matériau qui ne provoque pas d'étincelles.

(3) Les amorces sont préparées sur le lieu de sautage, au besoin, et ne doivent pas être transportées.

(4) Lorsque l'amorçage se fait à l'aide d'un explosif de type nitroglycérine, seul un outil ne causant pas d'étincelles doit être utilisé pour faire un trou dans l'explosif.

(5) Tout explosif amorcé :
- a) doit avoir un dispositif détonant correctement placé et suffisant pour créer l'explosion de façon efficace;
- b) lorsqu'il s'agit d'explosif en cartouche, doit avoir un détonateur inséré dans la cartouche de manière à ce qu'il ne peut être séparé ou sorti de la cartouche lors de l'opération de chargement;
- c) doit être sauté lorsqu'il est amorcé au moment prévu du sautage sauf si une autre marche à suivre a été préparée par le directeur donnée au comité et approuvée par l'inspecteur en chef.

(6) Lorsqu'un cordon détonant est utilisé :
- a) le chargement doit être effectué dans tous les trous;
- b) tout équipement non exigé pour l'opération de chargement doit être retiré du lieu de sautage avant que :
  - (i) les cordons ne soient connectés entre les trous ou reliés au circuit réel,
  - (ii) les dispositifs retardateurs ou les détonateurs d'amorçages ne soient

(c) the cord shall, for an underground blasting operation, be connected to the initiating detonator as close to the face being blasted as is possible.

14.35. (1) Where holes are loaded pneumatically with explosives,

(a) only semi-conductive hoses manufactured for such purpose shall be used;
(b) the semi-conductive hose used shall be maintained to ensure that the conductive element is not removed or otherwise damaged; and
(c) pneumatic loading equipment shall not be grounded directly to pipes, rails or other similar continuous conductors.

(2) Where holes are loaded pneumatically with explosives and electrical detonators are used,

(a) no plastic or other non-conducting liners shall be used;
(b) a detonator shall not be placed in the hole until the pneumatic loading of the hole has been completed, except where a procedure for doing otherwise has been established by the manager; and
(c) copies of the procedure have been given to the Committee and approved by the chief inspector.

Guarding

14.36. (1) Before a blast is detonated, a person shall be stationed at each entrance or approach to the blast area and instructed to prevent access to each place where

(a) blasting is to take place;
(b) the safety of persons may be endangered by the blasting; or
(c) a diamond drill hole intersection may connect with the blast.

(2) The blaster shall ensure that

(a) all persons have vacated the vicinity except those persons required to assist in blasting and guarding; and
(b) all areas of the mine that may be affected

reliés au circuit réel;

c) il doit, pour une opération de sautage souterraine, être relié au détonateur électrique placé le plus près possible du front de taille qui doit être sauté.

14.35. (1) Lorsque le chargement des trous s'effectue pneumatiquement :

a) seuls des boyaux semi-conducteurs fabriqués dans ce but doivent être utilisés;
b) le boyau semi-conducteur utilisé doit être entretenu afin de faire en sorte que l'élément conducteur ne soit pas retiré ou autrement endommagé;
c) l'équipement de chargement pneumatique ne doit pas être mis à la terre par attache directe à des tuyaux, des rails ou d'autres conducteurs continus identiques.

(2) Lorsque le chargement des trous s'effectue pneumatiquement et que des détonateurs électriques sont utilisés :

a) il est interdit d'utiliser des doublures en plastique ou non-conductrices;
b) il est interdit de placer un détonateur dans le trou avant que le chargement pneumatique du trou ne soit terminé, sauf si une autre marche à suivre a été préparée par le directeur;
c) des copies de la marche à suivre ont été données au comité et approuvées par l'inspecteur en chef.

Surveillance

14.36. (1) Avant chaque sautage, une personne doit être placée à chaque entrée ou aux abords avec instruction de prévenir l'accès à tout endroit où :

a) un sautage va avoir lieu
b) la sécurité des personnes peut être mise en danger par le sautage;
c) l'intersection d'un trou de sondage au diamant peut être connectée avec le sautage.

(2) Le boutefeu doit faire en sorte :

a) que personne, à part le personnel chargé d'assister dans le sautage ou d'assurer la surveillance, ne se trouve sur les lieux ou à proximité;

by the blasting operation are vacated.
R-026-99,s.68.

b) que tous les endroits de la mine qui peuvent être affectés par le sautage aient été évacués.
R-026-99, art. 68.

14.37. Where contiguous or adjacent claims or mines are being worked and there is disagreement as to the times that blasting operations should be conducted, the manager of either mine may appeal to the chief inspector who shall decide the time at which blasting operations may be conducted.

14.37. Lorsque les travailleurs dans des mines ou des concessions adjacentes ne parviennent pas à s'entendre sur l'horaire auquel des opérations de sautage doivent être conduites, le directeur de l'une ou l'autre mine peut en appeler à l'inspecteur en chef pour qu'il en fixe l'horaire.

Waiting Time

Temps d'attente

14.38. (1) No person shall return to a work place affected by a blasting operation
(a) where delay action detonators are used and a shot is heard, until 10 minutes have elapsed from the time the blast is initiated;
(b) until the blaster has disconnected the circuit trunk lines or lead wires from the blasting machine or power source and has short circuited the lines or wires; and
(c) where a blasting switch is employed, until the switch is locked in the open position.

14.38. (1) Nul ne peut retourner sur un lieu de travail visé par un travail de sautage avant :
a) l'écoulement de 10 minutes suivant la fermeture du circuit de tir, lorsque l'allumage se fait par des détonateurs électriques à retard et qu'un tir a été entendu;
b) que le boutefeu n'ait disconnecté les circuits réels ou les lignes de tir de l'exploseur ou de la source électrique et a court circuité les circuits ou les lignes;
c) que l'interrupteur de mise à feu ne soit verrouillé en position ouverte, s'il en a été utilisé un.

