AREVA

Kiggavik Project Final Environmental Impact Statement

Tier 2 Volume 10: Accidents, Malfunctions and Effects of the Environment on the Project

September 2014

History of Revisions

Revision Number	Date	Details of Revisions
01	December 2011	Initial release Draft Environmental Impact Statement (DEIS)
02	April 2012	Revised DEIS – to address comments received from the Nunavut Impact Review Board as part of their conformity determination released on January 18, 2012
03	September 2014	FINAL Environmental Impact Statement

Foreword

The enclosed document forms part of the Kiggavik Project Final Environmental Impact Statement (FEIS) submission, presenting potential environmental and social impacts to determine if the Project should proceed and if so, under what terms and conditions. The submission has been prepared for the Nunavut Impact Review Board by AREVA Resources Canada Inc. to fulfill the requirements of the "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.'s Kiggavik Project (NIRB File No. 09MN003)", to include new material or clarity provided during the review of the Draft Environmental Impact Statement, and to address company commitments and direction from the Nunavut Impact Review Board as outlined in the "Preliminary Hearing Conference Decision Concerning the Kiggavik Project (NIRB File No. 09MN003)".

The FEIS submission consists of a number of documents, as shown in the attached road map. These documents have been categorized into tiers, as follows:

- **Tier 1** document (Volume 1) provides a plain language summary of the Final Environmental Impact Statement.

- **Tier 2** documents (Volumes 2 to 10) contain technical information and provide the details of the assessments of potential Project environmental effects for each environmental compartment. Tier 2 Volume 11 contains executive, popular, and volume summaries in Inuktitut.

- The Tier 2 documents each have a number of technical appendices, which comprise the **Tier 3** supporting documents. These include the environmental baseline reports, design reports, modelling reports and details of other studies undertaken to support the assessments of environmental effects. Management plans are provided as Tier 3 documents.

Volume 1
Main Document

Volume 2 Project Description and Assessment Basis

- Governance and Regulatory Oversight
- Project Description
- Assessment Basis

2A Alternatives Assessment
2B Drilling and Blasting Design
2C Explosives Management Plan
2D Design of Ore and Mine Rock Pads and Ponds
2E Water Diversion and Collection Design
2F Design of Andrew Lake Dewatering Structure
2G Kiggavik-Sissons Road Report
2H Ore Storage Management Plan
2I Water Management Plan
2J Marine Transportation
2K Winter Road Report
2L All-Season Road Report
2M Roads Management Plan
2N Borrow Pits and Quarry Management Plan
2O Mine Site Airstrip Report
2P Occupational Health and Safety Plan
2Q Radiation Protection Plan
2R Preliminary Decommissioning Plan
2S Waste Management Plan
2T Environmental Management Plan
2U Hazardous Materials Management Plan
2V Mine Geotechnical Reports

Volume 3 Public Engagement and Inuit Qaujimajatuqangit

Part 1
- Public Engagement

Part 2
- Inuit Qaujimajatuqangit

3A Public Engagement Documentation
3B Inuit Qaujimajatuqngit Documentation
3C Community Involvement Plan

Volume 4 Atmospheric Environment

Part 1
- Air Quality and Climate Change

Part 2
- Noise and Vibration

4A Climate Baseline
4B Air Dispersion Assessment
4C Air Quality Monitoring Plan
4D Baker Lake Long-Term Climate Scenario
4E Noise and Vibration Assessment
4F Noise Abatement Plan

Volume 5 Aquatic Environment

- Surface Hydrology
- Hydrogeology
- Water and Sediment Quality
- Aquatic Organisms
- Fish and Fish Habitat

5A Hydrology Baseline
5B Geology and Hydrogeology Baseline
5C Aquatics Baseline
5D Groundwater Flow Model
5E Prediction of Water Inflows to Kiggavik Project Mines
5F Mine Rock Characterization and Management
5G Thermal and Water Transport Modelling for the Waste Rock Piles and Tailings Management Facilities
5H Waste Rock Water Balance
5I Hydrology of Waste Rock Piles in Cold Climates
5J Tailings Characterization and Management
5K Historical and Climate Change Water Balance
5L Kiggavik Conceptual Fisheries Offsetting Plan
5M Aquatics Effects Monitoring Plan
5N Hydrology Assessments
5O Sediment and Erosion Control Plan
5P Technical Assessments of Water Withdrawal Locations and Baker Lake Dock Site

Volume 6 Terrestrial Environment

- Terrain
- Soils
- Vegetation
- Terrestrial Wildlife

6A Surficial Geology and Terrain Baseline
6B Vegetation and Soils Baseline
6C Wildlife Baseline
6D Wildlife Mitigation and Monitoring Plan

Volume 7 Marine Environment

- Marine Water and Sediment Quality
- Marine Mammals
- Marine Fish

7A Marine Environment Baseline
7B Underwater Acoustic Modelling

Volume 8 Human Health

- Occupational Dose Assessments
- Human Health Risk Assessment

8A Ecological and Human Health Risk Assessment
8B Radiation Protection Supporting Document

Volume 9 Socio-Economic Environment and Community

Part 1
- Socio-Economic Environment

Part 2
- Heritage Resources

9A Socio-Economic Baseline
9B Archaeology Baseline
9C Human Resources Development Plan
9D Archaeological Resource Management Plan

Volume 10 Accidents, Malfunctions and Effects of the Environment on the Project

- Risk Assessments
- Effects of the Environment on the Project

10A Transportation Risk Assessment
10B Spill Contingency and Landfarm Management Plan
10C Emergency Response Plan

Volume 11 Executive, Popular and Volume Summaries Translated into Inuktitut

KEY:

Tier 1 Document	Tier 2 Document	Tier 3 Document
Main Documents	Environmental Effects Assessment Report	Technical Appendices, Baseline Reports, Technical Development and Management Plans

Executive Summary

As per the guidelines issued by the Nunavut Impact Review Board (NIRB 2011), AREVA Resources Canada Inc. (AREVA) has prepared this document as part of the Environmental Impact Statement (EIS) to assess the potential environmental effects associated with the Kiggavik Project (the Project).

The assessment basis considers Project activities under routine or normal construction, operating, and decommissioning scenarios. This volume considers accidents and malfunctions which are not part of planned activities or normal operation. During Inuit Qaujimajatuqangit (IQ) interviews and engagement activities, Kivalliq community members raised questions about the safety and hazards of mining in general (EN- AR KIA Apr 2007[1], EN- BLOG Dec 2010[2]) and concerns about accidents and malfunctions in particular (IQ-CIHT 2011[3], EN- AR OH Nov 2013[4], EN-CI OH Nov 2012[5], EN-WC OH Nov 2012[6]).

In order to meet the NIRB guidelines and address community concerns, this volume of the EIS describes potential accidents, malfunctions, and effects of the environment on the Project; discusses proposed measures to prevent these incidents; describes proposed mitigation and response measures; and assesses the resulting potential effects on the environment and health and safety if these incidents were to occur.

AREVA uses several approaches to risk assessment, depending primarily upon the stage of the Project and the end use of the information generated. These approaches include more general hazard identification and mitigation procedures, business risk models, and Hazard and Operability Studies (HAZOP)s. The approaches used at the current level of Project design seek to identify major risks that are best mitigated through design or have potential environmental effects that require assessment and mitigation. Community members have emphasized that procedures need to be in place to ensure that people[7] and wildlife[8] are protected in the event of an accident. Mitigation measures are proposed to mitigate risks to personnel, local communities, the environment, and the operation. Mitigation measures can be generally categorized as follows: measures to reduce the risk of an occurrence (design features such as site containment, management programs and routine monitoring); measures to minimize the consequences if the event occurs (emergency response, spill contingency, management and

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[1] EN- AR KIA Apr 2007: *How dangerous is uranium mining?*

[2] EN- BLOG Dec 2010*: Is it safe to work at a uranium mine?*

[3] IQ-CIHT 2011: *What would happen if a cup of uranium was spilled?*

[4] EN-AR OH Nov 2013: *Do accidents increase with colder temperatures?*

[5] EN-CI OH Nov 2012: *What about the risk of a diesel spill?*

[6] EN-WC OH Nov 2012: W*hat would happen if a plane of uranium crashed*?

[7] EN-BL NIRB April 2010: Uranium is of concern as it is dangerous. Proper procedures will have to be put in place to ensure that employees and employers are protected and that there are no exposures to the uranium and that there are preventions in place to prevent people from getting too close.

[8] EN-CI NIRB May 2010: Concerns over accidents and malfunctions from shipping and impacts to land and wildlife, which people live off.

monitoring programs); and measures to ensure control is regained before activities re-commence.

A preliminary Emergency Response Plan (Plan) has been prepared for the Project. The Plan provides general guidance for all emergencies related to the Project; describes the responsibilities, tasks and reporting requirements involved in an emergency; and details various emergency response situations including necessities of life emergencies, personnel emergencies, natural environment-related emergencies and operational emergencies.

To fully characterize and evaluate the potential accidents and malfunctions associated with the Project, a number of risk assessments using varying methodologies have been conducted. Risks are generally characterized by the likelihood of the incident occurring and the potential consequences to the environment, radiation exposure or health and safety. A screening level risk assessment encompassing all Project activities has identified a broad range of potential accidents and malfunctions. These risks have been further evaluated to identify preventative measures, response measures, and mitigation measures to minimize potential environmental effects. The screening-level assessment of accidents and malfunctions resulted in the characterization of most on-site environmental risks as low, while some health and safety risks, such as the risk of fire or explosion, as moderate.

Spills of fuel and other hazardous materials, including uranium concentrate, outside of site containment boundaries, were generally identified as moderate risk. Based on these results, coupled with concerns expressed by local communities, additional assessments were conducted on potential transportation accidents and malfunctions through the general and marine-specific transportation risk assessments.

The transportation risk assessment identified some moderate risk if a release of yellowcake were to occur. The risk of a truck rollover is highly unlikely and the consequences minor. For an airplane crash, the likelihood is unlikely while the consequences would be higher as some aquatic species may be affected. There would be minimal risk to human receptors if a yellowcake release were to occur as doses are expected to be well below the accepted limits. There will be stringent protocols, emergency response plans and preventative measures to ensure yellowcake release does not occur. Similar protocols will be in place to ensure fuel and reagents spills do not occur.

The marine risk assessment identified moderate risk activities that are considered acceptable with stringent controls. A number of these generally involve the potential for tug/barge grounding in Chesterfield Narrows. A moderate risk of a fuel spill in Baker Lake was identified. Further moderate risks were identified to occupational health and safety during anchoring operations in Chesterfield Inlet and barge docking activities at the Baker Lake dock site. Stringent protocols, emergency response capability, preventative measures such as double-hulled fuel barges, appropriate PPE, and pre-installed anchor systems will be implemented to mitigate these risks.

The results of the marine transportation risk assessment indicate that there is an unacceptable risk of a tug/barge grounding in Chesterfield Narrows due to navigational or maneuvering error during passage of a tug towing two barges. Therefore, the marine transportation plan includes passage of only one barge per tug while transiting the Narrows.

The natural environment has the potential to affect the Project through a number of mechanisms, including: extreme weather, such as blizzards, high winds, extreme precipitation, storm surges, fog; climate factors, such as thaw susceptible soils; seismic activity; wildlife encounters; and fires. The potential for these occurrences to cause accidents and malfunctions was assessed as part of the screening risk assessment.

Accident and malfunctions, including those caused or compounded by environmental hazards, are predicted to have no residual effects on the environment. Preventative measures, including design features, redundancy, secondary and tertiary containment, management plans, road management and safety shelters[9], preventative maintenance, routine operational and environmental monitoring, safe work plans, and training programs will be in place to reduce the probability of the incident occurring. Response measures, including trained emergency response teams, an emergency response plan, a spill contingency plan, spill kits, monitoring programs, trained first responders, and a staffed health centre, will be in place to reduce the consequences of an incident if one were to occur.

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[9] EN- BL OH Nov 2013: *Road management is extremely important for safety and safety shelters too.*

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ᒪᓕᒃᑕᐅᔪᒃᓴᐃᑦ ᓄᓇᕗᒻᒥ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᕿᒥᕐᕈᔨᖏᓐᓄᑦ (NIRB 2011) ᓴᖅᑭᑕᐅᔪᑦ ᒪᓕᒃᓱᒋᑦ, ᐊᕆᕚᒃᑯᑦ AREVA Resources Canada Inc. ᑖᑉᓯᒥᙵᑦ ᑎᑎᖅᑲᒥᒃ ᐋᕿᒃᓯᔪᑦ ᐃᓚᒋᔭᐅᑉᓗᓂ ᐊᑐᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᒧᑦ (EIS) ᖃᐅᔨᓴᕐᓂᐊᕐᓗᒍ ᐊᑐᑎᒥᒃ ᖃᓄᐃᙶᓕᖅᑎᑦᑎᓂᐅᔪᓐᓇᖅᑐᑦ ᐊᒃᑐᐊᔪᓄᑦ ᕿᒡᒐᕖᒃ ᐱᓕᕆᐅᒧᑦ Kiggavik Project (ᐱᓕᕆᐊᖅ).

ᖃᐅᔨᓴᐃᓂᖅ ᐃᓱᒪᒋᔭᖃᖅᑐᖅ ᐱᓕᕆᐊᑉ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᕆᑦ ᓴᓇᕐᓕᓕᐊᓂᒃᑯᑦ, ᐊᐅᓛᕐᓂᒃᑯᑦ, ᐊᒻᒪᓗ ᓄᖃᖅᐸᓪᓕᐊᑎᑦᑎᓂᐅᔪᓄᑦ. ᑎᑎᖅᑲᖅ ᐃᓱᒪᒋᔭᖃᖅᑐᖅ ᐱᓂᕐᓗᐊᕐᑭᓂᐅᔪᓂᒃ ᐊᒻᒪᓗ ᐊᔪᓕᖅᑐᓂᒃ ᑕᒪᒃᑯᐊ ᐃᓚᒋᔭᐅᖕᒋᑐᑦ ᐸᕐᓇᐅᑕᐅᓯᒪᔪᓂᒃ ᖃᓄᐃᓕᐅᕐᓂᐅᓂᐊᖅᑐᓄᑦ ᐅᕙᓂᖓᑦ ᐊᐅᓛᕐᓂᐅᔪᒧᑦ. ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᙱᑦ (IT) ᐱᔾᔪᑎᒋᐸᓗᒍ ᐊᐱᖅᓱᐃᓂᕐᒥᑦ ᐊᒻᒪᓗ ᐱᓕᕆᖃᑎᕐᕿᑦᓱᔭᕐᓂᐅᔪᓂᑦ, ᑭᕙᓪᓕᕐᒥᑦ ᓄᓇᓕᖕᒥᐅᑦ ᐊᐱᖅᑯᑎᖃᓚᐅᖅᑐᑦ ᐊᑦᑕᓇᖅᑐᖏᑦᑕᐃᓕᒪᓂᐅᔪᓂᒃ ᐊᒻᒪᓗ ᐅᔾᔨᕆᐊᓇᖅᑐᓂᒃ ᐅᔭᕋᖕᓂᐊᖅᑐᓕᕆᐸᓗᓂ (EN-AR KIA Apr 2007[1], EN-BLOG Dec 2010[2]) ᐊᒻᒪᓗ ᐃᓱᓖᑦᑐᑏᑦ ᐱᔪᐊᖅᑐᓂᒃ ᐱᓂᕐᓗᐊᕐᑭᓂᕐᒧᑦ ᐊᔪᓕᖅᑐᓄᓪᓗ (IQ-CIHT 2011[3], EN-AR OH Nov 2013[4], EN-CI OH Nov 2012[5], EN-WC OH Nov 2012[6]).

ᑎᑭᐅᑎᓂᐊᕐᓗᓂ NIRB–ᑯᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᖏᓐᓄᑦ ᐊᒻᒪᓗ ᐱᓕᕆᐊᕆᓂᐊᕐᓗᒋᑦ ᓄᓇᓕᖕᓄᑦ ᐃᓱᓖᑦᑐᑕᐅᔪᑦ, ᑖᓐᓇ ᑎᑎᖅᑲᖅ EIS–ᒥᑦ ᓇᓗᓇᐃᖅᓯᔪᖅ ᐱᓂᕐᓗᐊᕐᑭᓂᐅᔫᓇᖅᑐᓂᒃ, ᐊᔪᓕᕈᖕᓇᖅᑐᓂᒃ, ᐊᒻᒪᓗ ᖃᓄᐃᙶᓕᕈᑕᐅᔪᓂᒃ ᐊᑐᑎᒥᒃ ᐱᓕᕆᐊᒥᑦ ᐱᔪᓂᒃ; ᐅᖃᐅᓯᕐᑲᖅᑐᖅ ᖃᓄᐃᓕᐅᕈᑕᐅᔪᒪᔪᓂᒃ ᐱᓂᕐᓗᐊᕐᑭᓂᖅᑕᕐᑲᖅᑕᐃᓕᒪᓂᕐᒧᑦ; ᐅᖃᐅᓯᕐᑲᖅᑐᖅ ᐊᖏᕐᓗᐊᖏᑎᐊᖅᑎᑦᑎᓂᐅᔪᒪᔪᓂᒃ ᐊᒻᒪᓗ ᐅᐸᕐᓗᐊᕐᓂᕐᒥᒃ; ᐊᒻᒪᓗ ᖃᐅᔨᓴᐃᐸᓗᓂ ᖃᓄᐃᙶᓕᖅᑎᑦᑎᓇᔭᕐᓂᖅ ᖃᓄᐃᙶᓕᕈᑕᐅᔫᓇᖅᑐᒥᒃ ᐊᑐᑎᒧᑦ ᐊᒻᒪᓗ ᐋᓐᓂᐊᕐᑲᖅᑕᐃᓕᒪᓂᕐᒧᑦ ᐊᑦᑕᓇᖅᑐᖏᑦᑕᐃᓕᒪᑎᑦᑎᓂᕐᒥᒡᒎ ᑕᐃᒪᓐᓇᐃᑐᖅᑕᕐᑲᕐᓴᖅᐸᑦ.

ᐊᕆᕚᒃᑯᑦ ᐊᑐᕐᑲᑦᑕᖅᑐᑦ ᖃᐸᓯᑲᓪᓚᖕᓂᒃ ᐅᓗᕆᐊᓇᖅᑐᓕᕆᓂᕐᒥᒃ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ, ᐊᑐᖅᓱᒍᓱᐊᖅ ᓇᓅᓐᓂᕆᔭᖕᒐ ᐱᓕᕆᐊᑉ ᐊᒻᒪᓗ ᐊᑐᖅᑕᐅᕐᑲᑦᑕᖅᑐᑦ ᑐᑭᓯᐅᒪᔾᔪᑏᑦ ᓴᖅᑭᑕᐅᕙᓪᓕᐊᔪᑦ. ᑕᒪᒃᑯᓇᓂ ᐊᑐᖅᑕᐅᕐᑲᑦᑕᖅᑐᓂᒃ ᐃᓚᐅᔪᑦ ᐅᓗᕆᐊᓇᖅᑐᓂᒃ ᐃᓕᑕᖅᓯᓂᕐᒥᒃ ᐊᒻᒪᓗ ᐊᖏᕐᓗᐊᖏᑎᐊᖅᑎᑦᑎᓂᖅ ᖃᓄᐃᓕᐅᖅᐸᓪᓕᐊᔭᓇᐊᕐᑲᕐᓂᐅᔪᓂᒃ, ᐱᓯᓂᓯᒧᑦ ᐅᓗᕆᐊᓇᖅᑐᒧᑦ ᐋᕿᒃᓯᒪᔪᑦ, ᐊᒻᒪᓗ ᐅᓗᕆᐊᓇᖅᑐᑦ ᐊᒻᒪᓗ ᐊᐅᓛᕐᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓃᑦ (HAZOP)–ᓄᑦ. ᒫᓐᓇ ᐊᑐᖅᑕᐅᔪᑦ ᐱᓕᕆᐊᑉ ᓇᓅᓐᓂᕆᔭᖓᑦᑕ ᖃᓄᐃᙶᓂᕆᔭᖓᓄᑦ ᕿᓂᖅᑐᑦ ᐃᓕᑕᖅᓯᓂᕐᒥᒃ ᐅᓗᕆᐊᓇᑕᓂᒃ ᐊᖏᕐᓗᐊᖏᑎᒋᐊᖅᑕᐅᔪᑦ ᖃᓄᐃᙶᓂᕆᔭᖓᒍᑦ ᐅᕙᓂᖓᑦ ᖃᓄᐃᙶᓕᕈᑕᐅᑐᐃᓐᓇᕆᐊᑏᑦ ᐊᑐᑎᒧᑦ ᖃᐅᔨᓴᐃᓂᖅᑕᖃᕆᐊᖅᑐᓄᑦ ᐊᖏᕐᓗᐊᖏᑎᒋᐊᕐᓂᕐᒥᒡᓗ. ᓄᓇᓕᖕᒥᐅᑦ ᓇᓗᓇᐃᓚᐅᖅᑐᑦ ᖃᓄᐃᓕᐅᕆᐊᖃᕐᓂᕐᒧᑦ ᐊᑐᕆᐊᑏᑦ ᑕᐃᒪᐅᔭᕆᐊᖃᕐᓂᖏᑦ ᐃᓄᐃᑦ[7] ᐊᒻᒪᓗ ᓂᕐᔪᑏᑦ[8] ᒥᐊᓂᕆᔭᐅᕐᑯᓪᓗᒋᑦ

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[1] EN- AR KIA Apr 2007: ᖃᓄᖅ ᐅᓗᕆᐊᓇᖅᑎᒋᕙ ᓄᖕᒋᐃᑐᖅ ᐅᔭᕋᖕᓂᐊᖅᑕᐅᔪᓂ?

[2] EN- BLOG Dec 2010: ᐊᑦᑕᓇᖅᑑᕆᓚᖅ ᐱᓕᕆᐊᖃᕐᓗᓂ ᓄᖕᒋᐃᑎᓕᕆᓂᕐᒥᒃ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥ?

[3] IQ-CIHT 2011: ᓯᓂᐊᖅᐸ ᐃᕐᔪᓯᖅᑐᑦ ᐊᕐᕕᑎᑦᓯᒥᒃ ᑯᕕᔪᖅᑲᖅᐸᑦ ᓄᖕᒋᐃᑐᒥᒃ?

[4] EN-AR OH Nov 2013: ᐃᒃᐹᓴᕐᓂᖅᓴᐅᓕᕚᕐᒐᑦ ᐱᓂᕐᓗᐊᕐᑭᓂᖅᑕᕐᑲᕐᓂᖅᓴᐅᓕᖅᑲᑦᑕᖅᐸ?

[5] EN-CI OH Nov 2012: ᐅᖅᓯᐊᓗᕐᒥᓪᓕ ᑯᕕᔪᕐᑲᕐᓴᖅᐸᑦ?

