New Vision, New Focus, New Name

Nitrogen Response Plan v1.1

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July 3, 2014

Ms. Violet Camsell-Blondin
Wek'èezhìi Land and Water Board
#1, 4905-48th Street
Yellowknife, NT, CA X1A 2P6

RE: Nitrogen Response Plan Version 1.1

Dear Ms. Camsell-Blondin:

Dominion Diamond Ekati Corporation (DDEC) is pleased to provide the attached *Nitrogen Response Plan (NRP)*, *Version 1.1* as required under Part J, Item 11 of W2012L2-0001 and based on directives received from the Wek'èzhìi Land and Water Board (WLWB) on May 13, 2014. In partial fulfillment of licence requirement Schedule 8, Item 5.ii, DDEC contracted Golder Associates (Golder) to conduct a review of Blasting Operations and Explosives Management at the Ekati Diamond Mine, which is included as Appendix A of the attached plan.

The overall objective of the Nitrogen Response Plan is to minimize the amount of nitrogen entering the receiving environment at the Ekati Diamond Mine and is achieved by:

- Identifying current nitrogen sources and management activities;
- Reviewing current blasting and explosives management practices on site; and
- Creating an Implementation Plan to address recommendations made through the review of blasting and explosives management.

Key findings from the 2013 Golder report indicate that DDEC has many positive practices in place to contain, handle, use and dispose of explosives. Moreover, many of the recommendations made in a 2008 blast audit also conducted by Golder Associates have been incorporated into standard operating procedures on site. Golder concludes that the most significant area of potential for minimizing the availability of nitrogen for dissolution into minewater, and subsequent release to the receiving environment, is through improved usage practices in the open pits.

Changes to Version 1.1 of the NRP include:

1. Inclusion of an effective method to report total nitrogen entering and exiting mining process at Ekati, and a commitment to include these values in the 2014 Annual AEMP report (Section 2.5.4);
2. An explanation of why the use of a 70:30 mix of emulsion and ANFO is an appropriate operational practice at the Ekati Diamond Mine (Section 2.5.2);
3. Updates to Table 1 and 2 headings (Section 2.3);
4. A discussion of all relevant best practices in nitrogen management in the form of action items for the Implementation Plan (Section 4.2) and
5. An updated Implementation Plan (Section 4) that includes:
    a. All specific actions to be implemented in the NRP, an explicit statement of which of Golder's recommendations were accepted and to what degree and a justification of any recommendations not included in the NRP
    b. A timeline including the frequency of implementation of the actions already undertaken by DDEC and a timeline for the implementation of new actions.
    c. A commitment to report on the effectiveness of all NRP actions in the 2014 AEMP Annual report, due for submission to the WLWB on March 31, 2015.

DDEC trusts that you will find the report to be clear and informative. Please contact Kate Shea, Environmental Advisor - Fisheries and Aquatics at kathleen.shea@ekati.ddcorp.ca or 867-880-2115 or the undersigned at claudine.a.lee@ekati.ddcorp.ca or 867-880-2232 should you have any questions.

Sincerely,

Claudine Lee

Claudine Lee
Superintendent – Environment Operations

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Appendix A: Review of Blasting Operations and Explosives Management Plan at Ekati Mine

1. Nitrogen Response Plan Rationale and Objectives

Part J, Item 11 of Water Licence W2012L2-0001 stipulates that Dominion Diamond Ekati Corporation (DDEC) submit a Nitrogen Response Plan to the Wek'èezhìi Land and Water Board (WLWB) for approval. The objective of this plan is to minimize the amount of nitrogen entering the receiving environment at the Ekati Diamond Mine and is achieved through the following items detailed in this report, as prescribed in Schedule 8, Part 5:

a) Description of current nitrogen sources and management practices (Section 2);
b) Assessment of current blasting practices conducted by appropriate experts (Section 3); and
c) Development of an implementation plan to address recommendations from assessment described in b) above (Section 4).

2. Current Nitrogen Sources and Management Practices

Open pit and underground mining operations at the Ekati Diamond Mine involve blasting, which requires the use of ammonium nitrate-based blasting agents. For a number of reasons, discussed in detail in Appendix A, not all of these explosives are consumed during blasting and therefore become available for transport to containment facilities [i.e. the Long Lake Containment Facility (LLCF), Beartooth Pit, or the King Pond Settling Facility (KPSF)], and eventually to the receiving environment. The main pathways of transport, considering both underground and open pit activities, for these unconsumed explosives are:

- Dissolution into minewater and subsequent transportation in solution to a containment facility;
- Mucking as solid material adhering to waste rock and disposed of in waste rock storage areas, where it may be dissolved by rainwater; and
- Mucking as solid material adhering to kimberlite that is transported to the Process Plant, dissolved by water used in kimberlite processing and transported along with processed kimberlite in the form of discharge slurry to a containment facility (Golder, 2008).

All mine effluent, including minewater and process plant discharge, is retained in a containment facility. Over 90% of the process plant water is recycled back to the process plant after settlement of kimberlite solids. Excess water is released to the receiving environment provided that water quality is within the effluent quality criteria described in the Water Licence. Water quality compliance at the Ekati Mine has been excellent over its 15-year operating history.

2.1 Underground Minewater as a source of Nitrogen

Nitrogen (Nitrate-N and Ammonia-N) concentrations in minewater from the underground workings to containment facilities are monitored on a monthly basis through internal monitoring programs. Graphical analysis suggests that both nitrate and ammonia concentrations in underground minewater have been decreasing steadily in recent years, likely as a result of declining rates of development in Koala and Koala North workings (Figure 1).

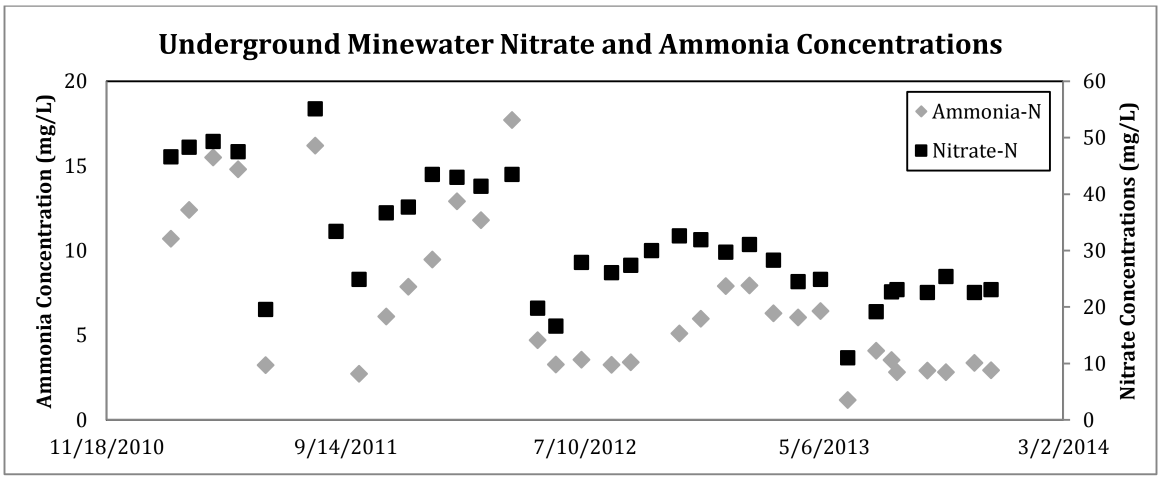

Figure 1- Underground minewater nitrate and ammonia concentrations from 2010-2013.

2.2 Open Pit Minewater as a Source of Nitrogen

There are currently no dewatering activities taking place in Misery Pit (i.e. until the pushback advances to an elevation that enables pumping from the pit bottom). Beginning in June 2014, there are no dewatering activities taking place in Fox pit as planned mining in the pit bottom has been completed. Prior to June 2014, Fox Pit sump water was sampled during open water on a monthly basis through internal monitoring programs (Figure 3). Nitrate and ammonia concentrations in Fox Pit minewater are comparable with those observed in underground minewater and are generally consistent over time. Periodically however, nitrate and ammonia concentrations in Fox Pit sump water were elevated above normal levels (for example in October 2013). During these periods, the sump was usually located close to blast patterns that had been problematic and may have experienced misfires, thus leading to temporarily increased availability of explosives for dissolution into minewater and subsequently elevated nitrogen levels in sump water. Sump locations within open pits are continually changing and are selected to accommodate crew safety, pit wall stability and ease of access. Mining, including dewatering activities, are scheduled to commence in the

Pigeon pit through the 2nd half of 2014. This water will be pumped to the Long lake Containment Facility.

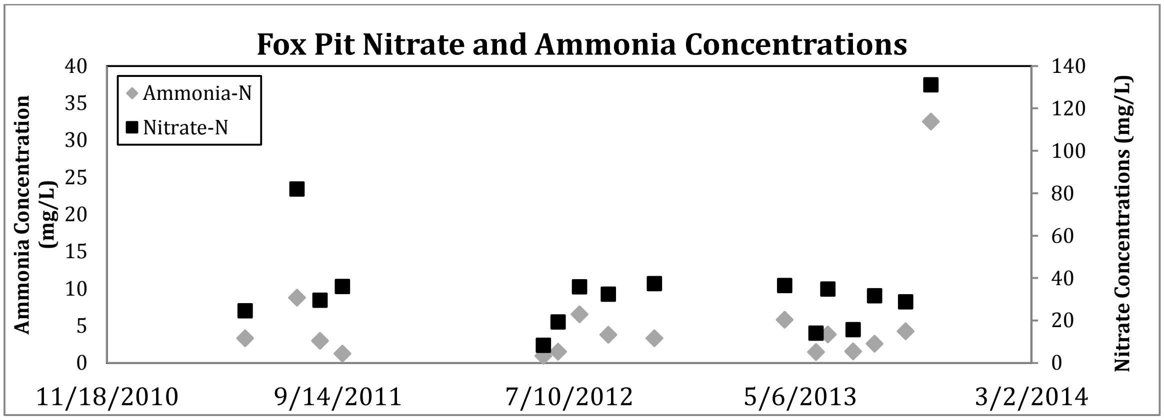

Figure 2- Fox Pit minewater nitrate and ammonia concentrations from 2011-2013.

2.3 Process Plant Discharge as source of Nitrogen

Processed kimberlite slurry water pumped from the Process Plant is a source of nitrogen at the Ekati Diamond Mine. Concentrations of nitrate and ammonia in process plant slurry are generally consistent over time, showing limited seasonal or annual trends (Figure 3). In 2012 and October 2013, the most recent data available, monthly loads of Nitrate (Total-N) from the Process Plant to containment facilities, which is dependent on both concentration and volume of discharge, ranged from 2,163 to 11,614 kg, averaging 6,932 kg/month (Table 1). Historically, process plant discharge, and the associated nitrate loads, were directed to the LLCF. In February 2013, construction of the process plant to Beartooth line was completed, allowing for process plant discharge to the decomissioned Beartooth pit in addition to the LLCF (Table 2).

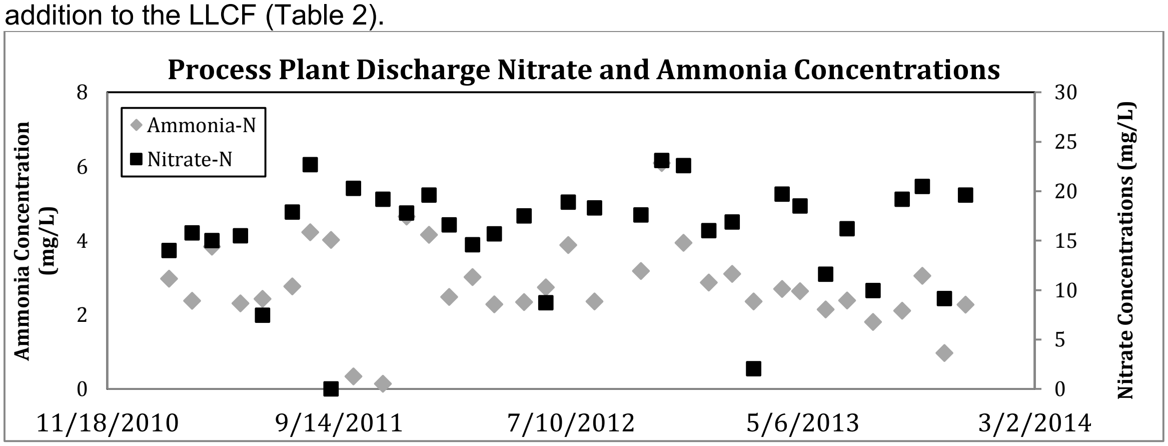

Figure 3- Process Plant slurry nitrate and ammonia concentrations from 2011-2013.

Table 1: Monthly Nitrate Loading from Process Plant to the LLCF in 2012 and 2013

Date	Process Plant Discharge Nitrate Concentrations (mg/L)	Volume Discharged (L)	Estimated Nitrate Loading to Containment Facility (kg)
Jan-12	19.6	462776000	9070
Feb-12	16.6	433581000	7197
Mar-12	14.6	444206000	6485
Apr-12	15.7	447902000	7032
May-12	17.5	475167000	8315
Jun-12	8.73	516383000	4508
Jul-12	18.9	545658000	10313
Aug-12	18.3	518906000	9496
Oct-12	17.6	484776000	8532
Nov-12	23.1	502770000	11614
Dec-12	22.6	444459000	10045
Jan-13	16.0	461741000	7388
Feb-13	16.9	173614000	2934
Mar-13	2.05	96975000	199*
Apr-13	19.7	115470000	2275
May-13	18.5	116899000	2163
Jun-13	11.6	274096000	3180
Jul-13	16.2	571516000	9259
Aug-13	9.95	596632000	5936
Sept-13	19.2	539820000	10365
Oct-13	20.5	452046000	9267

* Nitrate loading estimate from month of Mar-13 is likely the result of major process plant shutdown and/or the finalization of the Process Plant to Beartooth Line and is not representative of normal values.

Table 2: Process Plant Discharge to the LLCF and Beartooth Pit in 2012 and 2013.

	Process Plant Discharge to LLCF (m^3)	Process Plant Discharge to Beartooth Pit (m^3)
Jan-12	462,776	0
Feb-12	433,581	0
Mar-12	444,206	0
Apr-12	447,902	0
May-12	475,167	0
Jun-12	516,383	0
Jul-12	545,658	0
Aug-12	518,906	0
Sep-12	536,861	0
Oct-12	484,776	0
Nov-11	502,770	0
Dec-12	444,459	0
Jan-13	461,741	0
Feb-13	173,614	242,462
Mar-13	96,975	323,359
Apr-13	115,470	295,911
May-13	116,899	401,231
Jun-13	274,096	268,600
Jul-13	571,516	0
Aug-13	596,632	0
Sep-13	539,820	0
Oct-13	452,046	83,409

2.4 Current Trends and Management Practices

Nitrogen trends at the Ekati Diamond Mine are regularly assessed and monitored through internal monitoring programs, LLCF monitoring activities, monthly Surveillance Network Program (SNP) reports and the annual Aquatic Effects Monitoring Program (AEMP). Within the LLCF, Nitrogen loads have been decreasing over the last three years. In addition to this trend towards lower nitrogen loads over time in the LLCF, graphical observation also indicates a strong seasonal trend of increased nitrate and ammonia loads during winter months due to ice exclusion, and decreased loads following dilution associated with freshet (Figures 4 and 5).

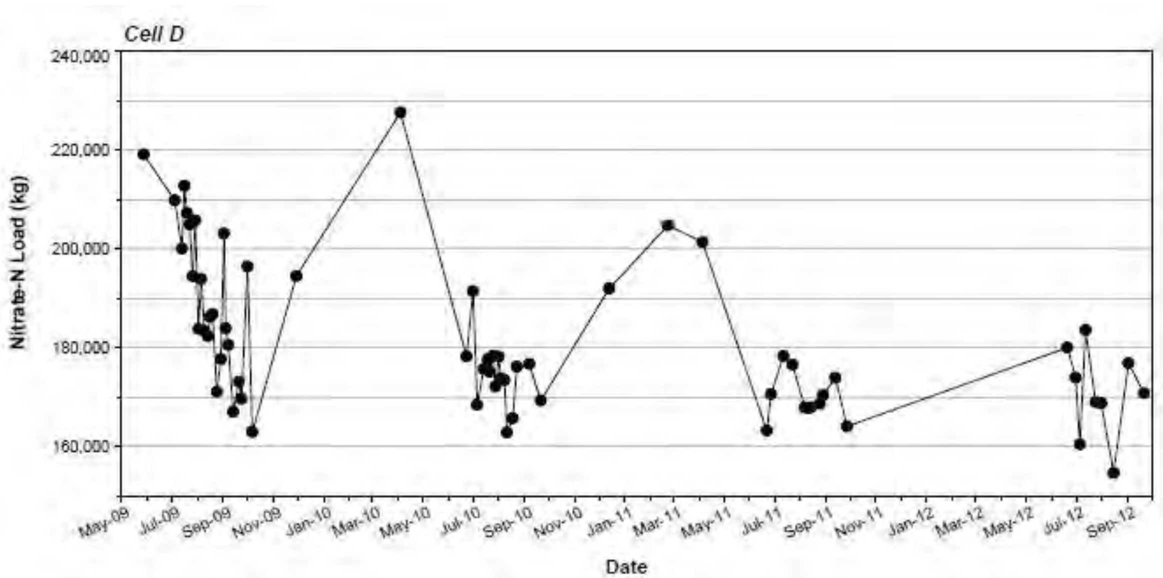

Figure 4- Nitrate as N Loads in Cell D of the LLCF, May 2009 to September 2012.

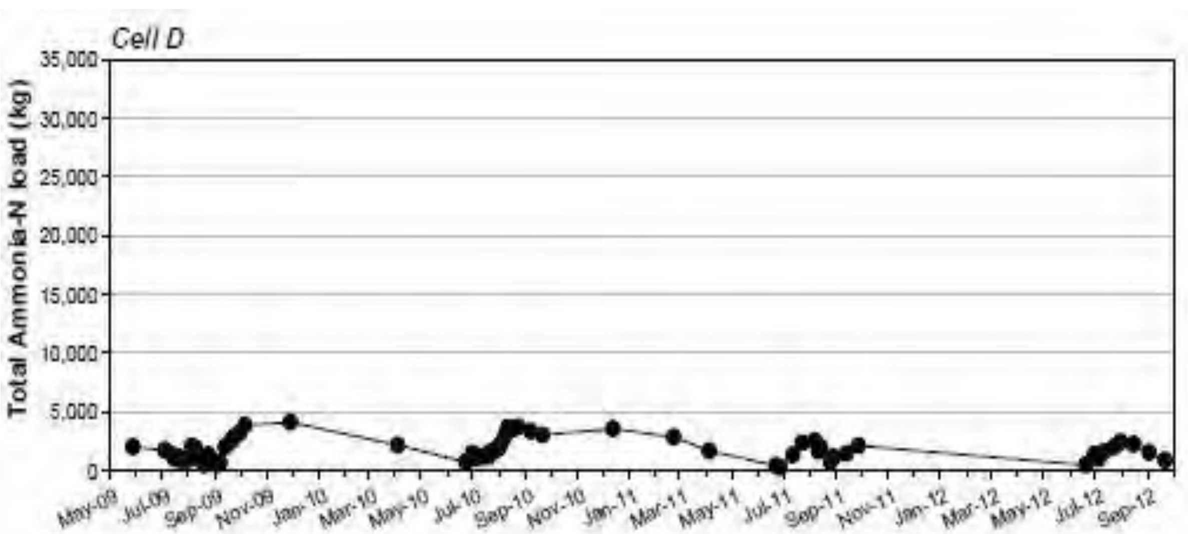

Figure 5- Total Ammonia as N Loads in Cell D of the LLCF, May 2009 to September 2012.

As reported in the 2012 AEMP, statistical and graphical analyses suggest that nitrate-N concentrations have increased in monitored lakes and streams downstream of the LLCF as far as Nema-Martine as a result of mine operations (Figure 6) (Rescan, 2013). Observed and fitted mean nitrate-N concentrations were less than the hardness dependent Site Specific Water Quality Objectives (SSWQO) for nitrate-N at all AEMP sites in 2012, and results indicate that concentrations in all sites have stabilized in recent years (Rescan, 2013).