(2) Where delay action detonators are used and no shot is heard, no person shall return to the work place affected by the blasting operation until the blaster has met the requirements of paragraphs (1)(b) and (c).

(2) Lorsque sont utilisés des détonateurs électriques à retard et qu'aucun tir n'est entendu, il est interdit à toute personne de retourner sur le lieu de travail visé par le sautage avant que le boutefeu n'ait respecté les exigences des alinéas (1)b) et c).

(3) This section does not apply where a central blasting procedure is in operation.

(3) Le présent article ne s'applique pas lorsqu'une marche à suivre centrale de sautage est en cours.

14.39. If a person has reason to believe that the gases produced during a blasting operation have not been removed or diluted to a safe degree by the ventilation system, he or she
(a) shall not return to a worksite after the blasting operation; and
(b) shall request the shift boss to test the air with a suitable instrument and explain the results to him or her.

14.39. Une personne ne doit pas retourner sur un lieu de travail si elle a des raisons de croire que les gaz produits par les explosifs n'ont pas été amenés à un niveau sans danger par le système de ventilation et elle doit demander au chef de poste de tester l'air à l'aide d'un instrument adapté et de lui en expliquer les résultats.

Surface Blasting

Sautage en surface

14.40. (1) The blaster in charge of a blast on the surface shall keep a record of each primary blast that includes a report of the following:

(a) the date, time and location of the blast;
(b) the burden, spacing, depth and number of holes blasted;
(c) the type of explosives used;
(d) the prevailing wind direction and speed at the time of the blast;
(e) the prevailing atmospheric conditions, and whether it is clear or overcast.

(2) The blaster in charge of a blast at a surface mine shall ensure that

(a) a warning is given by siren or horn;
(b) where necessary, signs are posted to warn traffic of the impending blast and guards are posted to stop traffic before the blast; and
(c) an all-clear signal is sounded after all danger from the blast has passed.

R-026-99,s.69.

Blastholes (Surface)

14.41. No mobile equipment shall be allowed within 8 m of any charged blasthole on the surface of a mine except

(a) mobile equipment that is transporting explosives and that has the exhaust directed above the cab; or
(b) other mobile equipment authorized in writing by the chief inspector.

Blasting Machines

14.42. (1) A blasting machine shall

(a) be of a type designed and manufactured specifically for the purpose for which it is used; and
(b) be kept in good mechanical and electrical condition.

(2) An authorized person shall test the power output of each blasting machine at the intervals and in the manner established by the manufacturer.

14.40. (1) Le boutefeu chargé d'un sautage à la surface d'une mine doit tenir un registre de tir de chaque tir primaire qui doit comprendre :

a) la date, l'heure et le lieu du sautage;
b) la disposition, l'espacement, la profondeur et le nombre de trous sautés;
c) le type d'explosif utilisé;
d) la direction prédominante et la force du vent au moment du sautage;
e) les conditions atmosphériques prédominantes, qu'elles soient bonnes ou couvertes.

(2) Le boutefeu chargé d'un sautage à la surface d'une mine doit faire en sorte :

a) qu'un avertissement soit donné à l'aide d'une sirène ou d'un avertisseur;
b) au besoin que des panneaux soient posés pour avertir la circulation de l'imminence du sautage et que des gardes soient en place afin d'arrêter la circulation avant le sautage;
c) qu'un signal de laisser-passer soit sonné une fois que tout danger provenant du sautage est écarté.

R-026-99, art. 69.

Trou de sautage (en surface)

14.41. Aucun engin mobile ne doit être autorisé dans un rayon de 8 m de tout trou de sautage chargé à la surface d'une mine sauf :

a) l'engin mobile qui transporte des explosifs et dont l'échappement est dirigé au-dessus de la cabine;
b) les autres engins mobiles autorisés par écrit par l'inspecteur en chef.

Exploseurs

14.42. (1) Un exploseur doit être :

a) d'un type spécialement étudié et fabriqué pour l'objectif qui lui est attribué;
b) tenu en bon état mécanique et électrique.

(2) Une personne autorisée doit soumettre tous les exploseurs aux essais et aux intervalles prescrits par le fabricant pour en vérifier la puissance de sortie.

(3) The test results shall be entered in a log-book, dated and signed by the authorized person who conducted the tests.

14.43. The blaster shall ensure that any residual charge remaining in the blasting machine after use is discharged in accordance with the manufacturer's instructions.

Blasting Cables

14.44. Blasting cables and blasting wires shall

- (a) be clearly distinguishable from other cables and wires;
- (b) be used for blasting purposes only;
- (c) be kept 150 mm from
  - (i) detonating cords,
  - (ii) power, lighting or communication cables, and
  - (iii) pipes, rails, ventilation ducting or other continuous metal grounded circuits;
- (d) be insulated for the maximum voltage that may be used; and
- (e) be not less than 12 AWG copper wire or thicker, and where expendable connecting wire is used, it shall not be less than 20 AWG copper wire.

(3) Les résultats des essais sont inscrits dans un registre, datés et signés par la personne autorisée qui a conduit les essais.

14.43. Le boutefeu doit faire en sorte que toute charge résiduelle soit éliminée après l'utilisation de l'exploseur en conformité avec les prescriptions du fabricant.

Conducteurs de mise à feu

14.44. Les conducteurs et les câbles de mise à feu doivent être :

- a) clairement identifiables des autres conducteurs et câbles;
- b) utilisés uniquement aux fins de sautage;
- c) tenus à 150 mm :
  - (i) des cordeaux détonants,
  - (ii) des câbles électriques de puissance, du circuit d'éclairage ou de communication,
  - (iii) des tuyaux, rails, des gaines de ventilation ou d'autres circuits métalliques continus mis à la terre;
- d) isolés pour la tension maximale pour laquelle ils peuvent être utilisés;
- e) en cuivre et d'une grosseur d'au moins 12 AWG et d'au moins 20 AWG lorsque sont utilisés des câbles de cuivre extensibles.

