

Appendix 31-1: Ammonia Management Plan



AGNICO EAGLE

MELIADINE GOLD MINE

Ammonia Management Plan

**MARCH 2023
VERSION 4**

EXECUTIVE SUMMARY

Agnico Eagle is committed to monitor Ammonia in all surface sumps, seeps, etc., in accordance with the site Water License, to implement a comprehensive and routine inspection program related to explosives management within the mine. This includes regular inspections at the explosives manufacturing facility by the explosive supplier and on-site manufacture (Dyno Nobel) to ensure all explosive products are stored in locked, sealed containers prior to use and to perform continuous review of analytical results such that mitigation measures can be implemented when increasing trends of ammonia are determined.

The Ammonia Management Plan provides guidance for monitoring ammonia levels at the mine site, as part of the conditions applying to waste disposal and management listed in the Amended Type A Water Licence 2AM-MEL1631 (the Licence) (NWB, 2021) for this water quality parameter.

TABLE OF CONTENTS

ᑭᐃᑦ ᑭᑦᑭᑦᑭᑦ	i
Executive Summary.....	ii
Table of Contents.....	iii
List of figures	iv
list of tables	v
Document Control	vi
Acronyms	vii
Units.....	vii
SECTION 1 • INTRODUCTION	1
1.1 Ammonia.....	1
SECTION 2 • EXPLOSIVE MANAGEMENT AND BLASTING PRACTICES	3
2.1 Ammonia.....	3
2.1.1 Explosive Storage.....	3
2.1.2 Roads	3
2.1.3 Mine	3
2.2 Ammonia Pathways.....	4
2.3 Explosives and Blasting	1
2.3.1 Explosives Products.....	1
2.3.2 Procedures and Practices	2
2.4 Monitoring.....	2
SECTION 3 • WATER MANAGEMENT	3
SECTION 4 • REPORTING	6
SECTION 5 • INSPECTION.....	7
SECTION 6 • REVIEW OF THE AMMONIA MANAGEMENT PLAN	8
References.....	9

LIST OF FIGURES

Figure 1. Location of surface Explosive and Detonator magazines, Emulsion Plant, Collection Ponds and monitoring stations..... 1

LIST OF TABLES

Table 1. Water Monitoring Station Included under the Meliadine Water License A, 2AM-MEL1631 3
Table 2. Monitoring Group (Meliadine Water License A, 2AM-MEL1631)..... 4

DOCUMENT CONTROL

Version	Date	Section	Page	Revision	Author
1	March 2017	All		Creation of the Document	Jeffrey Pratt, Agnico Eagle Environmental Coordinator
2	March 2020	All		General Update	Vanessa Smith, Agnico Eagle Project Coordinator
3	March 2021	All		General Update	Jawad Haloui, Agnico Eagle Engineering Superintendent Matthew Gillman, Water Management General Supervisor
4	March 2023	All 2.2 3.1		Minor text revisions Update of figure 1 Addition of sections to table 1	Agnico Eagle Environment Department

ACRONYMS

AEMP	Aquatic Effects Monitoring Program
Agnico Eagle	Agnico Eagle Mines Limited
AMP	Ammonia Management Plan
AN	Ammonium-nitrate
ANFO	Ammonium nitrate, fuel oil
AWAR	All-Weather Access Road
CCME	Canadian Council of Ministers of the Environment
CIRNAC	Crown-Indigenous Relations and Northern Affairs Canada
EE	Emulsion explosives
EEM	Environmental Effects Monitoring
KivIA	Kivalliq Inuit Association
the Licence	Amended Type A Water Licence 2AM-MEL1631
MDMER	Metal and Diamond Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
NWB	Nunavut Water Board
pH	potential Hydrogen
TDS	Total Dissolved Solids
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
WAD cyanide	Weak Acid Dissociable cyanide

UNITS

km	kilometre
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SECTION 1 • INTRODUCTION

Agnico Eagle Mines Ltd (Agnico Eagle) is committed to monitor Ammonia in all mine pit sumps, seeps, etc., in accordance with the Amended Type A Water Licence 2AM-MEL1631 (the Licence) (NWB, 2021), and implement a comprehensive and routine inspection program related to explosives management within the mine. This includes regular inspections at the explosives manufacturing facility by the explosive supplier and on-site manufacturer (Dyno Nobel) to ensure all explosive products are stored in locked, sealed containers prior to use and to perform continuous review of analytical results such that mitigation measures can be implemented when increasing trends of ammonia are determined. The Ammonia Management Plan (AMP) provides guidance for monitoring ammonia levels at the mine site, as part of the conditions applying to waste disposal and management listed in the License for this water quality parameter.