[6] EN-WC OH Nov 2012: ᓯᓇᔭᖅᐸ ᑎᕆᒦᕐᒥᒃ ᑲᓪᓚᑐᕐᑲᖅᐸᑦ ᐅᓯᔪᒥᒃ ᓄᖕᒋᐃᑐᒥᒃ?

[7] EN-BL NIRB April 2010: ᓄᖕᒋᐃᑐᖅ ᐃᓱᓖᓗᕐᓇᖅᑑᔪᖅ ᐅᓗᕆᐊᓇᖅᑑᓂᕐᓗᓂᑦ. ᖃᓄᐃᓕᐅᕆᐊᕐᑳᑦ ᑕᐃᒪᖖᒍᖅᑎᑕᐅᔭᕆᐊᕐᑲᕐᓂᐊᖅᑐᑦ ᐱᓕᕆᔨᐅᔪᑦ ᐱᓕᕆᕝᕕᐅᔪᓪᓗ ᒥᐊᓂᕆᔭᐅᕐᑯᓪᓗᑎᑦ ᑎᑭᐅᑎᓯᒪᔾᔪᑎᒋᓪᓚᑕᓗ ᓄᖕᒋᐃᑐᒧᑦ ᐊᒻᒪᓗ ᐱᑦᑕᐃᓕᒪᓂᖅᑕᕐᑲᓗᓂ ᐃᓄᐃᑦ ᖃᓪᓕᓗᐊᕐᑯᓇᕆᑦ.

[8] EN-CI NIRB May 2010: ᐃᓱᓖᑦᑐᑏᑦ ᐱᓂᕐᓗᐊᕐᑭᓂᐅᔪᓄᑦ ᐊᒻᒪᓗ ᐊᔪᓕᖅᑐᓄᑦ ᐅᓯᑲᑦᑕᖅᑐᓕᕆᓂᕐᒧᑦ ᐊᒻᒪᓗ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᓄᓇᒧᑦ ᓂᕐᔪᑎᓄᓪᓗ, ᐃᓄᖕᓂᒃ ᐃᑲᔪᐃᔪᑦ ᐃᓅᓂᕐᒧᑦ.

ᐱᓂᕐᓗᐊᕿᓂᖅᑕᕐᑲᕋᔭᖅᐸᒍᑦ. ᐊᖏᓗᐊᖏᑎᑦᑎᓇᓱᖕᓂᐅᔪᑦ ᐅᓗᕆᐊᓇᖅᑐᕕᕐᑯᓇᒋᑦ ᐃᓄᐃᑦ, ᓄᓇᓖᑦ, ᐊᕙᑎᒃᑦ, ᐊᒻᒪ ᐊᐅᓚᓃᕐᓂᐅᔪᖅ. ᐊᖏᓗᐊᖏᑎᑦᑎᓂᑦ ᓇᓚᐊᖕᓅᖕᖓᓕᖅᑎᓯᒪᔪᖕᓇᖅᑐᑦ ᐃᒪᓐᓇ: ᒥᒃᓵᒋᐊᖅᑎᑦᑎᓯᒪᓂᖅ ᐅᓗᕆᐊᓇᖅᑐᖅᑕᕐᑲᕋᔭᖅᐸᑦ (ᖃᐅᔨᖕᖓᓂᖏᑦ ᓱᕐᓗ ᐅᔭᕋᖕᓂᐊᕐᕕᖖᒦᑎᓐᓂᖅ, ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᑐᕌᖕᖓᔪᑦ ᐊᒻᒪ ᖃᐅᔾᔨᐊᕐᑲᑦᑕᐃᓐᓇᕐᓂᖅ); ᒥᑭᓛᒍᖕᖓᑎᓐᓂᖅ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᖅ ᑕᐃᒪᓐᓇᐃᑐᕐᑲᕋᔭᖅᐸᑦ (ᑐᐊᕕᓇᖅᑐᒃᑯᑦ ᐅᐸᓗᐊᓂᖅ, ᑯᕕᔪᖅᑕᕐᑲᕋᔭᖅᐸᑦ ᖃᓄᐃᓕᐅᕈᑏᑦ, ᐊᐅᓚᑦᑎᓂᖅ ᐊᒻᒪ ᖃᐅᔾᔨᐊᕐᑲᑦᑕᕐᓂᕐᒧᑦ ᑐᕌᖕᖓᔪᑦ); ᐊᒻᒪ ᖃᓄᐃᓕᐅᕈᑏᑦ ᐊᐅᓚᑦᑎᔪᖕᓇᖅᓯᑲᓐᓂᕐᓂᕐᒧᑦ ᖃᓄᐃᓕᐅᕐᓂᕋᓗᐃᑦ ᐱᒋᐊᑲᓐᓂᕐᑳᖅᑎᓐᓇᒋᑦ.

ᓱᕚᓪᓕᖅᐹᓕᐊᖅ ᑐᐊᕕᓇᖅᑐᒃᑯᑦ ᐅᐸᓗᐊᓂᕐᒧᑦ ᐸᕐᓇᐅᑎ (ᐸᕐᓇᐅᑎ) ᐱᓕᕆᐊᖑᓚᐅᖅᑐᖅ ᐱᓕᕆᐊᒨᕐᖓᐸᓗᒍ. ᐸᕐᓇᐅᑎ ᒪᓕᒃᑕᐅᔪᒃᓴᖅᑲᖅᑐᖅ ᑕᒪᐃᓄᑦ ᑐᐊᕕᓇᖅᑐᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᐊᒨᕐᖓᔪᓄᑦ; ᓇᓗᓇᐃᖅᓯᓯᒪᔪᖅ ᐱᔭᒃᓴᐅᑎᓂᒃ, ᐱᓕᕆᐊᒃᓴᐅᑏᑦ ᐊᒻᒪ ᐅᓂᑉᑳᓕᐅᓇᐊᖅᑲᕐᓂᐅᔪᑦ ᑐᐊᕕᓇᖅᑐᓕᕆᓂᕐᒧᑦ; ᐊᒻᒪ ᓇᓗᓇᐃᔭᖅᓯᒪᔪᑦ ᐊᔾᔨᒌᖏᑦᑐᓄᑦ ᑐᐊᕕᓇᖅᑐᓂᒃ ᐅᐸᓗᐊᓂᕆᓂᑦ ᐃᓚᐅᑉᓗᑎᒃ ᐃᓅᓯᕐᒧᑦ ᑐᐊᕕᓇᖅᑐᓕᕆᓂᑦ, ᐱᓕᕆᔨᓂᒃ ᑐᐊᕕᓇᖅᑐᓕᕆᓂᑦ, ᓯᓚᑉᑎᖕᓂᑦ ᖃᓄᐃᓕᓂᕐᒧᑦ ᑐᐊᕕᓇᖅᑐᓕᕆᓂᑦ ᐊᒻᒪ ᐊᐅᓚᓃᕐᓂᕐᒧᑦ ᑐᐊᕕᓇᖅᑐᓕᕆᓂᑦ.

ᓱᓇᐅᔪᖕᓇᕐᓂᖏᑦ ᐊᒻᒪ ᖃᐅᔨᓴᑦᑎᐊᕐᓂᐊᕐᓗᒍ ᐱᓂᕐᓗᐊᕿᓂᐅᔪᖕᓇᖅᑐᑦ ᐊᒻᒪ ᐊᔪᓕᕈᖕᓇᖅᑐᑦ ᐱᓕᕆᐊᒨᕐᖓᔪᑦ, ᖃᑉᓯᐊᕐᔪᐃᑦ ᐅᓗᕆᐊᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᐃᓃᑦ ᐊᑐᖅᓱᓂ ᐊᔾᔨᒌᖏᑦᑐᓂᒃ ᐋᕿᐅᒪᔪᓂᒃ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᑦ. ᐅᓗᕆᐊᓇᖅᑐᑦ ᓱᓇᐅᓂᖏᑦ ᐃᓕᑕᓇᔭᐅᖅᑲᑦᑕᖅᑐᑦ ᑕᐃᒪᓐᓇᐃᑐᕐᑲᕋᔭᖅᐸᑦ ᐊᒻᒪ ᖃᓄᐃᖕᖓᓕᕈᑕᐅᔪᖕᓇᕐᓂᐅᔪᑦ ᐊᕙᑎᒧᑦ, ᐆᓐᓇᖅᑐᒧᑦ ᑎᑭᓯᒪᓂᖅ ᐅᕙᓘᓂᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᓂᕐᒧᑦ ᐊᒻᒪ ᐊᑦᑕᓇᖅᑐᒦᑦᑕᐃᓕᒪᓂᕐᒧᑦ. ᕿᒥᕐᕈᓂᖅ ᓇᓃᓐᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᖅ ᑕᒪᐃᓂᒃ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᐃᓕᑕᖅᓯᓚᐅᖅᑐᑦ ᐊᔾᔨᒌᖏᑦᑐᓂᒃ ᐱᓂᕐᓗᐊᕿᓂᐅᔪᖕᓇᖅᑐᓂᒃ ᐊᒻᒪ ᐊᔪᓕᕈᖕᓇᖅᑐᓂᒃ. ᑕᒪᒃᑯᐊ ᐅᓗᕆᐊᓇᖅᑐᑦ ᖃᐅᔨᓴᖅᑕᐅᑲᓐᓂᓚᐅᖅᑐᑦ ᐃᓕᑕᖅᓯᔪᒪᓂᕐᒧᑦ ᑕᐃᒪᓐᓇᐃᑐᕐᑲᖅᑎᑦᑎᖏᓐᓂᕐᒧᑦ, ᐅᐸᓗᐊᓂᕐᒧᑦ, ᐊᒻᒪ ᐊᖏᓗᐊᖏᑎᑦᑎᒋᐊᕐᓂᕐᒧᑦ ᒥᑭᓛᒍᖕᖓᑎᓐᓂᕐᒥᒃ ᐊᕙᑎᒥᒃ ᖃᓄᐃᖕᖓᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓂᒃ. ᕿᒥᕐᕈᓂᕐᒥᒃ ᖃᐅᔨᓴᐃᓂᖅ ᐱᓂᕐᓗᐊᕿᓂᐅᔪᓂᒃ ᐊᒻᒪ ᐊᔪᓕᖅᑐᓂᒃ ᓱᓇᐅᓂᖏᓐᓂᒃ ᑕᒪᐃᓂᖅᑲᔭᖅ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ ᐅᓗᕆᐊᓇᖅᑐᓄᑦ ᐊᑎᒃᑑᔪᖅ, ᐃᓚᖏᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᓂᕐᒧᑦ ᐊᒻᒪ ᐊᑦᑕᓇᖅᑐᒦᑎᑦᑎᑕᐃᓕᒪᓂᖅ ᐅᓗᕆᐊᓇᖅᑐᓂᒃ, ᓱᕐᓗ ᐃᑯᐊᓪᓚᒃᑐᖅᑲᖅᐸᑦ ᖄᖅᑐᖅᑲᖅᐸᓪᓘᓂᑦ, ᕿᑎᐊᓃᓗᓂ.

ᐅᖅᓱᐊᓗᐃᑦ ᑯᕕᔪᑦ ᐊᒻᒪ ᐊᓯᖏᑦ ᐅᓗᕆᐊᓇᖅᑐᑦ ᐊᑐᖅᑕᐅᖅᑲᑦᑕᖅᑐᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᓄᖑᓯᐃᑐᑦ ᒥᑭᓪᓕᑎᖅᓯᒪᔪᑦ, ᐅᔭᕋᖕᓂᐊᕐᓂᐅᑉ ᑭᓪᓕᓕᐅᖅᑕᐅᓯᒪᓂᖓᑕ ᓯᓚᑖᓂᑦ, ᐃᓕᑕᓇᔭᐅᓚᐅᖅᑐᑦ ᕿᑎᐊᓃᓐᓂᖏᓐᓄᑦ ᐅᓗᕆᐊᓇᕐᓂᖓ. ᑕᒪᒃᑯᐊ ᖃᓄᐃᖓᓂᐅᔪᑦ ᒪᓕᒃᑯᒋᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᐃᓱᒫᓘᑕᐅᔪᑦ ᓄᓇᓕᖕᓂᑦ, ᖃᐅᔨᓴᐃᑲᓐᓂᕐᓂᖅᑕᕐᑲᓚᐅᖅᑐᖅ ᐊᓯᖅᑐᐃᓂᕐᒧᑦ ᐱᓂᕐᓗᐊᕿᓂᐅᔪᖕᓇᖅᑐᑦ ᐊᒻᒪ ᐊᔪᓕᕈᖕᓇᖅᑐᑦ ᐊᓯᖅᑐᐃᑲᑕᖕᓂᒃᑯᑦ ᐊᒻᒪ ᓯᑲᐅᑯᑦ ᐊᓯᖅᑐᐃᓂᕐᒧᑦ ᐅᓗᕆᐊᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᒃᑯᑦ.

ᐊᓯᖅᑐᐃᓂᕐᒧᑦ ᐅᓗᕆᐊᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᖅ ᐃᓕᑕᖅᓯᓚᐅᖅᑐᖅ ᐃᓚᖏᑦ ᕿᑎᐊᓃᓐᓂᖓᓂᒃ ᐅᓗᕆᐊᓇᖅᑐᑦ ᑯᕕᔭᖅᐸᑦ (yellowcake)–ᒥᑦ. ᐅᓗᕆᐊᓇᖅᑐᑦ ᓄᓇᒃᑰᕈᑎᒥᒃ ᐊᒃᓴᓗᑭᑖᖅᑐᖅᑲᖅᓗᓂ ᑕᐃᒪᓐᓇᐃᑐᖅᑲᕈᒥᓇᙵᑎᑦᑐᖅ ᐊᒻᒪ ᖃᓄᐃᖕᖓᓕᕈᑎᖕᖓ ᒥᑭᓗᓂ. ᑎᖕᒥᓲᕐᒥᑦ ᑲᑦᑐᖅᑲᖅᐸᒍᑦ, ᑕᐃᒪᓐᓇᐃᑐᖅᑲᕈᒥᓇᙵᑎᑦᑐᖅ ᖁᑦᑎᒃᑑᑉᐳᓂᓕ ᖃᓄᐃᖕᖓᓕᕈᑕᐅᔪᖕᓇᕐᓂᖓ ᐃᓄᖕᓄᑦ (yellowcake)–ᒥᒃ ᑯᕕᔭᖅᐸᑦ ᐊᖏᓂᖓ ᐊᑦᑎᖕᓂᖅᓴᐅᓇᔭᕐᒪᑕ ᓈᓪᒪᒋᔭᐅᔪᓂᒃ ᑭᓪᓕᐅᔪᓂᒃ. ᓴᙱᔫᔪᓂᒃ ᐋᕿᒃᓯᓯᒪᓂᐊᖅᑐᑦ, ᑐᐊᕕᓇᖅᑐᓄᑦ ᐅᐸᓗᐊᓂᕐᒧᑦ ᐸᕐᓇᐅᑎᓂᒃ ᐊᒻᒪ ᐱᑕᖅᑲᖅᑎᑦᑎᑕᐃᓕᒪᓂᒨᖕᖓᓕᔪᓂᒃ (yellowcake)–ᒥᒃ ᑯᕕᔭᖅᑯᓇᒍ. ᐊᔾᔨᐸᓗᖏᓐᓂᒃ ᐋᕿᒃᓯᓯᒪᓂᐊᖅᑐᑦ ᐅᖅᓱᐊᓗᐃᑦ ᐊᒻᒪ ᐊᓯᖏᑦ ᑯᕕᔪᑦ ᐱᑕᖅᑯᓇᒋᑦ.

ᐃᒪᕐᒥᐅᑕᓄᑦ ᐅᔪᕆᐊᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᒃ ᐃᓕᑕᖅᓯᓚᐅᖅᑐᑦ ᕿᑎᐊᓃᓐᓂᖓᓂᒃ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᐃᓱᒪᕆᔭᐅᔪᑦ ᓈᒻᒪᕆᔭᐅᓂᖏᑦ ᓴᓐᖏᔪᒥᒃ ᐊᐅᓚᑕᐅᓂᖃᕐᖁᑎᒃ. ᖃᑉᓯᐊᕐᔪᐃᑦ ᑕᒪᒃᑯᓇᓂ ᐃᓚᐅᔪᑦ ᐃᒃᑲᕐᓇᕈᐃᓐᓇᓇᐊᖃᕐᓂᖏᑦ ᓯᑲᐅᑦ Chesterfield Narrows-ᒥᑦ. ᕿᑎᐊᓂᑦ ᐅᔪᕆᐊᓇᖅᑐᑦ ᐅᖅᓱᐊᓗᖏᑦ ᑯᕙᔪᖃᖅᐸᒎᑦ ᖃᒪᓂᑦᑐᐊᕐᒥᑦ ᐃᓕᑕᕆᔭᐅᓚᐅᖅᑐᖅ. ᕿᑎᐊᓃᑐᓂᒃ ᐅᔪᕆᐊᓇᖅᑐᒃᑲᓐᓂᑦ ᐃᓕᑕᕆᔭᐅᓚᐅᕐᒥᔪᑦ ᐱᓕᕆᐊᓖᑦ ᐋᓐᓂᐊᕐᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᐊᒪᓗ ᐊᑦᑕᓇᖅᑐᒦᑦᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᑐᓚᒃᐸᓪᓕᐊᓂᕐᒥᒃ ᐊᐅᓛᕐᓂᖃᖅᑎᓪᓗᒋᑦ ᐃᒡᓗᓕᒫᕐᔪᖏᑦ ᐊᒪᓗ ᓯᑲᐅᑦ ᑐᓚᒃᐸᓪᓕᐊᑎᓪᓗᒋᑦ ᖃᒪᓂᑦᑐᐊᐸ ᐃᒃᓴᕐᕙᖓᓄᑦ. ᓴᓐᖏᔪᑦ ᐋᕿᒃᑕᐅᓯᒪᔪᑦ, ᑐᐊᕕᓇᖅᑐᓄᑦ ᐅᐸᓗᐊᔪᖓᕐᓂᖅ, ᐱᑕᖃᖅᑎᑦᑎᑦᑕᐃᓕᒪᓂᑦ ᓱᕐᓗ ᑭᓴᕝᕕᐅᓂᕐᒧᑦ ᐋᕿᒃᓯᒪᔪᑦ ᐊᑐᓕᖅᑎᑕᐅᓂᐊᖅᑐᑦ ᐊᖏᓗᐊᖏᑎᑦᑎᕆᐊᕐᓂᕐᒧᑦ ᑕᒪᒃᑯᓂᙱᑦ ᐅᔪᕆᐊᓇᖅᑐᓂᒃ.

ᖃᓄᐃᖓᓂᕆᔭᖓ ᓯᑲᐅᓂᒃ ᐊᔾᔭᖅᑐᐃᓂᕐᒧᑦ ᐅᔪᕆᐊᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᐅᑉ ᓇᔪᓇᐃᖅᓯᔪᖅ ᓈᒻᙱᑦᑐᒥᒃ ᐅᔪᕆᐊᓇᖅᑐᖅᑕᖅᑲᖅᑐᖅ ᓯᑲᐅᑦ ᐃᒃᑲᕐᓇᕈᐃᓐᓇᓇᐊᖃᕐᓂᖏᓐᓄᑦ Chesterfield Narrows-ᒥᑦ ᐱᔾᔪᑎᒋᐸᓗᒍ ᓇᒧᙵᐅᓂᖏᑦ ᓴᖑᐃᔭᕐᓂᖓᓘᓃ ᑕᐃᑯᓈᖅᐸᓪᓕᐊᑎᓪᓗᒋᑦ ᐅᒥᐊᕐᔪᐊᖅ ᑳᓪᐸᓗᓂ ᒪᕐᕉᖕᓂᒃ ᓯᑲᐅᓂᒃ. ᑕᐃᒪᓐᓇᒎᑦ, ᐃᒪᒃᑯᑦ ᐊᒡᒐᖅᑐᐃᓂᕐᒧᑦ ᐸᕐᓇᐅᑎᒥᑦ ᐃᓚᐅᔪᖅ ᑕᐃᑯᙱᐅᑎᓪᓗᒍ ᐅᒥᐊᕐᔪᐊᖅ ᐊᑕᐅᓯᕐᒥᒃ ᓯᑲᐅᒥᒃ ᑳᓪᓗᓂ Narrows-ᑰᖅᑎᓪᓗᒍ.

ᓯᓚ ᐊᒃᑐᖅᓯᓂᖃᕈᓐᓇᖅᑐᖅ ᐱᓕᕆᐊᒥᒃ ᖃᑉᓯᐊᕐᔪᒃᑎᒍᑦ, ᐃᓚᐅᑉᐳᑎᒃ: ᓯᓚᓗᒃᑎᓪᓗᒍ, ᓱᕐᓗ ᐱᖅᓯᖅᑎᓪᓗᒍ, ᐊᓄᕆᑐᑎᓪᓗᒍ, ᖃᐅᓯᕐᓇᕐᔪᐊᖅᑎᓪᓗᒍ, ᓯᓚᓗᓕᑳᓪᓚᖕᓂᒃᑯᑦ, ᑕᒃᓯᖅᑐᒥᑦ; ᓯᓚᐅᑉ ᖃᓄᐃᓐᓂᕆᔭᖓᓄᑦ, ᓱᕐᓗ ᐊᐅᒃᐸᓪᓕᐊᓂᖅ ᒪᓂᕋᒧᑦ; ᓄᓇᐅᑉ ᐃᑐᐊ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᖓᓄᑦ; ᓂᕐᔪᑎᓄᑦ ᑎᑭᑕᐅᖃᑦᑕᕐᓂᒃᑯᑦ; ᐃᑯᐊᓛᖅᑐᒧᓪᓗ. ᑕᐃᒪᓐᓇᐃᑐᖅᑐᐃᓐᓇᓇᐊᖃᕐᓂᐅᔪᖅ ᐱᓂᕐᓗᐊᕿᑎᑦᑎᓗᓂ ᐊᒪᓗ ᐊᔪᓕᖅᑎᑦᑎᓗᓂ ᖃᐅᔨᓴᖅᑕᐅᓚᐅᖅᑐᖅ ᐃᓚᒋᔭᐅᑉᓗᓂ ᕿᒥᕐᕈᓂᕐᒥᒃ ᐅᔪᕆᐊᓇᖅᑐᓂᒃ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ.