Procedures for Electric Blasting

14.45. Where blasting is initiated by means of electricity,

(a) if more than one shot is to be fired electrically, the blaster shall, immediately before blasting, test the electrical circuit with an instrument specifically designed and manufactured for testing blasting circuits immediately before blasting;

(b) if balanced circuits are required, each circuit shall be tested before firing with an instrument described in paragraph (a);

(c) if electric detonators are used

(i) the protective shunt shall not be removed from the leg wire until connections are made,

(ii) the leg wire shall not be shortened,

(iii) the blasting circuit trunk lines or lead wires to the face or faces shall be short-circuited while the leads from the detonators are being connected to each other and to the blasting lead lines,

(iv) the short-circuit referred to in subparagraph (iii) shall not be removed until all persons have left the worksites to be affected by the blasting operation, and

(v) the short-circuit referred to in subparagraph (iii) shall be located so that a premature explosion will not endanger the person opening the short-circuit; and

(d) before any person returns to the worksite affected by the blasting operation,

(i) the firing cables shall be removed from the battery, blasting machine or other source of electricity and shall be short-circuited, and

(ii) the blasting switch shall be locked in the open position.

Sautages faits électriquement

14.45. Lorsque le sautage est amorcé électriquement :

a) et qu'il y a plus d'un tir, le boutefeu doit essayer le circuit électrique immédiatement avant le sautage à l'aide d'un instrument spécialement étudié et fabriqué pour l'essai des circuits de sautage;

b) et qu'un équilibrage des circuits est éxigé, chaque circuit doit être essayé avant l'amorçage à l'aide de l'instrument décrit à l'alinéa a);

c) et que des détonateurs électriques sont utilisés :

(i) le dérivateur de protection ne doit pas être retiré du fil du détonateur jusqu'au moment où la connexion est faite,

(ii) les fils du détonateur ne doivent pas être raccourcis,

(iii) les circuits réels ou les ligne de tir de sautage reliés aux fronts de taille doivent être court-circuités pendant que les lignes de tir qui partent du détonateur sont reliées entre elles et aux conducteurs du sautage,

(iv) le court-circuit visé au sous-alinéa (iii) ne doit pas être retiré avant que toutes les personnes n'aient quitté le lieu visé par le travail de sautage,

(v) le court-circuit visé au sous-alinéa (iii) doit être placé de telle façon qu'une explosion prématurée est sans danger pour la personne qui ouvre le court-circuit;

d) et avant que toute personne ne retourne sur le lieu de travail visé par le travail de sautage :

(i) les câbles de mise à feu doivent être déconnectés de la batterie, de l'exploseur ou de toute autre source d'électricité et doivent être court-circuités,

(ii) l'interrupteur de l'exploseur doit être vérouillé en position ouverte.

Blasting from Power or Lighting Circuits

14.46. (1) Electrical power circuits used for blasting shall be

(a) from an isolated, ungrounded power source;

Sautage à partir du circuit de puissance ou d'éclairage

14.46. (1) Le circuit électrique de puissance utilisé pour le sautage doit :

a) provenir d'une source isolée et mise à la

and
(b) used for blasting only.

(2) An electrical power line blasting switch shall
(a) be designed for the purpose for which it is used;
(b) be kept in good condition;
(c) be constructed so that it automatically opens the circuit by gravity to short-circuit the blasting conductor;
(d) have the live side enclosed within a fixed box with a door
(i) that can be locked and unlocked only by the blaster in charge of the blasting, and
(ii) so arranged that the door cannot be closed unless the contacts of the firing circuit are in the opened and shorted position; and
(e) be electromagnetically operated where the power source exceeds 300 volts.

(3) Every electric power line blasting switch shall incorporate a lightning gap of at least 1.5 m between the blasting switch and the service switch, and the gap shall only be closed by a twist-type plug and cord assembly immediately before firing.

(4) Where a blasting circuit is used for more than one working place, each branch circuit shall be isolated by means of a locked isolating switch that automatically short-circuits the branch circuit or by another method approved by the chief inspector. R-026-99,s.70.

Central Blasting

14.47. (1) Where a common electrical source is used to initiate blasts in more than one work place, the manager shall
(a) ensure that arrangements are made for
(i) the continued shorting of the blasting cables,
(ii) a three-way switch for each individual blasting circuit that can be locked in either the shorted or closed position to provide for shorting, energizing or testing the circuit, and
(iii) identification of blasting cables and

terre;
b) être utilisé uniquement pour le sautage.

(2) Un interrupteur pour la ligne électrique de puissance pour le sautage :
a) est étudié pour l'utilisation qui en est faite;
b) est tenu en bon état;
c) est construit de façon à ouvrir automatiquement le circuit par gravité afin de court-circuiter le conducteur du sautage;
d) renferme le conducteur sous tension à même une boîte fixe avec une porte :
(i) qui ne peut être ouverte ou fermée que par le boutefeu chargé du sautage,
(ii) placée de telle façon qu'elle ne peut être fermée que si les contacts du circuit de tir sont en position ouverte et court-circuitée;
e) être électromagnétique si la source de puissance est supérieure à 300 volts.

(3) Tout interrupteur d'une ligne électrique de puissance de sautage doit comprendre un intervalle de protection contre la foudre formé par une fiche à mouvement hélicoïdal et raccordé immédiatement avant la mise à feu d'une longueur de 1,5 m entre l'interrupteur de l'exploseur et l'interrupteur de service.

(4) Lorsque le circuit de sautage est utilisé pour plus d’un lieu de travail, chaque circuit de dérivation doit être isolé par un sectionneur verrouillé qui court-circuite automatiquement les circuits de dérivation ou par une autre méthode approuvée par l’inspecteur en chef. R-026-99, art. 70.