1.1 Ammonia

Blasting of ammonium-nitrate (AN) explosives is typically the primary source of ammonia in areas of mining operations. It is used in ammonium nitrate and fuel oil (ANFO) explosives and emulsion explosives (EE). AN readily absorbs water and dissolves easily, thereby mobilizing ammonia in either groundwater or surface runoff. The commissioning of the Dyno Emulsion Plant in December, 2017 has eliminated the use of ANFO used at Meliadine in favour of EE.

Ammonia dissolved in water exists in equilibrium by interchanging un-ionized (NH_3) and ionized (NH_4^+) forms. The equilibrium is influenced by pH, temperature, and ionic strength (salinity) where the amount of un-ionized ammonia is favoured as the pH becomes more basic or as the water temperature or salinity increases. Un-ionized ammonia can readily pass across the gill surface and enter into the bloodstream of fish, while ionized ammonia passes with greater difficulty. Once inside the fish, both forms of ammonia can cause toxic effects (CCME, 2010). Furthermore, it should be noted that ammonia oxidizes to nitrite (NO_2) and nitrate (NO_3), the former being particularly toxic to fish and humans. Both nitrite and nitrate are regulated by the Canadian Council of Ministers of the Environment (CCME) for the Protection of Aquatic Life.

The AMP proposes the monitoring of blasting practices for the assessment of explosive quantity used and blast performance, and monitoring of water quality to determine ammonia

levels in waters within the mine site. The monitoring results can be used to review and adjust blasting practices or water management if ammonia levels need to be reduced.

SECTION 2 • EXPLOSIVE MANAGEMENT AND BLASTING PRACTICES

2.1 Ammonia

2.1.1 Explosive Storage

A total of fourteen (14) permanent explosive and detonator magazines are located on surface, North-West of the Meliadine main camp (Figure 1). There are seven (7) underground storage areas (magazines) of explosives and detonators, which are located on levels 200, 300 and 400. The explosive products arrive by barge at the Rankin Inlet Itivia port. On occasion, product must be flown up on dedicated cargo flights for unplanned work. They are then transported by ground to the Meliadine site and offloaded to their respective storage areas; explosives are stored in a timely manner in the designated magazines while raw materials are transported to the Emulsion Plant storage area.

The Emulsion Plant is located approximately 1.4 kilometers north-west of the mine site and is accessible via service roads. This area consists of the modular emulsion plant, commissioned on December 12, 2017, the raw material storage, and the garage. Ammonium Nitrate is stored at the Emulsion Plant in shipping containers. All raw material required for emulsion manufacturing are packed in shipping containers, which limits the possibility of spillage. The products are only removed from these containers prior to use at the emulsion plant.

Further information on explosive transport and storage can be found in the latest version of the Explosives Management Plan.

2.1.2 Roads

The All-Weather Access Road (AWAR) is a restricted access road constructed and operated by Agnico Eagle for ground transportation between Rankin Inlet and the Meliadine mine site. This road is used to transport explosive products from the Itivia facilities in Rankin Inlet to the emulsion plant area at the mine site. In preparation for blasting operations, explosive products are transported from the emulsion plant area to the appropriate blasting locations on surface and underground via the Mine site roads.

2.1.3 Mine

Explosives are used for the mining of surface infrastructure, waste rock, overburden and ore for surface and underground operations.

2.2 Ammonia Pathways

Emulsion not fully detonated (i.e. a partial detonation) within the blasting operations allows for mobilization of ammonia through several pathways on the mine site. In the underground mine, groundwater and mine service water runoff is the primary mechanism for mobilization of ammonia. This water is collected by underground sumps and recirculated in the mine service water network for mining operations. Water is also diverted from the service water network and pumped to surface for storage and subsequent treatment prior to discharge. On surface, similar mechanisms to the underground mobilization of ammonia are present in the open pits where blasting activities occur. Runoff in the open pits is captured by sumps and subsequently pumped to the surface runoff collection ponds or saline water storage depending on *in-situ* salinity (more information can be found in the Water Management Plan).