ᐱᓂᕐᓗᐊᕿᓃᑦ ᐊᒪᓗ ᐊᔪᓕᕐᓃᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᓯᓚᒧᑦ ᑕᐃᒪᓐᓇᐃᓕᔪᑦ, ᓂᕆᐅᕆᔭᐅᔪᑦ ᕿᒪᒃᑎᑦᑐᓂᒃ ᖃᓄᐃᖓᓕᕈᑕᐅᔾᔭᖕᖏᓐᓂᖕᖏᓐᓄᑦ ᐊᕙᑎᒧᑦ. ᐱᑦᑕᐃᓕᒪᑎᑦᑎᓂᖏᓐᓄᑦ ᐊᑐᖅᑕᐅᔪᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᖃᓄᐃᖓᓂᕆᔭᖏᑦ, ᐊᑐᕈᓐᓃᕐᓂᖏᓐᓄᑦ, ᑐᒡᓕᖓ ᐱᖓᓱᖓᓪᓗ ᐃᓂᕆᔭᐅᔪᑦ, ᐊᐅᓚᑦᑎᓂᖏᓐᓄᑦ ᐸᕐᓇᐅᑏᑦ, ᐊᑉᕐᑯᓯᕆᓂᖏᓐᓄᑦ ᐊᐅᓚᑦᑎᓂᖅ ᐊᒪᓗ ᐊᑦᑕᓇᖅᑐᒦᑦᑕᐃᓕᒪᙳᐊᑦ[9], ᐱᑕᖃᖅᑎᑦᑎᑦᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᐋᕐᕿᐊᖅᓯᓃᑦ, ᐊᐅᓛᕐᓂᐅᖏᓐᓇᖅᑐᑦ ᐊᒪᓗ ᐊᕙᑎᒥᒃ ᖃᐅᔨᕆᐊᖃᑦᑕᕐᓂᖅ, ᐊᑦᑕᓇᖅᑐᒦᖏᑦᑐᑎᒃ ᐱᓕᕆᐊᖃᕐᓂᖏᓐᓄᑦ ᐸᕐᓇᐅᑏᑦ, ᐊᒪᓗ ᐊᔪᕈᓐᓃᖅᓴᐃᓂᖏᓐᓄᑦ ᑐᕌᖓᔪᑦ ᓴᖅᑭᑦᑐᕐᑲᕋᔭᖅᐸᑦ ᒥᒃᓵᓂᑦ ᐊᖅᓯᑎᑦᑎᓂᖏᓐᓄᑦ ᑕᐃᒪᓐᓇᐃᑐᓂᒃ ᓴᖅᑭᑦᑐᕐᑲᕋᔭᖅᐸᑦ. ᐅᐸᓗᐊᓂᖏᓐᓄᑦ ᐱᓕᕆᐊᖑᔪᑦ, ᐃᓚᐅᔪᑦ ᑐᐊᕕᓇᖅᑐᓄᑦ ᐅᐸᓗᐊᔾᔪᐅᓂᐊᖅᑐᑦ, ᑐᐊᕕᓇᖅᑐᓄᑦ ᐅᐸᓗᐊᓂᖏᓐᓄᑦ ᐸᕐᓇᐅᑎ, ᑯᕙᔪᖃᖅᐸᑦ ᖃᓄᐃᓕᐅᕈᑎᓄᑦ ᐸᕐᓇᐅᑎ, ᑯᕙᔪᖃᖅᐸᑦ ᐊᑐᖅᑐᒃᓴᐃᑦ, ᖃᐅᔨᕆᐊᖃᑦᑕᕐᓂᖏᓐᓄᑦ ᑐᑦᑏᕐᓗᔪᑦ, ᐊᔪᕈᓐᓃᖅᓴᖅᓯᒪᔪᑦ ᓯᕗᓪᓕᐅᑉᓗᑎᒃ ᐅᐸᓗᐊᔾᔪᑦ, ᐊᒪᓗ ᐋᓐᓂᐊᕐᕕᒃ ᐱᓕᕆᔾᔪᖃᕐᑐᓂ, ᑕᐃᒪᐅᑎᑕᐅᓂᐊᖅᑐᑦ ᖃᓄᐃᓕᔪᖃᕐᑲᓗᐊᖅᐸᑦ.

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[9] EN- BL OH Nov 2013: *ᐊᑉᕐᑯᑎᒥᒃ ᐊᐅᓚᑦᑎᓂᖅ ᐱᒻᒪᕆᓪᓚᑦᑖᖑᔪᖅ ᐊᑦᑕᓇᖅᑐᖅᑕᖅᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᐊᒪᓗ ᐊᑦᑕᓇᖅᑐᖅᑕᖅᑲᓕᖅᐸᑦ ᕿᒫᕝᕕᖕᓄᑦ.*

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Attachments

Attachment A Kiggavik Project Risk Assessment - Result
Attachment B Evaluation of Radiation Exposures Related to Accidents and Malfunctions

Abbreviations

AED	Automated External Defibrillators
ANFO	Ammonium Nitrate/Fuel Oil
AREVA	AREVA Resources Canada Inc
Bq/m3	Becquerel per cubic metre
Bq/s	Becquerel per second
CNSC	Canadian Nuclear Safety Commission
DAC	Derived Air Concentration
DCFRn	Radon Dose Conversion Factor
DCFRnP	Radon Progeny Dose Conversion Factor
e.g.	Example
EIS	Environmental Impact Statement
ERn222	Radon emissions
ERP	Emergency Response Plan
ERT	Emergency Response Team
GPS	Global Positioning System
GDR	Gamma Dose Rate
Gy	Gray
HAZOPS	Hazard and Operability Studies
i.e.	id est (that is)
LLRD	Long Lived Radioactive Dust
Project	Kiggavik Project
m2	square metre
m3	cubic metre
m3/h	cubic metre per hour
MSDS	Material Safety Data Sheets
mGy/h	milliGray per hour
NIRB	Nunavut Impact Review Board

NLCA .... Nunavut Land Claims Agreement

PMP ....Probable Maximum Precipitation

PPE .... Personal Protective Equipment

Ra-226 .... Radium

Rn .... Radon

RnP .... Radon Progeny

SHEQ .... Safety, Health, Environment, Quality (SHEQ) Department

Sv .... Sievert

TMF .... Tailings Management Facilities

U3O8 .... Uranium Concentrate

WL ....Working Level

WTP .... Water Treatment Plant

µGy/h .... microGray per hour

µSv .... microSievert

µSv/h .... microSievert per hour

% U .... percent Uranium

1 Introduction

1.1 Background

The Kiggavik Project (Project) is a proposed uranium ore mining and milling operation located in the Kivalliq region of Nunavut approximately 80 km west of the community of Baker Lake (Figure 1.1-1). The Project is operated by AREVA Resources Canada Inc. (AREVA), in joint venture partnership with Japan-Canada Uranium Company Limited (JCU) and Daewoo International Corporation..

Within the Kiggavik Project there are two general site areas referred to herein as the Kiggavik site and the Sissons site. The two sites are located approximately 17 km apart. Three uranium ore deposits will be mined at the Kiggavik site: East Zone, Centre Zone and Main Zone. A uranium mill, related facilities, main accommodations, and landing strip will also be located at the Kiggavik site. The Sissons site has two uranium ore deposits to be mined: Andrew Lake and End Grid. Open pit mining will be used to extract the ore from the three Kiggavik deposits as well as the Andrew Lake deposit. Mining of End Grid ore will require underground methods.

All ore extracted from the mine sites will be processed through the Kiggavik mill. Mined out pits at the Kiggavik site will sequentially be used as tailings management facilities (TMFs) with East Zone being the initial TMF. The uranium product will be packaged and transported via aircraft to southern transportation networks. Initially, mill reagents, fuel and other supplies will be transported by barge to Baker Lake and then by truck to the mine site over a winter access road. An all-season road between Baker Lake and the Kiggavik Site is carried through the assessment as an option proposed as a contingency in case the winter road cannot adequately support the Project over its life-span.

Decommissioning of the Project will include demolition of site facilities, clean up and reclamation of any disturbed areas, closure of the TMFs and reclamation of mine rock piles to promote vegetative growth and to provide wildlife access.

Projection: NAD 1983 UTM Zone 14N
Creator: CDC Revised: TL
Date: 9/03/2014 Scale: 1:16,000,000
File:
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Geological Survey of Canada, AREVA Resources Canada Inc.*

FIGURE 1.1-1
GENERAL LOCATION OF PROPOSED KIGGAVIK PROJECT IN CANADA

ENVIRONMENTAL IMPACT STATEMENT
SECTION 1 INTRODUCTION

Kiggavik Project
AREVA

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The Kiggavik Project is subject to the environmental review and related licensing and permitting processes established by the Nunavut Land Claims Agreement (NLCA) (NIRB [Nunavut Impact Review Board] 2011), and to the licensing requirements of the Canadian Nuclear Safety Commission (CNSC). The Minister of Indian and Northern Affairs Canada (now Aboriginal Affairs and Northern Development Canada; AANDC) referred the Kiggavik Project to the NIRB for a Review under Part 5 of Article 12 of the NLCA in March of 2010.

The final NIRB “Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.’s Kiggavik Project (NIRB File No. 09MN003)” (NIRB 2011) were issued in May of 2011. AREVA submitted the Draft Environmental Impact Statement in December 2011 and again in April 2012 with the NIRB determining that the submission successfully conformed to the EIS guidelines in May 2012. Two review periods followed with the Information Request stage completed in January 2013 and the Technical Review stage completed in May 2013. An in-person technical meeting was hosted in Rankin Inlet, Nunavut by the NIRB in May 2013 with a Community Roundtable and a Pre-Hearing Conference (PHC) hosted in Baker Lake, Nunavut shortly after in June 2013. Following the Pre-Hearing Conference the NIRB issued the “Preliminary Hearing Conference Decision Concerning the Kiggavik Project (NIRB File No. 09MN003)” in July 2013.

1.2 Nunavut Impact Review Board Guidelines for The Environmental Impact Statement and Preliminary Conference Decision

The DEIS, including this volume, was determined by the NIRB on May 4, 2012 to have adequately addressed relevant sections of the NIRB “Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.’s Kiggavik Project (NIRB File No. 09MN003)” (NIRB 2011).

Greater clarity, consistency and, in some cases, additional design or assessment were provided within AREVA’s responses to information requests in January 2013 and technical comments in May 2013. AREVA commitments for the preparation of the FEIS and regulatory review requirements are listed in the NIRB PHC Decision dated July 2013. Changes from the draft to final EIS including the location of information related to information requests, technical comments, and PHC requirements is noted in the Final Environmental Impact Statement (FEIS) conformity table (Tier 1, Volume 1, Technical Appendix 1A

1.3 Purpose and Scope

The purpose of this document is to describe potential accidents and malfunctions associated with the Project and to characterize the potential interactions of those accidents and malfunctions with the environment and human health and safety.

The FEIS has been prepared to fulfil the intent of the NIRB Guidelines and PHC Decision, ultimately providing the information required to confidently proceed with an environmental assessment determination. The assessment has been influenced and reflects input provided from Inuit, Land Claim, Government, community, and other interested stakeholders

1.4 Report Content and Related Documents

In addition to this introduction section (Section 1), this document consists of the following sections:

- Section 2: provides an overview of the project.
- Section 3: describes accident and malfunction risk assessment approach and methods.
- Section 4: summarizes the preliminary Risk Management and Emergency Response Plan developed for the Project.
- Section 5: discusses the results of risk assessments for potential accidents and malfunctions, including incidents associated with mining, milling, transportation, and general activities. An assessment of the risk of radiation exposure associated with each accident and malfunction scenario considered is included as a supporting attachment. The influence of Inuit Qaujimajatuqangit and public engagement data on the assessments is also provided.
- Section 6: describes potential effects of the environment on the Project. This discussion focuses on identified environmental hazards.
- Section 7: summarizes the predicted residual effects from accidents and malfunctions and environmental hazards.

The potential effects of climate change on the predicted environmental effects of the Project have been assessed within numerous Tier 2 Volumes and Tier 3 Technical Appendices. The discussion in this Volume is focused upon the potential hazards to the Project associated with climate change.

Several Tier 3 documents are appended to this Volume to provide further details. AREVA recognizes the public concern associated with transportation accidents and therefore a detailed assessment of transportation risks is provided in Appendix 10A. The appendices to this volume are as follows:

- Technical Appendix 10A: Transportation Risk Assessment
- Technical Appendix 10B: Spill Contingency and Landfarm Management Plan
- Technical Appendix 10C: Emergency Response Plan

Design features and management plans developed to both prevent accidents and malfunctions and mitigate effects if they do occur have been fully described in Volume 2 and associated appendices. These features are briefly described, where necessary, within this Volume to provide context. Additional Tier 3 documents appended to other volumes in this EIS that provide more detailed information relevant to the assessment of accidents and malfunctions include:

- Technical Appendix 2C: Explosives Management Plan
- Technical Appendix 2D:Design of Ore and Mine Rock Pads and Ponds
- Technical Appendix 2F: Design for Andrew Lake Dewatering Structure
- Technical Appendix 2H: Ore Storage Management Plan
- Technical Appendix 2I: Water Management Plan
- Technical Appendix 2J: Marine Transportation
- Technical Appendix 2M: Road Management Plan
- Technical Appendix 2P: Occupational Health and Safety Plan
- Technical Appendix 2Q: Radiation Protection Plan
- Technical Appendix 2S: Waste Management Plan
- Technical Appendix 2U: Hazardous Materials Management Plan
- Technical Appendix 3C: Community Involvement Plan

2 Project Overview

2.1 Project Fact Sheet

Location	• Kivalliq Region of Nunavut, approximately 80 km west of Baker Lake. • The Project includes two sites: Kiggavik and Sissons (collectively called the Kiggavik Project). • The Kiggavik site is located at approximately 64°26'36.14"N and 97°38'16.27"W. • The Sissons site is located approximately 17 km southwest of Kiggavik at 64°20'17.61"N and 97°53'14.03"W. • The Kiggavik and Sissons sites are composed of 37 mineral leases, covering 45,639 acres.
Resources	• The total quantity of resources is currently estimated at approximately 51,000 tonnes uranium (133 million lbs U3O8) at an average grade of 0.46% uranium.
Life of Mine	• Approximately 12 years of production, based on studies to date. It is anticipated that pre-operational construction will require three years while remaining post-operational decommissioning activities will require ten years. • Date of Project construction will be influenced by favorable market conditions, completion of detailed engineering, and successful completion of licensing and other Project approvals.
Mining	• There are five individual mines proposed for the Project: East Zone, Center Zone and Main Zone at the Kiggavik site; End Grid and Andrew Lake at the Sissons site. • The three Kiggavik deposits and the Andrew Lake deposit will be mined by truck-shovel open pit, while End Grid will be an underground mine.
Mine Rock	• Mine rock will be segregated into material suitable for use in construction (Type 1), non-acid generating (Type 2), and potentially problematic material (Type 3). • Type 1, Type 2 and Type 3 rock will be managed in surface stockpiles during operation. • Upon completion of mining, Type 3 mine rock will be backfilled into mined-out pits.
Mill	• The ore will be processed in a mill at the Kiggavik site to produce 3,200 to 3,800 tonnes uranium (8.3 to 9.9 million lbs U3O8) per year as a uranium concentrate, commonly referred to as yellowcake.
Tailings	• The mill tailings will be managed at in-pit tailings management facilities constructed using the mined-out East Zone, Centre Zone and Main Zone open pits at the Kiggavik site. • Administrative and action levels will be used to control and optimize tailings preparation performance for key parameters.
Water Management	• A purpose-built-pit will be constructed at the Kiggavik site to optimize water management, storage, and recycling. • All mill effluent, tailings reclaim, and site drainage will be treated prior to discharge to meet the Metals Mining Effluent Regulations and site-specific derived effluent release targets. • Administrative and action levels will be used to control and optimize water treatment plant performance for key elements.

Site Infrastructure	• Power will be supplied by on-site diesel generators. • The operation will be fly-in/fly-out on a 7 to 14 day schedule with on-site employees housed in a permanent accommodations complex.
Access	• Access to the site will be provided by a winter road between Baker Lake and Kiggavik. An all-season road is assessed as an option should the winter road be unable to adequately support the Project. Supplies will be shipped to a dock facility at Baker Lake during the summer barge season and trucked to Kiggavik via the road. • An airstrip will be constructed and operated at site for transportation of personnel and yellowcake.
Environment	• Site-specific environmental studies have been on-going since 2007 • Public engagement and collection of Inuit Qaujimajatuqangit has been on-going since 2006; this information is integrated into the environmental effects assessment reports • AREVA's approach has been to integrate environmental assessment and decommissioning requirements into the Project design cycle to enhance mitigation of effects by design and to support the development of management, mitigation, and contingency plans to protect the environment
Benefits	• AREVA is negotiating an Inuit Impact Benefit Agreement with the Kivalliq Inuit Association • The total taxes and royalties to be paid on the Kiggavik project would be approximately $1 billion, payable to Nunavut Tunngavik Inc., Government of Nunavut, and Government of Canada. • The Project is expected to employ up to 750 people during construction and 400 to 600 people during operation.

The economic feasibility of the Kiggavik Project depends on 1) the production cost for the uranium concentrate including construction, operation and decommissioning costs and 2) the market value of the final product. The latest feasibility study completed for the Kiggavik Project was in November 2011. The study assessed the technical and economic viability of developing and operating a uranium mine and mill site in the Kiggavik area and estimated the capital cost of the Project at $2.1 billion and the operating cost at $240 million per year. This initial feasibility study will be updated and refined prior to a development decision. The market price for uranium concentrate over the last years has been within the range needed for a reasonable return on investment to its owners, however at the time of FEIS preparation was below the threshold needed for Project advancement. AREVA believes future opportunities are strong enough to encourage Project advancement with the intent of development that will coincide with viable future markets.

2.1 Assessment Basis

To ensure that the potential environmental and socioeconomic effects of the Kiggavik Project are adequately considered in this environmental assessment, it was determined that it would be advantageous to develop a clear "assessment basis" for the Project. The purpose of the assessment basis is to clearly and consistently define how the design parameters detailed in Tier 2 Volume 2 Project Description encompass the more conservative values for various design features and options. It is consistent with the precautionary principle to assess potential environmental effects conservatively to improve confidence that the Project can be realized within the predicted effects and approved environmental assessment.

The assessment basis is summarized in Table 2.1-1 and presented with greater detail in Tier 2 Volume 2 Section 20. For biophysical and some socio-economic effects, the range value with the greatest potential to result in an adverse effect is used. In the case of socio-economic benefits, the range value resulting in the lowest benefit is used.

Table 2.1-1 Project Assessment Basis

Project Activities/Physical Works	Parameter	Units	Parameter / Assumption Values	
			Base Case (PD)	Assessment Case
Overall	Production Rate	Tonnes U per year	3,200 – 3,800	3,200 - 4,000
	Mill Feed Rate	Kilotonnes per year	71 - 977	1,000
	Project Operating Life	Years	2 years pre-production 12 years production	25
	Project Footprint	Hectares (ha)	938	1,102
	Access Road Route	Not Applicable	Winter Road	Winter Road All-Season Road
	Dock Site Location	Not Applicable	Site 1	Sites 1,2, Agnico Eagle's Meadowbank Dock Site
Milling	Flowsheet	Not Applicable	Resin in Pulp (RIP)	Resin in Pulp (RIP), possibly solvent extraction (SX) and / or calciner
	Final Product	Not Applicable	Non-calcined uranium concentrate	Non-calcined or calcined uranium concentrate
Tailings Management	Containment volume	Million cubic metres (Mm^3)	28.4	30.0
	Total tailings volume (un-consolidated)	Million cubic metres (Mm^3)	21	30.0
	Design		Natural surround, no drain	Various design contingencies
Water Management	Freshwater requirements – no permeate or site drainage recycle	Cubic metres per day (m^3/day)	7,910	8,000
	Freshwater requirements –	Cubic metres per day (m^3/day)	2,000	8,000

Table 2.1-1 Project Assessment Basis

Project Activities/Physical Works	Parameter	Units	Parameter / Assumption Values	
			Base Case (PD)	Assessment Case
	permeate and site drainage recycle			
	Freshwater requirements - Sissons	Cubic metres per day (m^3/day)	60	60
	Treated effluent discharge at base quality – Kiggavik	Cubic metres per day (m^3/day)	2,707	3,000
	Treated effluent discharge – Sissons	Cubic metres per day (m^3/day)	1,700	1,700
Power Generation	Kiggavik peak load	megaWatt (MW)	13.0	13.0 – 16.8
	Sissons peak load	megaWatt (MW)	3.8	0 – 3.8
Logistics & Transportation	Number of barge trips – 5000t & 250 containers	Barge trips / year	9 - 31	31
	Number of barge trips – 7500t & 370 containers	Barge trips / year	7 - 22	22
	Number of truck trips – 56,000L & 48t	Truck trips / year	328 – 3,233	3,300
	Number of truck trips – 70,000L & 60t	Truck trips / year	243 – 2,405	2,500
	Number of yellowcake flights	Flights / year	310 - 350	355
Decommissioning	Period	Years	10	10

Under the *Nunavut Land Claims Agreement* and the *Nunavut Planning and Project Assessment Act*, the transportation of persons or goods does not trigger the definition of a transboundary project for an Article 12 Part 6 federal environmental assessment panel review unless that transportation is a substantial element of the project (NLCA 12.4.7(a)(ii) and NUPPAA 94(3)).

All resource development projects require the transport of goods to the project site and the transport of product to market. Proposed Project logistics and transportation infrastructure for the Kiggavik Project is presented in Tier 2 Volume 2 Section 10. There are existing, charted shipping lanes and flight routes throughout Canada and internationally. Projects with intense shipping programs may have increased the level of information for transportation in the project description and have assessed this in greater detail at the environmental assessment stage (e.g. Mary River), but more typically, the precedent is to focus the environmental assessment on the port or terminal area and, in some cases, immediately adjacent shipping activity (e.g. Irving Refinery, Newfoundland Transhipment, Kitimat LNG or Deltaport 3). Applying the precedent to the proposed Kiggavik Project, this would bound the assessment to include potential effects from barging in Chesterfield Narrows prior to reaching existing shipping routes in Hudson Bay and inclusion of potential accidents and malfunctions including take off and landing at the site airstrip prior to reaching altitude, but not product transport to its final destination.

The Kiggavik Environmental Impact Statement has included additional information on both marine and air transport that would be required to obtain licensing approvals with Transport Canada and the Canadian Nuclear Safety Commission.

Marine Transport

The Kiggavik marine assessment (Tier 2 Volume 7) has focused on the Chesterfield Inlet barging activities to Baker Lake as the main component of the environmental assessment, but has additionally provided information on potential effects to marine VECs in Hudson Bay and Hudson Strait.

Transiting through Hudson Bay and Strait, AREVA will follow established shipping routes recommended by Transport Canada and comply with federal legislation (e.g., *Shipping Act*) and regulations including those pertaining to safe operations, ballast water management, bilge water management, transportation of dangerous goods, and emergency response preparedness.

Air Transport

As a fundamental component of the environmental assessment, the Kiggavik accident and malfunction assessment (Tier 2 Volume 10) includes emergency response for necessities of life, personnel emergencies, natural environment-related emergencies and operational emergencies, as well as response strategies for a variety of spill scenarios. The assessment then considers the potential interactions of accidents and malfunctions with the environment and human safety taking into account the proposed mitigation measures including preventative measures and emergency response capabilities.