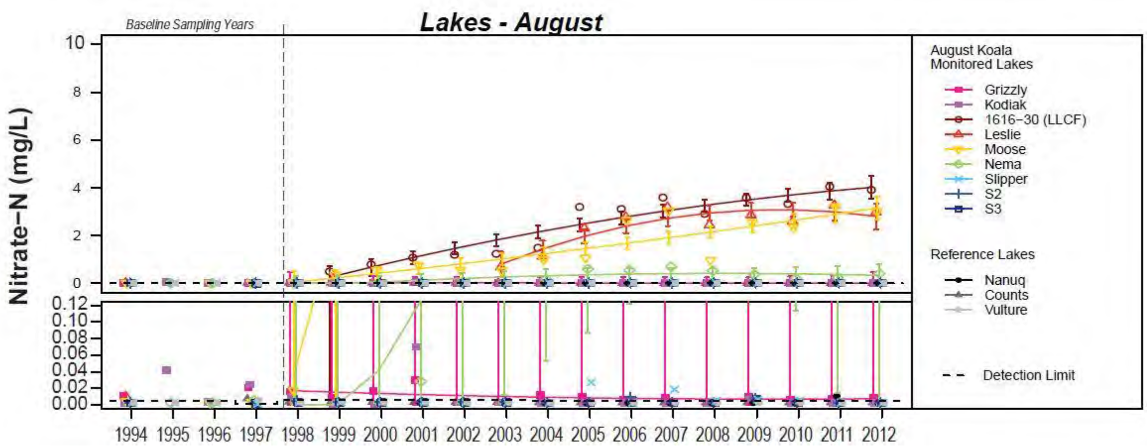

Figure 6- Observed and Fitted Means for Total Nitrate-N concentrations in Koala Watershed Lakes and Lac de Gras 1994-2012

The 2012 AEMP (Rescan, 2013), also reports that concentrations of total ammonia-N at all sites downstream of the LLCF were less than pH- and temperature-dependent Canadian Council of Ministers of the Environment (CCME) guidelines during the open-water season of 2012. Statistical and graphical analyses suggest that total ammonia-N concentrations have increased at all sites downstream of the LLCF as far as Slipper Lake (Figure 7). In all cases, however, concentrations of ammonia downstream of the LLCF have either stabilized or declined in recent years.

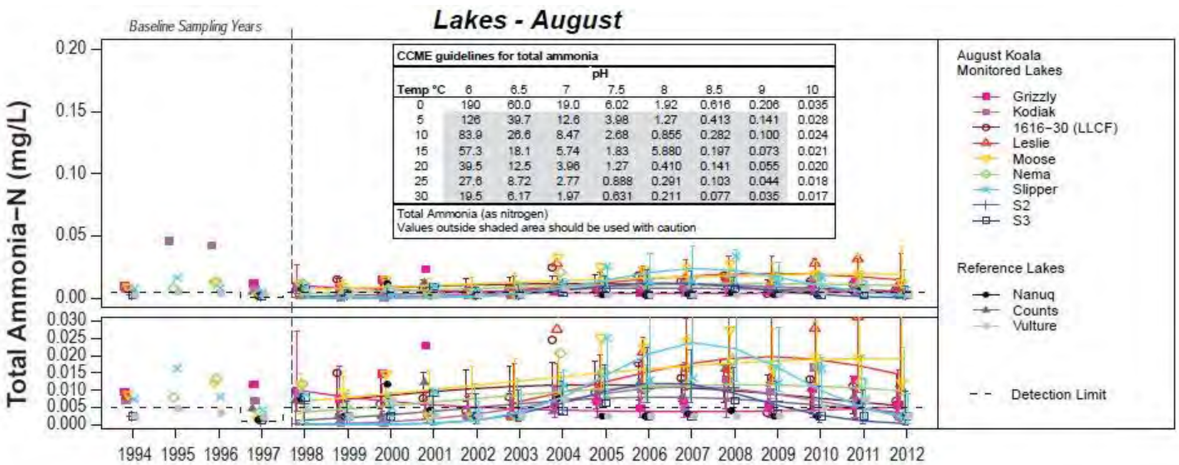

Figure 7- Observed and fitted means for Total Ammonia-N concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994-2012.

The observation that concentrations of nitrate and ammonia downstream of the LLCF have either stabilized or declined in recent years is consistent with the trend of decreasing nitrogen concentrations in the LLCF as well as the diversion of underground minewater and some process plant discharge to Beartooth Pit. Maximum nitrate and ammonia concentrations in the receiving environment at the Ekati Diamond Mine are expected to be reached in the winter of 2020 due to pumping out of Beartooth Pit, although these maximum concentrations are predicted to be less than benchmark concentrations for all AEMP sampling locations downstream of the LLCF (i.e. A maximum of 56 and 6% of benchmark concentration for nitrate and ammonia, respectively) (Rescan, 2012).

2.5 Current Nitrogen Source Control and Release Practices

DDEC recognizes the potential impact of increased nitrogen loading into surrounding water bodies and currently has several practices in place to limit both the amount of nitrogen available for dissolution through source control practices as well as the amount of nitrogen released from containment through release control practices.

2.5.1 Nitrogen Source Control Practices

Nitrogen source control activities designed to limit the amount of nitrogen available for dissolution into minewater or transportation to the process plant, and subsequent discharge to containment facilities, are continuously carried out at the Ekati Diamond Mine. Nitrogen source control activities are carried out by a number of departments and personnel on site and include:

- Continual assessment of drilling and blasting practices to ensure maximum blast efficiency and pit wall stability, and to minimize misfires;
- Periodic blast audits from external consultants, including the 2008 and 2013 Explosives Management audits by Golder;
- Supplementary training for drill and blast engineers to support and encourage continual development of best practices for staff, including training conducted in January 2014; and
- On-going spill control and clean-up activities to prevent and address spillage of explosives.

Additional activities to manage nitrogen sources at the Ekati Diamond Mine are discussed in more detail in Appendix A. Specific recommendations from the 2008 Blasting Audit conducted by Golder that have been implemented are discussed further in Section 2.6.

2.5.2. 70:30 Explosives Mix at the Ekati Diamond Mine

The use of a 70:30 ratio of emulsion and ANFO, respectively, has been standard practice at the Ekati Diamond Mine since 1998. This ratio was and continues to be in line with industry standards as it offers an appropriate balance of hydrophobicity, which is important for preventing the dissolution of nitrogen into mine water, and blasting energy which is necessary for ensuring pit wall integrity and stability. Although, in some cases, an 80:20 mix may be used at other locations, these sites often feature significantly wetter conditions than Ekati and therefore require greater relative quantities of hydrophobic emulsion to ensure that dissolution rates are sufficiently low. Since blast holes at Ekati are generally dry, a 70:30 ratio is appropriate for our site conditions.

2.5.3 Nitrogen Release Control Practices

In addition to source control practices, DDEC conducts a number of activities to regulate the release of nitrogen from containment facilities to the receiving environment. These practices highlight DDEC's commitment to adaptive management and will continue to be used in the future, wherever appropriate:

- Diversion of minewater streams and process plant discharge from the LLCF to the de-commissioned Beartooth Pit;

- Discharge of water from the LLCF during ice-free periods to maximize dilution effects;
- *In situ* LLCF fertilization study, whereby phytoplankton growth and the biological uptake of nitrogen was stimulated through the addition of phosphorus to the LLCF, successfully reducing the amount of nitrate available for discharge into the receiving environment (See Rescan, 2011);
- Additional research programs focused on the potential severity, ecological significance and persistence of changes to the aquatic community based on nutrient addition (i.e. the Aquatic Effects Synthesis Study, currently ongoing);
- Numerical modeling of water quality to evaluate potential effects in the receiving environment (Rescan, 2012);
- Development of a Site Specific Water Quality Objective for nitrate (Rescan, 2012b); and
- Development of an Aquatic Response Framework, which is currently under review by the WLWB, which will provide a tool for assessing nitrate source and release management strategies at the Ekati Diamond Mine by providing a direct link between the results of the AEMP and actions designed to ensure that nitrogen levels in the receiving environment remain within an acceptable range.

2.5.4 Nitrogen Mass-Balance

In the WLWB's decision package on Version 1.0 of the Nitrogen Response Plan, it was requested that DDEC incorporate "an effective method of reporting total nitrogen entering, re-used in and exiting (including potential losses in transportation) mining processes at Ekati, and to include these values in its annual AEMP report". While results of the AEMP indicate that concentrations of nitrate and ammonia are below hardness SSWQOs and pH- and temperature-dependant CCME guidelines, respectively, at all monitoring locations downstream of the LLCF, DDEC is committed to continuing diligent management, including the development of a mass-balance type equation for nitrogen at the Ekati Diamond Mine.

Nitrogen enters the mining process at the Ekati Diamond Mine through use of explosives in both underground and open pit mining. As previously described, a fraction of the nitrogen present in explosive materials may not be consumed during blasting and as such, can exit the mining process via one of three potential pathways:

- Dissolution into minewater and subsequent transportation in solution to a containment facility;
- Mucking as solid material adhering to waste rock and disposed of in waste rock storage areas, where it may be dissolved by rainwater; and

- Mucking as solid material adhering to kimberlite that is transported to the Process Plant, dissolved by water used in kimberlite processing and transported along with processed kimberlite in the form of discharge slurry to a containment facility (Golder, 2008).

Minewater is directly pumped out of the open pits (i.e. not “re-used” in the dewatering system in any way). Some minewater is circulated within the underground workings for drilling, representing a “re-use’ of the water that reduces the quantity of freshwater that would otherwise need to be delivered into the underground workings. However, the circulation of minewater in the underground mine does not represent any additional sources or losses of nitrogen to the minewater stream, and therefore does not affect the tracking of either source or release control practices. It is the quantity and concentrations of nitrogen that are pumped from the underground workings to the surface environment (LLCF or Beartooth pit) that are of interest. Circulation of underground minewater for drilling is undertaken on an as-needed basis from various intermediate sumps within the underground workings and, as such, is not readily measured. This water is ultimately pumped to surface where it is then captured in established sampling routines, as described above.

There is an inherent time delay that would complicate an attempted single-blast reconciliation in the underground mine due to interacting factors such as location within the underground workings relative to the collection sump and to other blasts, minewater residence/travel time, fault zone influx, and surface water influx. However, given that that the nitrate reconciliation is a matter of diligent management rather than environmental urgency (i.e. nitrate and ammonia concentrations in effluent and receiving waters are compliant or within water quality objectives and are decreasing over time), an annual reconciliation is appropriate and would not be expected to be greatly affected by a ‘time lag’ factor.

Based on the above, and in order to address the Board’s request to incorporate “an effective method of reporting total nitrogen entering, re-used in and exiting (including potential losses in transportation) mining processes at Ekati “, the following information will be provided in the in the 2014 Annual AEMP Report (to be submitted March 2015):

- 2014 Monthly summaries of explosives that are used in open pit and underground mines, including total N loads;
- 2014 Monthly summaries of internal monitoring programs tracking the amount of nitrogen exiting both underground and open pit mines in minewater streams;
- 2014 Monthly summaries of N loads in the process plant slurry; and

- Estimates of approximate nitrogen loading in waste rock that would be available for dissolution in runoff and transport to containment facilities.
- Estimates of any nitrogen lost during transportation, as reported in spill reports.

2.6 Identification of Past Recommendations and Rationale for Implementation

Recommendation (Section of 2008 Golder Report)	Implementation Status	Rationale/Comments
Nitrate Awareness Educational Programming (5.1)	Implemented	Explosive use and responsible management is provided as job-specific training for those qualified and required to work with explosives. Emergency Response Team members are trained to enact the Spill Contingency Plan as required. Continual effort has been made to update training modules for all employees to promote environmental awareness and job safety.
Decrease sleep times for open pit blasts (5.2.1)	Implemented	Sleep times have been reduced to less than one week.
Restrict water-soluble ANFO use in wet holes (5.2.2)	Implemented	Only water-resistant emulsion is now used in wet holes.
Reduce ANFO spillage (5.2.2)	Implemented	Concerted effort of drillers, blasters, and Polar Explosives employees has reduced spillage, as observed by Golder consultants in 2013 site visit.
Review choke use of blasting (5.2.3)	Not implemented	Unsupportable given established mining method at site.
Double Priming (5.2.3)	Not implemented	Unsupportable given pre-loading of holes.
Uphole Emulsion Retention (5.2.3)	Implemented	Birdies are used UG frequently as required in wet holes.
Blasthole Diagnostics including blast vibration monitoring, borehole camera, blasthole deviation and velocity of detonation (VOD) surveys (5.2.3)	Implemented vibration monitoring and blasthole deviation surveys. Borehole camera surveys or VOD analyses were not implemented.	Vibration monitoring and blasthole deviation surveys have been conducted periodically UG and the results of these surveys satisfactorily aided in blasthole diagnostics, thus eliminating the need for further diagnostic methods. Vibration monitoring for the Pigeon Open Pit (mining planned to commence 2nd half 2014) is in the process of being established.
Footwall Groundwater Modification Study (5.2.3)	Not implemented	Drilling of additional holes within production blasts for the purpose of dewatering along the hanging wall contact is undertaken when required. As such, no formal study has been conducted.

3. Review of Current Blasting Practices at Ekati

Please see Appendix A for the complete Blasting and Explosives Management Audit conducted by Golder Associates.

4. Implementation Plan

DDEC aims to continually reduce nitrogen sources to the receiving environment, monitor nitrogen trends at the Ekati Diamond Mine and adaptively manage increased nutrient loading if necessary. The *Review of Blasting Operations and Explosives Management Plan at Ekati Mine* Conducted by Golder Associates (Appendix A) concludes that many positive practices are currently in place to meet these objectives and offers recommendations for continued improvement.

The Golder Report states that the most significant potential improvements in minimizing the availability of explosives for dissolution into mine water can be realized by "improved handling and usage practices in the open pit and underground mines and in particular by minimizing malfunctions and misfires in the open pit"(Golder, 2013). Based on that assessment, and the specific recommendations offered by Golder towards that end, DDEC has developed the following Implementation Plan.

4.1 Recommendations included in Golder (2013) to be included in the Implementation Plan

Recommendation 1: Continue currently existing mitigation practices

Specific recommendations include:

- Managing the emulsion plant and AN storage facility with controls in place to capture accidental spills; and
- Monitoring of the nitrate levels in the LLCF, Beartooth and Misery Holding Ponds.

DDEC plans to fully incorporate both recommendations listed above toward continuing current mitigation practices into the Implementation Plan. As described in the Golder report, the processes and procedures in place at the AN facility and emulsion plant are well established and effective at preventing and minimizing the environmental effect of spillage. Effective management of these facilities takes place daily, and spill kits and catchment basins are in place on a permanent basis in order to facilitate spill clean-up. ERT spill response training takes place annually, over 2-3 training sessions to ensure that all ERT members have the skills necessary to safely and effectively respond to any potential spills.

Continual monitoring of nitrogen trends in the LLCF, Beartooth Pit and King Pond will also be fully incorporated into the Implementation Plan and continued as a requirement of W2012L2-0001 and through internal monitoring plans. LLCF nitrogen trends are monitored through monthly internal sampling in both Cells D and E four times during the open water season and at the Cell E discharge location weekly during discharge, prior to discharge, quarterly as part of the sampling conducted for bacteriology and twice annually as part of the chronic and acute toxicity tests and reported as part of the Surveillance Network Program reports, issued monthly.

Recommendation 2: Consider additional best practices

Golder specifically recommends:

- Bottom loading wet holes; and
- Using "birdie" plugs at the collar in wet underground production blasts to aid in explosive retention.

DDEC has already instituted both of these practices into standard operating procedures. Bottom loading wet holes is current practice in both underground and open pit mines whenever necessary based on blast requirements, ground conditions and other factors. "Birdie" plugs are also used at the collar in all underground production blasts to aid in the retention of explosives. As such, DDEC plans to fully incorporate these recommendations into its Implementation Plan.

Recommendation 3: Consider an education program to increase general awareness of nitrate and explosive loss to the environment that highlights the significance of obtaining a water licence in order to operate.

DDEC currently offers training to all employees regarding our commitment to the environment and a general introduction into operating requirements as part of orientation training upon their arrival to site. Additionally, there is a one-time education program in place specifically for those employees who work with explosives, which is run through the training department at the Ekati Diamond Mine. This program builds on the requirements of the Mines Act, which stipulates required levels of training and competency for those handling and transporting explosive materials. Further to this, all employees involved in loading and blasting activities are required to hold their blasting tickets, issued by WSCC, which must be renewed every 5 years.

DDEC will additionally continue to look for opportunities for increased communication of environmental commitments including through on-going waste management, wildlife awareness and other special presentations, which are delivered to various departments on site by Environment or Waste Management personnel on a rotating basis.

Recommendation 4: Continue to conduct operational reviews.

Golder recommends specific foci to ensure that:

- Plans are being followed;
- Drills are not over drilling holes;
- Blast holes are not overloaded with emulsion;
- The engineering team is informed of the condition of blast patterns prior to a tie-in map being created;
- Tie-in maps are checked;
- Patterns are checked once they have been tied in;
- Blast results are checked;
- Shovel operators and pit foremen are communicated with to confirm that blasted material is in the correct muck profile for the loading unit and that the designed fragmentation is being achieved; and
- Any misfires or excess emulsion remaining in the pit after a blast are reported to the environment department.

DDEC currently carries out operational reviews of drilling and blasting operations, and will continue to do so including focusing on the specific items above. Currently, operational reviews are conducted on a monthly basis. These reviews, which are collaborative effort of the drill and blast engineering team as well as the operational crews, are centered on reviewing videos, tie-ins and blast results, and are designed to continually identify potential problems with blasts or efficiencies that may be targeted. Additionally, individual blast reviews are conducted by the drill and blast engineering team for every blast in open pits, where results regarding fume release, rock breakage, fly rock and other blast issues are discussed. These current foci, as well all those indicated by Golder, will be incorporated into operational reviews moving forward and as such the recommendation will be fully incorporated into the Implementation Plan.

Recommendation 5: Consider near-field blast vibration monitoring to provide a means to compare blast designs with actual blast performance by diagnosing vibration traces in millisecond detail.

Near-field vibration monitoring can be an effective tool to assess blast performance and identify potential actions for improving blasting practices, and has been used at the Ekati Mine in the past. As such, DDEC will include a near-field vibration monitoring study in the Implementation plan and will report any relevant recommendations that may come from this study in the 2014 AEMP Annual Report (to be submitted March 2015).

Recommendation 6: If vibration monitoring reveals potential issues with certain holes in a blast, perform VOD measurements to ensure water infiltration, over-fuelling or shoot-throughs are not degrading the explosive performance and resulting in undetonated product.

Pending results of vibration monitoring, DDEC will investigate the use of VOD measurements to provide additional information regarding the aforementioned factors that may be affecting blast performance. The use and frequency of these additional measures will be determined following the completion of vibration monitoring.

Recommendation 7: Further blast diagnostics could employ borehole camera surveys in selected open pit production blasts to provide insight on the condition of the blastholes and how hole irregularities such as large cracks or cavities may be affecting blast loading and performance.

Pending results of vibration monitoring, DDEC will investigate the use of borehole camera surveys to provide additional information regarding the aforementioned factors that may be affecting blast performance. The use and frequency of these additional measures will be determined following the completion of vibration monitoring.

4.2 Additional Management Practices to be Included in the Implementation Plan

In addition to the seven recommendations made by Golder, DDEC is committed to investigating and implementing other relevant nitrogen management practices and source control at the Ekati Diamond Mine. These practices, which are already implemented at the Ekati Diamond Mine include:

- Full decontamination and cleaning of explosives trucks on an annual basis.
- Monthly internal inspection of trucks for any retention of explosives product. In the event of product retention, trucks are steamed out to remove any built-up residues. This procedure ensures that product is being continually removed from the trucks, thus eliminating the risk of contaminating fresh, effective explosives with older, potentially problematic explosives thus improving blast efficiency.
- Continual monitoring of the amount of explosives planned versus the amount of explosives used in each blast pattern to identify any potential losses during transportation or due to blast hole over-loading.