Sautage centralisé

14.47. (1) Lorsqu'une source électrique commune est utilisée pour l'amorçage de sautage dans plusieurs lieux de travail, le directeur doit faire en sorte :
a) que des dispositions soient prises pour :
(i) la mise en court-circuit continu des câbles de sautage,
(ii) prévoir un interrupteur à trois positions pour chaque circuit de sautage qui peut être vérouillé soit en position court-circuit, soit en position ouverte afin de prévoir le court-circuitage du circuit, la mise sous

switches;
(b) establish a blasting procedure
(i) setting out the method of connecting the blasting circuit trunk lines or lead wires to the electrical supply,
(ii) providing for the evacuation of all persons from the area of the blast,
(iii) setting out the method of testing the system to ensure that the proper connections have been made, and
(iv) providing a layout of the system; and
(c) send a copy of the blasting procedure to each person involved in blasting, to the Committee and to the chief inspector.

tension du circuit ou l'essai du circuit,
(iii) l'identification des câbles de sautage et des interrupteurs;
b) qu'une marche à suivre de sautage précise :
(i) la méthode de connexion des circuits réels de sautage ou des lignes de tir à la source électrique,
(ii) l'évacuation de toutes les personnes de la zone de l'explosion,
(iii) la méthode d'essai du système qui permet de faire en sorte que les connexions correctes ont été faites,
(iv) un plan du système;
c) qu'une copie de l'opération de sautage soit envoyée à toutes personnes qui participent à un sautage, au comité et à l'inspecteur en chef.

(2) Each person involved in blasting shall comply with the blasting procedure.

(2) Quiconque participe à un sautage doit suivre la marche à suivre.

Electrical Storms

14.48. (1) During an electrical storm or if an electrical storm appears imminent, the blasting site shall be evacuated and no blasting connections shall be made.

(2) The manager shall designate a person whose duty it shall be to make every reasonable effort to notify underground workers of an electrical storm.

(3) During an electrical storm, no connections shall be made underground and, if loading and blasting procedures have commenced, all persons underground shall be evacuated to safety in accordance with a procedure developed by the manager in consultation with the Committee and acceptable to the chief inspector. R-026-99,s.71.

Orages électriques

14.48. (1) Pendant un orage électrique ou à l'imminence d'un orage électrique, les lieux du sautage doivent être évacués et aucune connexion ne doit être faite.

(2) Le directeur doit désigner une personne dont la tâche est de mettre en oeuvre tout effort raisonnable afin d'avertir les travailleurs sous terre de l'orage électrique.

(3) Pendant un orage électrique, aucune connexion ne doit être faite sous terre et si les marches à suivre de chargement et de sautage ont commencé, toutes les personnes qui travaillent sous terre doivent être évacuées et mises à l'abri en conformité avec la marche à suivre préparée par le directeur, en consultation avec le comité et jugée satisfaisante par l'inspecteur en chef. R-026-99, art. 71.

Radio Transmitters

14.49. When electrical blasting operations are about to be conducted, no radio frequency transmitter shall be operated
(a) in a surface mine, within 20 m of such operations; and
(b) in an underground mine, within the distance provided as a standard of safety by CSA Standard Z65-1966, *Radiation Hazards*

Émetteurs radioélectriques

14.49. Lorsque des travaux de sautage par moyen électrique sont sur le point d'être effectués, aucun émetteur par radiofréquence ne doit être utilisé :
a) dans une mine à ciel ouvert, dans un rayon de 20 m autour de ces travaux;
b) dans une mine souterraine, à la distance prescrite comme étant la norme de sécurité établie par la norme Z65-1966 de la CSA

from Electronic Equipment.

Drilling

14.50. (1) No person shall commence drilling at a site unless the exposed face is

(a) subject to section 14.51, washed with water;
(b) carefully examined for misfires and cut-off holes, giving special attention to bootlegs; and
(c) conspicuously marked with the location of all misfires and cut-off holes.

(2) No person shall cut chip samples from an exposed face,

(a) until the face has been washed with water and carefully examined for misfires and cut-off holes; and
(b) within 2 m of any hole containing explosives.

14.51. In a mine where water cannot be used, the manager shall

(a) establish a procedure for checking each face for misfires and cut-off holes before drilling is commenced;
(b) ensure all persons are trained in the procedure; and
(c) provide a copy of the procedure to the Committee and to the chief inspector.

14.52. No person shall drill or allow drilling to be conducted

(a) in an underground mine
  (i) within 150 mm of any part of a bootleg, or
  (ii) within 2 m of a misfired hole, a cut-off hole or a hole containing explosives; and
(b) in a surface mine
  (i) within 1 m of any part of a bootleg, or
  (ii) within 5 m of a misfired hole, a cut-off hole, or a hole containing explosives. R-026-99,s.72.

14.53. No person shall drill within 8 m of a site on a face

intitulée *Radiation Hazards from Electronic Equipment.*

Forage

14.50. (1) Le forage est interdit dans un lieu avant que le front de taille exposé :

a) sous réserve de l'article 14.51, n'ait été lavé avec de l'eau;
b) n'ait été soigneusement examiné afin de relever les trous de raté et les trous coupés en accordant une attention spéciale aux culots;
c) n'ait été clairement marqué des trous de raté et des trous coupés.

(2) Il est interdit de couper des échantillons par éclat du front de taille exposé :

a) avant que celui-ci ait été lavé avec de l'eau et soigneusement examiné afin de relever les trous de raté et les trous coupés;
b) à moins de 2 m d'un trou chargé.

14.51. Dans une mine où l'eau ne peut être utilisée, le directeur doit :

a) établir une marche à suivre en vue de vérifier sur chaque front de taille, avant le début du forage, la présence de trous de raté et de trous coupés;
b) faire en sorte que toutes les personnes soient formées à la marche à suivre;
c) fournir une copie de la marche à suivre au comité et à l'inspecteur en chef.