In addition, AREVA has provided a risk assessment for uranium ore concentrate (UOC) that would be transported by aircraft from the Kiggavik site airstrip southward to connect with established ground transportation routes currently used for shipments of UOC from existing mines in northern Saskatchewan. The likelihood and consequence of incidents involving the air transport of UOC has been assessed considering the flight path from the Kiggavik site to the airstrip at Points North, Saskatchewan. An assessment of the likelihood and consequence of several incident scenarios occurring during subsequent ground transportation of uranium ore concentrates throughout Canada has further been included.

Transportation of UOC will be in accordance with regulations governing the safe transport of radioactive materials including the *Transportation of Dangerous Goods Regulations* and the *Packaging and Transport of Nuclear Substances Regulations*. Development of an Emergency Response Assistance Plan (ERAP) is a post-environmental assessment requirement that must be accepted by Transport Canada prior to shipment. AREVA currently maintains an ERAP for UOC transport in Canada.

3 Assessment Approach and Methods

AREVA uses several approaches to risk assessment, depending primarily upon the stage of the Project and the end use of the information generated. These approaches include more general hazard identification and mitigation procedures, business risk models, and Hazard and Operability Studies (HAZOPs). The approaches used at the current level of Project design seek to identify major risks that are best mitigated through design or have potential environmental effects that require further assessment. Future HAZOPs and more detailed risk assessments required through the licensing process for nuclear facilities will be conducted as the Project progresses through the basic and detailed design phases. Further, on-going change management and risk assessment processes will be in place to identify and mitigate risks during the construction, operations, and decommissioning phases of the Project.

To fully characterize and evaluate the potential accidents and malfunctions associated with the Project, a number of risk assessments using varying methodologies have been conducted. The first assessment presented encompassed all Project activities at a screening level. Based on the results of this assessment and concerns expressed by local communities (Section 5.1), more detailed assessments were conducted on potential transportation accidents and malfunctions.

3.1 Screening Risk Assessment Methodology

The Project-wide risk assessment was conducted by a cross-disciplinary team based on the following:

- AREVA's experience with the construction, operation, and decommissioning of mining projects
- Previous risk assessments conducted for the Project during the integrated design and environmental assessment process
- Review of previous accidents and malfunctions associated with projects in Nunavut and the Northwest Territories
- Review of community (Section 5.1) and regulatory agency concerns
- Knowledge of the Project and the proposed activities.

The approach was comprised of the following steps:

- Discuss each component of the Project and brainstorm potential accidents and malfunctions associated with each component.
- For each identified accident / malfunction:

1. Assess the likelihood of the event occurring based on the criteria shown in Table 3.1-1.
2. Assess the potential consequences of the event based on the criteria shown in Table 3.1-2. Key categories used for consequence assessment include health and safety, radiation exposure, and environment. Where more than one category applies, the category with the highest consequence rating is used in the assessment.
3. Assign a risk rating based on Table 3.1-3.
4. Discuss any additional mitigation measures that may be applied to reduce the risk rating for an accident or malfunction.

Table 3.1-1 Criteria for Assessing Likelihood

	Likelihood	Comments	Probability of Event Occurring within 40 years
Almost Certain	> 1 in 10 Years	It is likely that the event has occurred at the site if the facility is more then a few years old	Greater than 98.5%
Likely	1 in 10 to 1 in 100 years	Might happen in a career	Between 98.5% and 44%
Unlikely	1 in 100 to 1 in 1000 years	Conceivable – has never happened in this facility but has probably occurred in a similar plant somewhere else	Between 44% and 4%
Highly Unlikely	< 1 in 1000 years	Essentially Impossible	Less then 4%

Table 3.1-2 Criteria for Assessing Consequences

Category	Consequence Rating			
	1	**2**	**3**	**4**
Health & Safety Risk	Minor: Nuisance and irritation, ill health leading to temporary discomfort, first aid treatment, minor cuts and bruises, eye irritation from dust, area exceeds internal administrative level.	Moderate: Some loss of hearing, dermatitis, asthma, upper limb disorder, minor disability, medical aid required, lacerations, burns, concussions, serious sprains, minor fractures, area exceeds a Threshold Limit Value	Major: Deafness, ill-health leading to major disability, medical aid required, lost limb injury, amputation, major muscle strain, major fracture, poisoning, multiple injuries, area routinely exceeds a Threshold Limit Value	Catastrophic: Life-shortening diseases, acute fatal diseases, ill health leading to permanent disability, fatality, area exceeds a Threshold Limit Value and causes harm to individual.
Radiation Exposure Risk	Minor: Area exposure rate or dose exceeds an internal administrative level.	Moderate: Area exposure rate or dose exceeds regulatory action levels.	Major: Area exposure rate or dose exceeds regulatory dose limit.	Catastrophic: Dose exposure exceeds regulatory emergency dose limit.
Environmental Risk	Minor: Incident, spill or occurrence reportable to regulators, measurable impacts to the environment is localized, exceeds admin. level	Moderate: Incident, spill or occurrence reportable to regulators, measurable impact to the environment causes harm but limited to site, exceeds regulatory action level requiring an official investigation	Major: Incident, spill or occurrence causes extensive harm beyond property, impacts have short term or reversible effects, exceeds regulatory limits	Catastrophic: Life shortening incident, spill or occurrence causes ecosystem to be impaired, either long term or irreversible effect to the environment, public inquiry

Table 3.1-3 Risk Rating Matrix

Likelihood		Consequence			
		1	2	3	4
		Minor	Moderate	Major	Catastrophic
4	Almost certain: > 1 in 10 yrs	2	3	4	4
3	Likely: 1 in 10 to 1 in 100 yrs	2	3	3	4
2	Unlikely: 1 in 100 to 1 in 1000 yrs	1	2	2	3
1	Highly unlikely: < 1 in 1000 yrs	1	1	2	2

NOTES:
Where: 4 – High Risk; 3 – Moderate Risk; 2 – Low Risk; 1 – Negligible Risk

The results of the risk assessment are provided in Attachment A.

3.2 General Transportation Risk Assessment Methodology – Uranium Concentrate, Fuel and Hazardous Chemicals

The transportation risk assessment addresses the risks of transporting hazardous goods and uranium concentrate through various transportation modes (i.e. via truck, barge and aircraft) to workers, the public, and the environment. Risks were considered during routine operations and if an accident were to occur. Only those risks associated with accident and malfunctions are described in this volume; routine operations risks have been described in Volume 8 Human Health.

Uranium concentrate transportation was assessed considering air transportation from the Kiggavik site to a destination with ground link to the south and then transport to refineries via land route by truck. As discussed in Volume 2 and Appendix 2A, AREVA is proposing air only transportation for uranium concentrate.

The accident scenarios assessed involved:

- rollover and crash of trucks along transportation routes and release of yellowcake, and other chemicals;
- release of fuel during barge transportation; and
- airplane crash and release of yellowcake.

The assessment of risk of transportation of yellowcake, fuel, and reagents involved the assessment of probability of accidents scenarios and the assessment of the impacts of the bounding scenarios that would serve to illustrate the most severe potential consequences. The bounding scenarios are selected based on the following aspects.

- frequency of the occurrence
- quantity of hazardous substances involved
- duration and potential spatial extent of releases to the environment
- magnitude of the effect on the environment

For accident assessment, various transportation accidents statistics for various mode of transportation were used to calculate the frequencies of transportation accidents scenarios.

The following species were considered for the assessment of accidents:

- aquatic receptors;
- terrestrial receptors; and
- human receptors.

The assessment of consequences was based on the calculations of the chemical concentrations in various environmental media, exposure pathways modeling for various receptors, selection of appropriate benchmark and risk characterization via comparison of the calculated values with their corresponding benchmarks. The assessment of transportation risk is fully discussed in Appendix 10A.

3.3 Marine Transportation Risk Assessment Methodology

The methodology used for the marine transportation risk assessment is summarized here; complete details are included in Technical Appendices 2J and 10A. The assessment consisted of the following steps:

1. definitions of hazard/risk
2. operations analysis whereby conservative scenarios for assessment were defined
3. hazard identification and evaluation
4. root causal analysis of hazards whereby root causes were identified
5. hazard severity rating whereby hazards were assigned a rating based on a five-point scale
6. probability ranking whereby hazards were assigned a probability of highly unlikely, unlikely, possible, likely, or probable
7. assign risk levels based on the hazard severity rating and probability ranking
8. identify additional mitigation measures for high level risks considered unacceptable

9. re-evaluate unacceptable risks including additional mitigation measures.

3.4 Radiation Exposure Risk Assessment Methodology

An evaluation of potential radiation exposure was conducted for each accident and malfunction scenario discussed in Section 5 of this document. For accident or malfunction scenarios which do not involve radioactive materials, no incremental radiation exposure results. The evaluation is presented as Attachment B with comments relevant to the screening risk assessment integrated into discussion of each scenario. Estimates of radiation exposure are developed by evaluating the radiation exposure rates associated with the scenario, and the estimated duration of exposure, and compared to radiation dose limits. Radiological evaluation of transportation accident involving uranium ore concentrates are discussed in Appendix 10A, Transportation Risk Assessment.

4 Summary of Management Plans

4.1 Emergency Response Plan

A preliminary Emergency Response Plan (Plan) has been prepared for the Project, as Technical Appendix 10C – Risk Management and Emergency Response Plan, is intended to:

- provide a guidance document for all emergencies related to the Project;
- describe the responsibilities, tasks and reporting requirements involved in an emergency;
- be used in conjunction with other supporting plans and documents; and
- cover various emergency response situations including necessities of life emergencies, personnel emergencies, natural environment-related emergencies and operational emergencies.

A key component of the Plan is a trained Emergency Response Team (ERT). The team's responsibilities will include:

- implementation of onsite safety and emergency response procedures;
- responding to emergencies involving injuries and fatalities;
- assisting with evacuation procedures; and
- responding to emergencies involving fires or explosions control and mitigate spills or other accidental releases.

In addition to the ERT, personnel designated with responsibilities during an emergency include the Site General Manager, the Site Commander, and the Safety, Health, Environment, Quality (SHEQ) Department.

Training is an integral component of risk management and emergency response. All employees will undergo formal safety and emergency response training during orientation. The training will identify site-specific hazards and hazards associated with the Project in general. The training will also review standard operating procedures, use of personal protective equipment, initial response to an emergency situation, evacuation routes and muster locations, location of MSDS, spill containment and response, reporting and notification protocol and other general safety procedures. Employees will be provided fire extinguisher training in their first year of employment and then every 3 years following initial training. Employees will receive specific emergency response training as required for their positions; for example this may include confined space entry, self-rescue in freezing water or wilderness survival training. All supervisors will undergo standard first aid training.

The Emergency Response Team members will be trained in emergency identification and currently accepted response action techniques. Training will be related to specific emergency response roles, and will include:

- emergency chain-of-command;
- emergency response plan training;
- communication methods and signals;
- worker health and safety during emergency interventions;
- emergency equipment and use;
- emergency evacuation;
- offsite support and use;
- personal protective clothing;
- response to hazardous materials incidents;
- response to fire;
- wilderness survival training, ice and water rescue, search and rescue;
- fire response and fire fighting techniques;
- spill response procedures and techniques on land, water, snow, and ice, and during all four seasons including marine spill response;
- spill response equipment and materials, marine shoreline recovery operations, debriefing; and
- Emergency Response Team members will also receive training as Medical First Responders.

Emergency Response equipment will be maintained by the SHEQ Department and the ERT. There will be adequate emergency response equipment to handle all types of anticipated emergencies. Emergency facilities will include:

- command center and alternate command center;
- a health centre;
- an on-call centre at the camp accommodations for minor after-hour emergencies;
- spill response kit/supplies area; and
- a center for emergency vehicles and ERT equipment.

Emergency response equipment such as automated external defibrillators (AEDs), fire extinguishers, first aid kits, emergency showers and eye wash stations will also be placed in strategic locations throughout site.

4.2 Spill Contingency Plan

A preliminary Spill Contingency Plan has been prepared for the Project, as Technical Appendix 10B – Spill Contingency and Landfarm Management Plan, is intended to:

- help prevent or reduce the potential of spills of pollutants;
- prevent, reduce, or eliminate any adverse effects that result or may result;
- provide information and guidance on actions important for the prevention of spills;
- provide procedures to detect and respond to spills; and
- outline procedures and best practices for managing the contaminated soils landfarm.

The preliminary Spill Contingency Plan also addresses issues and concerns raised through stakeholder engagement and Inuit Qaujimajatuqangit (IQ) interviews (e.g. EN-BL NIRB April 2010[1], EN-AR KIA Apr 2007[2], IQ-CI09 2009[3]). Environmental Emergency Response will be a joint responsibility of the Safety and Environment Group. Procedures that will be created will encompass responsibilities of the person discovering the spill, as well as the responsibilities of the Environment Group and the responsibilities of the Emergency Response Team (ERT) if required. The ERT will participate in regular scheduled training and emergency response exercises to ensure that all members are trained in equipment use and spill response methods. The ERT members will be trained in emergency identification and currently accepted response action techniques.

If required, additional assistance from government agencies such as Environment Canada, the Canadian Coast Guard, Fisheries and Oceans Canada, Transport Canada, or companies specialized in spill response operations will be obtained.

All personnel will receive formal orientation upon arrival at the Kiggavik site. The spill contingency awareness plan is reviewed during their orientation by the EHS Group or designate including the location of Material Safety Data Sheets, location of spill kits, and additional supplies and tools. Training for spill contingencies consists of alerting personnel to be watchful for leaks or spills and where these are most likely, instruction in the use of the equipment and materials, introduction to the protocol of chain of command, and the legal requirement to report certain spills. Additionally, all personnel are given training in initial spill response methods (first responder), which emphasizes personal safety, containment of the spill, and how to get help.

A spill is defined as the discharge of a hazardous material out of its containment and into the environment. Potential hazards to humans, vegetation, water resources, fish and wildlife vary in severity, depending on several factors including nature of the material, quantity spilled, location and season. Fuel is the main product that may be spilled and therefore spill response procedures focus

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[1] EN-BL NIRB April 2010: *Concerns over potential spills and accidents onto the land and water. How will this be handled and planned for?*

[2] EN-AR KIA Apr 2007: *Suppose something spills. How would you clean it or store it?*

[3] IQ-CI09 2009: *The risk of fuel spills is also a worry*

on this hazardous material. Other substances that may be spilled include ammonium nitrate, mill process reagents, untreated effluent, and radiologically contaminated materials.

Detailed information in the Spill Contingency Plan includes:

- responsibilities of the first responders and their safety;
- identifying, containing and reporting a spill;
- spill response expectations for the ERT and supervisors;
- what is considered reportable and the reporting requirements; and
- spill site restoration.

Site information has been included in the plan, along with a description of the key features at all the sites and whether there will be containments. Descriptions have been included for pre- development facilities, Kiggavik Site, Sissons Site and the Baker Lake Port.

Based on the large volume of fuel required to be transported and stored at the Kiggavik Project, this represents the largest potential for spills to occur. Information provided includes:

- the pre-development and operational inventory;
- response equipment;
- storage volumes and locations; and
- transfer protocols for the handling of petroleum products.

Various spill scenarios have been postulated for the predevelopment phase and the operational phase. These spill and response scenarios are described and include:

- spill of fuel from metal drums, 10,000 L fuel bladders, or fuel tanks on tundra;
- spill of fuel on land;
- spill of fuel on water or ice;
- spill of fuel on snow;
- leak of fuel from distribution lines;
- fire at fuel storage tanks;
- crash at fuel storage tanks;
- release of propane;
- spill of radiologically contaminated materials;
- spill of potentially contaminated/drill return water into a water body;
- spill of ammonium nitrate;
- spill of sewage; and
- chemical spills.

In the event of a spill, the contaminated soil or ice/snow will be excavated and transported in appropriate containers to the designated landfarm area for treatment. Before commencing any removal of soil, gravel or vegetation regulatory agencies will be contacted. The landfarm will be located within the Kiggavik surface lease boundary in a designated area.

5 Assessment of Potential Accidents and Malfunctions

The results of the Project-wide screening risk assessment are provided in tabular format in Attachment A.1, Kiggavik Project Risk Assessment - Results. For brevity, radiation exposure and occupational health and safety have been grouped together in the following discussions; a supporting assessment of potential radiological exposure for accident and malfunction scenarios is included as Attachment A2. However, the consequences in terms of these elements are assessed separately in Attachment A. Furthermore, as there are many different types of hazards and risks in relation to health and safety and the environment, they have been grouped into broader categories wherever feasible to provide a concise, yet comprehensive, discussion. Some sections are applicable to more than one area; however for organizational purposes, the topics have been categorized into Mine Accidents and Malfunctions, Mill Accidents and Malfunctions, and General Accidents and Malfunctions.

The general transportation and marine transportation risk assessments are summarized in Sections 5.5 and 5.6.

The ensuing discussion for each section includes an examination of probability, potential mechanisms that could cause the incident to occur, and the types of mitigative and preventative measures in place. The potential effects on health and safety and the environment if the accident or malfunction were to occur are discussed. Based on the assessment of likelihood and consequence, the risk is categorized as negligible, low, moderate, or high.

5.1 Influence of Inuit Qaujimajatuqangit and Public Engagement on the Assessment

The potential for accidents and malfunctions have been highlighted as a topic of interest by the communities through IQ interviews and engagement initiatives. A number of questions and comments are related to the potential for spills along the marine shipping route, particularly near Chesterfield Inlet. People have also expressed concern about potential contamination of the land due to spills at the Project sites. Some illustrative examples include:

- *What contingency plans / protection plans are in place for accidents while transporting, storing and transferring of yellowcake (roads, ships, water and land)?* (EN-BL NIRB April 2010)
- *If there is an accident with the ships and/or barges what would happen?* (EN-KIV OH 09)
- *What kind of impact would there be on the animals if yellowcake was spilled into the environment?* (EN-CH KIA 2010)
- *My concern is I notice winters are different now. Ice is thin. People on overland haul should be careful. Still many loads to go to Kiggavik.* (EN-BL CLC Mar 2010)

- *What if something wrong happens at Kiggavik?* (EN-BL HS Nov 2010)
- *Are safety courses provided?* (EN-KIV OH 09)
- *Workers believe that mining is safer than it used to be. They are not worried about occupational health and safety overly; just about large accidents and evacuation* (IQ-BLRW 2009)
- *What would happen if a cup of uranium was spilled?* (IQ-CIHT 2011)
- *What about the risk of a diesel spill?* (EN-CI OH Nov 2012)

Based on the results of the screening assessment (Section 3) and concerns expressed by local communities, more detailed assessments were conducted on potential transportation accidents and malfunctions. For instance, as a means of addressing and evaluating concerns related to transportation of hazardous materials and yellowcake, AREVA has conducted two additional risk assessments targeted at transportation of hazardous materials. These two additional risk assessments were driven by community concerns related to yellowcake transportation:

1. Transportation of yellowcake by air has been a topic of particular concern identified through public engagement activities (EN-WC OH Nov 2012[4]). Consequently, the transportation risk assessment (Tier 3, Technical Appendix 10A) has been updated from the draft EIS (December 2011) to the final EIS (September 2014) to consider incidents along the flight path between the Kiggavik site and the start of the ground transportation network at Points North, Saskatchewan.

2. Concern has been raised about the subsequent risk and potential consequence of incidents which may occur during transportation of yellowcake along the ground transportation network (EN-RI OH Nov 2012[5]). A current assessment of risk and potential consequences has been conducted for yellowcake transportation along AREVA's existing transportation routes (SENES 2014) and is included for reference as Tier 3, Technical Appendix 10A, Attachment B.

Continually planning and preparing for the future is one of the four maligait or main laws which contribute towards 'living a good life' (Tagalik 2012). Inuit stakeholders exemplified this maligait in questions about AREVA's emergency preparedness (EN-BLOG Dec 2010[6], EN-CI NIRB May 2010[7], EN-CH OH Oct 2012[8], EN-AR KWB Oct 2013[9]). Community members require emergency response

[4] EN-WC OH Nov 2012: *What would happen if a plane of uranium crashed?*

[5] EN-RI OH Nov 2012: *If there was a yellowcake spill (by barge, air, road) what would be the effect on the environment?*

[6] EN-BLOG Dec 2010: *What is the extent of the emergency response equipment, material and manpower that will exist during the ongoing operation?*

[7] EN-CI NIRB May 2010: *Concerns over accidents and malfunctions from shipping and impacts to land and wildlife, which people live off*

[8] EN-CH OH Oct 2012: *There have been big spills in B.C. and Florida. What do we have in place if we have a spill during shipment in such a harsh environment?*

[9] EN-AR KWB Oct 2013: *The route to Baker Lake has shallow areas. Will there be emergency response?*

plans and assurance that measures are being taken to prevent accidents and successfully respond to one should it occur (EN-BL NIRB April 2010[10]). To address these concerns, AREVA has prepared a preliminary Emergency Response Plan (Tier 3, Technical Appendix 10C Risk Management and Emergency Response Plan) and a preliminary Spill Contingency Plan (Tier 3, Technical Appendix 10B – Spill Contingency and Landfarm Management Plan).

A tug master experienced with transit through Chesterfield Inlet was engaged to assist with the development of the marine transportation assessment. This exemplifies AREVA's understanding of the IQ guiding principle (Nunavut 2008) of Qaujimanilik/Ihumatuyuk, which means a person who is recognized by the community as having in-depth knowledge of a subject.

Based on community input, AREVA has proposed the inclusion of marine monitors aboard vessels (IQ guiding principle Qaujimanilik/Ihumatuyuk) and spill response training for communities (EN-CH HTO Jan 2014[11]) along the shipping route. ERAP Plans will be in place for the transport of materials and these will include arrangements for prompt response to incidents. Project reporting will include reports of incidents. AREVA will continue to keep Kivalliq communities updated on transportation and other project plans and operations by meetings with Hunter Trapper Organization (HTO), Councils and Public meetings and will continue to include community input in plans. A community involvement process (Tier 3, Technical Appendix 3C) will be in place during all phases to ensure that communities are informed of any accidents and malfunctions and to provide a means of registering concerns.

5.2 Mine Site Accidents and Malfunctions

5.2.1 Transportation of Ore

Ore will be hauled from the Sissons site to the Kiggavik site within covered trailers along the Kiggavik-Sissons access road. During active hauling, minor spillage from haul trucks can result from overfilling or dusting. Both mechanisms will be carefully controlled by limiting the maximum loads or, if necessary, controlling ore dust through the use of a dust suppressant. Small spills will be detected by routine radiometric surveys of the road surface and cleaned up.