4.3 Reporting

DDEC will include a report on the effectiveness of the Nitrogen Response plan, including an update to current nitrate and nitrite trends in the receiving environment in the 2014 AEMP Annual Report. Following this reporting period, it is expected that future iterations of the Nitrogen Response Plan will be accommodated in the Response Framework, which is currently before the board for approval.

The 2013 Golder report indicates that DDEC has many positive practices in place to contain, handle, use and dispose of explosives. By implementing the actions listed above, and continuing with monthly, annual and internal water quality monitoring programs, DDEC will continue to effectively monitor and control nitrogen sources to the receiving environment at the Ekati Diamond Mine.

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December 19, 2013

REPORT ON

REVIEW OF BLASTING OPERATIONS AND EXPLOSIVES MANAGEMENT AT EKATI MINE

Submitted to:

Dominion Diamond Ekati Corporation
1102 - 4920 52nd Street
Yellowknife, NT
X1A 3T1 Canada

Attention: Kathleen Shea,
Environmental Specialist

REPORT

Reference Number: 1314390011-001-R-Rev1-5000

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Explosive Manufacturer Fact Sheets

APPENDIX B
Blast Timing

GLOSSARY

Except where otherwise noted, glossary definitions are from the ISEE Blaster's Handbook (Stiehr 2011)

AN – **Ammonium Nitrate** – The ammonium salt of nitric acid represented by the formula NH_4NO_3.

ANFO - A blasting agent containing no essential ingredients other than prilled ammonium nitrate and fuel oil.

Backbreak – Rock broken beyond the limits of the last row of holes in a blast.

Burden – The distance from the borehole and the nearest free face or the distance between boreholes measured perpendicular to the spacing. Also the total amount of material to be blasted by a given hole.

Collar – The mouth or opening of a borehole or shaft.

Drawpoint[1] – An underground opening where gravity-fed ore from a higher level is collected and loaded into hauling units.

Emulsion – An explosive material containing substantial amounts of oxidizer dissolved in water droplets, surrounded by an immiscible fuel, or droplets of an immiscible fuel surrounded by water containing substantial amounts of oxidizer.

Gassing agent – Chemicals used to introduce gas bubbles to impart sensitivity and reduce density of explosive compositions.

Nonel – **Nonelectric detonator** – A detonator that does not require the use of electric energy to function.

Powder factor – The amount of explosive used per unit of rock.

Prill – **Prilled Ammonium Nitrate** – Ammonium nitrate in a pelleted or prilled form.

Pre-shear – A smooth blasting method in which cracks for the final contour are created by firing a single row of holes prior to the initiation of the rest of the holes in the blast pattern.

Primer – A unit, package or cartridge of explosives used to initiate other explosives or blasting agents, and which contains: (1) a detonator: or (2) detonating cord to which is attached a detonator designed to initiate the detonating cord.

Sensitizing (Explosive) – **Sensitivity** – A physical characteristic of an explosive material classifying its ability to be initiated upon receiving an external impulse such as impact, shock, flame, friction or other influence which can cause explosive decomposition.

Shoot-through[2] – Premature initiation caused by explosive gases penetrating cracks between holes.

Sleep time[3] – The time between explosives being loaded into a blasthole and their initiation.

---

[1] Definition provided by Golder

[2] Definition provided by Golder

[3] Australian Standard AS2187 Part 2-2006 2006

Spacing – The distance between boreholes. In bench blasting, the distance is measured parallel to the free face and perpendicular to the burden.

Stemming – Inert material placed in a borehole on top of or between separate charges of explosive material. Used for the purpose of confining explosive materials or to separate charges of explosive material in the same borehole.

Sub-drill – The practice of drilling boreholes below floor level or working elevation to insure breakage of rock to working elevation.

Toe burden – In bench blasting, excessive burden measured at the floor level of the bench.

1.0 INTRODUCTION

This report presents the results of an assessment undertaken by Golder Associates Ltd. (Golder) of the blasting practices at Dominion Diamond Ekati Corporation (DDEC) Ekati mining operations in the Northwest Territories, Canada. Golder completed a review of the blasting operations for the Ekati Mine (Ekati) in July 2008, and the current work is an update to this previous work.

Ammonium-nitrate (AN) blasting agents are believed to be the main source of nitrate in the mine waters. Depending on the type, blasting agents can be highly soluble and are thus easily mobilized to the environment by runoff and other means of contact with water.

The objective of the assessment was to complete a review of current blasting practices and explosives handling procedures at Ekati. This entailed an assessment of the handling and usage of blasting products on site and a review of the blasting practices being used in the open pit and underground mines. A high-level review of current nitrate levels and trends in mine waters was also completed.

The specific focus of the proposed work was an engineering study to identify the nature and potential magnitude of nitrogen compound sources. From this, appropriate measures were developed to target reductions in nitrogen compound loadings and, ultimately, reductions in nitrate levels in the Long Lake Containment Facility (LLCF) and discharge. Part of the assessment was to identify opportunities that could minimize the quantity of explosives that may not be handled in a controlled manner or properly detonated, and that then become available for dissolution by the mine site drainage water.

The second part of the work was to develop an implementation plan, in collaboration with DDEC personnel, to address the recommendations from the audit. This plan includes recommended actions to minimize nitrogen losses, a description of timelines to implement the actions, and a schedule to report on the effectiveness of the actions and revise the plan as needed.

2.0 SITE OVERVIEW

2.1 Chronology of Mine Operations

The Ekati Mine commenced operation in 1999, and since then both open pit and underground mining activities have been undertaken. Initially, production was from four open pit mines: Panda, Koala, Koala North, and Misery.

Current production is from two open pits, Fox and Misery, and from underground mining below the Koala and Koala North Pits. The underground mines are downward extensions of the previous open pit mining.

The chronology of production mining at the site is summarized in Table 2-1. The shaded cells represent production years.

Table 2-1: Chronology of Mine Operations

Mine	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Beartooth Pit															
Fox Pit															
Koala Pit															
Koala Underground															
Koala North Pit															
Koala North Underground															
Panda Pit															
Panda Underground															
Misery Pit															
Pigeon Test Pit															

2.2 Site Layout

The general mine layout is shown in Figure 2-1. For this report, there are three main areas of interest:

1) Main Operations Area: The Main Operations Area (MOA) incorporates the Beartooth, Panda, Koala, and Koala North mining activities (open pit and underground), as well as the main waste rock storage area, the ore processing plant, and mining support infrastructure such as the workshop, maintenance facilities, mine offices, and main camp.

2) Fox Pit Area: The Fox Pit Area (FPA) is located approximately 8 km southwest of the MOA and includes Fox Pit and an adjacent waste rock storage area.

3) Misery Pit Area: The Misery Pit Area (MPA) (shown in Figure 2-1) is located approximately 30 km southeast of the MOA and includes an adjacent waste rock storage area.

The AN storage building and emulsion plant are located approximately 1 km south of the main camp adjacent to the Fox haul road (see Figure 2-2).

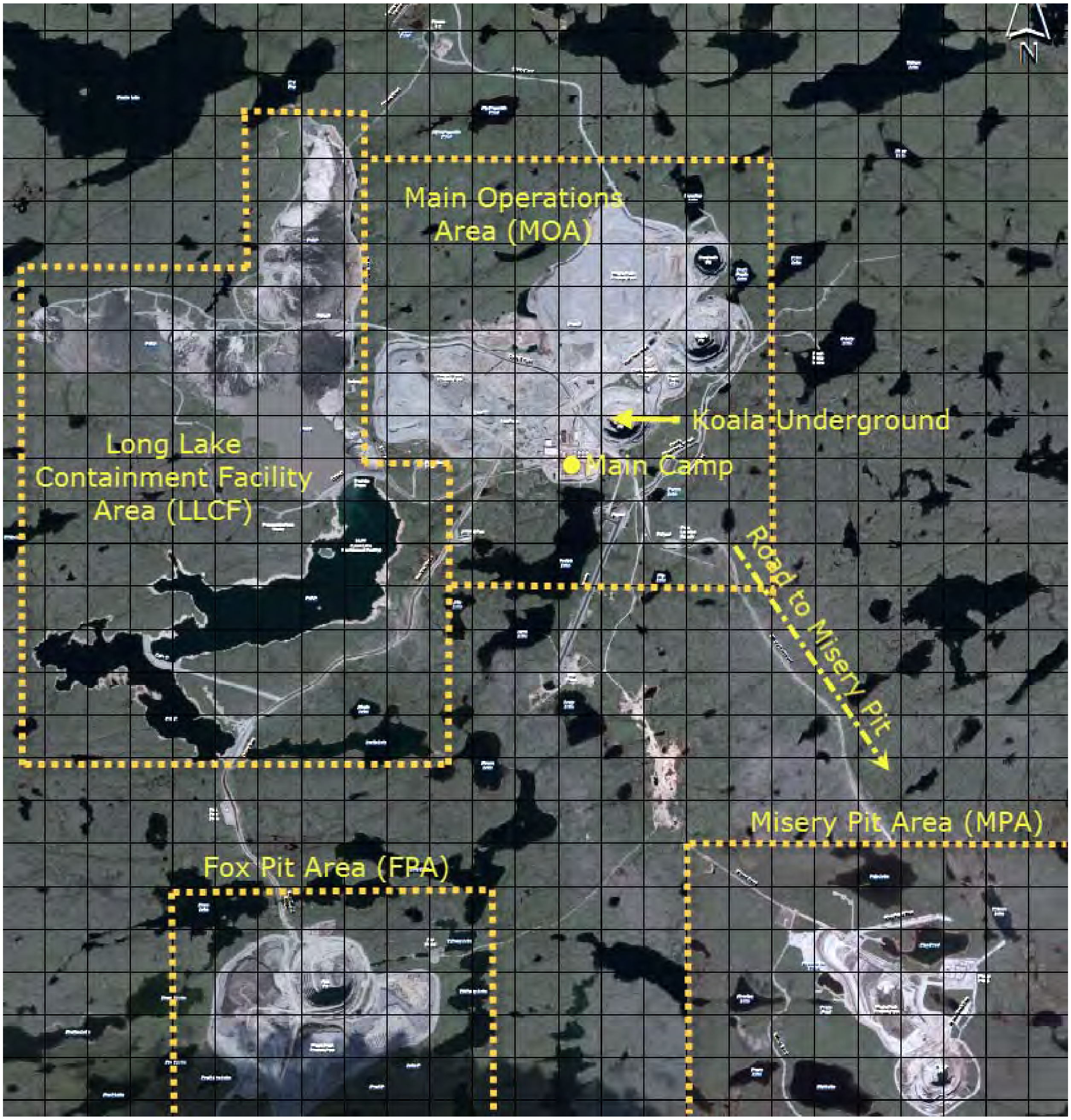

Figure 2-1: Ekati Mine Surface Infrastructure (modified from DDEC 2013)

Figure 2-2: Location of AN Storage Building and Emulsion Plant Relative to the Main Camp (modified from DDEC 2013)

2.3 Transportation and Handling of Explosives

Explosives are transported to site by truck on the winter road. The regular and high density prills used for the Dyno RU and Dyno Gold Lite are stored in the AN storage building (see Figure 2-2). The AN prills are delivered to the manufacturing facility by truck on an as-needed basis. The bulk explosives are transported to the open pit using emulsion trucks as shown in Figure 2-3. Figure 2-3a shows the loading of emulsion and Figure 2-3b shows the loading of AN prill.

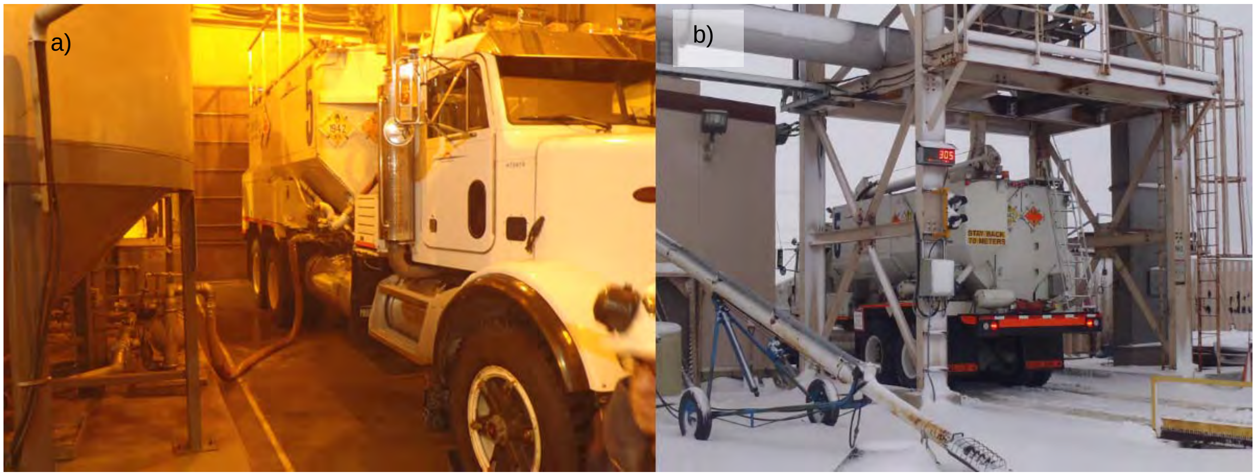

Figure 2-3: Bulk Explosives Truck for Open Pit Blasts

Figure 2-4 shows a) the transport containers used to b) transport emulsion to the underground, where eventually the emulsion is pumped to c) an emulsion loader to be transported to the headings.

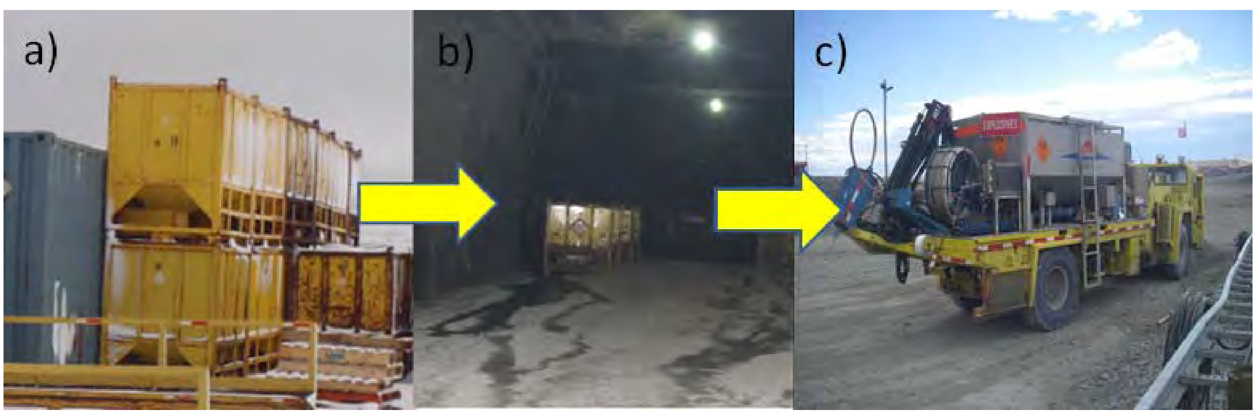

Figure 2-4: Emulsion Transport Underground

3.0 BLASTING ACTIVITIES

3.1 Open Pit Mining

Open pit mining is conducted at Misery Pit and Fox Pit with 10 m benches. The benches are triple stacked, ultimately reaching 30 m in height. Blastholes with a diameter of 270 mm (10^5/$_8$ in.) are drilled using either the Tamrock D90 or Atlas Copco Viper 275 rotary drills. Blastholes with a diameter of 165 mm (6½ in.) are drilled using the two Ingersoll-Rand DM45 drills. There are also two ranger drills (Sandvik DX700/DX800), which are used to drill 89 mm (3½ in.) and 102 mm (4 in.) pre-shear holes. The ranger drills are used to drill drain holes, toes, boulders, and other specialty holes. The blasted muck is excavated with shovels or loaders that load haul trucks.

The blasting activities in the pits include the following:

- pre-shear blasts;
- trim blasts;
- waste material blasts;
- kimberlite ore blasts; and
- other specialty blasts (e.g., example boulders, toes, sumps, ramp shots).

The explosives for trim blasts, waste stripping blasts, and kimberlite production blasts are loaded using a bulk emulsion truck. The explosives used for the pre-shear and other specialty blasts are loaded with pre-packaged products, as per Table 3-1. The manufacturer fact sheets for the explosives used on site are shown in Appendix A.

Table 3-1: Pre-shear Pattern and Loading Standards

Material	Kimberlite	Granite	Schist
Hole diameter (mm (in.))	89 (3½)	165 (6½)	89 (3½)
Spacing (m)	1.0	2.0	1.7
Explosive used	Dynosplit C (22 mm)	A50 Detagel	A50 Detagel / Dynosplit C (32 mm)
Collar with no stemming(m)	1.0	3.0	3.0

Pre-shear blasts are designed to minimize damage to the final wall. This type of blasting is carried out in advance of the waste and trim blasting. The holes are loaded with a decoupled explosive (Detagel A50), and the collars are not stemmed (see Figure 3-1). The number of holes detonated in each pre-shear blast is limited to about 50 to prevent excessive vibrations in the rock mass behind the final wall.

Figure 3-1: Pre-shear Loading

Trim blasting practices are applied in the section of the pit between the pre-shear blasts and the main production blasts. The objective of the trim blast is to fragment the rock in front of the pre-shear line while not damaging the rock in the final pit wall. Key considerations for trim blasts at Ekati include the following:

- limiting the number of production rows in a blast (typically six to seven);
- reducing the blasthole diameter;
- increasing the collar length on the rows closest to the pre-shear line;
- reducing burden and spacing for the rows closest to the pre-shear line; and
- cleaning the face of the blast to reduce the confinement for the final row.

A typical trim blast cross-section is shown in Figure 3-2.

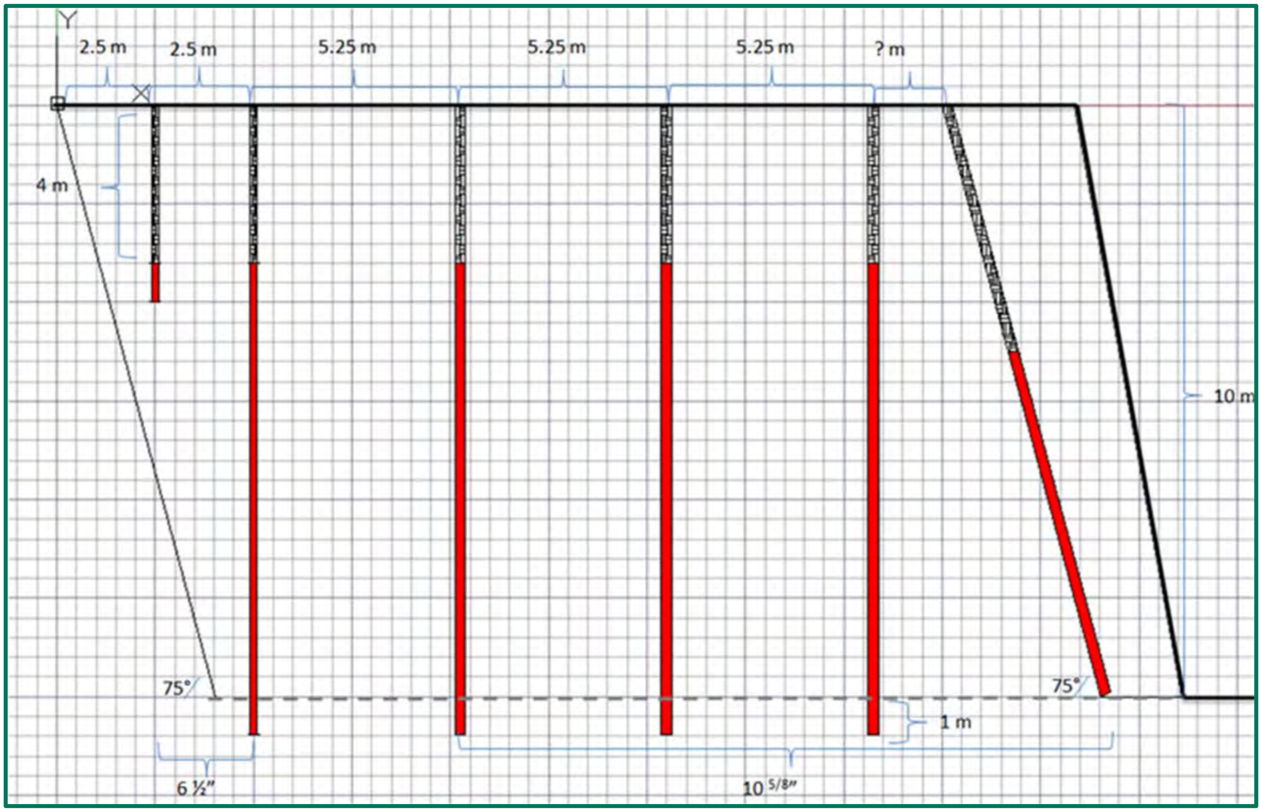

Figure 3-2: Schist Trim Blast Cross-section

The row of holes closest to the face, which are drilled on an angle around 75° and referred to as satellite holes, are field fitted and therefore distances vary. The DDEC blasters in the field emphasized that these satellite holes were necessary because there were issues with the toe being too hard to dig. The satellite holes are not loaded according to the same parameters as the rest of the pattern.