14.52. Il est interdit de forer ou de permettre de forer :

a) dans une mine souterraine, selon le cas :
  (i) à moins de 150 mm de toute partie d'un culot,
  (ii) à moins de 2 m d'un trou de raté, d'un trou coupé ou d'un trou chargé;
b) dans une mine à ciel ouvert, selon le cas :
  (i) à moins de 1 m de toute partie d'un culot,
  (ii) à moins de 5 m d'un trou de raté, d'un trou coupé ou d'un trou chargé. R-026-99, art. 72.

14.53. Il est interdit de forer à moins de 8 m du chantier where explosive loading operations are being conducted.

14.54. No person shall drill in loose rock produced by blasting unless

(a) the rock has been thoroughly examined to ensure that it does not have any holes containing explosives;
(b) an engineered offset pattern is utilized to prevent overlaying of holes; and
(c) where a hole containing explosives is discovered, the drilling is conducted in accordance with section 14.56.

14.55. Where it is impracticable to make the examination required by paragraph 14.50(1)(b) or to use an offset pattern as required by paragraph 14.54(1)(b), a remotely controlled drilling procedure developed by the manager in consultation with the Committee and acceptable to the chief inspector shall be employed. R-026-99,s.73.

Misfired Holes

14.56. (1) Where an explosive charge has been misfired or cut-off, no work may be performed in the area other than that required to make the area safe and to deal with the misfire in accordance with subsection (2).

(2) A misfire or cut-off hole shall be

(a) reblasted with a fresh primer if necessary;
(b) washed out, subject to subsection (3); or
(c) dealt with in accordance with subsection (4) or the procedure established under subsection (5).

(3) No person shall wash out an explosive charge that contains an explosive that is

(a) nitro-glycerine sensitized;
(b) not water soluble; or
(c) not described as an explosive that may be washed out in the procedure established under subsection (5).

(4) A hole may be drilled for the purpose of reblasting a missed hole once a shift boss has determined, in consultation with the driller, the location, angle and depth of the hole to be drilled, and the shift boss shall remain present throughout the drilling of the hole and

d'un front de taille où une opération de chargement d'explosifs est en cours.

14.54. Il est interdit de forer dans du roc désagrégé, résultat de sautage à moins :

a) que le roc n'ait été examiné de façon approfondie afin de faire en sorte qu'il ne contienne pas de trous chargés;
b) d'utiliser un patron décalé mis au point afin de prévenir la superposition de trous;
c) que le forage ne soit effectué en conformité avec l'article 14.56, lorsqu'un trou chargé est découvert.

14.55. Une marche à suivre de forage contrôlée à distance élaborée par le directeur, en consultation avec le comité et qui satisfasse l'inspecteur en chef doit être utilisée lorsqu'il est impossible de procéder à l'examen exigé en vertu de l'alinéa 14.50(1)b) ou d'utiliser un patron décalé tel qu'exigé en vertu de l'alinéa 14.54(1)b). R-026-99, art. 73.

Trous de raté

14.56. (1) Lorsque la mise à feu d'une charge explosive a été ratée ou coupée, aucun autre travail que celui exigé pour rendre le lieu sans danger ne doit être effectué dans le secteur en conformité avec le paragraphe (2).

(2) Un trou raté ou coupé doit être :

a) soit sauté à nouveau avec une nouvelle amorce si nécessaire;
b) soit lavé, sous réserve du paragraphe (3);
c) soit pris en charge en conformité avec le paragraphe (4) ou avec la marche à suivre établie en vertu du paragraphe (5).

(3) Il est interdit de laver pour la retirer du trou une charge explosive qui contient un explosif qui :

a) soit est sensibilisé à la nitro-glycérine;
b) soit n'est pas soluble dans l'eau;
c) soit n'est pas désigné dans la marche à suivre établie en vertu du paragraphe (5) comme étant un explosif qui peut être lavé.

(4) Un trou peut être foré dans le but de faire sauter un trou raté, une fois que le chef de poste a déterminé, en accord avec le foreur, l'endroit, l'angle et la profondeur de forage du trou. Le chef de poste doit rester présent tout au long du forage du trou et ce trou ne peut se trouver à

such hole shall not be closer to any part of a missed hole than 150 mm underground or 1 m in a surface operation.

(5) The manager shall prepare a written procedure that describes the
- (a) types of explosives that may be washed out of or removed from a misfired or cut-off hole;
- (b) the type of equipment and method to be used; and
- (c) the method that may be adopted in blasting relief holes drilled in accordance with subsection (4).

R-026-99,s.74.

14.57. (1) Work shall not be abandoned or discontinued at a worksite until the material broken at the time of the blasting of the last round of blastholes has been cleaned from the face or place of blasting and the face or place has been thoroughly examined for the presence of explosives in misfired or cut-off holes.

(2) Where a misfired or cut-off hole is found during the examination required by subsection (1), it shall be dealt with in accordance with section 14.56 without delay and in any event before the worksite is abandoned or further work is discontinued.

Adjacent Workings

14.58. Before a connection is made between two underground workings,
- (a) where practicable, an examination shall be made of the workings towards which the active working is advancing to determine whether the work can proceed in a safe manner, and the results of the examination shall be recorded in a log-book; and
- (b) all approaches to both working places shall be guarded before blasting when the distance between the working places is less than the greater of
  - (i) twice the length of the longest drill steel used, and
  - (ii) 8 m from the bottom of the longest hole.

moins de 150 mm pour un travail souterrain ou moins de 1 m pour un travail en surface de toute partie du trou raté.

(5) le directeur doit préparer une marche à suivre écrite qui décrit :
- a) le type d'explosif qui peut être lavé ou retiré du trou de raté ou coupé;
- b) le type d'équipement et la méthode utilisés;
- c) la méthode qui peut être utilisée pour le sautage des trous de dégagement forés en conformité avec le paragraphe (4).

R-026-99, art. 74.

14.57. (1) Il est interdit d'abandonner ou d'interrompre un travail sur un lieu de travail avant que les déblais dus au sautage de la dernière volée n'aient été dégagés du front de taille ou du lieu du sautage et que le front de taille ou le lieu n'ait été soigneusement examiné afin de relever la présence d'explosifs dans des trous de ratés ou des trous coupés.