Severe damage or rolling of the trailer could result in a major spill of ore. The most likely causes of a major spill would be collision, severe weather, or human error. Preventative measures include

[10] EN-BL NIRB April 2010: *Concerns over potential spills and accidents onto the land and water. How will this be handled and planned for?*
[11] EN-CH HTO Jan 2014: *Have you talked about anchoring and emergency response with communities?*

campaigning of ore transport and the inclusion of surplus capacity in both the Kiggavik and Sissons ore pads. As such, travel during poor weather is not expected to be required in order to maintain sufficient feed to the mill. AREVA is in agreement with community members that road management is critical to ensure the safe transport of ore (EN-BL OH Nov 2013[12]). Additional preventative measures will include:

- Road design in accordance with the Nunavut *Mine Health and Safety Act*; with a minimum horizontal curve radius of 500 m, maximum grade of 5%, and safety berms along the embankment.
- Spill prevention measures will be in place prior to construction activities and will be detailed in the Spill Contingency and Emergency Response procedures.
- Truck drivers will be trained in heavy equipment operation and safe driving practices.
- All workers will be trained in spill prevention and emergency response procedures.
- Copies of these procedures and emergency contacts will be maintained in areas and vehicles where they are readily available and accessible to workers.
- All trucks will be fitted with first responder spill kits and first aid kits.
- Speed will be reduced to 30 km/h over major crossings.
- Hauling will be conducted in campaigns during fair weather as much as possible.
- During ore haul, all personnel will be notified on the radio that the road is being used for hauling ore to ensure they follow proper ore haul road procedures. All vehicles will be in radio contact to prevent collisions and provide warning of road hazards.
- Routine maintenance is conducted on the ore trailers including brake tests and daily equipment checks to minimize potential equipment malfunctions.
- Roads will be maintained and graded regularly.
- Snow clearing, when required, will be conducted in advance of hauling.

[12] EN-BL OH Nov 2013: *Road management is extremely important for safety, including the use of safety shelters when needed.*

These preventative measures are considered to reduce the probability of a major spill of ore to "unlikely".

The response to ore spillage would be as follows:

- Contact will be made immediately with Kiggavik Central Control to initiate the Spill Contingency Plan and Emergency Response Plan. Emergency Response team members will mobilize to the site of the accident within 30 minutes of response initiation.
- If safe to do so, immediate measures will be taken to reduce/prevent dispersion of the ore downstream using silt curtains and containment berms.
- Any ore remaining on the ground surface will be collected and any contaminated snow, soil and vegetation recovered. Materials unsuitable for milling will be placed in the contaminated waste storage area.
- Surveys will be conducted to ensure the area meets regulatory guidelines. The incident will be reported as described in the Spill Contingency Plan.
- An assessment of any environmental effects of the spill will be conducted and any restoration work required to remediate the site will be completed.
- Monitoring will be conducted as required.

Spill response and clean up would mitigate the effects of an ore spill, resulting in short-term moderate environmental effects. Spillage of materials on-site benefit from increased operational control over an incident relative to an off-site occurrence. Responses to on-site incidents have greater resources immediately available to mitigate environmental impacts than incidents which occur remotely from the site, hence, spills within the project footprint are discussed separately from spills which may occur during off-site transportation.

It is not anticipated that there would be any health or safety consequences resulting from an ore spill. Health and safety risks associated with general vehicle collisions are addressed in Section 5.4.5.

Conclusion: The environmental risks associated with transportation of ore are considered low.

5.2.2 Improper Segregation of Mine Rock and Ore

Segregation of mine rock types will be based on several layers of control, including geological modeling, sampling of drill cuttings, use of probe data and overhead scanner data. However, given the large volumes of rock moved by mining activities, at times mine rock or ore may be placed on the incorrect stockpile; for instance, Type 3 mine rock placement on the Type 2 mine rock stockpile.

Therefore, these stockpiles will be routinely monitored and radiometrically surveyed by staff. When mine rock or ore is identified on the incorrect stockpile, it will be collected and placed on the correct stockpile. The potential for interaction of incorrectly placed materials with the aquatic environment is further mitigated through the collection and sampling of drainage from all stockpiles. Therefore, although the likelihood of this incident over the life of the Project is likely, the environmental consequences are considered negligible.

There would be no health and safety consequences associated with this malfunction.

Conclusion: The risk of environmental consequences associated with segregation of mine rock and ore is considered low.

5.2.3 Release of Contaminants from Surface Ore Stockpiles

Ore stockpiles at the Kiggavik and Sissons sites will be contained within an engineered pad and drainage collection system. The release of contaminants from surface ore stockpiles to the aquatic environment could result from a leak in the ore pad whereby drainage is not collected in the ditches and pond. This occurrence would be detected by a leak detection system beneath the ore pad. There will also be routine sampling of down gradient groundwater monitoring stations. In the event that a deterioration of water quality was detected down gradient of one of the ore stockpile pads, further investigation would be conducted to identify the location of the leak. Once the leaking area is identified, the liner would be unearthed and repaired. Any contaminated water would ultimately report to the down-gradient open pits and be treated. Any remaining accumulation of contaminants resulting from leakage through the liner would be further cleaned during decommissioning to mitigate effects. The net result would be a localized, short-term interaction with the site groundwater, with negligible environmental effect.

No effects on health and safety are anticipated for release of contaminants from surface ore stockpiles. Furthermore, the conditions of the environment are favourable for the majority of the year as the ground is frozen, thus no dissolution occurs if a leak were to occur.

Conclusion: The risk of release of contaminants from surface ore stockpiles is considered low.

5.2.4 Failure of Slopes and Ground Control

Slope failures will be possible in the open pits due to unanticipated poor ground conditions, improper blasting, and seismic events. An unanticipated failure could lead to a fatality; however the likelihood of this is considered highly unlikely given proper pit design, slope monitoring and proper pit operation. Pits are designed conservatively to ensure, as far as practical, that no substantial slippage occurs throughout its life. More minor rock falls are anticipated and therefore safety berms are included in the pit design.

Ground control failures in an underground mining environment can lead to rock falls and more severe cave-ins. These can be prevented by anticipating when poor ground conditions may be encountered and by adopting proper blasting, backfilling, rock bolting, screening and shotcreting practices. These activities will be planned and monitored by ground control staff. In areas where poor ground control is expected, the mining method and ground control measures will be adjusted accordingly.

Major slope failures on stockpiles can lead to health and safety incidents. Slope stability will be monitored to ensure that a massive slope failure does not occur. Visual inspections will include: observing the walls for overhangs, loose, boulders, water inflows and potential changes in the face. The travelway will also be inspected for adequate and competent berms and surface conditions such as being dusty or slippery or areas requiring repair. The travelway ditches are inspected for proper containment of water inflows (i.e. not blocked or silted in). The wall faces immediately adjacent to the travelway are inspected for overhangs or loose that could pose a safety hazard to those using the travelway.

The TMF pit walls will be surveyed regularly for wall movement. During spring break-up periods surveys will be done more often if deemed necessary due to potential movement resulting from consistent freeze/thaw cycles and above normal runoff. Any unanticipated or unusual observations will be reported to the Mill Manager and the area will be secured until it is safe for entry.

It is considered highly unlikely that a major slope failure causing serious health and safety consequences will occur. The environmental consequences would be minor.

Conclusion: The risk of health and safety consequences associated with ground control and slope failures is considered low.

5.2.5 Falls into Pit

It is conceivable that people or vehicles could fall into the open pits. The probability of these incidents is reduced through the use of barriers or berms in high risk areas and through equipment operator training. Mining activities will be curtailed during white-out conditions to prevent vehicle accidents. However, since serious injury could result, these incidents have been identified as a risk.

Concern has been raised that wildlife could also fall into the pit (EN-RB NIRB April 2010[13]). However, this was assessed as a low risk due to lack of occurrence in the past.

The environmental consequences of this accident are considered negligible.

Conclusion: The risk of falls into the open pits is considered low.

5.2.6 Andrew Lake Dewatering Structure Failure

The likelihood of a major failure of the Andrew Lake dewatering structure is considered low due to the design standards used and the low pressures exerted by the shallow water. The proposed dewatering structure is extremely wide and the core is expected to be frozen. Any unplanned sudden breach is not expected. If for some reason a breach did occur, there would be heavy equipment available on site to plug the breach immediately. Potential environmental effects to Andrew Lake through release of sediment during repair are considered short-term and moderate.

Health and safety risks could include injury if personnel are in the immediate area when dyke failure occurred. However, given the shallow nature of the lake, major injuries would not be anticipated.

Conclusion: The risk of a failure of the Andrew Lake Dewatering Structure is considered negligible.

5.2.7 Pit and Underground Flooding

Open pit or underground flooding is considered unlikely due to the low hydraulic conductivity in the surrounding bedrock and the diversion ditches on surface that will minimize any surface inflows into the mines. Adequate pumping capacity within the mines will be available to recover water that enters the pit or underground workings. If flooding were to occur, additional pumping capacity would be available on-site to supplement the dewatering rate. There will be adequate storage and treatment capacity to accommodate additional short-term flows. If conditions dictate, mine operation will be curtailed if there is risk to health and safety of personnel.

Conclusion: There risk of mine flooding is considered negligible.

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[13] EN-RB NIRB April 2010: *Concerns over the pits and potential for caribou falling into the pits when migrating.*

5.2.8 Diversion Channels

Drainage around the site is facilitated with freshwater diversion channels which take advantage of local topography to route flow around the site through channels constructed using berms and excavations depending on the channel alignment topography. The construction of these diversion structures follows best management practices and is more fully described by Appendix 2E. All channels are designed to convey runoff from a probable maximum precipitation (PMP) event of 184 mm over a 24 hour period Probable Maximum. For context, this is about two and a half times greater than the 1:100 year return period precipitation event (75 mm in 24 hours). Given the robust design of the diversion channels, overflow of these channels has a low probability.

The diversion channels intercept and re-route clean water from contacting the site hence the concentrations of contaminants of potential concern in these waters will resemble natural concentrations found in surface waters in the vicinity of the site. There is potential for some sediment transport where runoff from adjacent disturbed areas could report to the channel. Best Management Practices for erosion and sediment control will be implemented with the intention of trapping sediment close to the source (i.e., silt fences, check dams in flow pathways, revegetation, etc.) during construction and operations where required. Erosion and Sediment Control measures are outlined in Technical Appendix 5O. Where flow velocities exceed the erosion resistance, armouring in the diversion channels using riprap and geotextile will be implemented where required will reduce the potential for erosion and sediment transport within the channels. The water in the diversion channels is benign.

Conclusion: The risk of overflow or breach of a diversion channel is considered negligible.

5.3 Kiggavik Mill and Associated Facilities

5.3.1 Ruptures and Spills from Mill and Effluent Treatment Process Tanks and Pipes

An uncontrolled discharge of process solutions resulting from a tank overflowing or a ruptured pipeline within the mill or Water Treatment Plants (WTPs) will be contained within buildings. Concrete berms will be in place around each process area to contain any spillage from these tanks. The bermed areas will be graded to drain to sumps and pumps which will collect any spilled material and return it to process. Tertiary containment will be provided by berms at all mill and WTP doors to further contain any material that might escape the process containment areas, therefore providing three layers of protection against the release of process solutions to the environment. Therefore, it is considered unlikely that process solutions from within the mill or WTPs could spill outside of the buildings.

In the unlikely event that a spill escapes the mill or WTPs, emergency response procedures will be in place to respond to spills of contaminated water and process solutions. A typical response to a spill would include ensuring worker safety in the area, isolating the source, containing spilled material, and clean up of the area. Spill response coupled with site design of runoff control works will ensure that any spill of process solutions would be contained within developed areas. Therefore, spills of process solutions are expected to result in minimal effects to the environment.

There are no health and safety risks associated with this malfunction.

Conclusion: The risk of a spill of process solutions or slurries from within the mill or WTPs is considered low.

5.3.2 Freezing of Tanks, Site Ponds and Tailings

There will be a small number of process tanks located outside of the mill within secondary containment. Several design features will be in place to prevent freezing of the tank contents, including: limited residence time, the temperature of the solutions, temperature monitoring, and the insulated design of the tanks. However, it is considered likely that, over the life of the Project, a combination of equipment malfunction and low outdoor temperatures could cause the solution to freeze. Ponds are subject to freezing over the winter months; however this is not expected to pose any environmental or safety risks. The tailings being directed into the TMF may freeze if there is inadequate water coverage.

It is not expected that there would be any environmental and health or safety risk associated with this malfunction. A short-term operational risk exists as production may cease until repairs are completed. If there were a breach of the tank due to frozen material, the concrete secondary containment system would capture any spillage of material. If the material was to breach the concrete containment, the spill would be contained within the mill terrace. Emergency response personnel and operations would respond to cleanup the spill.

Conclusion: The environmental risk associated with freezing of process solutions or slurries from outdoor process tanks, site ponds and the tailings in the TMF is considered low.

5.3.3 Spills from Tailings Transfer Pipelines

External pipelines will be used to transport tailings from the mill to the TMFs. Based on experience, the probability of freezing or a breach of the line (e.g. at a flange) is considered almost certain over the life of the Project. Therefore, design features and operational procedures will be in place to contain any spillage from the pipeline. Dual containment will be provided for the tailings lines to prevent the release of these materials as the result of a pipeline rupture. These lines will be situated within the developed areas of the site, where runoff is contained to prevent the release of materials to the surrounding environment in the case of secondary containment failure. The lines will be monitored by instrumentation and routinely inspected by the operations group to ensure that a leak is detected quickly. Preventative maintenance will be conducted to minimize the likelihood of a breach.

Spill response and clean up procedures will be in place to deal with a spill of these materials, thereby mitigating any potential environmental effects. There are no health and safety consequences associated with this malfunction.

Conclusion: The environmental risk associated with a spill of tailings from the tailings pipeline is considered low.

5.3.4 Overflow of the Tailings Management Facility (TMF) and Sewage, Monitoring and Site Collection Ponds

There will be a number of natural and engineered controls in place to ensure that the TMFs are not overfilled. The freeboard proposed for the TMFs is 5 m below the overburden interface, which is substantially greater than the Probable Maximum Precipitation (PMP) value of 184 mm in a 24 hour storm. Excess reclaim water in a TMF will be handled by any or all of the following: increasing reclaim flow to the Kiggavik WTP, , temporarily storing excess reclaim in one of the other TMFs, Given these preventative measures, it is considered highly unlikely that a TMF could overflow.

If a TMF were to overflow, actions would be immediately taken to reduce levels in the pit by pumping reclaim as noted above. Additional emergency pumping would be installed if required. The mine rock stockpiles located down-gradient of the TMFs would facilitate placement of berms to contain the overflow. The environmental consequences of this malfunction are considered moderate on the basis that, although very unlikely, some volume of untreated reclaim water could escape site containment. If this occurred, the affected area would be remediated and monitored to ensure that there are no long-term effects to the environment.

There are a number of preventative measures to ensure the site ponds do not overflow. The discharge into the ponds can be controlled manually and stopped whenever required. There is a 1 metre freeboard to ensure the pond is not breached. There are visual checks performed by the operators and environment technicians on a regular basis. There are also high level alarms on significant ponds to ensure personnel are notified if the levels reach a critical level.

There are no health and safety consequences associated with this malfunction.

Conclusion: The risk of overflow of a TMF, sewage, monitoring and site collection ponds is considered negligible.

5.3.5 Uranium Concentrate Spill within Mill

Multiple mitigation measures are used in the mill and during loading to ensure containment of uranium concentrate and protection of employees:

- The mill will be built based on radiation protection considerations which include criteria on long lived radioactive dust control (i.e., sumps, hoses and sloped floors) and contamination control rules (i.e., containment of material in circuits and graded floors to sumps).
- Radiation protection training will be provided to all workers.
- Radiation protection staff will be available 24 hrs/day to provide guidance and answer questions.
- Mill operators will be trained in job specific tasks related to the load out area and loading tasks, (i.e., operation of a forklift, inspection of drums).
- Potential radiation exposures not identified in individual worker dose assessments due to workers conducting non-routine activities will be identified, an assessment of potential dose conducted, and a safe work permit issued, as required. The safe work permit describes any constraints (e.g. time duration), and specialized equipment or procedural requirements for the non-routine activity.
- Regular review meetings will be held with mill and radiation protection staff to review worker doses with respect to past and upcoming work.
- Focus will be on contamination control measures using personal protective equipment and measures to minimize egress of uranium concentrate into unintended locations.

Due to the frequency of uranium concentrate handling within the mill, and based on experience, uranium concentrate spills within the mill are considered likely. The most probable cause of a spill is puncture of a sealed drum with a forklift. If a spill of uranium concentrate during loading were to occur, the response would consist of the following:

- The operator would contact and inform supervisor of punctured drum and spilled uranium concentrate.
- The operator would follow protocol identified in work instructions for cleaning up the spilled product and returning the remaining product back into the process for re- packaging. This will include:
  - o Personal protective equipment will be worn during clean up of spill and when transferring remaining drum contents either into another drum or putting the uranium concentrate back into the process, (i.e., disposable coveralls, rubber gloves, a powered air purifying respirator); and
  - o Contamination control measures will be used to prevent egress of material to areas outside of the spill (e.g. area washed down, equipment used in clean-up cleaned after use).

- Radiation Protection personnel will be available to:
  - o Provide guidance; and
  - o Conduct monitoring as required.

The radiation exposure during this malfunction would be considered minor, whereby an internal administrative level would be exceeded. Experience indicates that this exceedance is rare. In the case of a punctured drum, the operator would have minimal exposure to uranium concentrate, and in most cases the administrative levels would not be exceeded.

A spill of this nature would have negligible environmental consequences as it would be fully contained within the mill or on the mill terrace.

The risk of yellowcake spills outside of site containment areas are addressed in more detail in Technical Appendix 10A and Section 5.5.

Conclusion: The risk of a uranium concentrate spill within the mill is considered low.

5.3.6 Scrubber Stack Failure

Stacks associated with various processes at the mill will be equipped with scrubbers to reduce dust and COPC emissions resulting from the operation. The scrubbers will be instrumented to provide on-line continuous monitoring. Furthermore, all scrubbers will be on a routine preventative maintenance program to ensure proper operation. Nevertheless, experience indicates the probability of a short-term scrubber stack failure is almost certain.

Failure of a scrubber can result in elevated air emissions of total particulate and other contaminants. Any period of elevated air emissions due to scrubber failure would be of short duration as the malfunction would be quickly identified by on-line monitoring or routine checks. The scrubber would be taken off-line and repaired. Therefore, the environmental and health and safety consequences of this malfunction are considered minor.

Conclusion: The environmental and health and safety risks associated with a scrubber stack failure in the mill are considered low.

5.3.7 Acid Plant Malfunction

An acid plant malfunction can result in low conversion efficiencies and subsequently high stack sulphur dioxide emissions. Continuous stack monitoring for sulphur dioxide emissions and operational monitoring of the process will provide feedback to the operators as to the performance of the plant. Operational action levels will be in place, which define the upper bound of normal operating conditions with respect to emissions from the acid plant. If these levels are approached, adjustments will be made to return the acid plant to normal operating conditions. This system of monitoring and operational control minimizes the potential for a serious malfunction to develop. Nevertheless, short-term excursions while adjustments to the process are made are almost certain. The occurrence may result in elevated ambient sulphur dioxide concentrations immediately down wind of the acid plant.

Due to the expected short duration of release of sulphur dioxide emissions should the acid plant malfunction; it would not be expected to have an impact on human health or the environment. Consequences are considered minor.

Conclusion: The risk associated with an acid plant malfunction is considered low.

5.3.8 Power Failure

An on-site power failure is considered likely. The failure could result from damage to power lines or powerhouse malfunction, particularly during extreme weather, equipment malfunction, fire, lightning, or human error. Preventative measures to reduce power failures will include routine maintenance on equipment, mitigating fire risks, installing lightning protection on buildings such as roof top lightning rods to provide grounding protection and permitting only authorized entry into electrical rooms.

The Project's electrical generation and distribution system will be designed to ensure that emergency power from diesel generators is available to maintain personnel and process safety, and site containment. There will be maintenance and emergency procedural guidelines in the event of a power outage. Employees will be trained in emergency procedures.

In the case of a general and extended power failure compounded with failures of existing back- up generating capabilities, additional measures would be required to avoid exposure of operators to elevated radon concentrations and to ensure that process solutions, contaminated water, and chemicals are contained. The mill ventilation equipment is an active safety system designed for radiation protection where the defense-in-depth concept is applied; there are both redundant ventilation systems, and redundant power supplies. The plan for complete power loss includes suspension of facility operation followed by evacuation of plant personnel. Subsequent re-entry to the facility would require workplace monitoring and the possible use of filtered air breathing system or self contained breathing apparatus. Portable, emergency electrical power will enable normal ventilation to be re-established and allow critical pumps to be started to maintain containment.

In the event of an underground power failure where the main system of ventilation for the underground mine fails, all personnel working underground will be informed, all diesel powered equipment will be shut down; and where a hazard to persons exists, all persons will be evacuated to the surface of the mine or to an approved refuge station in accordance with the emergency procedures. No entry of persons will be permitted until the ventilation has been restored, a complete change of air has occurred throughout the mine and the active workings have been inspected. There will be stand-alone back-up power generating capacity at the Sissons site to allow safe shut down of the operation and evacuation of personnel if there were power failure.

Potential consequences to health and safety and the environment due to a power failure are considered minor.

Conclusion: The risk associated with on-site power failure is considered low.

5.3.9 Falls into Lined Ponds

It is conceivable that people, animal or vehicles could fall into the lined ponds. Based on experience, this accident is considered likely. The probability of these incidents is reduced through adequate design of the access roads to the ponds and operator training. The operator will also have an elongated tool to minimize stretching into the pond for sample collection. For ponds that are deemed higher risk, for example where samples will be manually taken on a regular basis, it may be necessary to build a structure to facilitate easier access to the pond and eliminate the risk of falling in.

Employees who obtain a sample from any ponds will be also required to wear a radio to call for help if required and wear a personal flotation device. There will also be buoys located on the side of each pond for rescue should anyone fall in. Anyone working with sewage will be offered the vaccine to protect them from Hepatitis A/B; so any worker who may fall in would be protected.

It is feasible that an animal may enter a pond and not be able to climb out. Based on experience, larger animals will generally be able to climb out. The risk to the animal health from this minor contact with site solutions is considered low. Routine inspections will be conducted on a daily basis by the Operations and Environment group so any animals that may fall in will be removed. These groups will also observe the ponds for any liner damage on a regular basis.

If wildlife entry into ponds is a recurring issue during Project operations, consultation with the local communities will be conducted to determine the optimal method of deterring the animals from entering.

Conclusion: The risk associated with falls into site ponds is considered low.

5.3.10 Occupational Health and Safety Incidents

Occupational Health and Safety is described in more detail in Technical Appendix 2P. There are tasks which pose a higher risk due to the scope of work, hazards associated with the work and potential consequences. These tasks include but are not limited to:

- confined space work;
- working with powered mobile equipment;
- lock-out and energized work;
- high voltage work;
- working at heights and fall protection;
- working with hazardous chemicals; and
- working in cold conditions.