The standard parameters for trim blasts are shown in Table 3-2.

Table 3-2: Trim Pattern Standard Parameters

Material	Kimberlite		Granite	
Hole diameter (mm)	165	270	165	270
Distance from pre-shear (m)	3.0	n/a	2.0	2.5
Spacing (m)	4.25	n/a	3.0	3.5
Collar – post gassing (m) [(a)]	4.0	n/a	4.0	4.0

[(a)] If the trim pattern is in granite or schist, then a 6 m collar is used; otherwise, for all other rock types a 4.0 m collar is used for both 165 mm and 270 mm diameter blastholes.

n/a = Not applicable.

Production blasting is carried out in a similar manner for blasts in both the waste rock and kimberlite, except that the blasts in kimberlite have no sub-drill, and the unloaded collar length is slightly longer than for the blasts in waste rock. Table 3-3 shows the standard parameters used for production blasts.

Table 3-3: Production Pattern Standard Parameters

Material	Kimberlite		Granite		Schist	
Hole diameter (mm)	165	270	165	270	165	270
Burden (m)	3.7	5.25	3.7	5.25	3.7	5.25
Spacing (m)	4.25	6	4.25	6	4.25	6
Subdrill (m)	0	0	1	1	1	1
Collar (m)	2.5 to 3	3.5 to 4	3	4	3	4
Delay between rows (ms)	150	230	150	230	150	230
Delay between holes (ms)	35	50	35	50	35	50

The powder factor is estimated to be approximately 0.5 kg/t.

3.2 Open Pit Blasting Practices

The standard blast designs for the Misery and Fox Pits are summarized in Table 3-4.

Table 3-4: Standard Open Pit Blast Designs

Parameter	Pre-shear	Trim	Production Waste	Production Ore	Special (e.g., ramp, sump)
Hole diameter (mm)	165	165	270	270	270
Drill pattern	line	staggered	staggered	staggered	square
Bench height (m)	30	10	10	10	varies
Burden (m)	n/a	4.0	5.25	5.5	5
Spacing (m)	2.0	4.0	6.0	6.0	5
Sub-drill (m)	1.0	0.0	1.25	0.0	0.0
Collar (m)	3.0	3.0	4.0	3.5	varies
Rock density (t/m^3)	2.72	2.72	2.72	2.24	2.72
Explosive type	cartridged slurry	doped emulsion	doped emulsion	doped emulsion	doped emulsion
Explosive name	Detagel A50	Dyno Gold Lite 70%	Dyno Gold Lite 70%	Dyno Gold Lite 70%	Dyno Gold Lite 70%
Emulsion/ANFO ratio	n/a	70/30	70/30	70/30	70/30
Sensitizing	n/a	gassed	gassed	gassed	gassed
Explosive density (g/cc)	1.20 [(a)]	1.20	1.20	1.20	1.20
Loading density (kg/m)	1.9	26	69	69	varies
Explosive length (m)	7.0	7.0	7.0	6.5	varies
Powder factor (kg/m^3; kg/t)	n/a	1.12; 0.41	1.34; 0.53	1.4; 0.60	varies
Priming	n/a	cast booster 1 lb.	cast booster 1 lb.	cast booster 1 lb.	cast booster 1 lb.
Stemming length (m)	0.0	3.0	4.0	3.5	varies
Stemming material	none	crushed stone	crushed stone	crushed stone	crushed stone
Detonator type	A-50 Detagel (1¾ in.)	350 ms Nonel	350 ms Nonel	350 ms Nonel	350 ms Nonel
Delay between hole time (ms)	n/a	35	35	35	35
Row to row time (ms)	n/a	109	109	109	109

[(a)] Cartridge density.
n/a = Not applicable.

Pre-shear blasts utilize 165 mm diameter holes that are typically 30 m long (10 m on ramps) and extend the full three stacked benches. Blastholes are drilled on 2.0 m centres. The holes are loaded with Detagel A50, which is a 45 mm diameter, pre-packaged continuous emulsion explosive specifically designed for pre-shear blasts. The explosive is loaded by hand to within 3.0 m of the collar. In order to mitigate damage from explosive gases, no collar stemming is used. Holes within the pre-shear blasts are tied together with detonating cord (Primacord 5) and detonated simultaneously. A maximum of 50 holes are blasted at a time; occasionally, groups of 5 to 10 holes are detonated at a time with a 35 ms delay between groupings.

The pit production and trim blasts are loaded using a bulk loading truck (see Figure 2-3).

The blasthole loading procedure for dry holes is as follows:

1) The depth of hole is measured and the presence or absence of water is noted.
2) The toe of the hole is primed with a 1 lb. booster and Nonel detonator.
3) The loading hose is pushed slightly into the collar of the hole.
4) The explosive is pumped (cascaded) into the hole.
5) The depth to the top of the explosive is measured continually and the progressive rise of the column of explosive is noted. If the column rise is observed to be slow or it stops, the explosive is likely exiting from the blasthole, and pumping of the explosive is stopped and some stemming is added to the hole. Another primer is then positioned in the hole and charging is resumed.
6) When the explosive reaches the desired elevation, pumping is stopped.
7) The primer is pulled up from the toe of the hole approximately 1 m so that it is in the explosive product and not in mud at the bottom of the hole.
8) The holes are left open until the gassing reaction is complete (approximately 0.5 hour).
9) Blastholes are stemmed with crushed rock.

The blasthole loading procedure for wet holes is as follows:

1) The depth of hole is measured and the presence or absence of water is noted.
2) The toe of the hole is primed with a 450 g (1 lb.) booster and Nonel detonator.
3) The loading hose is pushed to the bottom of the hole.
4) The explosive is pumped down the hose and the hose is slowly retracted, keeping the hose within the explosive.
5) The depth to the top of the explosive is measured continually and the progressive rise of the column of explosive is noted. If the column rise is observed to be slow or it stops, the explosive is likely exiting from the blasthole, and pumping of the explosive is stopped and some stemming is added to the hole. Another primer is then positioned in the hole and charging is resumed.

6) When the explosive reaches the desired elevation, pumping is stopped.

7) The primer is pulled up from the toe of the hole about 1 m so that it is in the explosive product and not in the water or mud at the bottom of the hole.

8) The holes are left open until the gassing reaction is complete (approximately 0.5 hour).

9) Blastholes are stemmed with crushed rock.

The average sleep time for Misery and Fox Pits is less than one week.

Figure 3-3 shows a) bulk emulsion truck at Fox Pit, b) moving between hole while loading bulk emulsion, c) a dry hole being loaded and measured and d) stemming of a blasthole with 1 in. minus crushed stone approximately 30 minutes after loading emulsion.

Figure 3-3: Open Pit Blasthole Loading

While spending time with the blasting crew, it became apparent there may be a lack of continuity not only between the drilling and blasting teams but also engineering and operations. Without someone managing both the drill and blast operation, issues could arise.

3.3 Underground Mining

The two currently operating underground mines at Ekati are Koala North and Koala. Koala North is a sub-level retreat operation and is depicted in Figure 3-4a. Koala is a sub-level caving operation and is depicted in Figure 3-4b (BHP Billiton 2005).

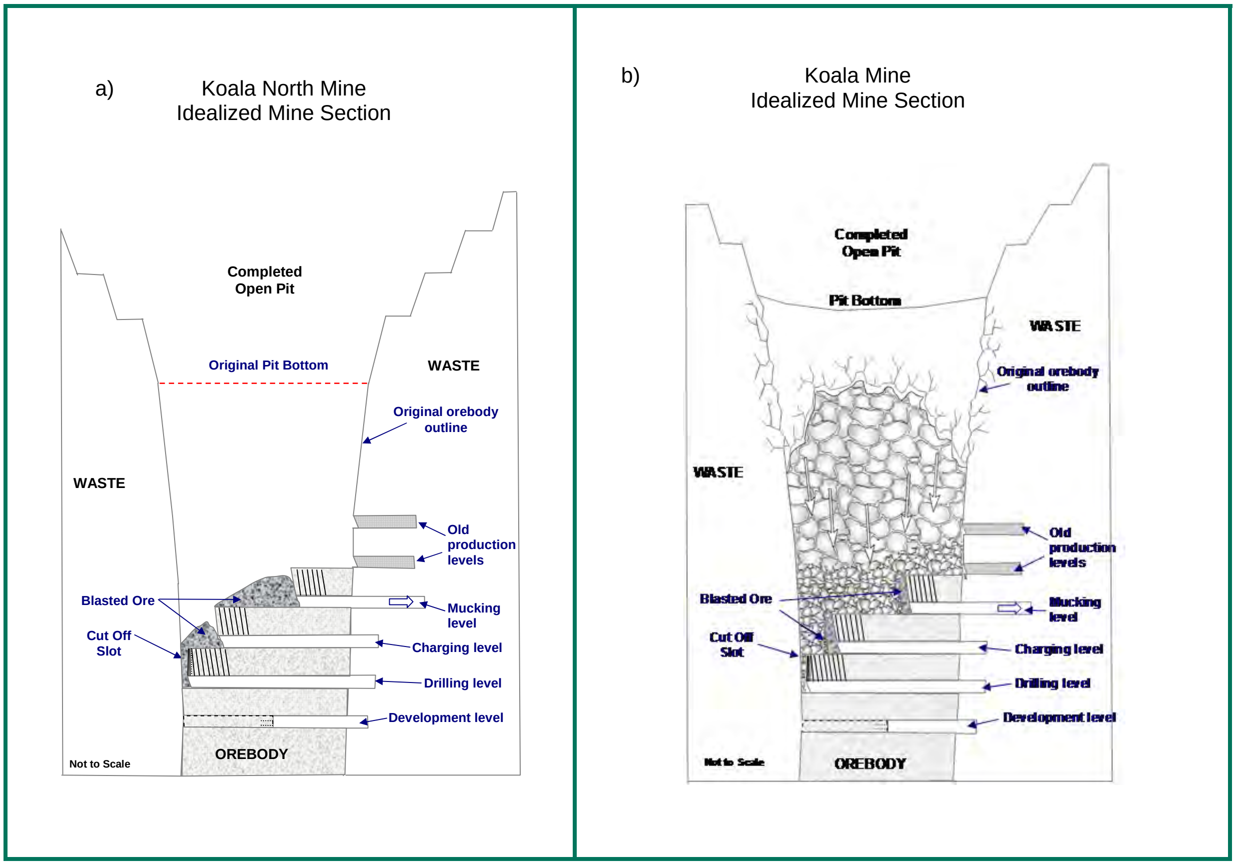

Figure 3-4: Idealized Underground Mine Sections for Koala North and Koala Mines (BHP Billiton 2005)

Note: Idealized mine section is simplified cartoon depiction of a mine section model.

3.3.1 Underground Production Blasting

Koala North Underground Mine

No loading of production blasts occurred at Koala North Mine during Golder's site visit. This section is therefore based on written procedures for the mine as well as discussion with Ekati underground staff. Production mining at Koala North involves full face blasting in which the ore that was broken in the prior blast is drawn down to just above the brow of the retreating drawpoint. This leaves a void between the face of the next blast and the reposing muckpile, except at the immediate brow. This void provides free face relief for the next blast and allows most of the broken muck to move forward when the blast is initiated. One ring is fired per blast to maximize recovery of ore, minimize choking, and minimize damage to the brow and subsequent rings. Each ring contains 11 up-holes up to 27 m in length.

In addition to the ring that is about to be blasted, two additional rings are always in a pre-loaded condition (i.e., loaded with explosive but not primed). This avoids having to load blast rings close to brows damaged from prior blasting. An additional ring is also drilled but not loaded after each blast so that production drilling operations are always undertaken well back from the brow. Thus, for a given one-ring blast, there is one primed ring, two pre-loaded (unprimed) rings, and an empty drilled ring. The blast ring is primed at a depth of approximately 8 m up the hole (collar primed) using a fiberglass rod to manually push the primer/detonator assembly into the emulsion

Koala Underground Mine

Production blasting had ceased temporarily at Koala Mine and only one development blast occurred at the time of Golder's site visit. This section is therefore based on written procedures for the mine as well as discussion with Ekati underground staff. At Koala, each ring is fired as a choked blast directly against caving muck that is tight to the blast face. One ring is blasted at a time to maximize recovery, minimize "freezing" of the blasted muck, and minimize damage to the brow and subsequent rings. A ring typically contains nine holes up to 27 m in length.

The approach used at Koala for drilling, pre-loading, and priming rings is similar to that employed at Koala North Mine. Two rings are pre-loaded, and one ring is drilled in advance of blasting a single ring. The blastholes are primed at a depth of approximately 8 m from the collar.

3.3.2 Underground Production Blasting Designs

The standard production blast designs for Koala and Koala North underground mines are shown in Table 3-2.

Table 3-2: Standard Underground Production Blast Designs

Parameter	Koala	Koala North
Hole diameter (mm (in.))	102 (4)	102 (4)
Drill pattern	ring dip – ~45° to 90° dump – 10°	ring dip – ~30° to 90° dump – 10°
Maximum ring depth (m)	26 to 27	26 to30
Toe burden (m)	3.0	3.0
Spacing (m)	3.0	3.0
Collar (m)	2.5/5.0	2.5/5.0
Blast size	1 ring	1 ring
Rock density kimberlite (tonne/m^3)	2.24	2.24
Rock density granite (tonne/m^3)	2.72	2.72
Explosive type	emulsion	emulsion
Explosive name	Dyno RU	Dyno RU
Sensitizing	microballoon	microballoon
Explosive density (g/cc)	1.20	1.20
Loading density (kg/m)	69	69
Powder factor (kg/m^3; kg/t)	0.91; 0.36	0.91; 0.36
Explosive length (m)	up to 25	up to 25
Priming	Spartan 90 (cast 90 g booster)	Spartan 90 (cast 90 g booster)
Stemming material	none	none
Detonator type	25/500 Snapdet [a]	25/500 Snapdet [a]
Delay between holes time (ms)	25	25
Typical sleep time (days)	up to 14	up to 14

[a] For blasts where complex timing or extra accuracy is warranted, Smart Shot detonators are used.

The ring blasts are loaded using a bulk emulsion loader. The blasthole loading, priming, and blasting procedures for ring blasts are as follows:

1) The depth of hole is measured.

2) The presence or absence of water is noted.

3) The holes are loaded depending on water conditions

   - For dry holes, the holes are pre-loaded as follows:

     a) The loading hose is pushed to the toe of the hole.

     b) The explosive is pumped to the toe of the hole while slowly retracting the hose, keeping the hose within the explosive.

     c) When the explosive reaches the designed length from the collar of the hole, pumping is stopped.

   - For wet to very wet holes, the holes are left open and are not pre-loaded. These holes are now loaded immediately prior to priming as follows:

     a) The loading hose is pushed to the toe of the hole.

     b) The explosive is pumped to the toe of the hole while slowly retracting the hose, keeping the hose within the explosive.

     c) When the explosive reaches the design length from the collar, pumping is stopped.

     d) A “birdie” plug is inserted after the priming to keep the emulsion from slumping from the hole.

4) Prior to blasting a ring, the pre-loaded holes are primed at a depth of approximately 8 m from the collar (collar primed) using the following procedure:

   a) The open length of hole to the emulsion is checked with a long fiberglass rod, and if the length is 8 m, the hole is primed. If the emulsion has slumped from the hole and the open length is more than 8 m, the loader returns and the hole is reloaded.

   b) The hole is primed by pushing the primer/detonator assembly into the emulsion with the fiberglass rod to a depth of 8 m from the collar or as close to that depth as possible. A 90 g booster is used for the Dyno RU emulsion.

   c) The rod is disconnected from the booster and withdrawn from the blasthole. Any emulsion that adheres to the rod is wiped from the rods. The product that is removed by wiping is discarded on the muck pile.

5) At shift change, the primed holes are tied-in. The hole-to-hole delays are provided by the 25 ms surface delay on the Snapdet.

6) One to two electric detonating caps are connected to the shock-tube of the Snapdet to start the initiation process. The electric cap(s) are attached to an electric lead wire that in turn connects to a blasting machine.

3.3.3 Underground Development Blasting Designs and Procedures

The standard blast designs for development blasting in kimberlite and granite at Koala and Koala North underground mines are shown in Table 3-3.

Table 3-3: Standard Underground Development Blast Designs

Parameter	Development
Hole diameter (mm (in.))	45 (1¾)
Drill pattern	varies between crews; no design standard; crews mark up and drill their own rounds
Round depth (m)	kimberlite – 2.0 granite – 4.0
Drift dimensions	varies depending on the opening (e.g., draw point, ramp); each type and location will have standard dimensions
Collar (m)	0.6 to 0.9
Rock density (tonne/m^3)	kimberlite – 2.24 granite – 2.72
Explosive type	wet holes – Unigel (32 x 400 mm) dry holes – ANFO in bad ground back holes – Dynosplit D (22 x 600 mm)
Priming	Unigel (32 x 400 mm)
Stemming material	none
Detonator type	Nonel long period (LP)

The development blasts are loaded using an ANFO (ammonium nitrate / fuel oil) loader vehicle. Typical loading, tie-in, and blasting procedures are as follows:

1) All development is loaded from the top down.
2) The depth of the hole is measured. Using the ANFO hose blow out the holes to remove water and cuttings.
3) The presence or absence of water is noted and the appropriate explosive is used depending on whether the conditions are wet or dry (Table 3-3).
4) The detonator/primer assembly is pushed to the toe of the blasthole. The holes are primed with Unigel, 32 by 400 mm cartridge explosive.
5) The holes are pneumatically loaded with explosive, leaving an open length of hole at the collar as specified in the design.
6) The Nonel long period (LP) caps are connected via the detonating cord.
7) An electric detonator is connected to the detonating cord. This in turn is connected to an electric wire.
8) At the time of the blast, the blasting machine is connected to the electric connecting wire. The blast is then initiated.

4.0 SOURCES OF NITRATE IN THE SITE DRAINAGE WATER

A major objective of any mining operation is to prevent wastage and spillage of explosive products. In addition to the direct cost of loss of product, all of the product that is brought to site that is not actually detonated or "consumed" by the blasting process, or that is not collected and disposed of in a controlled manner, is available for dissolution by drainage water. Spills can occur during the transportation of the explosive products to site, and during transportation and handling on the mine site.

A detailed assessment of spillages that might occur during transportation and handling of explosives on site was not carried out by Golder during the site visit. It is understood that the processes and procedures to deal with spillages and to dispose of undetonated waste explosives and products collected in a solid form in the operational areas have been well established and are effective. Spill kits and constructed catchment basins were observed while on site and are shown for the AN storage facility (Figure 4-1 a, b) and the emulsion plant (Figure 4-1 c, d).