Mobilization of ammonia directly from AN in storage or explosives in storage magazines would require exposure to environmental runoff, in the form of precipitation on surface or groundwater inflow to the underground mine. As described in section 2.1.1, AN is stored in shipping containers for protection from environmental exposure and is only removed when required for emulsion production. Emulsion is produced as needed at the Dyno Emulsion Plant and temporarily stored in a sealed tank prior to being delivered for blasting operations on surface and underground. None of the products are readily exposed to the environment where mobilization and runoff of ammonia could occur. In the unlikely possibility of runoff infiltration to these previously mentioned storage locations and resulting mobilization of these ammonia sources, an analysis of watershed delineations indicates that drainage will be directed toward local lakes E3 and B7. Water quality monitoring of Lake E3 is identified in Table 2 of the Licence as monitoring station MEL-15. Monitoring of lake B7 for ammonia is performed under peninsula lakes monitoring in the AEMP.

Runoff from underground explosives storage described in section 2.1.1 is not anticipated due to the lack of exposure to a source of groundwater inflow in the explosive and detonator magazines. In the event an inflow was to occur in these locations, runoff containing ammonia from these storage locations would report to the sump network or pumped to surface saline water storage.

Blasting residuals are also expected to be attached to waste rock and ore materials, which are transported from the underground mine to their respective storage and processing facilities. Residuals from waste rock may be washed off by precipitation and be ultimately conveyed to collection pond catchments in which ore or waste rock are located (CP1, CP2, CP3, CP4, CP5 and CP6). All these pathways are monitored in accordance with the Licence. No contact water from the waste rock or ore will be drained towards watercourses outside of the Mine's water management infrastructures.

Figure 1 show the Mine's collection ponds and the location of the monitoring stations where ammonia concentrations are measured according to the Licence and AEMP.