There will be multiple layers of protection to ensure that workers are adequately protected from the hazards of these higher risk jobs. These controls will include:

- An initial hazard assessment will be performed with the worker(s) and supervisors prior to the work being performed, including review of the scope of work, identification of hazards, identification of control measures and identification of who will perform the work.
- Workers will be provided with specialized training to ensure they are knowledgeable with their tasks, aware of the risks and know how to protect themselves. In some instances, they may require certification to demonstrate they are trained and authorized to perform the work.
- For these higher risk categories, written procedures and work instructions will describe how to conduct the work safely.
- Each type of category will have specialized safety equipment and controls that ensure the job can be performed safely. For example, in addition to training and procedure requirements for confined space entry work, a permit issued by the Safety Group will be required, gas testing will be performed for every entry, localized ventilation may be required, an emergency self-rescue winch may be required and a safety attendant will be required.
- Employees will be provided with the proper personal protective equipment to ensure they are protected should they become exposed to a risk.
- Routine internal audits and inspections of these types of work will ensure that any shortcomings are identified and corrected.
- Emergency personnel will be trained with respect to these potentially hazardous environments and how to safely secure the scene and perform a rescue if required.

Occupational health and safety incidents will be thoroughly investigated to determine root cause(s) and follow-up actions implemented to ensure continuous safety improvement.

Experience in industrial environments indicates that occupational health and safety incidents can occur, and consequences to health and safety can range from minor to catastrophic. An occurrence of these occupational health and safety incidents would have minimal effect on the environment.

Conclusion: The risks associated with occupational health and safety accidents are considered moderate.

5.4 General Accidents and Malfunctions

5.4.1 Spill Risks within Project Footprint

Spills are highlighted as a common risk in Attachment A, Kiggavik Project Risk Assessment – Results and, based on general mining industry experience, the likelihood of a spill during the life of the Project is almost certain. Therefore, there are numerous measures in place to prevent spills and to minimize severity and effects if a spill does occur.

Materials noted at risk of spill within the Project footprint include:

- mine water;
- diesel fuel (EN-CI OH Nov 2012[14]), oil, ANFO, and other hazardous materials;
- acid and other reagents;
- ore;
- yellowcake;
- tailings;
- site and stockpile drainage; un-treated effluent;
- treated effluent;
- un-treated sewage;
- treated sewage; and
- contaminated waste.

As described in Volume 2, the mine sites have been designed to provide contingency containment in the open pits and site ponds. Preventative measures, such as safety interlocks and operator training will be in place, as will spill contingency measures. If these measures are for some reason inadequate, spills on the mill terrace will ultimately drain to the open pits or tailings management facilities (TMFs) and will therefore be contained within the site. When evaluating the consequence

[14] EN-CI OH Nov 2012: *What about the risk of a diesel spill?*

rating for spills, both the environmental hazard associated with the material spilled, and the location of the spill, are considered. The location of the spill is a factor in evaluating the consequence. On-site incidents will benefit from having greater resources immediately available to mitigate environmental impacts than incidents which occur remotely from the site, hence, spills within the project footprint are discussed separately from spills which may occur during transportation (Section 5.5).

Environmental consequences of spills of pit water, on-site reagents, tailings, site and stockpile drainage, un-treated effluent, un-treated sewage, and contaminated waste are considered minor, as all handling and transport will be contained to the immediate mine sites and emergency response and spill contingency measures will be immediately implemented.

There are some health and safety risks associated with spills of hazardous materials, such that a potential exists for people in the vicinity of a spill to be exposed to fumes or corrosive materials. These are mitigated through on-going training efforts, appropriate design interlocks, and proper personal protective equipment (PPE) for hazardous materials handling.

Ore, yellowcake, treated effluent, treated sewage, reagents, diesel fuel, and other hazardous materials are transported outside the immediate mine sites containment areas and therefore additional measures are required to mitigate the risks of spill. These risks are discussed in separate sections of this document.

Conclusion: The health and safety risks associated with on-site spills are considered and range from low to moderate. The environmental risk is considered low.

5.4.1.1 Leakage from Site Ponds

Ponds will be used to contain site runoff, contaminated water and treated effluent. On going leakage from these ponds could result in adverse effects to the quality of shallow groundwater in the active layer. All lined ponds will be designed in accordance with regulations. Containment and leak detection systems will be constructed where needed. Additionally, synthetic pond liners will be inspected regularly to ensure their integrity. Following each inspection, maintenance is performed to repair any damage identified. In combination, this approach will serve to effectively minimize leakage from lined ponds. Further, where possible, ponds will be located up-gradient of the open pits and TMFs such that any leakage is ultimately contained on the site. Finally, as a contingency plan, any significant accumulations of contaminants resulting from leakage through the liner will be cleaned up during decommissioning, thereby eliminating the potential for a long-term source of active layer contamination. Any interaction with the site active layer would be localized and negligible over the long-term.

No health and safety risks are associated with this malfunction.

Conclusion: The environmental risk associated with leakage from lined ponds is considered low.

5.4.1.2 Spill of Treated Effluent

The treated effluent from the Kiggavik and Sissons WTPs will be transferred in separate pipelines to their points of discharge into Judge Sissons Lake.

AREVA's experience has indicated that it is almost certain that a pipeline breach or leak will occur in these lines over the life of the project. Therefore, additional measures to contain and mitigate risk to the environment include:

- Secondary containment along the pipelines in the form of berms and collection ponds to contain any spilled material from the pipeline.
- In addition to a leak detection system and interlock, treated effluent discharge lines are patrolled on a regular basis by Operations teams to provide early detection of any leaks or rupture of these lines. Early detection and proper spill response and clean up serve to mitigate the effects of discharge of treated effluent to an unintended area.
- Routine maintenance inspections of the pipeline, berm, and pond integrity will be conducted to prevent material failure.
- Repair work will be completed immediately if integrity of the pipeline, berm or pond is compromised.
- Preventative maintenance will be conducted, particularly at flanges, to reduce the likelihood of breach.

These measures are considered to reduce the likelihood of a spill of treated effluent reaching the aquatic environment to unlikely.

In the unlikely event that a leak is not detected at the same time a containment pond is breached, the maximum volume of treated effluent that could reach the aquatic environment is the volume of one monitoring pond, which will be approximately 1,300 m3. Response measures that will be in place are as follows:

- Upon discovery of the spill, treated effluent pumping will be suspended. Operators will be trained in emergency shutdown procedures to ensure this happens safely.
- The Spill Contingency Plan will be initiated and a spill response team will be mobilized to the spill site.
- If possible, the breach will be repaired to allow containment of any remaining effluent within the secondary containment berms.
- Temporary berms/socks will be placed to prevent any further discharge to the aquatic environment.
- Any contaminated snow, soil, and vegetation will be collected and placed in the contaminated waste storage area.

- An assessment of any environmental effects of the spill will be conducted and any restoration work required to remediate the site will be completed.
- The spill will be reported within 24 hours as outlined in the Spill Contingency Plan.
- Monitoring will be conducted as required.

Given the quality of the treated effluent, any environmental effects are anticipated to be minor and localized to the immediate area where the effluent entered the waterbody.

Any waterbodies or watercourses potentially affected would be monitored and if necessary, additional measures taken to minimize any environmental effects.

No health and safety consequences are anticipated for a spill of treated effluent.

Conclusion: The environmental risk associated with a treated effluent spill is considered low.

5.4.1.3 Outside Spills within the Project Footprint

It is feasible there will be situations that due to improper snow removal, may alter the berms or culvert blockage and there may be a release of contaminated snow beyond the project footprint. As this is likely to happen over several times during the life of the project, it has been given a moderate rating. Upon recognition of the incident, all spilled material would be cleaned up immediately and any necessary sampling and monitoring performed. If the event occurred during spring/summer months, there may be a release of contaminated run-off water. This spill would be cleaned up immediately and any sampling and monitoring performed. The long term effects on the environment are expected to be negligible as the amounts of contamination is expected to be minor.

Conclusion: The environmental risk associated with spills outside the project footprint is considered moderate.

5.4.2 Release of Off-Specification Effluent

Extensive programs will be in place to monitor and control treated effluent quality from the WTPs. Treated water will be sent to the monitoring ponds before discharge. The monitoring ponds will serve as a checkpoint prior to batch discharge to Judge Sissons Lake. A composite sample will be taken automatically as the pond is filled. The pond contents will be “held” while the Lab analyzes the sample. The Lab results will be forwarded to the Mill Supervisor, who determines if the treated effluent meets specification and can be discharged. Only with Supervisor approval is the treated effluent in the pond discharged to Judge Sissons Lake.

However, isolated, short-term discharges of treated effluent at concentrations above discharge limits may be possible if there is both a plant malfunction and operator error. This event is considered unlikely. The maximum volume of off-spec effluent that could be discharged will be 1,300 m3, which is approximately 25% of the total amount of treated effluent to be discharged per day.

Response to such an occurrence, in addition to an incident investigation to identify and address the root cause, would include monitoring of receiving water chemistry to determine if the incident had any effect on water quality in Judge Sissons Lake and potentially curtailing treated effluent discharges to allow additional mixing of effluent with downstream waters. In the extreme case where the effluent is substantially off-specification, potential environmental effects are considered moderate.

Conclusion: The environmental risk associated with release of off-specification effluent is considered low.

5.4.3 Spill of Jet Fuel & De-icing Fluid

Jet fuel and de-icing fluid will be used by the aircraft frequenting the Pointer Lake airstrip. The fuel and de-icing fluid will be stored in double walled containers on the airstrip and in approved storage facilities. The storage facilities will include concrete berms to contain any potential leaks. The fuel pumps will have appropriate automatic safety interlocks. Should a spill occur, the emergency response team and/or the Environmental Group will respond and implement the Spill Contingency Plan. Any spillage of fuel or de-icing fluid will be cleaned up immediately and a spill kit containing spill absorbent material will be readily available. All employees handling the materials will be trained in proper dispensing and first response to spills.

It is not expected there is any risk to health and safety of personnel if a spill of fuel or deicing fluid occurred.

Conclusion: The environmental risk associated with spills of jet fuel or de-icing fluid is considered low.

5.4.4 Hazardous Substance Storage and Release

Numerous hazardous substances will be used for the Project. These materials will be transported to the Project sites in accordance with Transport Canada's Transportation of Dangerous Goods Regulations. Potential accidents and malfunctions associated with transport are assessed in the transportation Risk Assessment (Technical Appendix 10A) and summarized in Section 5.5. The following discussion addresses risks associated with hazardous materials stored and handled on the Project sites.

Hazardous substances will be stored and used on the Project sites in accordance with all applicable regulations. Secondary containment, meeting regulatory requirements, will be provided in all cases as a means of protection against a spill resulting from failure of the storage facilities. In addition, all hazardous substance storage facilities will be equipped with high level alarms and safety interlocks to prevent over filling of these vessels.

Outdoor fuel and waste oil tanks will be of double wall construction to contain leakage from the primary vessel. Additionally, these tanks will be placed on concrete pads within containment berms to negate any effects of small spills during fuel transfer.

Concrete dykes will be in place around all hazardous materials storage vessels within the mill to contain any spillage from these tanks to the immediate area. The areas contained by the dykes will drain to sumps, which will collect any spilled material. The mill itself will provide tertiary containment for any material that might escape the containment dykes, therefore providing substantial protection against the release of hazardous substances to the environment.

Employees will be trained in the handling of hazardous materials. Material and task-specific procedures will be in place to ensure safety design features are properly used and appropriate PPE is worn when tasks involving hazardous materials are conducted.

Experience suggests that minor spills of hazardous materials do occur on mine sites, and therefore, the probability of a minor spill is considered likely.

In the event of a release of hazardous materials from an outdoor storage vessel, or spill escaping from the mill, emergency response procedures will be initiated. A typical response to a spill would include ensuring worker safety in the area, isolating the source, containing spilled material, and clean up of the area. Spill response coupled with site design of runoff control works will ensure that any spill from hazardous substance and dangerous goods storage facilities would be contained within developed areas.

Conclusion: The environmental and health and safety risks associated with the storage and handling of hazardous materials is considered low.

5.4.5 Vehicle Collisions

Vehicles may collide with other vehicles, personnel, structures or wildlife. Rollovers are also possible. Community concerns were raised about vehicular safety (EN-RB NIRB April 2010[15]). These incidents may result from human error, extreme weather or equipment malfunction. Preventative measures to prevent vehicle collisions will include:

- having trained operators to operate vehicles;
- performing vehicle inspections daily prior to operating vehicle;
- scheduled vehicle maintenance;
- use of headlights;
- enforcement of specified speed limits;
- personnel walking in high risk areas in dark conditions are required to wear reflective clothing, or reflective band;
- vehicles will have reverse alarms;
- use of high-visibility vehicle markings, reflective decals, flags, and lights;
- closure of roads if necessary during extreme weather or caribou migration; and
- road maintenance such as grading the road, snow removal and dust control.

Measures to minimize the consequence of vehicle collisions include:

- use of seatbelts in vehicles;
- establishing and adhering to speed limits; and
- light-duty vehicle safety features such as airbags.

Vehicle collisions are considered likely with the expected frequency of vehicle usage for the Project. It is anticipated that with the controls implemented, the consequences of collisions will be minor and personnel will be adequately protected. However, experience dictates that vehicle collisions can result in major consequences to health and safety.

Emergency measures include having a radio and first aid kit in each vehicle. Check-in and working-alone procedures will be in place to ensure that personnel working off-site are accounted for. The emergency response team will be trained to secure an accident scene, contain any spills and extricate personnel from vehicles if required. It is possible that a vehicle collision could affect the

[15] EN-RB NIRB April 2010: *Concerns over vehicles going off the road. This problem should be looked at during the review stage to prevent a major accident from happening.*

environment, if it led to a spill or leak of material, particularly in proximity to waterbody or watercourse. Further assessment of this type of accident is provided in the Transportation Risk Assessment.

Conclusion: The health and safety risks associated with vehicle collisions are considered moderate.

5.4.6 Fire Risks

Fires are identified as a risk for the Project as there will be many heat sources required for the operation, and flammable and explosive materials will be used. Some potential sources of fires will include:

- electrical panel and transformer malfunctions;
- pumps malfunction;
- vehicle overheating;
- jet fuel spill;
- use of flammable materials such as kerosene ;
- heat producing tasks such as welding, grinding, cutting;
- incinerator operation;
- lightning strikes;
- tundra fires;
- human activity (e.g. improper disposal of cigarettes);
- portable heat sources; and,
- fires associated with explosions.

The risk of fire will be minimized through several preventative measures, including appropriate design and maintenance of tank farms and solvent extraction, preventative maintenance programs, lightning protection for buildings, proper storage of flammable materials, grounding of equipment and vehicles during hazardous material offloading, housekeeping to minimize fire risks, implementation of fire watch monitoring of fire prone tasks, fire drills and hazardous materials handling training.

It is possible that equipment may catch fire during its operation due to the presence of fuel and hydraulic fluid that may catch fire in the event of equipment failure or malfunction. Scheduled preventative maintenance programs will be in place for all vehicles and vehicle inspections will be conducted daily; these include looking for broken or leaking hydraulic or fuel lines. Response measures will include having a fire extinguisher available in each vehicle; extinguishers will be inspected on a monthly basis. Personnel will also be trained on how to respond to fires in vehicles. For some pieces of heavy equipment such as haul trucks, there will be an automatic engine shutoff and pressure relief system in the event there is a fire.

In the event of a major or potentially major fire within the mill or camp, the first alarm will be given by the central fire alarm system, by a patrolling operator or by an employee. Conventional fire protection systems will include sprinklers, standpipes with hose outlets, portable fire extinguishers of various types, fire pumps, hydrants, and a fully equipped fire truck. The emergency response team will be trained in fire fighting and equipment use. All employees will be trained in fire alarm procedures and the use of a standard fire extinguisher.

If the mill sustained widespread damage, an extended shutdown would result, pending necessary repairs. Damage to the mill effluent and water treatment circuits would also cause a shut down of those circuits and the inability to treat mill effluent and TMF reclaim water would in turn result in a shut down of the mill and TMF reclaim pumping system respectively. Repairs would be conducted as quickly as possible, and where necessary, temporary equipment would be installed to allow water treatment of the TMF reclaim water to resume.

Fires are considered a risk in the underground environment. This risk is mitigated through preventative measures, controlling the entry of flammable material underground, placement and maintenance of refuge stations throughout the mine, the installation of a secondary escape-way in a fresh air raise, and through Mine Rescue response capability.

The environmental consequences of a major fire include the potential release of fumes, smoke and dust. It is anticipated that even a major fire would be contained to the Project site and would have at most a minor localized effect on the surrounding environment.

Conclusion: The health and safety risks associated with fire are considered moderate.

5.4.7 Explosion Risks

Explosion risks inherently exist with the use of explosive materials, and therefore the transportation, storage, and handling of these materials are heavily regulated under the *Explosives Act and Regulations and the Nunavut Mine Health and Safety Act*. Additional information is provided in the Explosives Management Plan (Technical Appendix 2C).

The largest volume explosive materials that will be used on the Kiggavik site include ammonium nitrate/fuel oil (ANFO) and hydrogen peroxide. An additional minor explosion risk is associated with the operation of the incinerator; whereby pressurized containers or other prohibited waste could be placed in the incinerator through human error or failure of training programs.

The health and safety consequences of an uncontrolled explosion can be catastrophic as fatalities may result. Therefore, preventative measures will be of key importance. These measures will include:

- proper design of explosive storage facilities and the hydrogen peroxide storage building;
- training and refresher training programs for employees involved in handling explosives or hydrogen peroxide;
- only authorized personnel will be permitted to the explosives storage areas;
- extensive written handling procedures for these materials;
- training for all employees in proper waste segregation; and,
- inspection of incinerator feed.

The environmental consequences of an explosion and any associated fire include the potential release of fumes, smoke and dust. The environmental effects would be largely contained on the Project site and are therefore considered minor.

Conclusion: The potential risk of explosion to health and safety is considered moderate and justifies the extensive safety protocols that will be in place.

5.4.8 Spill of Exploration Drill Cuttings

During exploration drilling, mineralized drill cuttings will be collected in tote bags and transported by helicopter to the Kiggavik site for storage and processing through the mill. The totes will be placed in large tubs to reduce splattering. Non-mineralized drill cuttings will be pumped to a sump or depression on the land.

There are two mechanisms by which mineralized drill cuttings could spill; first, if improper segregation procedures are used, mineralized cuttings could be pumped to the sump area intended for non-mineralized cuttings; second, mineralized drill cuttings could spill if improper slinging practices are used.

A number of preventative measures will be in place to prevent mineralized cuttings from being deposited on the land. Project geologists can generally identify at what depth mineralization is expected and collection of cuttings in tote bags is initiated before that depth is reached. In addition, gamma measurements are taken during drilling and cuttings collection begins when a minimum gamma reading is reached. Finally, the non-mineralized sump is surveyed by radiation protection personnel upon completion of the drill hole. If mineralized cuttings have been deposited, they are collected and the area cleaned until cleared.

All drillers and Supervisors will be trained in proper slinging practices. Only helicopter pilots with substantial slinging experience will be used. The tote bags are closed and slung in tubs to reduce the potential for spillage in the unlikely event the load is dropped from the helicopter. If a spill were to occur, the affected area would be cleaned until cleared. Monitoring would be conducted as necessary.

There are no health and safety consequences associated with this malfunction.

Conclusion: The environmental risk of a drill cuttings spill is considered low.

5.4.9 Waste Management

Waste materials such as recyclable and non-recyclable domestic wastes, industrial wastes, chemically/radiologically contaminated wastes, and hazardous wastes will be identified, handled and disposed of according to the Waste Management Plan (Technical Appendix 2S). Each waste category will have its own waste management strategy that has been specifically designed for that particular waste product. The waste management facilities will be routinely inspected and scanned for radioactivity to ensure proper disposal and handling of waste. Recycling of wastes is encouraged within the waste management program, wherever feasible.

The potential malfunctions associated with waste management programs primarily involve failure of segregation protocols. While waste segregation procedures will be enforced and training provided, it is anticipated that, at times, waste will be placed in the wrong disposal stream. The sections below describe how waste is separated and disposed of to ensure it will have minimal effect on the environment.

Conventional waste materials that originate from mining, milling and water treatment areas, may be chemically or radiologically contaminated. These materials will be collected in designated dumpsters and transported to the designated contaminated waste storage area on the edge of one of the TMFs. During decommissioning, this material will be buried in one of the TMFs.

It is possible that chemically or radiologically contaminated waste could be placed in the wrong dumpster and transported to either the industrial landfill or a clean storage area. The dumpsters and designated clean storage and waste areas will be routinely monitored for residual contamination by the Radiation Protection Group to ensure that any improperly segregated materials are diverted to the appropriate storage area.

Hazardous substances and dangerous goods, consisting of waste oil/fuel filters, waste antifreeze, waste oil and waste batteries will be collected in designated containers and transported for recycling or disposal at an off-site registered facility. Empty drums that typically contain product residue such as oil, antifreeze and grease will be returned to suppliers for reuse. A hazardous materials storage building and designated storage pad on the mill terrace will be used to store the containers until there is sufficient quantity for shipment. Hydrocarbon contaminated soil and snow originating from clean up around the fuelling areas, maintenance shops and minor spills are placed in an area maintained on top of the clean waste rock stockpile for remediation of hydrocarbon contaminated materials.

These materials could pose a hazard if improperly segregated at source and either incinerated or landfilled. Training will be provided to emphasize the importance of properly handling hazardous materials and only trained employees will be permitted to handle them. Furthermore, placement of materials on the hazardous materials pad will be controlled by the Environment Group to ensure that materials are placed in the appropriate container. Materials entering the incinerator will be inspected to prevent incineration of improperly segregated materials. The landfill will also be routinely inspected to identify improperly placed materials and divert them to the appropriate stream.

There are no health and safety consequences anticipated for these malfunctions. Routine inspection of waste storage areas and removal of improperly segregated materials are expected to reduce any environmental consequences to minor.

Conclusion: The environmental risk associated with improper waste segregation is considered to range from negligible to low.

5.4.10 Stranded at Site

There is a risk of people being stranded at Project sites due mechanical failure of the aircraft or extreme weather conditions. The risk to human safety from stranding is considered low as there will be adequate supplies of food and shelter for extended periods.

The risk of becoming injured or suffering a medical condition and becoming stranded at site is even lower; however if this situation were to occur, there will be a Health Centre and the Occupational Health Nurse will monitor the condition of the patient with the assistance of the Emergency Response Team until the person can be evacuated from site. The Health Centre will be in close consultation with the company physician until the person can be removed from site.

There are no environmental consequences associated with this malfunction.

Conclusion: The risk associated with being stranded at site is considered low.

5.4.11 Stranded on Road

Concerns have been raised by community members on how drivers may become stranded during poor weather on the roads (EN-AR OH Nov 2013[16]). It is conceivable that vehicles may become stranded on the Baker Lake-Kiggavik access road. This could happen due to vehicle malfunction or extreme weather conditions. A preventative maintenance program and shiftly pre-operational checks will be implemented to reduce the likelihood of vehicle malfunction. Drivers will be required to travel in pairs during the winter in case one vehicle malfunctions on the road. To address the potential of winter whiteout conditions, there will be emergency shelters located along the Baker Lake-Kiggavik road that drivers can take shelter in until conditions improve. These shelters will contain enough supplies for 10 days.

There are no environmental consequences anticipated for this malfunction.

Conclusion: There is a moderate risk associated with stranding along the access road.