Figure 4-1: Spill Kits and Catchment Basin Examples at the AN Storage Facility and Emulsion Plant

The largest potential sources of undetonated explosive product are in the open pit and underground mines as a result of handling and usage practices and/or malfunctions that occur after the blast is detonated. Any undetonated or unconsumed product is either dissolved or mucked as follows:

- dissolved by water that enters the open pit or underground mine and is pumped to surface and then to the water storage facility;
- mucked as solid material adhering to the waste rock and disposed of in the waste rock storage areas where it will likely be progressively dissolved by rainfall and runoff that seeps into the waste piles and is collected as surface drainage; or
- mucked as solid material adhering to the ore that is trucked to the processing plant where it is dissolved by the water used to process the kimberlite, and ultimately discharged to the tailings facility.

Further discussion on the availability of undetonated and unconsumed blasting products in and around the open pit and underground mining operations is presented below.

4.1.1 Open Pit Blasting

The following are the most significant potential sources of undetonated explosives from open pit blasting that might be available for dissolution by mine drainage water:

- spillage of emulsion during the movement of the loading hose between blastholes;
- dissolution of the emulsion during the loading of wet blastholes; and
- incomplete detonation of the emulsion during the blast.

The overall loading and operating practices observed during the site inspection carried out by Golder were good, and very little spillage was observed. An example of a spillage mitigation technique was the installation of a bucket to catch emulsion trapped in the loading hose while the emulsion truck is moving (see Figure 4-2).

Figure 4-2: Bucket Used to Catch any Emulsion that May Drip from the Hose.

It was noted during the 2008 review that sleep times at Fox Pit were up to two weeks and the recommendation was to reduce these to less than one week. Sleep times for all patterns, both in Fox and Misery Pits, are now generally less than one week. Patterns that have standing water are typically loaded and shot in the same day.

There are a number of causes of blast malfunctions and incomplete detonation of explosives in open pit mines. They are often indicated by poor muck profile, poor fragmentation, decreased dig rate, and/or orange fumes that may be visible immediately after the blast. Orange blast fumes are often observed after blasts, indicating some degree of blasting inefficiency, possibly as a result of water/mud in the blastholes, discontinuous explosive columns, overfuelling of holes, and/or extended sleep times. It is understood that these fumes are observed less frequently after blasts in waste rock.

In order to clean out remaining emulsion from the various components in the bulk explosives truck (e.g., the hopper, the hose), drivers will sometimes overfuel the last hole being loaded. Cleaning the components prior to driving back to the emulsion plant is necessary to ensure no emulsion has time to gas within the hopper, auger, or hoses. If the emulsion is not cleared, it could have time to gas and could clog the system. This overfuelling, however, can contribute to the reduction in detonation performance and to various fumes being produced.

Incomplete detonation may also be occurring because of misfires, which in turn could be caused by improper blast timing. Delays between blastholes and rows of holes are used to enhance fragmentation between adjacent holes, reduce ground vibration, and to provide a means of directing the heave and material displacement. However, setting delay times that are excessively long or not having a large enough buffer zone between detonating holes and any hole that has yet to be initiated can cause misfires. Golder reviewed some sample blast tie-in maps and videos provided by DDEC. Figure 4-3 shows a blast tie-in map from Misery Pit (M400-49). The figure shows the tie-in map used to tie in the blast. Because the time between rows is 230 ms and the down the hole delay for each hole is 500 ms, the first hole (E01) fires before most of the pattern has even been initiated. In fact, hole C02 has not even been initiated before the first hole is already firing. See Appendix B for more details on the blast analysis.

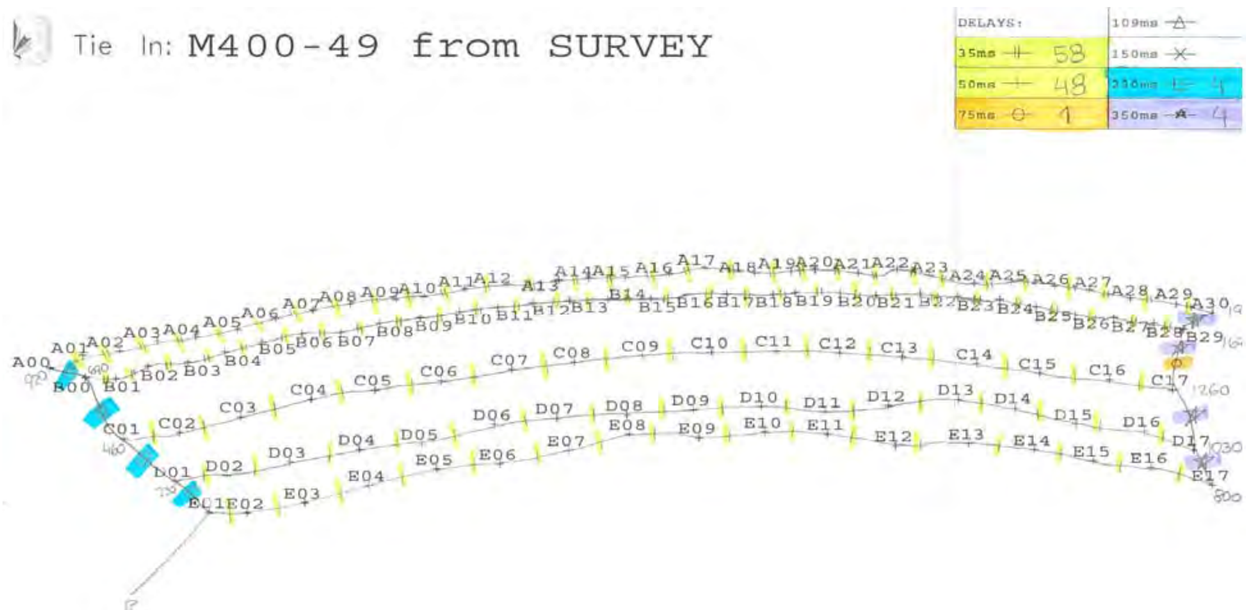

Figure 4-3: Analyzed Blast

4.1.2 Underground Production Blasting

As noted in Section 3.3.1, no loading of production blasts occurred at Koala North or Koala Mines during Golder's site visit. This section therefore is based on written procedures for the mine as well as discussion with Ekati underground staff. The potential sources of undetonated explosives available for dissolution by mine drainage water from underground production blasting are discussed below. The following represent the major potential sources of nitrate from underground production blasting that will likely be dissolved by mine drainage water:

- Incomplete detonation of explosives in pre-loaded blastholes may occur as a result of dislocation and/or disruption of the holes by preceding choked blasts. This situation is most likely to occur at Koala Mine because the blasts are choked. The choked nature of the blast results in excessive vibrations and high gas pressures being generated. These conditions then cause backbreak damage. If such backbreak damage extends to the pre-loaded holes, there may be dislocation of the explosive column in one or more holes.

There may also be disruption of the explosives if explosive gases penetrate along discontinuities into these pre-loaded columns. Such "shoot-throughs" from hot gases and the associated shock energy may disrupt pre-loaded charges and cause blasting malfunctions.

- Incomplete detonation of the explosives may occur in long blastholes (up to 30 m long) that are single-primed at the collar. This may result in inefficient or ineffective detonations within the long column lengths. The explosive manufacturer of Dyno RU recommends that this explosive always be double-primed when bulk explosive columns exceed 6 m (20 ft.) long, and that one primer should be positioned near the collar and one near the far end of the hole.
- Slumping of the emulsion may occur in the pre-loaded blastholes prior to priming. This creates voids or air gaps along the explosive column, and the column may not detonate along its entire length. Gaps as small as a few centimetres can disrupt the column detonation (known as explosive gap sensitivity). Any undetonated explosive will then fall into the muckpile and eventually be dissolved by mine drainage water or process water.
- Emulsion may be removed or dislodged from the pre-loaded blastholes. This most often occurs in wet holes. Golder understands this is less common than at the time of the 2008 audit. Since then, wet or very wet holes are left unloaded until the day of the blast. Dry holes which are pre-loaded tend to be less likely to have emulsion removed or dislodged.
- Poor blasting performance and incomplete detonation as a result of blasthole drilling deviation, particularly in the 100 mm (4 in.) diameter blastholes drilled up to about 30 m long.
  - If there is significant blasthole deviation, one of two situations may occur:
    - Explosive in holes that are widely spaced cannot move the burden effectively, and this could lead to damage to the rock mass and pre-loaded charges.
    - The explosive in holes that are close together could become dead-pressed and desensitized prior to initiation. This is due to the shock energy from one charge impacting a neighbouring hole and damaging the sensitizing microballoons, causing the detonation to fail.
  - Golder's previous review in 2008 recommended that tube rods could be used to minimize hole deviation. These larger, thicker rods fill more of the hole during drilling and allow less flex in the drill string. Longhole drills are now fitted with tube steel rods and blasthole deviation is likely to have been reduced.

4.1.3 Underground Development Blasting

The potential sources of undetonated explosives available for dissolution by mine drainage water from underground production blasting were identified during the underground inspection and are discussed below. Figure 4-4a shows the loading of a development blast in Koala Mine.

Two primary potential sources were observed. One was a minor amount of ANFO spillage resulting from blowback during the pneumatic loading of blastholes and moving the hose from hole to hole as shown in Figure 4-4b. Another was direct loss of nitrates by means of dissolving in water as shown in Figure 4-3b.

ANFO, which is the primary explosive for development blasts, has no water resistance and will dissolve readily in water. ANFO is used in all dry development blasts except for the lifter holes, where water typically pools at the advancing face. Golder's previous review in 2008 recommended that all wet holes be loaded with water resistant explosive. A cartridge water-resistant explosive (Dyno Unigel) is now used in the lifter holes and in any areas where there are wet holes. The current procedure is likely to have significantly reduced the amount of AN entering the water system through dissolution of ANFO.

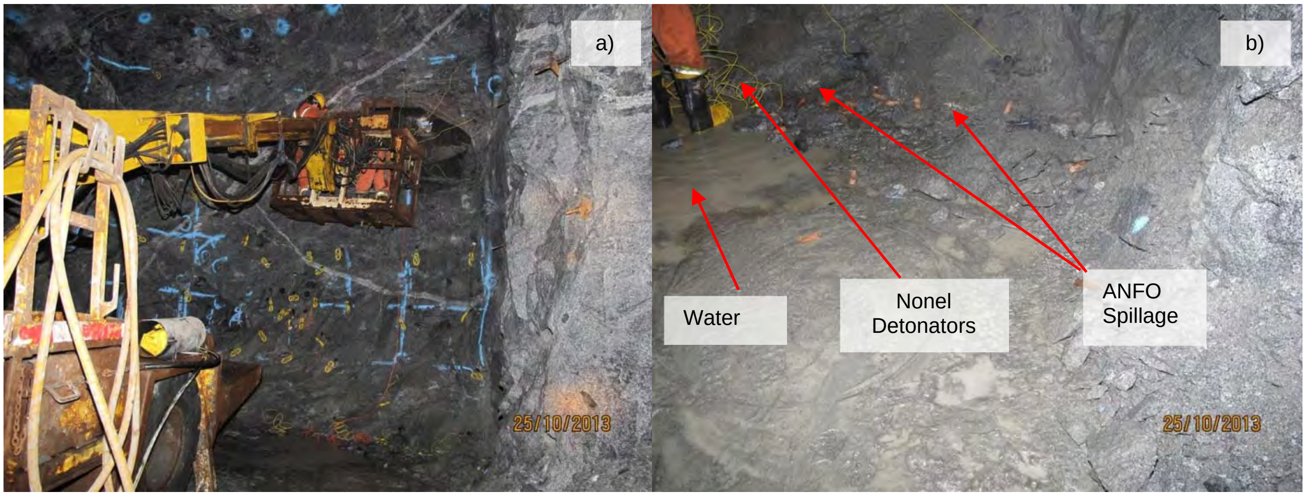

Figure 4-4: Development Blast Loading

5.0 MINIMIZING THE AVAILABILITY OF EXPLOSIVE PRODUCTS FOR DISSOLUTION

Surface water is currently either pumped along pipes or pumped into trucks and hauled to the LLCF from three main areas:

1) Fox Pit Area.

2) Pigeon Pit.

3) Main Operations Area.

Once the water enters the LLCF, it can slowly move into Cell D. From Cell D it can be pumped into Cell E. Likewise from Cell E it can be pumped and released into Leslie Lake (see Figure 5-1).

The water from the underground mines is pumped into Beartooth pit and contained (see Figure 5-1).

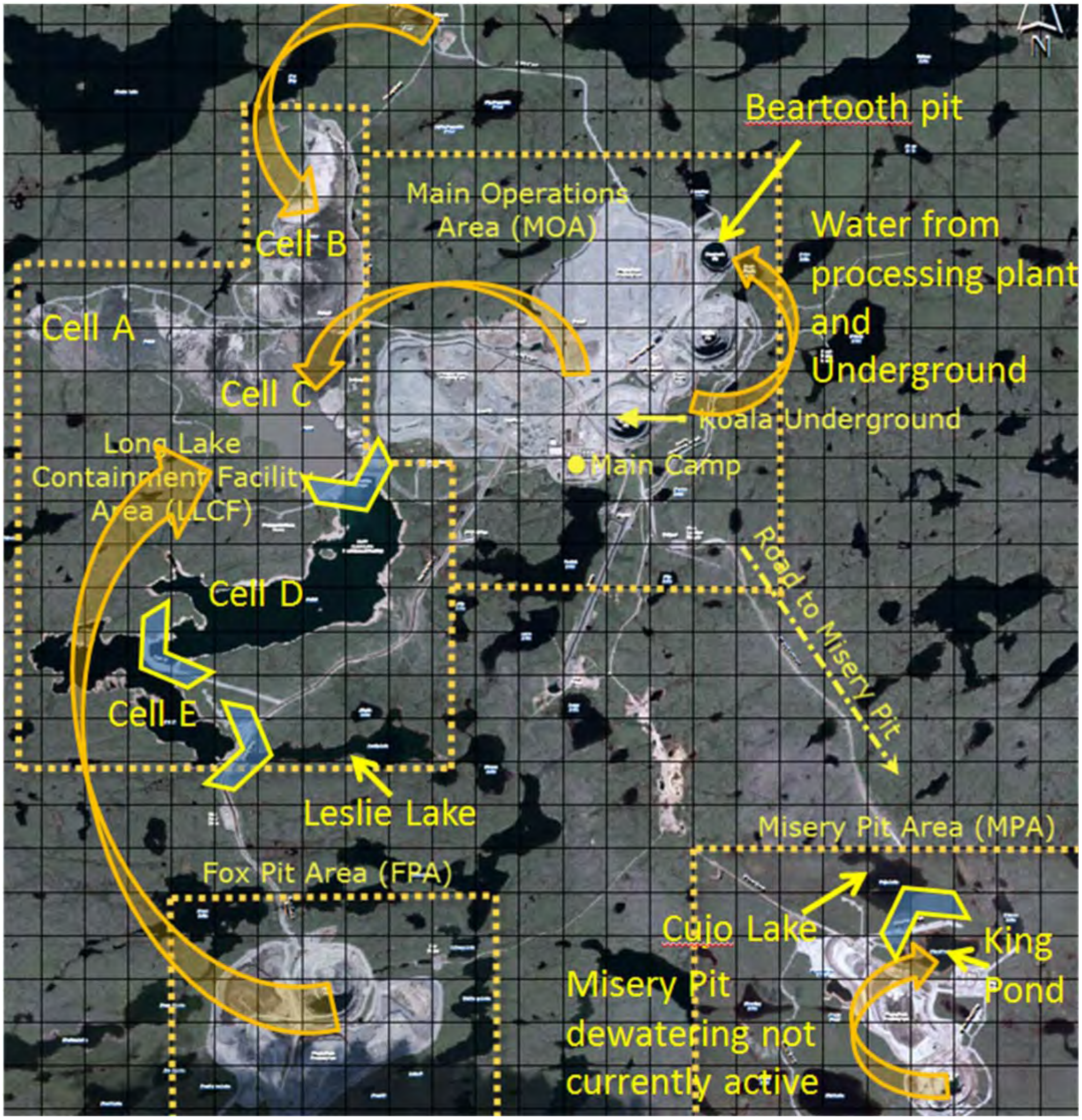

Figure 5-1: Mine Water Flow Diagram With Yellow And Blue Flow Directions (modified from DDEC 2013)

Water from Misery Pit is not currently being pumped into King Pond. Waste rock from Misery Pit is being dumped into Desperation Pond. Water from Desperation Pond is periodically pumped into Carrie Pond (see Figure 5-1).

The most significant potential improvement in minimizing the availability of explosive product available for dissolution by the mine drainage water can be achieved by improving handling and usage practices in the open pit and underground mines and by minimizing malfunctions and misfires.

5.1 Improved Handling and Usage

The first priority to improving explosive handling and usage is to promote awareness with the employees who work with and around explosives. Employees should understand and appreciate that spillage of explosives and eliminating malfunctions and misfires are very important site issues to control the contamination of the site drainage water.

An educational program could be implemented at the mine to increase the general awareness of nitrate and explosive issues related to mining at Ekati. A program similar to what has been implemented to manage waste disposal could be adopted. This educational campaign could be designed to inform the employees and contractors of the following:

- the presence of explosive material, what it is, and where it originates;
- the significance of explosive loss and obtaining a water license in order to operate;
- the causes of loss;
- preventative measures; and
- reporting and cleanup requirements.

5.2 Improved Blasting to Minimize Malfunctions and Misfires

5.2.1 Open Pits

The key issues associated with open pit blasting appear to be potentially overloading holes and misfires. From the blast observed at Fox Pit, it appears the pattern may have been overloaded, potentially due to additional emulsion being added to holes that have fissures or have widened due to caving. An additional 25 to 30 kg of emulsion was being added to each hole to account for the estimated loss.

It is unknown at this stage to what extent incomplete detonations currently occur in Misery or Fox Pits. It is understood that they are not occurring to such an extent that breakage of the rock is being seriously affected. Incomplete detonation may be occurring to a degree that undetonated explosives are available for direct dissolution by mine water in the pit, or for delayed dissolution in the waste rock piles or the ore processing plant. Also, the observation of colourful fumes in numerous blast videos viewed suggests that incomplete detonation is occurring. Whether the incomplete detonation is happening because of voids in the rock that are less than the critical diameter of the explosive or because of some other factor such as overfuelling or contamination, ways to minimize the risk of incomplete detonation should be considered.

To reduce the possibility of misfires occurring due to improper tie-in designs, a review of the blasting standards should be undertaken by a qualified blast consultant. Blasting software programs such as JKSimblast can be used to assist in designing blasts. Golder used this software to simulate a Misery Pit blast (M400-49) and identified an issue with the timing. Appendix B illustrates how such blasting software can be used as a tool to assist blasting engineers to develop a tie-in map that allows enough time between holes and rows to achieve the desired blast profile while ensuring most, if not all, of the blast surface detonators have initiated prior to the first hole firing.

Near-field blast vibration monitoring (monitoring ground vibrations from blasting within 30 m of the blasts) is recommended to provide a means to compare blast design with actual blast performance by analyzing the diagnostic vibration trace in millisecond detail. Typically, holes that misfire, and/or that generate distorted or non-classical vibration wave forms or wave amplitudes that are too high or too low, can be identified from analyses of monitored vibration traces. This information can then be used to understand why blasting problems are being experienced and the design changes that may be required.

VOD (velocity of detonation) tests could be performed on selected blastholes where water may be an issue. The VOD test will give an idea whether or not water is negatively affecting the performance of the emulsion.

A borehole camera survey is recommended to provide information regarding the condition of typical boreholes. Irregularities such as voids, water inflow, and dislocations should provide valuable information and insight regarding probable causes for poor blast performance.

5.2.2 Underground Production Blasts

While choke blasting is considered to be a significant contributing cause to nitrate loss, it is integral to the sub-level caving mining method. There is no obvious modification to the method that will alleviate all or most of the problems associated with this type of blasting with little to no burden relief.