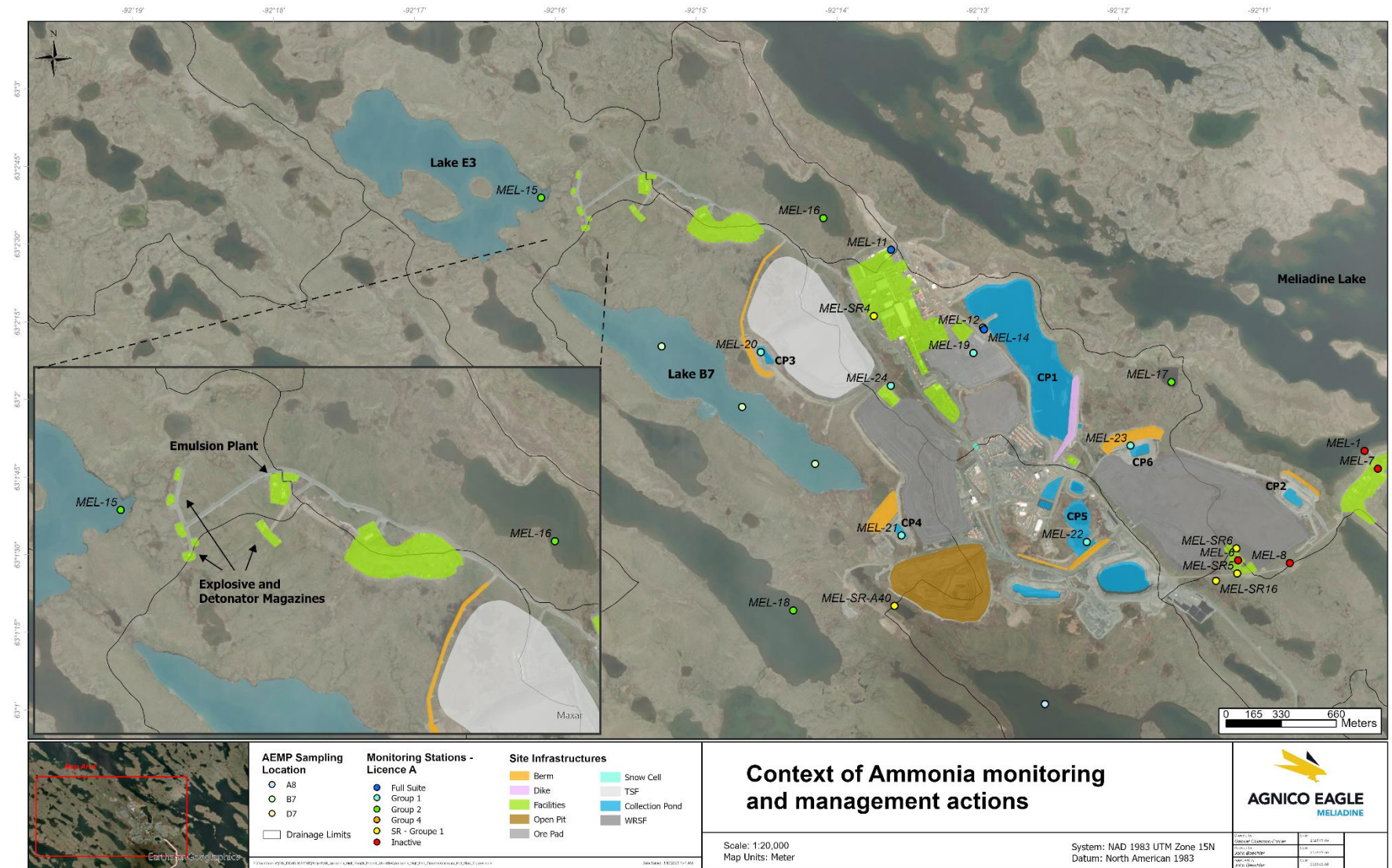


Figure 1. Location of surface Explosive and Detonator magazines, Emulsion Plant, Collection Ponds and monitoring stations.

2.3 Explosives and Blasting

Based on experience at other open pit mines in the Canadian Arctic, the largest potential source of ammonia in mine water will be from explosive residue from blasting. Depending on the wetness of the site, water may leach explosives from blastholes prior to the blast. Other forms of ammonia release from AN are explosives flowing into cracks and fissures in the rock and not detonating, or from an incomplete detonation of the explosive column and misfired blastholes. Emulsion is an AN based explosive (66-84% AN) and is used as a blasting agent at the Meliadine site. Emulsion breaks down slower than Ammonia Nitrate Fuel Oil (ANFO) and less product is dissolved in wet environments. Emulsion is the preferred blasting agent at Meliadine.

Blasting operations on site include monitoring of explosive quantities, blast design, procedures and practices. Combined with water monitoring, the compilation of these data is used to assess blasting performance. The results of this blasting performance assessment are used to adjust and improve blasting practices as needed to:

- a) Optimize the use of explosives; and
- b) Increase the completion and efficiency of explosive detonations.

Any modifications to blast design are intended to decrease the amount of ammonia that may become available for mobilization in mine water.

This section summarizes the explosive products and blasting design parameters, procedures and practices employed at Meliadine. Associated monitoring is also discussed.

2.3.1 Explosives Products

Explosive products used at the mine site include emulsion, packaged explosives, cast boosters, detonating cords, non-electric delay detonators and non-electric lead lines. Of these products, the greatest potential for water contamination comes from the bulk explosives. Presently, Meliadine uses Emulsion as the primary explosive for its blasting operations.

Although bulk explosives, including both surface and underground Emulsion, are water resistant, contaminants can be leached from the product if it is left in contact with standing or flowing water for extended periods. The performance of the explosive, and hence the potential for post-blast contaminations, deteriorates with the length of time that the explosive remains loaded (i.e., sleep time). Blast procedures currently in use are designed to minimize sleep time so that standing or flowing water is not in contact with the explosive for extended periods.

2.3.2 Procedures and Practices

Quality control procedures are in place to verify AN content in bulk explosives. Quality control procedures for the Emulsion occur at the plant. The primary factors that may reduce the amount of ammonia available for mobilization in mine water are:

- Explosives handling
- Completeness of detonation

Emulsion spillage during loading could (as emulsion is resistant to water) be a source of ammonia that could be carried by water collected in the sumps. Spillage control protocols, procedures and handling of spilled material, and explosive management for storage and transport, are in place at the Meliadine site.

Incomplete detonation results in higher ammonia residue on the blasted rock. Evidence of incomplete detonation is often observed as an orange fume after a blast and sometimes an orange pigment on the blasted rock. Explosives that have failed to detonate may be observed in the muckpile. Muckpiles are routinely inspected by Meliadine personnel for signs of incomplete detonation.

2.4 Monitoring

Monitoring of explosive handling and blasting is as follows:

- a) Explosive quantities: Records of explosive quantities used for blasting are kept for each blasting event and will be conserved throughout the mine life.
- b) Design parameters: Blast design parameters are in place. Blast design at the face is determined by the jumbo operator as required.