(2) Lorsqu'un trou de raté ou un trou coupé est découvert pendant l'examen exigé en vertu du paragraphe (1), il doit être traité immédiatement, et dans tous les cas, en conformité avec l'article 14.56, avant l'abandon ou l'interruption d'un travail sur un lieu de travail.

Travaux adjacents

14.58. Avant la jonction entre deux chantiers souterrains :
- a) il doit être procédé à un examen, si cela est possible, du chantier vers lequel se dirige le front d'avancement afin de déterminer si le travail peut se pousuivre sans danger et les résultats de l'examen doivent être consignés dans un registre;
- b) toutes les voies d'accès aux deux lieux de travail doivent être gardées avant tout sautage lorsque la distance entre les deux lieux de travail est inférieure à la plus grande des longueurs suivantes :
  - (i) deux fois la longueur du plus long foret d'acier utilisé,
  - (ii) huit mètres à partir du fond du plus long trou.

14.59. Where blasting operations are likely to intersect a diamond drill hole, the manager shall prepare a procedure to ensure that the work can be carried out safely.

Mine Closure - Disposal of Explosives

14.60. (1) When a mine is to be closed down, an authorized person shall remove or dispose of all explosives at the mine unless permission is given by the chief inspector to leave explosives at the mine.

(2) Explosives shall be suitably disposed of when a mine is closed down.

(3) Where explosives are left at a closed down mine without the permission of the chief inspector, he or she may arrange for the disposal of the explosives, and the costs so incurred constitute a debt due from the owner of the mine to the Workers' Compensation Board that may be recovered in any court of competent jurisdiction. R-026-99,s.75.

PART XV

EXPLORATION

15.01. In this Part,

"exploration activity" means any underground exploration work, any disturbance of the surface by mechanical means or any diamond drilling for the purpose of finding a mineral, but does not include work at a producing mine or exploration work involving the exclusive use of hand tools; (*travaux d'exploration*)

"isolated camp" means a camp that is normally reached by air. (*campement isolé*)

15.02. (1) Before any exploration activity is commenced, the owner shall submit to the chief inspector

(a) an operational plan containing details of the location, the proposed method of exploration, the type of equipment to be used and the numbers of persons to be employed; and

(b) a safety program concerning the health and safety of persons employed in the

14.59. Lorque des travaux de sautage sont susceptibles de croiser des trous de forage au diamant, le directeur doit préparer une marche à suivre afin de faire en sorte que le travail puisse se poursuivre sans danger.

Fermeture de mine — Destruction des explosifs

14.60. (1) Lors de la fermeture d'une mine, une personne autorisée enlève ou détruit tous les explosifs de la mine à moins que l'inspecteur en chef ne donne l'autorisation de laisser les explosifs dans la mine.

(2) Lors de la fermeture d'une mine les explosifs doivent être détruits de manière appropriée.

(3) Lorsque des explosifs sont laissés dans une mine fermée sans l'accord de l'inspecteur en chef, il peut prendre les dispositions nécessaires en vue de leur destruction, les frais afférents étant payables par le propriétaire de la mine à la Commission des accidents du travail qui pourra, le cas échéant, recourir à tout tribunal compétent pour recouvrer les sommes en jeu. R-026-99, art. 75.

PARTIE XV

EXPLORATION

15.01. Les définitions qui suivent s'appliquent à la présente partie.

«campement isolé» Campement qui est normalement atteint par air. (*isolated camp*)

«travaux d'exploration» Travaux d'exploration souterrains, perturbation de la surface par des moyens mécaniques ou forage au diamant en vue de la découverte de minéraux. La présente définition exclut les travaux effectués à l'aide d'outils à main ou les travaux qui ont lieu dans une mine productrice. (*exploration activity*)

15.02. (1) Avant le début de travaux d'exploration, le propriétaire remet à l'inspecteur en chef :

a) un plan opérationnel contenant des détails au sujet de l'emplacement des travaux, de la méthode d'exploration envisagée, du type d'équipement à utiliser et du nombre de personnes à employer;

b) un programme de sécurité concernant la santé et la sécurité des personnes qui

APPENDIX C

DFO Comments on the Draft Environmental Impact Statement for the Proposed Kiggavik Project

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DFO file : 08-HCAA-CA7-00002

NIRB file : 09MN003

January 24th, 2011

Mr. Ryan Barry
Director, Technical Services
Nunavut Impact Review Board
P.O. Box 1360
Cambridge Bay, Nunavut
X0B 0C0

Via E-mail to:
info@nirb.ca

Dear Mr. Barry:

Subject: Department of Fisheries and Oceans Comments on the Draft Environmental Impact Statement Guidelines for the Review of the Proposed Kiggavik Project

The Department of Fisheries and Oceans (DFO) would like to thank the Nunavut Impact Review Board (NIRB) for the opportunity to review and comment on the draft Environmental Impact Statement (EIS) guidelines for AREVA Resources Canada Inc.'s Kiggavik Project.

As you are aware, DFO is the federal department responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and freshwater. DFO would like to provide the following comments on the Draft EIS guidelines within the scope of our mandate and regulatory responsibilities.

General Comment

Section 36 (3) of the *Fisheries Act* prohibits the deposit of deleterious substances in waters frequented by fish unless authorized by regulation. Based on discussions with AREVA Resources Canada Inc., DFO is of the understanding that the effluent proposed to be discharged into Sik Sik Lake and/or Judge Sissons Lake would not exceed the authorized limits for deleterious substances as permitted under Schedule IV of the *Metal Mining Effluent Regulations.*

It should be noted that the discharge of effluent with deleterious substances above these limits into either Sik Sik Lake, Judge Sissons Lake or any other water body frequented by fish would be prohibited without an amendment to Schedule II of these same regulations. Should AREVA Resources Canada Inc. determine that the effluent would not satisfy the limits established in Schedule IV, additional information above and beyond what is currently found in the EIS guidelines would be required prior to the Government of Canada contemplating an amendment to Schedule II of the *Metal Mining Effluent Regulations.* Please note that Environment Canada has the lead administrative authority for the pollution prevention provisions (Section 36(3)) of the *Fisheries Act.* The proponent should refer to Environment Canada if further information is required on Section 36(3) or the *Metal Mining Effluent Regulation.*

Section 6.5.3 Ground Transportation and Associated Water Crossings.