5.4.12 Fall through Ice

Some employees will be required to travel or work on frozen lakes; there is a risk that they may fall through the ice, although the likelihood of this is considered unlikely given preventative measures. There will be procedures in place to monitor ice conditions to ensure it is safe for travel. Employees working or traveling on ice will work in pairs at a minimum. Employees will be trained in ice safety including how to recognize unsafe conditions and what to do if they fall through. The Emergency Response Team will be trained on how to rescue someone if they fall through ice and how to treat hypothermia. The person would be evacuated as soon as possible. Nevertheless the health and safety consequences could be fatal.

There will be a potential effect on the environment if a loaded truck loaded passes through the ice; this is addressed in Appendix 10A and Section 5.5.

Conclusion: The health and safety risk associated with falls through ice are considered moderate.

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[16] EN-AR OH Nov 2013: *Baffinland ran into a problem when 4 pick-ups got stuck in stormy weather on road. Distance between shelters were too far and survival packs carried in pick-ups were not adequate.*

5.4.13 Firearm Incident

Although firearms will be strictly controlled on site, it is feasible that someone could bring an un-authorized firearm onto site. There will be a policy that prohibits bringing unauthorized firearms to site; AREVA will have the authority to search any suspicious packages brought onto site. Authorized and trained personnel are permitted to have a firearm on site for approved reasons such as to control wildlife if required; this will be designated personnel likely in the Services Department. Firearms will be stored onsite in accordance with the law and regulations and Site policies. No hunting will be permitted onsite. Professional assistance to deal with anger and mental health issues will be available to all employees through the Human Resources Department and Employee Family Assistance Program.

If an unauthorized firearm were discovered on site, security personnel would be notified and the firearm would be taken away from the individual and the individual removed from site if required.

There are no anticipated environmental consequences associated with this malfunction.

Conclusion: The health and safety risk associated with un-authorized firearms is considered low.

5.4.14 Missing Persons

There are some positions that will require employees to work in remote areas. There may be instances where an employee(s) may become missing due to unexpected extreme weather, equipment malfunction and become stranded or lost or they may be injured and unable to return to camp. There will be several mitigative measures in place to ensure employees are not at unnecessary risk of becoming missing. These measures include knowing the area they will be traveling, notifying their supervisor of their planned route and area of work, stating what time they will be returning, monitoring the weather forecast before heading out, ensuring they have emergency supplies should they become lost, are appropriately clothed for outdoor exposure, having a radio or satellite phone with them, trained in use of GPS, trained in first aid, trained in winter survival and traveling using a buddy system.

Potential health and safety consequences could be major to catastrophic if a person becomes lost in extreme weather. Should a person(s) become lost, there will be trained persons on the Emergency Response Team to perform a search and rescue operation. Other authorities and groups will be called upon to assist if required.

There are no environmental consequences associated with this accident.

Conclusion: The potential health and safety risk associated with missing person(s) is considered moderate.

5.4.15 Disruptions of Accommodation Camp

There may be instances where disruptions to camp amenities may occur due to equipment malfunctions or weather issues. Loss of heat due to disruption of fuel supply or diesel generator malfunctions will be prevented through performing routine maintenance on generators and having a back-up system in the event a generator does malfunction. Fuel supply is not expected to be an issue. There would be minimal effects to the environment unless there were a fire, which would release smoke and particulates into the atmosphere.

Loss of power may happen due to interruption caused by equipment malfunction and extreme weather conditions. Short periods of loss of power are not expected to have major detrimental effects. Longer periods are not expected as emergency back-up generators will be available.

Loss of shelter may result due to various issues such as loss of heat, fire, and damage to the camp building. Intermediary measures will be taken to relocate individuals as necessary until the building is habitable.

Interruption of potable water supply may occur if there is contamination of the water supply or if the pipeline is damaged or freezes. There will be preventative measures in place to ensure the water does not get contaminated. In the event these measures are inadequate, water may be taken from another source until the clean-up is complete. Alternate supplies of water will be provided to workers.

Food supply may be affected due to issues such as food contamination, aircraft not able to land, or there is loss of power. Food contamination will be avoided by preventative measures which include food safety training for personnel involved with food preparation, regular inspections of the camp kitchen by the Health Centre nurse and kitchen supervisor, monitoring of food storage temperatures, ensuring there is always a minimum supply of food taking into account contingency supplies. Loss of power is expected to have a minimal effect on food supply as there will be back-up power supplies available if necessary to ensure adequate refrigeration.

Interruption to sewage treatment will be possible due to equipment malfunction or sewage back- up. As a preventative measure a certified plumber will always be on site. Sewage treatment will be monitored by the Water Treatment Plant Operators. They will be aware of any changes before discharge to the environment occurs. Emergency measures will include temporary containment of grey water until approved sewage treatment can be restored. There would be minimal effect on the environment.

It is not expected that any disruption to the camp accommodations would place any employee in imminent danger.

Conclusion: The risks associated with disruptions to accommodation services are considered low.

5.4.16 Medical Emergency/Medical Conditions

It is feasible that someone may experience a medical emergency during their shift at the Project. AREVA has received questions about what facilities will be on-site for emergencies (IQ-RIW 2009[17]).

To minimize the risk to personnel who may have a pre-existing medical condition, all personnel will be requested to report any medical conditions to the Health Centre upon arriving to site. All personnel are asked to have their medications with them at all times. The Health Centre will have a limited inventory of emergency medication available and may be able to treat and stabilize some emergency conditions with the guidance of the company physician. The Project will also have AED (Automatic External Defibrillators) placed in strategic locations at each site. The ERT will be trained to recognize certain medical conditions and apply first aid treatment. The Health Nurse will have capabilities to stabilize and evacuate the patient if required to a health facility or hospital.

There would be no effect on the environment if a person experienced a medical emergency.

Conclusion: The risk associated with medical emergencies is considered low.

5.4.17 Aircraft Incidents

Aircraft incidents are possible as there will be regular flights to and from the site, however, the likelihood of a major accident causing fatality is considered highly unlikely given preventative measures. There are extensive safety and preventative maintenance programs which follow federal aviation requirements to ensure the safe operation of aircraft. AREVA will maintain stringent requirements when selecting aircraft carriers and will conduct routine audits and inspections to ensure the carriers are operating safely.

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[17] IQ-RIW 2009: *The women were also worried about worker health and safety, and wanted to know what kinds of medical facilities would be on site in the event of an emergency*

The environmental risks associated with an aircraft incident involving uranium concentrate is assessed in Section 5.5 and Technical Appendix 10A.

Conclusion: The risks associated with an aircraft incident are considered low.

5.4.18 Other

There are hazards that will be common to various types of work performed at all Project sites. These seemingly benign hazards can have serious consequences. As such, controls in the form of engineering controls, PPE and administrative controls will be in place for each hazard to eliminate or mitigate the associated risks. The hazards identified include:

Slipping and Tripping – Proper footwear will be required for all employees. AREVA will provide an annual stipend to all minesite employees for CSA-approved footwear. Housekeeping will be crucial in preventing trips and slips including keeping the area tidy, snow removal, use of sand on icy surfaces and cleaning up wet surfaces. Inspections will be conducted on a regular basis by area supervisors, employees, the Safety Group and the Occupational Health Committee (OHC) to ensure areas are maintained to adequate standards. There would be negligible effect on the environment if a slip and trip incident occurred.

Noise – There will be noise levels within the mill and mine areas that could result in hearing loss if mitigation measures are not taken. There will be engineered noise controls implemented for specific pieces of equipment and processes in place to reduce equipment noise levels. There will be a hearing conservation program in place to ensure workers are aware of the hazards of noise and know how to properly protect themselves. Hearing protection equipment such as ear plugs and ear muffs will be provided to all employees. Employees who are at risk will be provided with an annual hearing test to monitor their hearing; results will be discussed with each individual employee. Noise surveys will also be performed on a scheduled basis to monitor noise levels at the site. Further discussion of mitigation controls and potential noise sources are discussed in Technical Appendix 4F (Noise Abatement Plan). Potential noise effects on the environment during normal operations are assessed in Technical Appendix 4E (Noise and Vibration Assessment).

Equipment Interactions – Due to the nature of the work at the mill, mine and associated facilities, much of the work will involve working with tools or powered machinery. There is a risk that an individual may become injured through interaction with these tools or machinery. Common types of injuries associated with tools include being hit by, pinned against, entanglement or punctures. The controls that will be in place to minimize the possibility of someone becoming injured include guards wherever feasible, inspection of the equipment prior to use, tagging out broken or malfunctioning equipment, training on the equipment, use of adequate PPE, confining loose hair and eliminating loose clothing and ensuring proper procedures are followed when using the tool or machinery. There would be minimal effect on the environment if an incident involving such equipment interactions occurred.

Conclusion: There will be health and safety hazards that are common to many types of jobs at the Kiggavik Project; controls will be implemented to reduce the likelihood of someone becoming injured. It is not expected that any of these incidents would have any effects on the environment.

5.5 General Transportation Risk Assessment

The general transportation risk assessment (Technical Appendix 10A) is a compilation of the assessment of the risks associated with the transportation of yellowcake and other chemicals for the Project. The assessment addresses the risks of transporting hazardous goods and uranium concentrate through various transportation modes (i.e. via truck, barge and aircraft) to workers, the public, and the environment. Risks were considered during routine operations and if an accident were to occur. Only those risks associated with accident and malfunctions are described in this volume; routine operations risks have been described in Volume 8 - Human Health.

5.5.1 Yellowcake Release

The combined frequencies of crash and rollover along the haul route between the Kiggavik Site and the airstrip was 4.7 x 10-5. No significant adverse environmental effects are expected as there is no water crossing along the route and any release to ground can be contained and cleaned effectively. The risk is negligible and no residual environmental effects are expected.

The in-flight crash frequency of air transport into a large lake was 1.1x10-4 per year for Kiggavik-Points North (year round). An accident between the Kiggavik site and airstrip is highly unlikely, with minor consequences.

The results assessing exposure to uranium from the various yellowcake spills are summarized in Table 6.10 through 6.13 for aquatic and terrestrial species within Tier 3 Appendix 10A: Transportation Risk Assessment. These results indicate that a spill of yellowcake into a large lake may have moderate risk as aquatic and waterfowl that have an aquatic based diet may be affected. However, the effects are transient in nature and contained within local areas in the vicinity of the spill for most cases.

The results of the ecological risk assessment indicate that terrestrial species (caribou and arctic ground squirrel) would not be at risk following a short-term major spill of yellowcake onto land from an aircraft accident. Likewise, short-term ingestion of contaminated water resulting from an accident would not result in potential risks to caribou. This risk assessment addresses community concerns such as: *what would happen if a plane of uranium crashed (EN-WC OH Nov 2012) and what kind of* *impact would there be on the animals if yellowcake was spilled into the environment* (EN-CH KIA 2010)?

It is expected that the environment fully recovers from such spills after the appropriate response and cleanup following each accident scenarios.

For human receptors, the dose estimates are well below (<1 mSv/yr) the Canadian Nuclear Safety Commission regulatory incremental dose limit of 1000 μSv/yr for members of the public as well as the Health Canada dose constraint limit of 300 μSv/yr.

5.5.2 Spill of Fuel and Reagents

The frequencies of spill near water (due to roll-over or crash) can be up to 3×10^{-4} per year for diesel fuel, and 2×10^{-4} per year for sulphur on the longest routes. The frequencies are more than an order of magnitude lower (with a maximum of 2×10^{-5} per year) for other materials since the quantities transported are much lower. For small quantities of oil spilt from vessels, the frequency of spill is 71 per billion barrels of oil transported.

The frequency of release of fuel (from tanker or fuel bunker) during marine transport was estimated at 0.027 per year.

A spill of fuel to water may result in a change in surface water quality. Following a fuel spill, steps will be immediately taken to reduce and mitigate the local impact of the spill by containing the plume with fuel containment booms and collecting the fuel from the surface of the water. Lake water sampling will also be conducted to monitor the movement of the spilled fuel and its potential to cause an adverse effect. After clean-up, all collected fuel will be stored, or disposed of safely in accordance with applicable regulations.

With respect to fish exposure, during the daytime, the fish population density is very low compared with the population at the depths greater than 2 m because of the exposure to high energy environment at the surface. During the night, the fish population move to the higher depths. This will allow a timely clean up of the residual oil from the surface of water while the fish exposure is minimal.

Following a spill, the fuel may be washed to the shoreline where benthic exposure is possible. Wave action makes the nearshore zone at Baker Lake Dock or Chesterfield Inlet unfavorable for benthic communities. For the areas with higher densities of benthic invertebrates, the populations of such communities, as well as rooted aquatic plants, are expected to recover after the cleanup is completed.

As opposed to crude oil, diesel fuel does not leave viscous or high density residues on the shore lines that could physically coat the bodies of ecological receptors. In addition, the spill is expected to be relatively small temporally and spatially, and no lasting residual effect is expected from this accident scenario; however, as a result of this fuel spill, there may be environmental effects experienced on the aquatic environment.

Therefore, long-term exposure of aquatic species is not expected from this scenario.

If the spill cannot be contained locally, the plume of spilled fuel may move toward the intake of a drinking water system.

Protection of the drinking water system against a potential fuel spill will involve a multiple-barrier approach that includes:

- preventive measures to reduce the likelihood of a fuel spill from occurring;
- mitigative measures to contain the spilled fuel; and
- notification to the operators of nearby drinking water supply for appropriate action.

Advanced notification procedures will be in place to inform applicable drinking water supply operators of any spill where there is potential for the contamination of the drinking water supply. The notification will ensure that the operator has adequate time to take precautions and appropriate actions before the plume of spilled fuel reaches the intake of the drinking water supply system. The limited nature of the spill that would result from this scenario would add an additional level of protection against contamination concerns.

Adverse effects resulting from a fuel spill on the quality of a community's drinking water are very unlikely and any effects would be mitigated prior to reaching the water supply of those in the community. There are no residual effects anticipated as a result of this scenario.

5.5.3 Fire and Explosion

The frequencies of fire and explosion for various routes can be up to 1.6 x 10^{-6} per year for diesel fuel, and 2.1 x 10^{-6} per year for ammonium nitrate on the longest routes. The frequencies are more than an order of magnitude lower for other materials as the quantities transported are much lower.

Some oil may reach surface water during a fire; the effects of this are considered bounded by the fuel spill scenario discussed in the previous section. If a fuel truck is involved in a fire, it is anticipated that during a fire, atmospheric release will originate from the diesel fuel and the tires of the truck.

In case of a fire following a fuel transportation accident scenario, all efforts would be made to extinguish the fire as rapidly as possible in order to prevent releases to the atmospheric environment. Considering all mitigating activities, it is expected that full cleanup of the surrounding environment will be possible following this accident scenario.

The burning of fuel oil is largely accepted to result in short-term effects at close vicinity of the fire, provided that measures are put in place to stop the fire as rapidly as possible in order to minimize the extent of the smoke plume. As a result of the rapid response and the ensuing mitigation measures that will be put in place, it is not expected that there will be residual effects from this scenario.

5.6 Marine Transportation Risk Assessment

There are a number of unique hazards associated with marine transport and these proposed activities have generated substantial interest from the Kivalliq communities; therefore, Project marine transportation risks have been further evaluated in a risk assessment associated with the Marine Transportation Plan (Technical Appendix 2J). This document provides a detailed breakdown of various tasks related to marine transport, the hazards related to each task and what types of controls will be in place. It compares the risks before controls are implemented and after controls are implemented. The risk assessment tables are found in the Marine Transportation Plan in Technical Appendix 2J, Appendix B & C and the results are summarized below.

The results of the risk assessment indicate that there is an unacceptable risk of a tug/barge grounding in Chesterfield Narrows due navigational or maneuvering error during passage of a tug towing two barges. Therefore the marine transportation plan includes passage of only one barge per tug while transiting the Narrows.

The risk assessment identified moderate risk activities that are considered acceptable with stringent controls. A number of these generally involve the potential for tug/barge grounding in Chesterfield Narrows; however, the causes of these incidents are related to mechanical failure or conflicting traffic in the Narrows and are considered mitigable by measures such as mechanical redundancy and the implementation of a traffic control program.

Further moderate risks were identified to occupational health and safety during anchoring operations in Chesterfield Inlet and barge docking activities at the Baker Lake dock site. Stringent protocols, appropriate PPE, and pre-installed anchor systems will be implemented to mitigate the risk. A risk of substantial damage or sinking of a vessel resulting from ice was identified. Mitigation measures include only sailing during the open water season and the use of ice class vessels.

A moderate risk of a fuel spill in Baker Lake was identified. Emergency response measures include spill kits located on board the vessels and at numerous locations along the route. Preventative measures to address the root causes of a spill include the use of double-hulled fuel barges and are also incorporated in the protocols for barge docking and transiting of the Narrows.

6 Effects of the Environment on the Project

The natural environment has the potential to affect the Project through a number of mechanisms:

- extreme weather, including blizzards, high winds, extreme precipitation, storm surges, fog;
- climate factors, including thaw susceptible soils;
- seismic activity;
- wildlife encounters; and
- tundra fires.

This section further identifies and evaluates the potential effects of the environment on the Project. Mitigation measures are proposed to mitigate risks to personnel, local communities, the environment, and the operation. Mitigation measures can be generally categorized as follows:

- measures to reduce the risk of an occurrence (design features and management programs)
- measures to minimize the consequences if the event occurs (management programs and response); and
- measures to ensure control is regained before activities re-commence.

Continuous improvement in the form of incident investigation, reporting, and follow-up will also be used to ensure lessons are learned to further reduce the risk.

The following discussion overlaps to some extent with the previous sections in this Volume since environmental hazards can be a contributing factor in Project accidents and malfunctions. Effects of these events on health and safety and the environment are addressed in the previous sections.

6.1 Extreme Weather and Meteorological Effects

The meteorological effects that may affect the Project consist primarily of local and regional variations from mean climatic conditions, including extended drought, severe temperatures, major precipitation, flooding, severe wind and blizzards (EN-WC KIA Jan 2012[18]).

[18] EN-WC KIA Jan 2012: *Saskatchewan has fewer storms than we do here. Has this been looked into?*

These extreme weather conditions could potentially have the following impacts on the Project:

- increased risk to personnel safety;
- damage to infrastructure and process stream containment;
- upsets to the site water balance resulting in excess effluent or lack of sufficient fresh water; and
- difficulties in transporting personnel, supplies and perishable goods to site due to reductions in shipping windows

Ultimately, these events could lead to a short to medium-term operational curtailment or shut down.

Potential effects of extreme weather and mitigation measures are summarized in Table 6.1-1.

Table 6.1-1 Potential Effects of Extreme Weather on the Project

Hazard	Potential Effects on the Project	Mitigation Measures
Extended drought	• Need for increased freshwater withdrawals • Potential mill operational difficulties if sufficient water is not available • Additional dusting and requirements for dust control	• Monitoring of effects on fresh water withdrawal lake (Siamese Lake and Mushroom Lake) • Increased monitoring frequency • Robust water management system; use of TMFs and PBP to store site drainage for recycle • Use of a secondary water source with regulatory approval
Extreme precipitation and flooding	• Increase in treated effluent discharge • Potential loss of pond containment • Over-topping site diversion and dewatering structures • Flooding open pits • Back-up of drainage at culverts • over-topping roads Bridge wash-out Ferry capsize • Damage to ferry infrastructure • Damage to dock site	• Containment ponds and diversion structures designed to handle PMP • Conservative WTP design • Contingency containment in • PBP and TMFs • Monitoring and maintenance of bridges, roads and culverts
Extended blizzard	• Personnel injury or fatality Spill / loss of containment Increased snow loading on • infrastructure	• Design to code for snow loads • Emergency shelters • Arctic corridors • Curtailment of outdoor work • Emergency Response and Spill • Contingency procedures

Table 6.1-1 Potential Effects of Extreme Weather on the Project

Hazard	Potential Effects on the Project	Mitigation Measures
Severe wind	• Personnel injury or fatality • Damage to infrastructure and potential loss of containment	• Design to code • Ultimate containment within mill terrace, open pits • Curtail outdoor work, particularly work at heights • Work shelters to minimize wind • Emergency Response procedures
Extreme temperature lows	• Personnel injury or fatality • Damage to mobile equipment	• Design to code • Curtail outdoor work, work shelters where possible to minimize effects of cold temperatures • Emergency Response procedures to ensure personnel safety

6.2 Climate Change

The potential effects of climate change on the predicted environmental effects of the Project have been assessed within the Tier 2 Environmental Assessment Volumes (Volumes 4, 5, 6, 7, 8, and 9). Additional discussion is provided in Technical Appendices 4D, 5D, 5G, 5J, and 5K. Northerners have been adapting to changes in climate for generations (Bolton et al. 2011). Some comments from Inuit Qaujimajatuqangit and public engagement suggests that climate change is happening (EN-BL CLC 2010[19], IQ-WCCR 2011[20]) although there are also other comments are in contrast with climate change (EN-RB OH 2012[21]). The following section is focused upon the potential hazards to the Project associated with climate change.

Climatic effects, including climate change, have the potential to affect the Project during both the operational, decommissioning and post-decommissioning phases. Significant climate change during operation could affect the site water balance, the stability of mining faces, the site heat balance, transportation of supplies and the stability of foundations and roads. After mine closure, climate

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[19] EN-BL CLC 2010: *My concern is I notice that winters are different now. Ice is thin.*

[20] IQ-WCCR 2011: *Freeze-up is later now than in the past.*

[21] EN-RB OH 2012: *8-9 years ago in Baker Lake, I noticed that when I looked at the lake, the water levels were much lower. It was dry where so much water was before.*

change could affect the atmospheric, aquatic and terrestrial environments. The potential effects and mitigation measures are presented in Table 6.2-1.

Table 6.2-1 Potential Effects of Climate Change on the Project

Hazard	Potential Effects on the Project	Mitigation Measures
Reduction in Permafrost and ice- rich soils	• Creep settlement or thermal degradation of roads, stockpiles, buildings • Failure of road embankments • Slumping or failure of pit slope • Instabilities in underground • openings • Slumping or landslide on large landforms • Increase in inflow to mines	• Geotechnical investigations in areas of critical infrastructure • Appropriate design in potential problem areas • Appropriate design of bridges and foundations • Inspections and repair of roads and foundations • Pit slope stability monitoring • Underground ground control monitoring
Increase in run-off	• Loss of site containment • Increase in treated effluent discharge • Over-topping site diversion and dewatering structures • Flooding open pits • Back-up of drainage at culverts • over-topping roads	• Containment ponds and diversion structures designed to handle PMP • Conservative WTP design • Contingency containment in PBP and TMFs
Decrease in winter-road operating window	• Logistics challenges and associated costs • Spill / loss of containment • Loss of power • Fire and/or explosion	• All-season road option
Change in open water season	• Logistical challenges and associated costs	• Multiple marine transport options

6.3 Seismic Events

There have been some concerns raised by community members about how an earthquake would affect mining activities (–EN-RB OH Nov 2012[22]). The risk of seismic events are low, however, there are mitigative measures in place should one happen during the operation of the Kiggavik Project.