Loading standards are in place for the Meliadine Mine for both surface and underground operations. These standards are followed when loading explosives.

SECTION 3 • WATER MANAGEMENT

Water quantity and quality monitoring assist in the monitoring of ammonia loadings from explosive residuals. The Licence (NWB, 2021) includes monitoring stations that are used for the monitoring of ammonia loadings. The stations that specifically monitor for ammonia are listed in Table 1. Table 2 lists the monitoring parameters for each group.

Table 1. Water Monitoring Station Included under the Meliadine Water License A, 2AM-MEL1631

Station	Description	Phase	Monitoring Parameters	Frequency
MEL-D-1 to TBD	Dewatering: Water transferred from lakes to Meliadine Lake during dewatering of these lakes	Construction	As per Part D, Item 12	Prior to discharge and Weekly during discharge
			Volume (m ³)	Daily during periods of discharge
MEL-SR-1 to TBD	Surface Runoff: runoff downstream of Construction areas at Meliadine Site and Itivia Site, Seeps in contact with the roads, earthworks and any Runoff and/or discharge from borrow pits and quarries	Construction and Operations	As per Part D, Item 18	Prior to Construction and Weekly during Construction
			Group 1	Monthly during open water or when water is present upon completion
MEL-11	Water intake from Meliadine Lake	Construction, Operation, and Closure	Full Suite	Monthly during periods of intake
			Volume (m ³)	Daily during period of intake
MEL-12	<i>Contact Water Treatment Plant (pre-treatment): coming from CP1, off the pipe and not in the pond</i>	<i>Construction (prior to release), Operations, and Closure</i>	Group 1	<i>Monthly during periods of discharge</i>
MEL-13 ^(a) (and AEMP Stations)	Mixing zone in Meliadine Lake and MDMER exposure stations for final discharge point within mixing zone	Construction (prior to release), Operations, and Closure	Full Suite, Group 3 (MDMER)	Monthly during periods of discharge
MEL-14	Contact Water Treatment Plant from CP1 (post-treatment): end of pipe in the plant before offsite release	Construction (upon effluent release), Operations, and Closure	Full Suite, Group 3	Prior to discharge and Weekly during discharge
			Volume (m ³)	Daily during periods of discharge
			Acute Lethality	Once prior to discharge and Monthly thereafter
MEL-15	Local Lake E-3	Operations, and Closure	Group 2	Bi-annually during open water

Station	Description	Phase	Monitoring Parameters	Frequency
MEL-16	Local Lake G2	Construction, Operations, and Closure	Group 2	Bi-annually during open water
MEL-17	Local Pond H1	Construction, Operations, and Closure	Group 2	Bi-annually during open water
MEL-18	Local Lake B5	Construction, Operations, and Closure	Group 2	Bi-annually during open water
MEL-19	CP2, Collection of drainage from WRSF3	Construction, Operations, and Closure	Group 1	Monthly during open water or when Water is present
MEL-20	CP-3 Collection of drainage from dry stacked tailings	Operations, and Closure	Group 1	Monthly during open water or when Water is present
MEL-21	CP-4 Collection of drainage from WRSF1	Operations, and Closure	Group 1	Monthly during open water or when Water is present
MEL-22	CP-5 Collection of drainage from WRSF1 and WRSF2	Construction, Operations, and Closure	Group 1	Monthly during open water or when Water is present
MEL-23	CP-6 Collection of drainage from WRSF3	Construction, Operations, and Closure	Group 1	Monthly during open water or when Water is present
MEL-24	Seepage from the Landfill between the landfill and Pond H3	Construction, Operations, and Closure	Group 1	Monthly during open water or when Water is present
MEL-25	Secondary containment area at the Itivia Site Fuel Storage and Containment Facility	Construction, Operation, Closure	Group 4, Volume (m ³)	Prior to discharge or transfer of Effluent

In addition to the monitoring listed in Table 1, any surface runoff locations identified as potential receptors for increased ammonia are sampled as well.

Table 2. Monitoring Group (Meliadine Water License A, 2AM-MEL1631)

Group	Parameters
1	pH, turbidity, hardness, total alkalinity, sodium, magnesium, potassium, calcium, fluoride, silicate, chloride, sulphate, total dissolved solids (TDS; calculated ^(a,b)), total suspended solids (TSS), total cyanide, ammonia nitrogen, nitrate, nitrite, phosphorus, orthophosphate, Total Metals (aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, and zinc).