DFO suggests bullet 8 of this section include a discussion as to how the design and size of watercrossings will ensure adequate flow capacity to accommodate storm flows (e.g. 1 in 100 year or greater storm events) and to prevent velocity barriers to fish movement or migration. DFO also recommends adding a bullet requesting a description of any infilling of lake, wetland or stream habitats associated with road construction and the potential impacts to fish and fish habitat.

DFO would also request that the proponent identify the location of waterbodies or watercourses and volumes of water required from each for the construction of any winter roads. The proponent should refer to DFO's *Protocol for Winter Water Withdrawal from Ice-covered Waterbodies in the Northwest Territories and Nunavut* for further guidance on these information requirements.

Bullet 9 of this section identifies "Procedures and structures designed to mitigate/ manage potential impacts to wildlife and wildlife movement during construction and operation". DFO would also like the proponent to describe any proposed procedures or mitigation structures planned for the protection of fish and fish habitat.

As the proponent is contemplating a cable ferry as a method of crossing the Thelon river, DFO suggests adding a bullet requesting design details of the ferry docking/ landing sites.

Section 6.5.10 Exploration

Please include the following bullet:

- *Description of any exploration activities occurring on or near waterbodies and the mitigation measures that will be implemented to prevent impacts to fish and fish habitat.*

Section 8.1.10.2 Impact Assessment

DFO suggests revising bullet 2 of this section to:

- *Potential direct or indirect effects on fish and invertebrate biota and habitat of both, including aquatic species at risk, from any changes to the aquatic or*

riparian environments, as a result of any in-water works or Project activities in close proximity to waterbodies.
- *Potential impacts to fish due to blasting in or near waterbodies, including noise and vibration impacts.*

For further guidance on blasting in or near water, DFO advises the proponent to refer to the following guide for any works or undertakings that involve the use of confined or unconfined explosives in or near Canadian fisheries waters:

http://www.dfo-mpo.gc.ca/habitat/role/141/1415/14155/explosives-explosifs/index-eng.asp.

Please note that experience in the northern environments indicates that the 100 kPa IPC threshold, as stated in the *DFO Guidelines for the Use of Explosives in or Near Canadian Waters,* is not adequately protective of fish. A threshold of 50 kPa should be used for the IPC.

Section 9.4.16 Fish Habitat No Net Loss Plan

DFO will also require a monitoring program as part of the No Net Loss Plan, to demonstrate the habitat compensation works are functioning as intended.

DFO trust this information is useful to the NIRB for the drafting of the revised EIS guidelines. If you have any questions, please feel free to contact me at (867) 669-4933 or by e-mail at Nicola.Johnson@dfo-mpo.gc.ca.