Decreasing the burden has been found to be beneficial in other mines and should be investigated further. A 3 m burden is at the upper limit of what is typically used in sub-level cave mining. However, decreasing the burden also makes it more difficult and potentially more hazardous to prime the next ring of holes near the brow. It may also result in the previously blasted kimberlite being compacted more, which further impedes the flow of muck to the drawpoint. A more detailed review of the conditions at the brow should be undertaken to assess if there is potential to reduce the burden, perhaps in combination with improved support of the back of the drawpoint and modified priming procedures.

Other ways of improving blasting could be considered and are outlined below. However, due to the limited remaining mine life of the underground operations, economics must be considered.

Loading Methodology

Within the confines of the existing system (i.e., always having two rows of holes pre-loaded), a method to load a second primer near the toe of the holes should be investigated. Ensuring complete detonation of the entire charge column in each hole could significantly improve blasting performance. A potential approach that should be investigated is to develop a technique to push a second primer further up the hole, although this will likely be difficult to achieve due to the viscosity of the emulsion and the need to work overhand. Another option is to install a high-grain detonating cord along the hole that can serve as a continuous booster, although the effectiveness and safety of this, and the potential to meet regulatory approval, needs to be investigated.

Consideration could also be given to attempting to intercept groundwater flows, particularly the high flows in some locations at the granite/kimberlite contact, prior to loading and before the water flows into the blastholes. This is already attempted periodically at particularly problematic locations, but could be extended when very wet conditions are anticipated.

Blast Diagnostics

Near-field blast vibration monitoring (monitoring ground vibrations from blasting within 30 m of the blasts) is recommended to provide a means to compare blast design with actual blast performance by analyzing the diagnostic vibration trace in millisecond detail. Typically, holes that misfire, and/or that generate distorted or non-classical vibration wave forms or wave amplitudes that are too high or too low, can be identified from analyses of monitored vibration traces. This information can then be used to understand why blasting problems are being experienced, and the design changes that may be required.

Borehole camera surveying is recommended to provide information regarding the condition of the boreholes. Irregularities such as voids, water inflow, rubble zones, collapsed zones, and dislocations should provide valuable information and insight regarding probable causes for poor blast performance.

VOD (velocity of detonation) tests could be performed on selected blastholes where water may be an issue. The VOD test will give an idea whether or not water is negatively affecting the performance of the emulsion.

Improved Control of Groundwater Inflows

A study should be undertaken to assess possible ways of controlling the groundwater inflows that are very prevalent on the hanging wall side of the deposit. The inflows are relatively large, and the water is flowing into the blastholes and dissolving or removing some of the explosive. Techniques need to be developed to reduce, intercept, or redirect the flows in the production areas. The aim would be to control the water that is currently entering the mine along and adjacent to the hanging wall contact ahead of the production. This will likely increase the probability of the emulsion remaining in the blastholes and being detonated as planned without being dissolved.

5.2.3 Underground Development Blasts

At the time of Golder's 2008 audit, only wet lifter holes in the development blasts were being loaded with water-resistant explosives. All other blastholes were loaded with ANFO, including those in wet areas. However, the policy has changed, and ANFO is only loaded in dry holes and where water will not flow back into loaded holes or pool at the face. Water-resistant holes are loaded with water-resistant explosives (Unigel).

In Golder's 2008 audit, a significant amount of ANFO spillage was observed as the result of blowback at the ANFO loader. Golder understands that extra attention was paid to this in order to reduce the amount of spillage at the face. The primary objective was to minimize the amount of explosive available to be dissolved by the mine water. During Golder's recent site visit, very little ANFO spillage was observed at the site of the development blast in the Koala Mine.

In general, the development blasts were carried out well, with attention paid to minimizing the amount of explosives that would dissolve at site or remain in the muckpile for eventual dissolution in the waste pile or at the processing facility.

6.0 CONCLUSIONS

During the Ekati review, Golder was able to spend time with both open pit and underground crews and observe how loading and handling of the explosives is conducted. Many positive practices were observed to contain, handle, use and dispose of explosives. It is noted that during the site review many of the recommendations made in 2008 to mitigate AN loss to mine water have been implemented by Ekati and these are highlighted below:

- In open pit blasts, sleep times have been reduced to less than one week from up to two weeks in 2008.
- In underground development blasts there were two significant improvements since our review in 2008 that would lead to a reduced AN loss to the environment:
  - Very little ANFO spillage was observed through blowback at the collar. Observations made during the 2008 review indicated that there was potential to lose an estimated 0.5 kg/hole over approximately 50 holes (i.e., 25 kg of ANFO with every round). Since any ANFO that spills onto the wet floor of the drift will be dissolved by this water, the amount available to be dissolved has significantly improved.
  - All wet blastholes are now loaded with water resistant explosives. During the 2008 review, ANFO was loaded in all development blastholes, except for the lifter holes. This change in practice means that significantly less explosives will dissolve and release nitrates into the water.
- In the underground production blasts, there were two significant improvements since 2008 that would lead to a reduced AN loss to the environment:
  - The slumping of explosives from loaded blastholes has been reduced by the practice of delaying the loading of wet holes until just before the blast. This reduces the amount of explosives dislodged from the blastholes as well as the potential for partially detonated holes caused by a gap in the explosive column where the explosive slumped.
  - The switch to tube steel in the drill rods has reduced drill deviation of long blastholes. This will improve the blast performance by reducing the potential for holes to deviate too close to or too far from each other.

From the assessment, Golder concludes that the most significant potential improvement in minimizing the availability of explosive product available for dissolution by the mine drainage water can be realized by continuing to improve the usage practices in the open pits. This can potentially be achieved by minimizing blasthole malfunctions and misfires.

7.0 RECOMMENDATIONS

Golder recommends that the following tasks and practices be considered for incorporation into an implementation plan:

- Continue mitigation practices, such as:
  - managing the emulsion plant and AN storage facility with controls in place to capture accidental spills, and
  - monitoring the nitrate levels of the LLCF, Beartooth, and Misery holding ponds.
- Consider the following practices:
  - bottom loading wet holes, and
  - using “birdie” plugs at the collar in wet underground production holes to aid in explosive retention.
- Consider an education program to increase the general awareness of nitrate and explosive loss to the environment and that highlights the significance of obtaining a water license in order to operate.
- Continue to conduct operational reviews with specific focus on ensuring that:
  - plans are being followed;
  - drills are not over drilling holes;
  - blastholes are not overloaded with emulsion;
  - the engineering team is informed of the condition of blast patterns prior to a tie-in map being created;
  - tie-in maps are checked;
  - patterns are checked once they have been tied in;
  - blast results are checked;
  - shovel operators and pit foremen are communicated with to confirm that blasted material is in the correct muck profile for the loading unit and that the designed fragmentation is being achieved, and
  - any misfires or excess emulsion remaining in the pit after a blast are reported to the environmental department.
- Consider near-field blast vibration monitoring to provide a means to compare blast designs with actual blast performance by diagnosing vibration traces in millisecond detail.
- If vibration monitoring reveals potential issues with certain holes in a blast, perform VOD measurements to ensure water infiltration, over-fuelling or shoot-throughs are not degrading the explosive performance and resulting in undetonated product.
- Further blast diagnostics could employ borehole camera surveys in selected open pit production blasts to provide insight on the condition of the blastholes and how hole irregularities such as large cracks or cavities may be affecting blast loading and performance..

8.0 CLOSURE

We trust that the information contained in this report meets your requirements. Please contact the undersigned if any additional information is required or if there are any questions concerning this proposal.

GOLDER ASSOCIATES LTD.

Danny Tolmer, P.Eng
Senior Mining Engineer

Dave Sprott, P.Eng.
Principal, Senior Mining Engineer

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APPENDIX A

Explosive Manufacturer Fact Sheets

Technical Data Sheet

Detagel™ Presplit

Description

Detagel™ Presplit is a watergel explosive produced in various diameters and in continuous lengths. *Detagel™ Presplit* contains a continuous length of detonating cord running through the entire length of the presplit package. This enables the user to use any length desired and to tie-in very quickly to either detonators or other detonating cord.

Application

Detagel™ Presplit is the ideal solution for construction cuts, high-walls, bank retention and slopes. *Detagel™ Presplit* is also approved by the United States Forest Service (USFS) for fireline usage.

Key Benefits

- *Detagel™ Presplit* is one continuous line of detonating cord throughout the entire length which ensures steady velocity through the shear line, producing a straight wall cut to as high a degree as allowed by geology.
- The all-inclusive cost allows ease of job estimation. There is no need to add cord, tape, couplers, makeup labor or additional accessories. Each case contains splicing ties for attaching string loads.
- *Detagel™ Presplit* can easily be loaded by one person, which will may reduce overall labor costs per job.
- *Detagel™ Presplit* is formulated for Fume Class 1.

Technical Properties

Detagel™ Presplit		
Cartridge Density		1.20
Velocity of Detonation[1]		7,010 m/s 23,000 ft/s
Water Resistance		Excellent
Fume Class		1
Relative Effective Energy (REE) [2]	Relative Weight Strength (RWS)	103
	Relative Bulk Strength (RBS)	154

Packaging

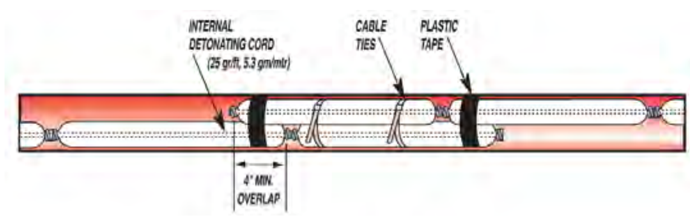
Detagel™ Presplit is one continuous line of High Explosive Hexamine Nitrate Slurry per case. Each case also contains splicing ties for attaching string loads. All *Detagel™ Presplit* products are packaged in high strength, tear resistant film cartridges that are packed into 25 kg (55 lb) fiberboard cartons. *Detagel™ Presplit* is available in the following sizes:

Size (mm)	Size (in.)	# of links per line	Film Type
22 x 400	7/8 x 16	1 @ 129	Valeron
32 x 400	1 ¼ x 16	1 @ 63	Valeron
40 x 400	1 ½ x 16	1 @ 42	Valeron
45 x 400	1 ¾ x 16	1 @ 34	Valeron
50 x 400	2 x 16	1 @ 24	Valeron

Recommendations for Use

Splicing

When it becomes necessary to connect two lengths of presplit explosive together, use the plastic cable ties provided in each case. The two splicing cartridges **overlap the respective** adjoining cartridges by about 4 inches (100 mm). The loose ends of the two splicing cartridges are secured with plastic tape to keep them from springing outward at an angle.



Detagel™ Presplit

Priming and Initiation

There is a continuous length of detonating cord running through *Detagel™ Presplit,* no additional products are required.

Sleep Time Within Blastholes

The sleep time in a blasthole is influenced by the extent of damage to the packaging and by the nature of any water present.

Storage And Handling

Product Classification

Authorized Names:	*Detagel™ Presplit*
Proper Shipping Name:	Explosive, blasting, type E
Classification:	1.1D
UN No:	0241
Packing Group:	II
EX Number:	2002040230

All regulations pertaining to the handling and use of such explosives apply.

Storage

Store *Detagel™ Presplit* in a suitably licensed magazine for Class 1.1D explosives. The cases should be stacked in the manner designated on the case. *Detagel™ Presplit* has a **shelf life** of two years from date of manufacture when stored properly in an approved, well-ventilated high explosives magazine.

Detagel™ Presplit is best stored at temperatures above -15°C (+5°F). This is especially important in cold weather "load and shoot" worksites where there is insufficient in-hole warm-up time.

For recommended good practices in transporting, storing, handling, and using this product, refer to the "Always and Never" booklet packed inside each carton.

Transport

Detagel™ Presplit should be transported between -40°C (-40°F) and +40°C (104°F).

Disposal

Disposal of explosives materials can be hazardous. Methods for safe disposal of explosives may vary depending on the user's situation. Please contact an SEC Technical Representative for information on safe practices.

Safety

The post detonation fume characteristics of *Detagel™ Presplit* make the product suitable for both underground and surface blasting applications. Users must ensure that adequate ventilation is provided prior to re-entry into the blast area.

Detagel™ Presplit can be initiated by extremes of shock, friction or mechanical impact. As with all explosives, *Detagel™ Presplit* must be handled and stored with care and must be kept clear of flame and excessive heat.

Trademarks

Detagel™ is a trademark of Hallowell Manufacturing LLC. 3600 NW 74th St, Columbus, KS 66725-0348.

Disclaimer

The information contained herein is based on experience and is believed to be accurate and up to date as at the date of its preparation. However, uses and conditions of use are not within the manufacturer's control and users should determine the suitability of such products and methods of use for their purposes. Neither the manufacturer nor the seller makes any warranty of any kind, express or implied, statutory or otherwise, except that the products described herein shall conform to the manufacturer's or seller's specifications. The manufacturer and the seller expressly disclaim all other warranties, INCLUDING, WITHOUT LIMITATION, WARRANTIES CONCERNING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Under no circumstances shall the manufacturer or the seller be liable for indirect, special, consequential, or incidental damages without limitation, damages for lost or anticipated profits. Explosives based on Ammonium Nitrate such as *Detagel™ Presplit* may react with pyritic materials in the ground and create potentially hazardous situations. Hallowell Manufacturing LLC. accepts no responsibility for any loss or liability arising from use of the product in ground containing pyritic or other reactive material.

Hallowell Manufacturing LLC.
3600 NW 74th Street
Columbus, KS 66725-0348

Detagel™ Presplit

Emergency Contact Telephone Numbers

For chemical emergencies (24 hour) involving transportation, spill, leak, release, fire or accidents:

Canada: Hallowell Manufacturing LLC. Canada emergency response **1-877-561-3636**

USA: Chemtrec **1-800- 424-9300**

For lost, stolen or misplaced explosives:

USA: BATFE **1-800-800-3855**. Form ATF F5400.0 must be completed and local authorities (state / municipal police, etc) must be advised.

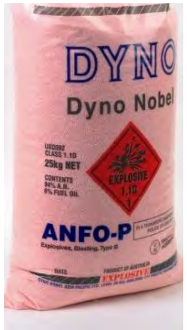
Notes

1. Confined at 5°C (41°F). In the borehole the detonation travels from the point of initiation through the continuous presplit column. The entire borehole detonates from top to bottom virtually instantaneously. The effective velocity of the *Detagel™ Presplit* acting to develop the presplit shear line is approximately 14,000 fps (4,267 mps). VOD will depend on application including explosive density, blasthole diameter and degree of confinement. The VOD range is based on minimum unconfined and calculated ideal.
2. The "Relative Effective Energy" (REE) of an explosive is the energy calculated to be available to do effective blasting work. Energy values are based on standard ANFO with a density of 0.84 g/cc and a cut-off pressure of 100Mpa. Other computer codes may give different values.

ANFO

Prilled Ammonium Nitrate

Technical Information

Description

ANFO is a nominal 94:6 (wt%) blend of porous ammonium nitrate prill (Detaprill®) and fuel oil. It is a dry, free flowing bulk explosive; formulated to ensure the appropriate oxygen balance providing optimal energy and sensitivity.

Application

ANFO has zero water resistance and has a wide variety of applications in dry hole blasting conditions.
It is one of the most cost efficient blasting agents available for use in small, medium or large diameter applications. When pneumatically loaded; ANFO may also be used effectively in underground development and tunnelling applications.

Advantages

ANFO provides excellent heave energy compared with explosives that contain a high emulsion content.
The low bulk density of ANFO provides excellent charge distribution throughout the blasthole.

Properties

	Poured	Blow Loaded
Density (g/cm^3) [1]	0.82	0.95
Min Diameter (mm)	75	25
Energy (MJ/kg) [2]	3.7	3.7
Typical VOD (m/s) [3]	2500 – 4500	2000 – 4000
RWS [4]	100	100
RBS [5]	100	116

NOTES:

1. *Values* are indicative average densities only, determined under laboratory conditions by Dyno Nobel technical personnel at Dyno Nobel's Mt Thorley Technical Centre. Observed densities may differ or vary under field conditions. Nominal in hole density only.
2. All Dyno Nobel energy values are calculated using a proprietary Dyno Nobel thermodynamic code – Prodet. Other programs may give different values.
3. These results represent a range of VODs collected from numerous Dyno Nobel blast sites throughout the Asia Pacific region over a period of time. The velocity of detonation actually recorded in use is dependent upon many factors, including: the initiation system used, the product density, blasthole diameter and ground confinement. The values stated are typical of those recorded for the product in various hole diameters, densities and ground types, and may not be achievable under all circumstances.
4. Relative Weight Strength (RWS) and Relative Bulk Strength (RBS) are determined using a density of 0.82g/cm³ and an energy of 3.7MJ/kg for ANFO.
5. RBS depends on the final density of the product at the time of loading.

ANFO

Prilled Ammonium Nitrate

Technical Information

Recommendations

Priming Requirements – It is recommended that ANFO should be primed with a cast booster for all hole diameters. Depending on the application, ANFO may be primed with a suitable diameter detonator sensitive cartridge explosive (Powermite® Pro). For specific priming requirements, please contact your Dyno Nobel representative. Additional boosters should be used when the column height exceeds 10 metres or where there is risk of column disruption.

Maximum Hole Depth – ANFO can be detonated successfully in depths up to 75m.

Shelf Life – ANFO has a maximum shelf life of six (6) months dependent on temperature and humidity conditions. Storage in a high humidity and high temperature environment will accelerate product breakdown and should be avoided. Signs of ANFO degradation are hardening or caking which can lead to difficulty in loading and as a result, may lead to poor blasting performance.

Sleep Time – Under normal conditions in dry and stemmed blast holes, ANFO may be slept for periods up to six (6) weeks. The sleep time may be limited to the recommended sleep time of the initiating system. The presence of water will dramatically reduce the sleep time. For applications where unusual or specific conditions exist please consult your local Dyno Nobel representative for advice.

Reactive Ground Conditions – ANFO is not designed for use in conditions where reactive sulphides are present.

Ground Temperature – ANFO is suitable for use in ground with a temperature of 0°C to a maximum of 55°C. For applications in ground with temperatures outside this range, contact your Dyno Nobel representative.

Packaging

ANFO is available in bulk through specialised truck delivery systems.

Dangerous Goods Classification

Product Name:	ANFO
Correct Shipping Name:	Explosive, Blasting, Type E
UN Number:	0082
DG Class:	1.1D

Safe handling, transportation and storage

First Aid – You can find detailed first aid information on the relevant Dyno Nobel Material Safety Data Sheet. Refer to www.dynonobel.com for more information if required.

Safety - All explosives are classified as dangerous goods and can cause personal injury and damage to property if used incorrectly.

Transportation and Storage - All explosives must be handled, transported and stored in accordance with all relevant regulations. Stock should be rotated such that older product is used first.

Remember, the explosive products discussed in this document should only be handled by persons with the appropriate technical skills, training and licences.
While Dyno Nobel has made every effort to ensure the information in this document is correct, every user is responsible for understanding the safe and correct use of the products. If you need specific technical advice or have any questions, you should contact your Dyno Nobel representative.

Dyno Nobel Asia Pacific Pty Limited (ACN 003 269 010) is a subsidiary of Incitec Pivot Limited (ACN 004 080 264) Level 8, 28 Freshwater Place, Southbank Vic 3006.

March 2012
VERSION 6

DYNO GOLD® LITE

Technical Information

BULK EXPLOSIVES

Unsensitized Gassable Bulk Emulsion Matrix

Product Description

DYNO GOLD LITE is an unsensitized repumpable bulk emulsion matrix specifically formulated to be sensitized during loading at the borehole using Dyno Nobel chemical gassing technology. DYNO GOLD LITE, Dyno Nobel's high performance, booster sensitive emulsion explosives or emulsion/ANFO blend explosives containing up to 50% DYNO GOLD LITE, can be used in 65 mm (2-1/2 in) and larger boreholes depending upon the amount of ANFO used in the emulsion/ANFO blend. The amount of chemical gassing and the percentage of emulsion in DYNO GOLD LITE emulsion explosive and emulsion/ ANFO explosive blends can vary (between 1.10 and 1.30 g/cc and 50%-100% emulsion) to deliver explosive performance to best match specific blasting requirements. Refer to the data table at right for the physical properties and loading methods for some typical DYNO GOLD LITE emulsion/ANFO explosive blends.