Group	Parameters
2	<p>Total and Dissolved Metals: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, thallium, tin, titanium, uranium, vanadium, and zinc.</p> <p>Nutrients: ammonia-nitrogen, total Kjeldahl nitrogen, nitrate-nitrogen, nitrite-nitrogen, orthophosphate, total phosphorus, total organic carbon, dissolved organic carbon, and reactive silica.</p> <p>Conventional Parameters: bicarbonate alkalinity, chloride, carbonate alkalinity, turbidity, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphate, pH, total alkalinity, TDS (calculated^(a,b)), TSS, total cyanide, free cyanide, and weak acid dissociable (WAD) cyanide.</p>
3	<p>MDMER parameters: total cyanide, arsenic, copper, lead, nickel, zinc, radium-226, TSS, pH, sulphate, turbidity, and aluminum.</p> <p>MDMER additional requirements: Effluent volumes and flow rate of discharge, Acutely Lethality tests (Rainbow Trout and <i>Daphnia magna</i>) and environmental effects monitoring (EEM).</p>
4	Total arsenic, total copper, total lead, total nickel, TSS, ammonia, benzene, toluene, ethylbenzene, xylene, total petroleum hydrocarbons (TPH), and pH.
Full Suite	Group 2, TPH, and turbidity.
Flow	Flow data-logger.
Field measurements	Field pH, specific conductivity, dissolved oxygen, and temperature

MDMER - Metal and Diamond Mining Effluent Regulations (SOR/2002-222).

^(a) Standard Methods (Method 1030E, APHA 2012)

^(b) $TDS_{Calc} (mg/L) = (0.6 \times \text{Total Alkalinity as } CaCO_3) + \text{Sodium} + \text{Magnesium} + \text{Potassium} + \text{Calcium} + \text{Sulfate} + \text{Nitrate} + \text{Fluoride} + \text{Silicate}$

Where: Nitrate is the NO₃⁻ anion (multiply nitrate as nitrogen result by 4.427);
Silicate is the SiO₃²⁻ anion (multiply reactive silica as SiO₂ result by 1.266)

SECTION 4 • REPORTING

Reporting of ammonia concentrations at the sampling stations listed in Table 1 is included as part of the requirement of the Licence (NWB, 2021). The reporting frequency is required by the Licence (NWB, 2021), and includes:

- Monthly reports of the compiled water quality monitoring results, sent to the Nunavut Water Board (NWB), Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC) Water License Inspector and to the Kivalliq Inuit Association (KivIA); and
- An annual report submitted to the NWB, KivIA, CIRNAC, Nunavut Impact Review Board (NIRB), Government of Nunavut, and other interested parties. This report summarizes monitoring results for each sampling station, annual seep water chemistry results, receiving environment water quality monitoring results, spills and any accidental releases, measured flow volumes, effluent volumes and loadings, and results of QA/QC analytical data.

Mine operation and environment personnel reviews on a monthly basis the data gathered from the sampling stations in Table 1 and from the monitoring action proposed under the AMP. Results of these further studies and/or changes to the AMP monitoring actions will be transmitted to the Nunavut Water Board for review.

SECTION 5 • INSPECTION

On a regular basis, the Engineering department conducts inspections in the blasting area to ensure that the loading procedures are being implemented (in order to minimize blasting residues). In addition, environmental inspections are undertaken at explosive product storage facilities (Dyno Nobel) to ensure that explosives products are stored in sealed containers and that there is no spillage. If any non-conformities are observed, follow up actions are undertaken, and corrective measures are put in place.

SECTION 6 • REVIEW OF THE AMMONIA MANAGEMENT PLAN

Review of the results of the site water quality and AMP monitoring during the year may provide new information, and/or indications that changes to the AMP are necessary. When revisions are warranted, an updated AMP will be submitted to the Nunavut Water Board for review.

REFERENCES

American Public Health Association (APHA, 2012). Standard Methods for the Examination of Water and Wastewater, 22nd Edition, with updates to 2015. Washington, DC, USA.

CCME (2010), Canadian Water Quality Guidelines for the Protection of Aquatic Life, Ammonia.

NWB (Nunavut Water Board) (2021). Amended Water Licence No: 2AM-MEL1631. Agnico-Eagle Mines Ltd. May 2021.