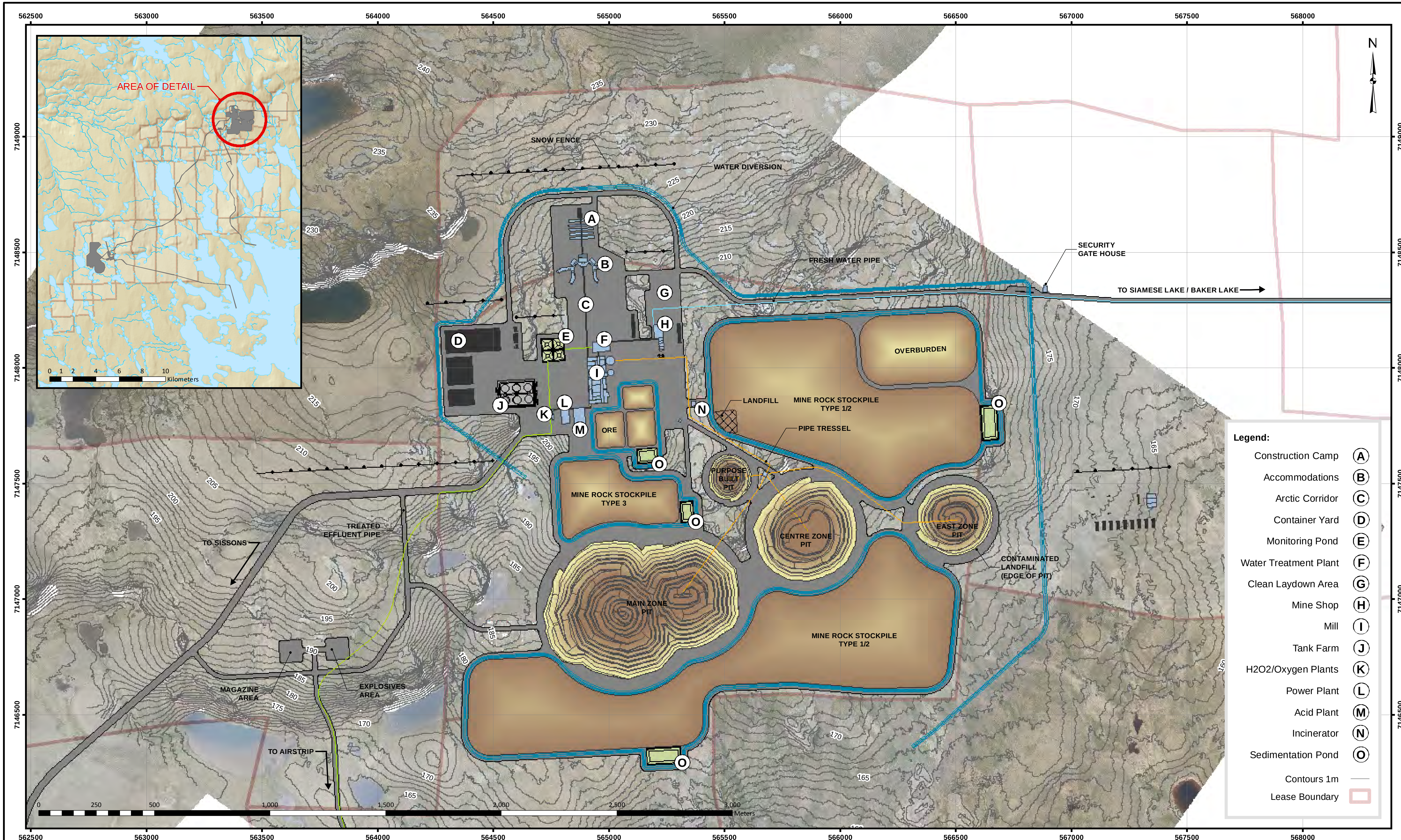
Sincerely,

Nicola Johnson
Environmental Assessment Analyst
Fisheries and Oceans Canada

cc. Beverley Ross, Fisheries and Oceans Canada
Lyndon Kivi, Fisheries and Oceans Canada
Derrick Moggy, Fisheries and Oceans Canada

APPENDIX D

Current Site Plans (Provided by AREVA)



Projection: NAD 1983 UTM Zone 14N
Creator: CDC Revised: TL
Date: 06/23/2014 Scale: 1:15,000
Data Sources: *AREVA Resources Canada Inc.*

FIGURE 1
KIGGAVIK GENERAL SITE LAYOUT

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 2

Kiggavik Project
AREVA

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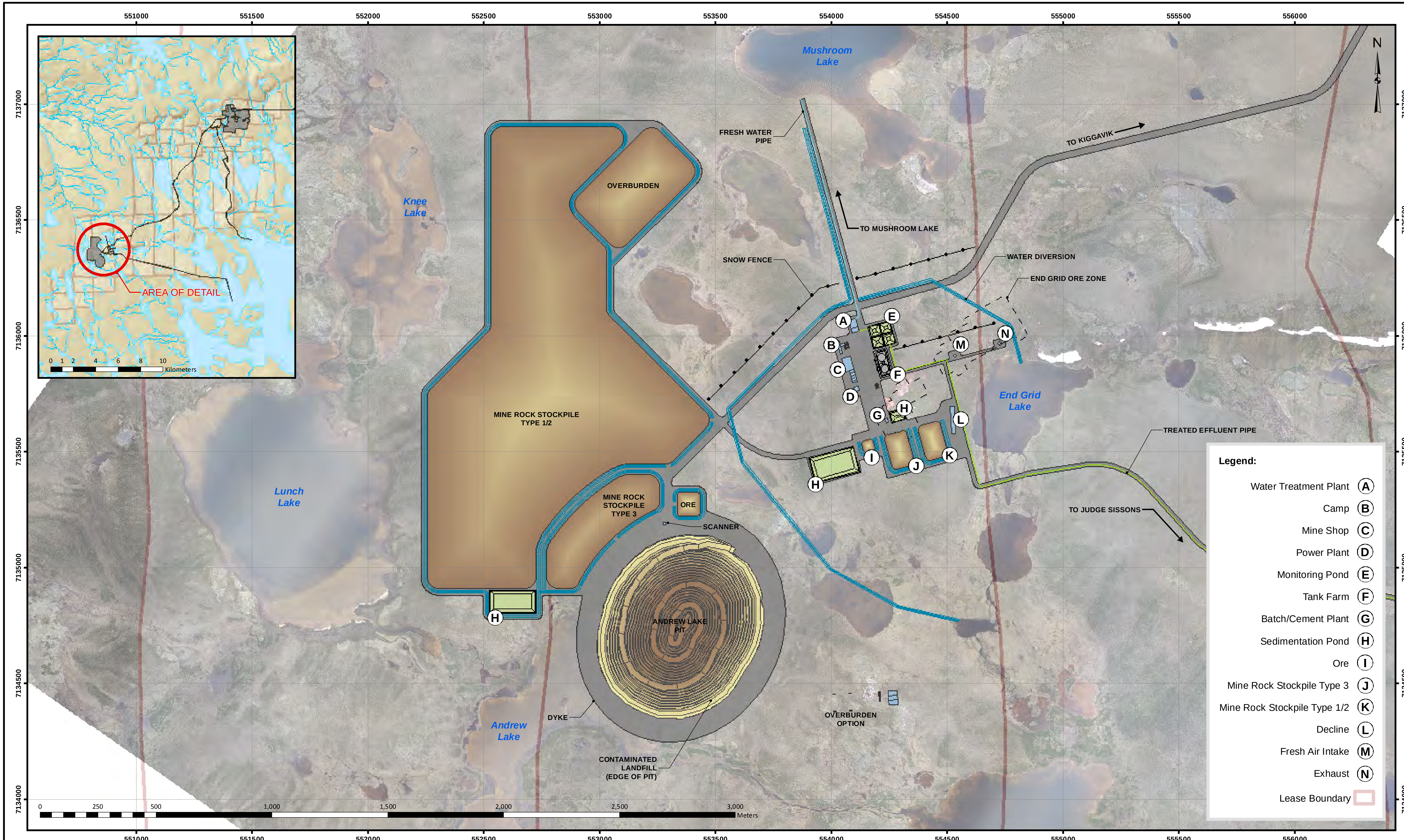

Projection: NAD 1983 UTM Zone 14N
Creator: CDC Revised: TL
Date: 06/23/2014 Scale: 1:15,000
Data Sources: *AREVA Resources Canada Inc.*

FIGURE 1
SISSONS GENERAL SITE LAYOUT

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 2

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Kiggavik Project
AREVA

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