Application Recommendations

- DYNO GOLD LITE emulsion matrix is not detonable as shipped and must be sensitized with Dyno Nobel chemical gassing technology for use.
- Only ANFO manufactured with emulsion compatible AN prills is recommended for use in DYNO GOLD LITE emulsion/ANFO explosive blends.

Properties

MSDS #1052

Percent Emulsion		100	70	60	50
Density[a]	(g/cc) Avg	1.20	1.20	1.20	1.25
Energy[b]	(cal/g)	680	740	760	780
	(cal/cc)	815	890	910	975
Relative Weight Strength[b]		0.77	0.84	0.86	0.89
Relative Bulk Strength[b,c]		1.13	1.23	1.26	1.36
Velocity[d]	(m/sec)	4,800	4,500	4,300	4,300
	(ft/sec)	15,700	14,800	14,100	14,000
Detonation Pressure[d]	(Kbars)	69	61	55	47
Gas Volume[b]	(moles/kg)	45.4	44.8	44.6	44.4
Water Resistance		Excellent	Excellent	Excellent	Good
Minimum Diameter	(mm)	65	75	100	150
	(inches)	2.5	3	4	6
Loading Method		Pump	Pump	Pump	Auger
Critical Density	(g/cc)	1.30	1.30	1.30	1.30

[a] Borehole density can be varied from about 1.10 to 1.30 g/cc to match applications.
[b] All Dyno Nobel Inc. energy and gas volume values are calculated using PRODET™, a computer code developed by Dyno Nobel Inc. for its exclusive use. Other computer codes may give different values.
[c] ANFO = 1.00 @ 0.82 g/cc
[d] Unconfined @ 100mm (4 in) diameter, average density; 150mm (6 in) for 50/50 blend.

Hazardous Shipping Description

Blasting agent, 1.5D UN0332 II
Explosives Blasting Type E

1.5 D 1

See Product Disclaimer on page 2

DYNO Dyno Nobel

Groundbreaking Performance

DYNO GOLD® LITE

Technical Information

Application Recommendations (continued)

- The minimum cast booster weight recommended for use as a primer for DYNO GOLD LITE emulsion explosives or emulsion/ANFO explosive blends is 340 g (12 oz).
- **ALWAYS** double prime when bulk explosive columns exceed 6 m (20 ft). One primer should be positioned near the bottom of the hole and the second nearer the top of the explosive column.
- **NEVER** use detonating cord in borehole diameters less than 159 mm (6¼ in).
- **NEVER** use DYNO GOLD LITE in boreholes deeper than 30 m (100 ft). Consult your Dyno Nobel representative for an alternative product.
- **ALWAYS** use average borehole loading density for blast design and to estimate explosive requirements, although chemically gassed emulsion explosives provide a unique loading density gradient in the borehole with highest density at the bottom and lowest density at the top. Consult the density/depth curves to determine average borehole density.
- **NEVER** load augered DYNO GOLD LITE emulsion/ANFO blend with 50% ANFO into boreholes where standing water is present! Augered DYNO GOLD LITE emulsion/ANFO explosive blend with 50% ANFO is for use in dry or dewatered boreholes only. To produce consistently good results, wet boreholes must be dewatered. After dewatering, check the borehole to ensure there is no re-entering or residual water. As soon as the borehole is confirmed dry, immediately prime and load. When standing water remains in a borehole, use only pumped DYNO GOLD LITE emulsion ANFO blends with 0 to 40% ANFO.
- Borehole sleep time is two (2) weeks. Where geology is wet and extended sleep times are anticipated, it is best practice to use pumped DYNO GOLD LITE emulsion/ANFO blends with 0 to 40% ANFO. Where product will sleep overnight and less water resistant blends are being considered, consult your Dyno Nobel representative for loading recommendations.
- **ALWAYS** use delivery equipment specifically designed or approved by Dyno Nobel. DYNO GOLD LITE emulsion explosives or DYNO GOLD LITE emulsion/ANFO explosive blends require specialized delivery equipment which must be operated only by personnel who have received Dyno Nobel chemical gassing training.
- DYNO GOLD LITE emulsion explosive or DYNO GOLD LITE emulsion ANFO explosive blend delivery equipment should be calibrated periodically to ensure blend quality and explosive performance. Ensure safety systems are operational before each use.
- Routinely monitor the DYNO GOLD C LITE emulsion explosive and DYNO GOLD LITE emulsion/ANFO explosive blend density to ensure that equipment remains in calibration during loading.

Transportation, Storage and Handling

- DYNO GOLD LITE can be stored for 6 months at temperatures between -18ºC and 32ºC (0ºF and 90ºF). Older product should be used first and all storage tanks should be kept clean of residual product.
- Use only pumps which have been approved by Dyno Nobel for 5.1 emulsion matrix transfer. Pump type, pump speed, worn pump parts, repeated repumping and pumping against high hose pressures can increase Dyno Gold viscosity and decrease shelf life.
- **ALWAYS** monitor emulsion pump performance and check pumps periodically for excessively worn parts. Design storage facilities to minimize repeated pumping.
- Transport, store, handle and use DYNO GOLD LITE in compliance with federal, state, provincial and local laws governing bulk oxidizing liquids.

DYNO® RU

Technical Information

Sensitized Bulk Emulsion

Product Description

DYNO RU is a booster sensitive, high performance, repumpable bulk emulsion explosive designed specifically for use in underground construction, quarry and mining operations. Applications include drift and raise development, shaft sinking and tunneling. In addition, other underground mining methods in which DYNO RU has proven effective are room and pillar, mechanized cut and fill, vertical crater retreat, uppers retreat, benching and block caving.

Application Recommendations

- The minimum cast booster weight recommended for use as a primer for DYNO RU is a 10 gram cast booster @ 5º C (40º F) and above; 90 gram cast booster down to -20º C (-4º F).
- **ALWAYS** double prime when bulk explosive columns exceed 6 m (20 ft). One primer should be positioned near the bottom of the hole and the second near to the collar.
- **ALWAYS** ensure primers are in the explosive column.
- **ALWAYS** consult a Dyno Nobel representative for specific recommendations before designing a DYNO RU blasting program involving the use of detonating cord. DYNO RU may be used with detonating cord only under special conditions.
- Maximum hole depth is 30 m (100 ft) but special formulations are available for deeper boreholes. Consult your Dyno Nobel representative for details.

Properties

MSDS #1062

Density	(g/cc) Avg	1.19
Energy[a]	(cal/g)	690
	(cal/cc)	830
Relative Weight Strength[a]		0.78
Relative Bulk Strength[a]		1.14
Velocity[c]	(m/sec)	5,500
	(ft/sec)	18,000
Detonation Pressure[c]	(Kbars)	91
Gas Volume[a]	(moles/kg)	41.7
Water Resistance		Excellent
Minimum DIameter	(mm)	45
	(in)	1.75
Loading Method		Pumped or Extruded
Fume Class		IME1 and NRCan1[d]

[a] All Dyno Nobel Inc. energy and gas volume values are calculated using PRODET™, a computer code developed by Dyno Nobel Inc. for its exclusive use. Other computer codes may give different values.

[b] ANFO = 1.00 @ 0.82 g/cc

[c] Unconfined in 50mm (2 in) diameter.

[d] Approved by Natural Resources Canada as NRC Fume Class 1

Hazardous Shipping Description

Explosive, Blasting, Type E 1.5D UN 0332 II

1.5 D 1

DYNO Dyno Nobel

Groundbreaking Performance

DYNO® RU

Technical Information

- Borehole sleep time is one (1) month.
- **ALWAYS** insert the loading hose to the back of the hole before pumping DYNO RU to optimize loading density.
- **ALWAYS** consult your Dyno Nobel representative for special equipment and loading recommendations before planning a DYNO RU blast program that requires collar loading.
- Specialized equipment features are necessary to enable the DYNO RU emulsion explosive to remain in upholes after loading. Contact your Dyno Nobel representative for equipment recommendations.
- **ALWAYS** check any DYNO RU loading system before each use to ensure that all components meet operational standards including all safety systems. Equipment should be calibrated periodically to ensure emulsion explosive quality and explosive performance.

Transportation, Storage and Handling

- DYNO RU can be stored for 3 months at temperatures between 0º F and 90º F (-18º C and 32º C). Older product should be used first and all storage tanks should be kept clean of residual product.
- Use only pumps which have been approved by Dyno Nobel for 1.5 emulsion explosive transfer. Pump type, pump speed, worn pump parts, repeated repumping and pumping against high hose pressures can increase DYNO RU viscosity and decrease shelf life.
- **ALWAYS** monitor emulsion pump performance and check pumps periodically for excessively worn parts. Design storage facilities to minimize repeated pumping.
- Transport, store, handle and use DYNO RU in compliance with federal, state, provincial and local laws governing bulk explosives.

Dyno Nobel Inc.
2650 Decker Lake Boulevard, Suite 300, Salt Lake City, Utah 84119 USA
Phone 800-732-7534 Fax 801-328-6452 Web www.dynonobel.com

DYNOSPLIT®

Technical Information

Nitroglycerin Dynamite

Product Description

DYNOSPLIT is a specially formulated nitroglycerin dynamite packaged in rigid 600 mm (24 in) long paper cartridges available in either 19 or 22 mm (¾ or ⅞ in) diameters. A plastic or paper coupler, attached to one end, allows easy assembly into a continuous length. DYNOSPLIT is designed for pre-splitting or cushion blasting in surface operations and for smooth wall, contour or trim blasting underground.

Application Recommendations

- Minimum detonating cord is 5.3 g/m (25 gr/ft).
- Minimum detonator is No. 8 strength.
- Minimum temperature is -40°C (-40°F).
- Linear charge weight:
  - D = 19 mm (¾ in) diameter = 0.42 kg/m (0.28 lbs/ft)
  - D = 22 mm (⅞ in) diameter = 0.57 kg/m (0.38 lbs/ft)
  - D1 = 22 mm (⅞ in) diameter = 0.42 kg/m (0.28 lbs/ft)

- **ALWAYS** trace columns over 2 m (6 ft) long with detonating cord securely attached to each cartridge.
- **ALWAYS** decouple the explosive charge when presplitting; that is, select larger borehole diameters to reduce borehole pressure. In surface applications, always stem to minimize air blast and plug the borehole above the explosive column to prevent stemming from filling the air/water space. In underground drifting applications, plug the borehole after the explosive column to prevent the explosive column from being ejected out of the borehole during detonation of the drift round.

Properties

MSDS #1019

		D[e]	D[e]	D1
Diameter	(in)	¾	⅞	⅞
Density	(g/cc) Avg	1.40	1.40	0.82
Energy[a]	(cal/g)	995	995	930
	(cal/cc)	1,440	1,440	940
Relative Weight Strength[a]		1.13	1.13	1.05
Relative Bulk Strength[a,b]		2.00	2.00	1.30
Velocity[c]	(m/s)	2,600[c]	2,700[d]	1,875
	(ft/s)	8,500[c]	8,900[d]	6,150
Detonation Pressure[c]	(Kbars)	24[c]	26[d]	7[d]
Gas Volume[a]	(moles/kg)	32	32	38
Water Resistance	(@ 12 ft)	24 hrs	24 hrs	8 hrs
Fume Class		IME1 & NRCan1[e]		Not for use underground
Maximum Water Depth		8 m (25 ft)		

[a] All Dyno Nobel Inc. energy and gas volume values are calculated using PRODET™ the computer code developed by Dyno Nobel Inc. for its exclusive use. Other computer codes may give different values.
[b] ANFO = 1.00 @ 0.82 g/cc
[c] Unconfined @ 19 mm (¾ in) diameter
[d] Unconfined @ 22 mm (⅞ in) diameter
[e] Dynosplit D is IME1 and is approved by Natural Resources Canada as Fume Class 1.

Hazardous Shipping Description

Explosive, Blasting, Type A, 1.1D, UN 0081 II

1.1D
1

DYNO Dyno Nobel

Groundbreaking Performance

DYNOSPLIT®

Technical Information

DYNAMITES

Transportation, Storage and Handling

- DYNOSPLIT must be transported, stored, handled and used in conformity with all applicable federal, state, provincial and local laws and regulations.
- For maximum shelf-life, dynamite must be stored in cool, dry and well-ventilated magazines. Dynamite inventory should always be rotated by using the oldest materials first. For recommended good practices in transporting, storing, handling and using this product, see the booklet "Prevention of Accidents in the Use of Explosive Materials" packed inside each case and the Safety Library Publications of the Institute of Makers of Explosives.

Decoupled Borehole Pressure (psi)

Product Diameter (in)	Borehole Diameter (in)				
	1 ⅞	2 ½	2 ¾	3	3 ½
¾[a]	16,766	7,941	6,198	4,943	3,311
⅞[a]	27,600	13,064	10,196	8,132	5,447
¾[b]	--	48,468	37,830	30,171	20,208
⅞[b]	--	72,732	56,768	45,275	30,325
⅞[a]	9,576	4,533	2,821	2,821	1,890
⅞[b]	--	52,849	32,897	32,897	22,034

Diameter x Length		Linear Charge Weight		Qty / Case	Nominal Case Weight	
mm	in	kg/m	lbs/ft		kg	lbs
19 x 600	¾ x 24	0.42	0.28	80	20	44
22 x 600	⅞ x 24	0.57	0.38	60	19.5	43.2
22 x 600	⅞ x 24	0.42	0.28	60	19.5	34.8

[a] DYNOSPLIT alone.
[b] DYNOSPLIT with detonating cord trace along its length.

- Diameter as labeled is nominal inside diameter. Actual outside diameter is 20mm (0.79 in) for 19 mm (¾ in) and 23 mm (0.90) for 22 mm (⅞ in).
- Note: All weights are approximate.

D
D1

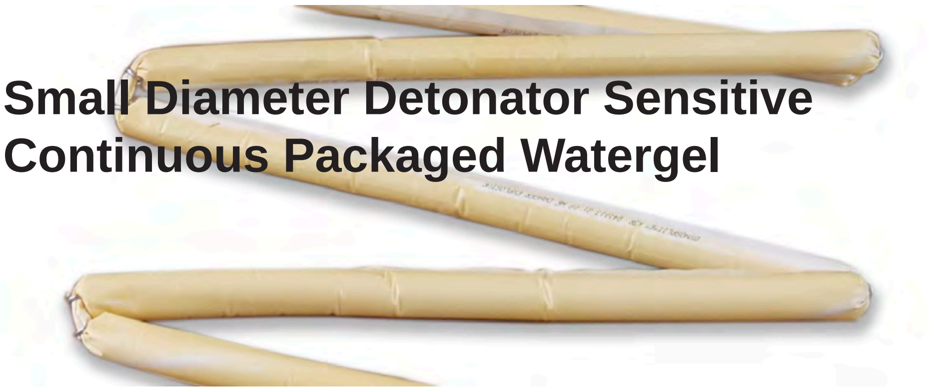
Case Dimensions

67 x 35 x 12 cm 26½ x 13¾ x 4¾ in

DYNOSPLIT® C

Technical Information

PACKAGED EXPLOSIVES



Small Diameter Detonator Sensitive Continuous Packaged Watergel

Product Description

DYNOSPLIT C is a detonator-sensitive, small diameter, water resistant, packaged watergel explosive designed for both surface and underground perimeter control applications such as contour, presplit and cushion blasting. DYNOSPLIT C is manufactured as a continuous packaged watergel, crimped every 400 mm (16 in) and traced internally with detonating cord. The continuous column can be cut to fit the designed load length, doubled or tripled as necessary to increase the explosive charge weight per foot and spliced to extend its length. In addition, the continuous column provides consistent borehole pressure throughout the entire loaded zone resulting in a uniform tensile shearing effect.

Application Recommendations

- **ALWAYS** use a Dyno Nobel high strength detonator or equivalent at internal product temperatures higher than 4º C (40º F). The product remains 5.3 g/m (25 gr/ft) detonating cord sensitive to 10º C (50º F).
- **ALWAYS** use a rope of sufficient strength to support the explosive column weight whenever loading boreholes with depths exceeding 25 m (80 ft) or when the explosive column weight exceeds 11 kg (25 lb). Attach the rope along the entire length of the powder column in 2 m (6 ft) intervals and secure the rope at the borehole collar.
- **ALWAYS** prime the second cartridge from the top of the explosives column if priming DYNOSPLIT C with an electric or nonelectric detonator. Punch the cartridge a few inches from its bottom. Insert the detonator and push it down firmly towards the bottom of the cartridge/aluminum wire clip. Ensure that the detonator is in close proximity to the internal detonating cord. Using the leg wires or shock tube, tie at least 2 half hitches on both the 1st and 2nd cartridges. With plastic tape, secure the primer cartridge at the point where the detonator was inserted as well as at each half hitch above that insertion.

Properties*

MSDS #1084

Density	(g/cc) Avg	1.20
Relative Weight Strength		1.03
Relative Bulk Strength		1.54
Velocity[b]	(m/s)	>7,010
	(ft/s)	>23,000
Water Resistance		Excellent
Fume Class		IME1 & NRCan1[c]
Shelf Life Maximum		1 year (from date of production)

[*] Dynosplit C is manufactured for Dyno Nobel by Hallowell Manufacturing by whom all properties and application recommendations were provided.

[b] Unconfined @ 5°C (41°F). The effective velocity of Dynosplit C acting to develop the presplit shear line is approximately 4,267 m/s (14,000 fps).

[c] Approved by Natural Resources Canada as Fume Class 1.

Hazardous Shipping Description

Explosive, Blasting, Type E, 1.1D, UN 0241 II

1.1D
1

See Product Disclaimer on page 2

DYNO Dyno Nobel

Groundbreaking Performance

DYNOSPLIT® C

Technical Information

- **ALWAYS** use detonating cord with a coreload of 5.3 g/m (25 gr/ft) or greater as the downline when priming DYNOSPLIT C with detonating cord. Expose approximately 40 cm (16 in) of the internal detonating cord by slitting the first explosives cartridge at the top of the explosives column and removing the the plastic film packaging and the explosives product from around the detonating cord. Attach the internal detonating cord tail directly to the initiating detonating cord downline using a square knot.
- **ALWAYS** use the plastic cable ties provided in each case to splice two lengths of DYNOSPLIT C together. Overlap the ends of the two lengths by 4 inches to be spliced by one full cartridge and use two cable ties to attach the overlapped cartridges side by side. Pull the ties down tight to complete the splice.

Transportation, Storage and Handling

- DYNOSPLIT C must be transported, stored, handled and used in conformity with all applicable federal, state, provincial and local laws and regulations.
- Packaged watergel has a shelf life of one (1) year when stored at temperatures between -18ºC and 38º C (0ºF and 100ºF). Explosive inventory should be rotated. Avoid using new materials before the old. For recommended good practices in transporting, storing, handling and using this product, see the booklet “Prevention of Accidents in the Use of Explosive Materials” packed inside each case and the Safety Library Publications of the Institute of Makers of Explosives.

Packaging

Size		Weight / Length		Length / Case	
mm x 400	in x 16	kg / m	lbs / ft	m / 25 kg case	ft / 55 lb case
22	7/8	0.48	0.32	52	170
32	1 1/4	0.95	0.64	26	86
40	1 1/2	1.49	1.00	16	54
50	2	2.45	1.65	10.2	33

- Listed weights include the internal detonating cord coreload.
- Note: All weights / lengths are approximate.

PRIMACORD®

Technical Information

Detonating Cord

Properties

MSDS #1126

See Page 2 for PRIMACORD Detonating Cord properties

Product Description

PRIMACORD detonating cords are flexible linear explosives with a core of PETN explosive encased in a textile outer jacket. PRIMACORD detonating cord detonates along its entire length at a velocity of approximately 7,000 m/s (23,000 ft/s). PRIMACORD detonating cords are designed for use as trunklines and/or downlines in various mining, quarrying and construction applications.

Application Recommendations

- ALWAYS cut detonating cord with a sharp, non-sparking knife.
- NEVER attempt to cut detonating cords by abrasion or with a blow from a sharp or blunt object.
- ALWAYS use square knots to extend/join detonating cords that will propagate self-to-self. When connecting downlines to trunklines, always use a clove hitch knot and keep incoming and outgoing cords at right angles to avoid possibility of cut-offs.
- NEVER join PRIMACORD 1, 2 and 3 together with knots because it will not propagate self-to-self.
- ALWAYS use a detonating cord product, such as PRIMACORD 4Y or 4R or detonating cord with a greater explosive coreload as a trunkline to initiate PRIMACORD 1, 2 or 3.
- ALWAYS use a double wrap clove hitch knot to connect PRIMACORD 1, 2 and 3 detonating cord to the trunkline cord.
- NEVER allow trunklines and/or downlines to cross.
- Minimum recommended initiating detonator is a No. 8 strength.
- Minimum recommended cord initiator is a 3.6 g/m (18 gr/ft) detonating cord, such as PRIMACORD 4Y or 4R, or another detonating cord with an equal or greater explosive coreload.

Transportation, Storage and Handling

- PRIMACORD must be transported, stored, handled and used in conformity with all federal, state, provincial and local laws and regulations.
- For maximum shelf life (5 years), PRIMACORD must be stored in a cool, dry, well ventilated magazine. Explosive inventory should be rotated. Avoid using new materials before the old. For recommended good practices in transporting, storing, handling and using this product, see the booklet "Prevention of Accidents in the Use of Explosive Materials" packed inside each case and the Safety Library publications of the Institute of Makers of Explosives.

Hazardous Shipping Description

Cord, Detonating, 1.1D, UN 0065, II EX 1992020035

1.1D
1

PRIMACORD®

Technical Information

Packaging

Product	PETN Coreload		Outside Diameter		Tensile Strength		Color / Counter	Weight / Case		Spools / case	Length / Spool		Net Explosives Content (NEC) / 1000 ft	
	g/m	gr/ft	mm	in	kg	lbs		kg	lbs		m	ft	kg	lbs
PRIMACORD 1	1.5	7.5	3.18	0.125	68	150	Yellow / 5 Black	9	20	2	610	2000	0.5100	1.0720
PRIMACORD 2.5	2.4	12.5	2.8	0.110	27	60	Orange / 4 Black	12	25	2	610	2000	0.8117	1.7857
PRIMACORD 3	3.2	15	3.66	0.144	113	250	Red / 1 Black & 1 White	13	29	2	610	2000	1.0200	2.1440
PRIMACORD 4Y	3.6	18	3.61	0.142	68	150	Yellow / 1 Black	6	14	2	305	1000	1.2200	2.5720
PRIMACORD 4R*	3.6	18	3.61	0.142	68	150	Red	4	8	2	610	2000	1.2200	2.5720
PRIMACORD 5	5.3	25	3.99	0.157	68	150	Red / 1 Black	11	25	2	458	1500	1.7000	3.5730
PRIMACORD 8	8.5	40	4.47	0.176	90	200	Red / 2 Black	11	24	2	305	1000	2.7200	5.7160
PRIMACORD 10	10.8	50	4.70	0.185	90	200	Yellow / 2 Black	12	27	2	305	1000	3.4000	7.1450

* Pull-out Box

NOTE: Higher coreload detonating cords are available. Please contact your Dyno Nobel representative for details.

TROJAN® SPARTAN® SR™

Technical Information

Shock Resistant Cast Booster

Product Description

TROJAN SPARTAN SR cast boosters are detonator sensitive, high density, high energy molecular explosives available in three sizes designed to optimize initiatiion of all booster detonator sensitive explosives.

In addition to the internal through-tunnel and detonator well, the TROJAN SPARTAN SR (Shock Resistant) cast booster has an internal sleeve to protect the circuit board in electronc detonators and is designed specifically for use with Dyno Nobel's DigiShot®, DigiShot Plus and SmartShot® electronic detonators. The Trojan Spartan SR can, however, also be used with any detonator (minimum length = 8.89 cm / 3.5 in) that may require additional protection from high shock, water hammer, effects during decking, corner operations or in certain geologies

The TROJAN SPARTAN SR (Shock Resistant) cast booster also incorporates the unique Caplock™ feature which holds the detonator in place more securely and makes it more difficult for the detonator to be pulled out of capwell position while it is being lowered into the borehole. Even with this new Caplock feature, the detonator can still be removed if necessary.

Properties

MSDS #1108

Density	(g/cc) Avg	1.65
Velocity	(m/sec)	7,550
	(ft/s)	24,800
Detonation Pressure (Kbars)		235
Water Resistance		6 months with no loss of sensitivity
Shelf Life Maximum		5 years (from date of production)
Maximum Usage Temperature		65°C (150°F)

All Dyno Nobel Inc. energy and gas volume values except Velocity and Detonation Pressure are calculated using PRODET™ the computer code developed by Dyno Nobel Inc. for its exclusive use. Other computer codes may give different values.

Velocity and Detonation Pressure are the result of empirical methods during May 2009.

IMPORTANT!!! WARNING!!!!! IMPORTANT!!!!!

NEVER USE A DETONATOR LESS THAN 8.89 CM / 3.5 in LONG WITH THE TROJAN SPARTAN SR CAST BOOSTER. MISFIRES MAY RESULT.

Product Description continued

TROJAN SPARTAN SR cast boosters are formulated from the highest quality PETN and other high explosive materials ensuring reliability, consistency and durability in all blasting environments.

The fluorescent yellow container makes the TROJAN SPARTAN booster more visible on the blast site and reduces the possibility of misplaced charges.

Hazardous Shipping Description

UN 0042 Boosters, 1.1D PG II

1.1D
1

See Product Disclaimer on page 2.

TROJAN® SPARTAN® SR™

Technical Information

Application Recommendations

- **NEVER** force the detonator into the through-tunnel, the detonator-well or otherwise attempt to clear these areas if obstructed. If the through-tunnel or detonator-well does not accommodate the detonator, do not use the booster. Notify your Dyno Nobel representative.
- **ALWAYS** use a detonator with a minimum length of 8.89 cm (3.5 in). The detonator well length is 10.2 cm (4.0 in).
- Extremely low temperatures do not affect the performance of cast boosters with commercial detonators. Low temperatures do affect detonators and detonating cord. Be certain your initiation system is suitable for your application in extremely low temperatures. Cast boosters are more susceptible to breakage during handling in extremely cold temperatures.

Transportation, Storage and Handling

- Dyno Nobel cast boosters must be transported, stored, handled and used in conformity with all federal, state, provincial and local laws and regulations.
- For maximum shelf life (5 years), Dyno Nobel cast boosters must be stored in a cool, dry, well ventilated magazine. Explosive inventory should be rotated. Avoid using new materials before the old.

Packaging

Unit Weight		Unit Dimensions				Case Quantity	Gross Weight/ Case	
		Length		Diameter				
g	oz	cm	in	cm	in		kg	lbs
350	12	11.9	4.7	5.0	2.0	49	16.9	39.5
400	14	11.9	4.7	5.5	2.2	40	16.7	36.8
450	16	11.9	4.7	5.8	2.3	36	16.9	37.3

Note: All weights and dimensions are approximate.

Case Dimensions

42 x 33 x 14 cm   16 ½ x 13 x 5 ½ in

UNIGEL®

Technical Information

Semi-Gelatin Nitroglycerin Dynamite

Product Description

UNIGEL is a semi-gelatin dynamite designed to satisfy the vast majority of explosive applications in soft to medium rock types. It is particularly suited for application in horizontally bedded, laminated and/or fractured formations and where water conditions are not excessive. In addition to use as the main charge in the borehole, UNIGEL is also an excellent primer for ANFO.

Application Recommendations

- UNIGEL is an excellent primer for Dynomix (ANFO), Dynomix-WR (WR ANFO) or other detonator sensitive packaged product and can be used as a secondary primer in hard seams or at the top of the explosive column.
- Minimum diameter is 25 mm (1 in).
- Minimum detonator is No. 8 strength.
- Depending on storage conditions, dynamites may become difficult to punch. This does not affect performance. Use softer cartridges to make up primers.
- Dynamites are susceptible to sympathetic detonation when applied in very wet conditions where boreholes are closely spaced and/or where geological conditions promote this effect. Consult your Dyno Nobel representative for recommendations where these conditions exist.

Properties

MSDS #1019

Density	(g/cc) Avg	1.30
Energy[a]	(cal/g)	955
	(cal/cc)	1,240
Relative Weight Strength[a]		1.09
Relative Bulk Strength[a,b]		1.72
Velocity[c]	(m/s)	4,300
	(ft/s)	14,100
Detonation Pressure[c]	(Kbars)	60
Gas Volume[a]	(moles/kg)	37
Water Resistance		Good
Fume Class		IME1 & NRCan1[d]

[a] All Dyno Nobel Inc. energy and gas volume values are calculated using PRODET™ the computer code developed by Dyno Nobel Inc. for its exclusive use. Other computer codes may give different values.

[b] ANFO = 1.00 @ 0.82 g/cc

[c] Unconfined @ 32 mm (1¼ in) diameter.

[d] Approved by Natural Resources Canada as Fume Class 1.

Hazardous Shipping Description

Explosive, Blasting, Type A, 1.1D, UN 0081 II

See Product Disclaimer on page 2

DYNO Dyno Nobel

Groundbreaking Performance

UNIGEL®

Technical Information

DYNAMITES

Transportation, Storage and Handling

- UNIGEL must be transported, stored, handled and used in conformity with all applicable federal, state, provincial and local laws and regulations.
- For maximum shelf-life, dynamite must be stored in cool, dry and well-ventilated magazines. Dynamite inventory should always be rotated by using the oldest materials first. For recommended good practices in transporting, storing, handling and using this product, see the booklet "Prevention of Accidents in the Use of Explosive Materials" packed inside each case and the Safety Library Publications of the Institute of Makers of Explosives.

Packaging

Diameter x Length		Qty / Case	Case Type	Nominal Case Weight	
mm	in			kg	lbs
32 x 200	1 1/4 x 8	88	DA	18	40
50 x 200	2 x 8	34	DB	19	42
50 x 400	2 x 16	17	DB	19	42
65 x 400	2 1/2 x 16	10	DB	17	37
75 x 400	3 x 16	8	DE	20	44

**Available upon request.

- UNIGEL is available in a wide variety of sizes. Custom sizes are subject to surcharge and may require longer than usual lead times.
- Note: All weights are approximate.
- Check with your Dyno Nobel representative should you have any questions.

Case Dimensions

DA	45 x 34 x 17 cm	17¾ x 13⅜ x 6⅜ in
DB	45 x 34 x 15 cm	17⅞ x 13⅜ x 5⅞ in
DE	45 X 34 X 17 cm	17⅝ x 13 5/16 x 6¾ in

APPENDIX B

Blast Timing

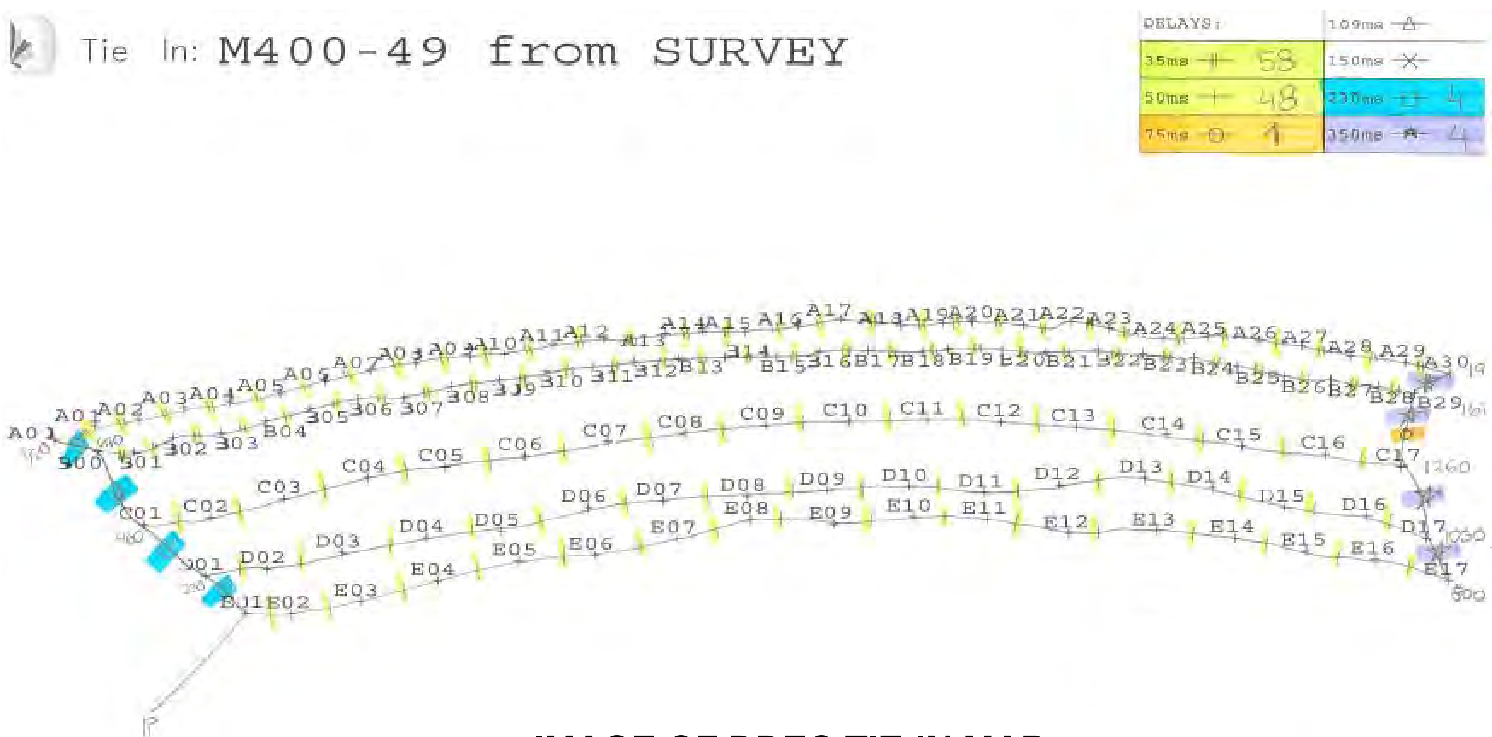
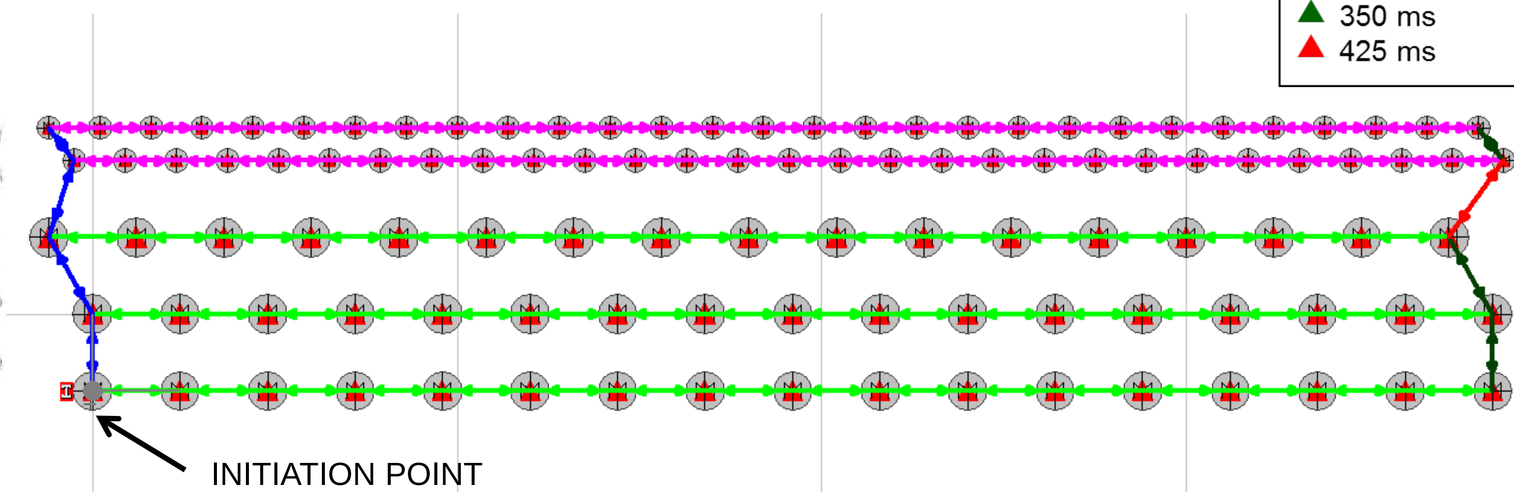
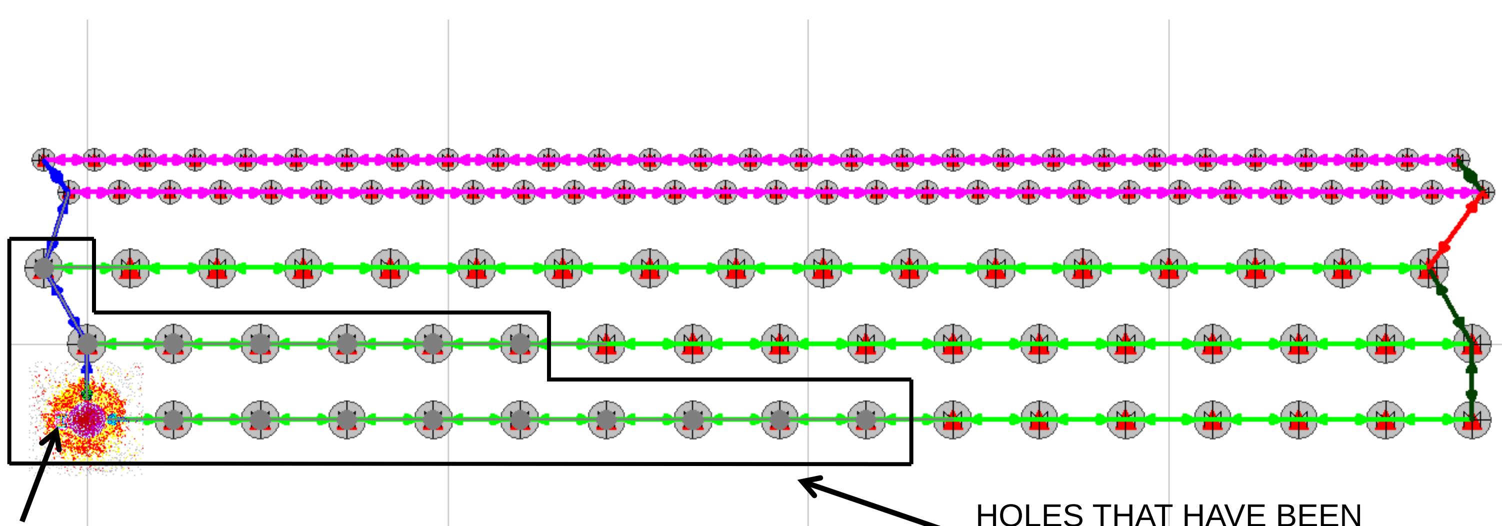


IMAGE OF DDEC TIE-IN MAP

LEGEND
- 0 ms
- 35 ms
- 50 ms
- 75 ms
- 230 ms
- 350 ms
- 425 ms



JKSIMBLAST TIE-IN (AS PER DDEC TIE-IN MAP)



JKSIMBLAST SIMULATED BLAST

IMAGE FROM BLAST VIDEO

	02DEC13		CR	DT		
REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW

CLIENT
DOMINION DIAMOND EKATI CORPORATION

CONSULTANT
Golder Associates

PROJECT 13-1439-0011
REVIEW OF BLASTING OPERATIONS AND EXPLOSIVES MANAGEMENT AT EKATI MINE

TITLE
M400-49 BLAST DESIGN

DRAWING No.
SHEET No.

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
500 - 4260 Still Creek Drive
Burnaby, British Columbia, V5C 6C6
Canada
T: +1 (604) 296 4200