[22] EN-RB OH Nov 2012: *What if there was an earthquake at the time you were mining?*

Table 6.2-1 below provides an assessment of potential effects of an earthquake, consequences and mitigation measures AREVA will have in place to manage an earthquake.

Seismic events, such as earthquakes, have the potential to damage Project buildings and equipment, earthworks structures, roads and bridges. The potential infrastructure damage creates associated risks to human safety and risk of environmental impact due to spills and breach of containment. Damage to infrastructure could lead to curtailment or shut down of production while repairs are made. Specific potential effects on the Project as a result of a seismic activity and the proposed mitigations are listed in Table 6.3-1.

Table 6.3-1 Potential Effects of Seismic Activity on the Project

Potential Effects on the Project	Related Potential Consequences	Mitigation Measures
Damage to water crossings	• Traffic accident: personnel injury and/or spill • Restricted cross-drainage	• Design to code • Emergency Response and • Spill Contingency procedures • Survey and repair of culverts and bridges post-event
Damage to buildings	• Personnel injury • Spill / loss of containment • Loss of power • Fire	• Design to code • Fail safe shut downs where required (powerhouse, mill) • Emergency Response and • Spill Contingency procedures
Damage to hazardous good storage (fuel tanks, peroxide storage)	• Personnel injury • Spill / loss of containment • Loss of power • Fire and/or explosion	• Design to code • Fail safe shut downs where required (powerhouse, mill) • Emergency Response and • Spill Contingency procedures
Damage to site drainage structures and lined ponds	• Spill / loss of containment	• Design to code • Ultimate containment within mill terrace, open pits
Damage to Andrew Lake dewatering structure	• Flooding in Andrew Lake pit • Temporary loss of fish or fish habitat in Andrew Lake	• Design to code • Emergency Response procedures to ensure personnel safety
Rock falls in open pits or rock stockpiles	• Personnel injury	• Design to include appropriate safety benches
Ground fall in End Grid underground mine	• Personnel injury • Loss of power	• Ground control measures • Emergency Response procedures to ensure personnel safety

As indicated in the risk assessment, the risk of seismic and tsunami events in the Kiggavik area is considered low and therefore the above effects are considered highly unlikely to occur.

6.4 Wildlife Encounters

Wildlife encounters are not expected to substantially affect the Project. Curtailment of activity may be required in some instances, such as during a large migration of caribou directly through the Project area.

Isolated wildlife encounters have the potential to affect the Project through personnel injury/fatality and traffic accidents. These encounters will be minimized through proper waste management practices, proper incinerator operation, safe work procedures and closure of roads and operations when necessary. Refer to the Wildlife Monitoring and Mitigation Plan (Technical Appendix 6D) for further discussion.

6.5 Tundra Fires

An uncontrolled tundra fire could affect the Project through damage to equipment and infrastructure, requiring curtailment of activities. Potential consequences of a fire on site are detailed in Section 5.4.

All efforts would be made to extinguish the tundra fire early and/or prevent it from impinging on site boundaries. The Emergency Response Team will be trained in fire-fighting techniques. If required, assistance would be requested from other operations in the region, communities and government agencies.

It is considered highly unlikely that an uncontrolled tundra fire will affect the Project.

7 Summary of Residual Effects from Accidents and Malfunctions and Environmental Hazards

Accident and malfunctions, including those caused or compounded by environmental hazards, are predicted to have no residual effects on the environment. Preventative measures, including design features, redundancy, secondary and tertiary containment, management plans, preventative maintenance, routine operational and environmental monitoring, safe work plans, and training programs will be in place to reduce the probability of the incident occurring. Response measures, including trained emergency response teams, an emergency response plan, a spill contingency plan, spill kits, monitoring programs, trained first responders, and a staffed health centre, will be in place to reduce the consequences of an incident if one were to occur.

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Attachment A Kiggavik Project Risk Assessment - Result

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Marine Transportation							
Spill of fuel or other hazardous goods in Chesterfield Inlet	Grounding, extreme weather, fire, ship collision, human error or equipment malfunction during fuel/material transfer	1	1	3	2	2	Technical Appendix 2J - Marine Transportation
Spill of fuel or other hazardous goods into Hudson Bay	Extreme weather, fire, ship collision, human error, act of war, piracy	1	1	2	2	2	Technical Appendix –2J - Marine Transportation
Spill of fuel or other hazardous goods near Churchill	Grounding, extreme weather, fire, ship collision, human error or equipment malfunction during fuel/material transfer	1	1	2	2	2	Technical Appendix –2J - Marine Transportation
Spill of fuel of other hazardous goods in Baker Lake	Extreme weather, fire, ship collision, human error	1	1	3	2	2	Technical Appendix –2J - Marine Transportation
Interruption of transport	Blocking of Chesterfield Inlet due to grounding	1	1	1	3	2	Technical Appendix –2J - Marine Transportation
Collision with smaller vessel	Human error	3	1	1	2	2	Technical Appendix –2J - Marine Transportation
Marine mammal strike	Human error	1	1	1	2	1	Tier 2 Volume 7 Environmental Assessment - Marine Environment

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Baker Lake Dock Facility							
Fuel spill along north shore Baker Lake	Human error or equipment malfunction/failure during transfer; Damage to tanks/pipes due to collision; operator error; vandalism; corrosion over time;	1	1	3	2	2	Tier 2 Volume 10 Environmental Assessment - Accidents and Malfunctions 5.5.2, 5.6 Emergency Response Plan (ERP) 8.4.7, 8.4.8 Technical Appendix 10–B - Spill Contingency and Landfarm Management Plan Technical Appendix 2J - Marine Transportation
Collision of tug/barge with dock, shore, other vessels	Extreme weather; human error	1	1	1	4	2	Technical Appendix 2J - Marine Transportation
Collision of mobile equipment with vehicles, other infrastructure (note other operations)	Extreme weather (fog, white out, storm, winds)	2	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5 Technical Appendix 10C E–P - 8.3.1, 8.4.5
Introduction of invasive species	Bilge water discharge	1	1	2	2	2	Tier 2 Volume 7 Environmental Assessment, - Marine Environment
Fire	Vandalism; equipment malfunctions; human error; improper storage of materials	2	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.6 Technical Appendix 10C ERP -8.4.2 Technical Appendix 2P Occupational Health and Safety (OH&S) Plan – 3.6, 3.12

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Explosion	Vandalism; equipment malfunctions; human error; improper storage of materials	4	1	2	1	2	Tier 2 Volume 10 Environmental Assessment Accidents & Malfunctions 5.4.4, 5.5.3 Technical Appendix 10C E–P - 8.4.10, Technical Appendix 2C – Explosives Management Plan Technical Appendix 2U Hazardous Management Plan
Baker Lake - Kiggavik Access Road							
Truck/Maintenance Vehicle through ice	Improper winter road prep / procedures; weather warm; extreme weather causes truck to deviate from winter road	4	1	3	2	3	Technical Appendix 10A – Transportation Risk Assessment 4.2.4.3 Technical Appendix 10C E–P - 8.4.6 5.4.12
Truck collides with ice ridges	Improper winter road prep / procedures; extreme weather causes truck to deviate from winter road	2	1	2	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions - 5.4.5 Technical Appendix 10 C ERP - 8.2.3, 8.3.1 Technical Appendix OH&S Plan - 3.2, 3.12
Single Truck collision	Extreme weather; human error; wildlife; local traffic	2	1	2	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5 Technical Appendix 10C E–P - 8.2.1, 8.3.2, 8.4.5, Technical Appendix 10A – Transportation Risk Assessment

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Truck stranding in poor weather	Extreme weather; equipment malfunction	2	1	1	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions - 5.4.11 Technical Appendix 10C E–P - 8.4.5
Truck collision with public traffic, wildlife		4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions - 5.4.5, 6.4 Technical Appendix 10A – Transportation Risk Assessment Technical Appendix 10C ER–P - 8.3.2, 8.4.5
Road embankment failure		2	1	2	2	2	Technical Appendix 10A – Transportation Risk Assessment
Bridge failure	Wash-out; ice break-up; slope failure	2	1	2	1	1	Technical Appendix 10A – Transportation Risk Assessment
Spill into Thelon	Truck through ice or ferry malfunction/capsize in extreme weather	4	1	3	2	3	Technical Appendix 10A – Transportation Risk Assessment
Ferry breaks away	Collision, grounding, injury; caribou disturbance	2	1	1	2	2	Technical Appendix 10A – Transportation Risk Assessment
Ferry collision with watercraft; collision with ferry or cable	Human error; equip malfunction	2	1	1	2	2	Technical Appendix 10A – Transportation Risk Assessment

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Yellowcake Transportation							
Spill during truck transport to airstrip	Collisions with vehicles/wildlife, road embankment failure, extreme weather, human error	1	2	3	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.5.1 Technical Appendix 10A – Transportation Risk Assessment Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10–B - Spill Contingency and Landfarm Management Plan
Spill during flight, take-off or landing	Aircraft incident/crash	2	2	3	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.5.1 Technical Appendix 10A – Transportation Risk Assessment AREVA Resources Canada Inc, Emergency Response Assistance Plan, (ERAP 2-0088)
Spill in plane	Drum failure; human error (improper packing)	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.5.1 Technical Appendix 10A – Transportation Risk Assessment AREVA Resources Canada Inc, Emergency Response Assistance Plan, (ERAP 2-0088)

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
Spill during loading /offloading	Dropping sea can, piercing with fork-lift	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.5.1 Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10–B - Spill Contingency and Landfarm Management Plan AREVA Resources Canada Inc, Emergency Response Assistance Plan, (ERAP 2-0088)
Contamination release	Failure of contamination control process (human error/instrument error)	1	1	1	2	1	Technical Appendix 2Q Radiation Protection Plan
Other Air Transportation							
Aircraft incident/crash	Extreme weather; aircraft malfunction; wildlife on runway; human error	4	1	3	1	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.17 Technical Appendix 10C - ERP 8.2.3
Spill de-icing fluid	Equipment malfunction, human error	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.3 Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10B - Spill Contingency and Landfarm Management Plan

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
Spill jet fuel	Equipment malfunction, human error	1	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.3 Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Spill radioactive cuttings	Slinging incident; equipment malfunction; human error	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.8 Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Open Pit Mining							
Major slope failure in pit	Seismic event; poor ground control/conditions; permafrost melting; improper blast/fly rock	4	1	1	1	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.4 Technical Appendix 10C - ERP – 8.4.1
Major slope failure on stockpile	Seismic event; poor stockpile loading/management; permafrost melting; improper blast/fly rock	4	1	2	1	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.4 Technical Appendix 10C - ERP – 8.4.1
Truck collision (with truck or wildlife)	Extreme weather; human error	2	1	1	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5, 8.4.5 Technical Appendix 10C - ERP 8.3.2

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Rock fall in pit or stockpile	Seismic event; poor ground control/conditions; permafrost melting; improper blast/fly rock	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.4 Technical Appendix 2C OH&S Plan 3.12 Technical Appendix 10C - ERP 8.4.1
Blast malfunction - incomplete consumption of explosives	Human error; material degradation;	1	1	2	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.7 Technical Appendix 10C - ERP – 8.4.10 Technical Appendix 2C Explosives Management Plan
Truck-pedestrian collision	Extreme weather; human error	4	1	1	1	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.16 Technical Appendix 10C - ERP – 8.2.1, 8.3.1
Fall into pit - personnel (fall to next bench)	Extreme weather; human error	3	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.5, 6.1 Technical Appendix 10C – ERP 8.3.1
Fall into pit – wildlife (fall to next bench)		1	1	1	1	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.5
Fall into pit - equipment	Extreme weather; human error	2	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.5 Technical Appendix 10C – ERP 8.3.1, 8.2.1

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Pit flooding	Andrew Lake dewatering structure failure;	2	1	2	1	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.6
Pit flooding	Unanticipated artesian pressure or fracturing;	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.7 Technical Appendix 10C – ERP 8.3.3
Diversion Channel Overflow	Overflow or breach of diversion channel	1	1	1	1	1	Tier 3 Appendix 2E – Freshwater Diversions and Wasterock Collections Channels Tier 3 Appendix 5O - Conceptual Erosion and Sediment Control Plan
Spill of pit water	Pipeline failure; human error; equip collision; corrosion	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.3, 5.4.1 Technical Appendix 10C – ERP 8.4.8
Spill of hazardous material (diesel, oil, ANFO)	Human error, equip malfunction	1	1	2	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.4, 5.5.2 Technical Appendix 10C - ERP 8.4.9 Technical Appendix 2U - Hazardous Management Plan
Vehicle roll over/off stockpile	Human error, equip malfunction; extreme weather	4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5 Technical Appendix 10C - ERP 8.4.5, 8.3.1, 8.2.1

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Type 3 mine rock placed on Type 1/2 stockpile	Improper segregation; human error; instrumentation malfunction	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.2
Ore placed on Type 1/2 stockpile	Improper segregation; human error; instrumentation malfunction	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.2
Equipment fire	Human error; equip malfunction; collision	2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.6 Technical Appendix 10C – ERP - 8.4.2
Electric shock causing fatality	Human error, equip malfunction, lightning strike	4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 8.3.10 Technical Appendix 2P – OH&S Plan 3.12, 7.2 Technical Appendix 10C - ERP 8.2.1
Underground Mining							
Ground failure / opening collapse	Seismic event; poor ground control/conditions; permafrost melting; improper blast/fly rock; improper backfill prep or placement	4	2	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.4 Technical Appendix 10C - ERP 4, 8.4.1
Rock fall	Improper screening rock bolts shotcrete	4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.4 Technical Appendix 10C - ERP 4, 8.4.1

Potential Accidents and Malfunctions	Potential Causes	Consequence Health and Safety	 Radiation Exposure	 Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Blast malfunction; incomplete	Human error; material degradation;	1	1	2	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.7 Technical Appendix 10C - ERP 4, 8.4.2, 8.4.3
Flooding underground	Unanticipated artesian pressure; dewatering equip malfunction	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.7 Technical Appendix 10C - ERP 4, 8.3.3
Ventilation failure	Power failure; equipment malfunction; human error	1	2	1	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.8 Technical Appendix 10C - ERP 4, 8.1.2, 8.4.3
Power failure	Damage to power lines, equipment malfunction, fire, lightning, human error sabotage	1	2	1	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.8 Technical Appendix 10C - ERP 4, 8.1.2, 8.4.3
Vehicle collisions with vehicles	human error	4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5 Technical Appendix 10C - ERP 4, 8.4.3, 8.4.5
Vehicle collisions with people	human error	4	1	1	1	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5 Technical Appendix 10C - ERP 4, 8.4.3, 8.4.5

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Fire	Panel shortage, vehicle fires	2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.6 Technical Appendix 10C - ERP 4, 8.4.2, 8.4.3
Spill of hazardous material (diesel, oil, ANFO)	Human error, equip malfunction	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.4 Technical Appendix 10C - ERP 4, 8.4.2, 8.4.3
Improper application of shotcrete/shielding	Human error; equip/material malfunction	1	1	1	4	2	Technical Appendix 10C - ERP 4
Ore Stockpiles							
Spill of ore along Sissons access road	Collisions with vehicles or wildlife; embankment failure; human error; extreme weather	1	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.1 Technical Appendix 10A - Transportation Risk Assessment Technical Appendix 10C ERP – 8.4.4 8.4.8
Loss of drainage containment	Over topping collection pond	1	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.3
Loss of drainage containment	Liner leak	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.3
Vehicle collision with truck or people or infrastructure or wildlife	Icy conditions; extreme weather, human error	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5, Technical Appendix 10C - ERP 8.3.1, 8.3.2, 8.4.5

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Inadequate equipment shielding	Poor design/maintenance; human error	1	1	1	4	2	Technical Appendix 2Q - Radiation Plan
Ore spill	Slope failure on stockpile; seismic event; poor ground control/conditions; permafrost melting	1	1	2	1	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.3
Fall from stockpile	Icy conditions; extreme weather, human error	2	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.10, 5.4.16 ERP
Milling							
Lack of / poor ventilation	Power failure; equipment malfunction; human error;	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.8 Tier 2 Volume 8 Environmental Assessment Report - Human Health – 5.3.5.2.2, 6.4.4.6.2 Technical Appendix 2Q Radiation Protection Plan
Power failure	Damage to power lines, equipment malfunction, fire, lightning, human error sabotage	1	2	1	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.8 Technical Appendix 10C - ERP 8.1.2
Scrubber malfunction	Power failure; equipment malfunction; human error;	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.6
Fire	Malfunction in SX, electrical failure, lightning strikes; human error	2	2	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.6 Technical Appendix 10C ERP- 8.4.2

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Explosion	Improper H2O2 handling; power failure; human error	4	2	2	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.7 Technical Appendix 10C ERP- 8.4.10
Reagent spill during transfer	Power failure; human error; pipeline failure	2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.4 Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Slurry spill exiting mill	Power failure; human error; pipeline failure	1	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1 Technical Appendix 10C ERP – 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Yellowcake spill during loading	Human error; equip malfunction	1	2	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.5 Technical Appendix 10C ERP - 8.4.4 Technical Appendix 2Q – Radiation Protection Plan Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
Acid spill out door or utilidor	Loss of power; human error; pipeline failure	3	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.1, 5.3.7 Technical Appendix 10 C – ERP 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Vehicle collisions	Extreme weather; human error	2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.5 Technical Appendix 10C - ERP 8.2.1, 8.4.5
Electric shock causing fatality	Human error, equipment malfunction, lightning strike; failure of lockout procedure	4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.10 Technical Appendix 10C ERP 8.2.1 Technical Appendix 2P - OH&S Plan 3.12, 4.3
Occupational health and safety incidents	Confined space, lock-outs, trapping, slipping, tripping, falling, pressure incidents, noise, acid, H_2O_2 , reagent exposures, electric shock, people/equip interactions	2	1	1	4	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.10, 5.4.18
Freezing of outdoor tanks/thickeners	Power failure, extreme temp, mechanical failure	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.2

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Infrastructure damage	Seismic events; snow load; extreme weather	2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 6.1,6.3,6.5 Technical Appendix 10C ERP – 8.2.1
Powerhouse							
Fuel spill outside containment	Collision, pipeline break, corrosion; improper offloading; human error	1	1	2	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1 ERP 8.4.8 Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.1, 5.3.7 Technical Appendix 10 C – ERP 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Fire		2	2	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.6 Technical Appendix 10C ERP- 8.4.2
Explosion		4	1	2	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.7 Technical Appendix 10C ERP- 8.4.10
Electric shock causing fatality		4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.10 Technical Appendix 10C ERP 8.2.1 Technical Appendix 2P - OH&S Plan 3.12, 4.3

Potential Accidents and Malfunctions	Potential Causes	Consequence Health and Safety	 Radiation Exposure	 Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Power failure	Damage to power lines, equipment malfunction, fire, lightning, human error sabotage	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.8 Technical Appendix 10C - ERP 8.1.2
Water and Waste Management							
Discharge of off- spec tailings	Improper treatment/ neutralization	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.2
Spill of tailings	Pipeline freeze, break, human error	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.3 Technical Appendix 10C - ERP 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Freezing of tailings in TMF	Improper water cover depth	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.2
Fall in the TMF (people, animals, vehicles)		1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.2.5 Technical Appendix 10C – ERP 8.2.1
TMF Overflow	Extreme precipitation, equipment malfunction, power failure, human error	1	1	2	1	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.4

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Spill of untreated effluent	Freezing, pipeline break	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.1 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan Technical Appendix 2I – Site Water Management Plan
Discharge of off- spec effluent.	Human error	1	1	2	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.2 Technical Appendix 2I – Site Water Management Plan
Spill of treated effluent	Liner leak, pipeline break, slope failure on monitoring ponds	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1.2 Technical Appendix 10C – ERP 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Monitoring ponds freeze	Extreme temperature; human error	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.2
Fall into monitoring ponds (people, animals, vehicles)		1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.9
Monitoring ponds overflow		1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.4

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Site collection ponds / PBP overflow	Extreme weather, human error	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.4
Contaminated water release outside of mill terrace	Improper management of contaminated snow or water (human error, improper drainage channel maintenance, culvert blockage)	1	1	2	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1.3 Technical Appendix 10C – ERP 8.4.4, 8.4.8 Technical Appendix 10 B - Spill Contingency and Landfarm Management Plan
Radiologically contaminated waste improperly disposed	Contaminated waste improperly segregated; human error	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.9 Technical Appendix 2S – Waste Management Plan 8.4.8
Incinerator explosion (within chamber)	Improper segregation of burnables; equipment malfunction; human error	3	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.9 Technical Appendix 10C - ERP 8.4.10 Technical Appendix 2S – Waste Management Plan
Hazardous materials release by incineration; waste oil burning	Hazardous waste improperly segregated; human error	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.9 Technical Appendix 2S – Waste Management Plan

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Hazardous materials release by landfilling	Hazardous waste improperly segregated; human error	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.9 Technical Appendix 10C - ERP 8.4.9 Technical Appendix 2S – Waste Management Plan
Hazardous materials release by shipping with recyclables	Hazardous waste improperly segregated; human error	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.9 Technical Appendix 10C - ERP 8.4.9 Technical Appendix 2S – Waste Management Plan
Hazardous waste spill during shipment to treatment facility	Collision, extreme weather	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.4 Technical Appendix 10C - ERP 8.4.9 Technical Appendix 10B - Spill Contingency and Landfarm Management Plan Technical Appendix 2U - Hazardous Materials Management Plan
Hazardous waste spill	Containment breach; spring freshet (improper drainage from pad)	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.4 Technical Appendix 10C - ERP 8.4.9 Technical Appendix 10B - Spill Contingency and Landfarm Management Plan Technical Appendix 2U - Hazardous Materials Management Plan

Potential Accidents and Malfunctions	Potential Causes	Consequence Health and Safety	 Radiation Exposure	 Environment	Likeli-hood	Risk Rating-based on highest level consequence	Reference to Assessment/ Controls
Release of off-spec sewage	Human error; equipment malfunction	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.2
Spill of untreated sewage	Human error; equipment malfunction	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1 Technical Appendix 10C - ERP 8.4.8 Technical Appendix 10B - Spill Contingency and Landfarm Management Plan
Spill of treated sewage	Human error; equipment malfunction	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1.2 Technical Appendix 10C - ERP 8.4.8 Technical Appendix 10B - Spill Contingency and Landfarm Management Plan
Fall into sewage sludge ponds (people, animals)	Human error;	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.9
Overflow sewage sludge ponds	Human error; equipment malfunction	1	1	1	2	1	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.3.4

Potential Accidents and Malfunctions	Potential Causes	Consequence			Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
		Health and Safety	Radiation Exposure	Environment			
Spill of sewage from vacuum truck	Human error; equipment malfunction	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.1 Technical Appendix 10C - ERP 8.4.8 Technical Appendix 10B - Spill Contingency and Landfarm Management Plan
Accommodation Camp							
Fire		2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15 Technical Appendix 10C - ERP 8.1.1, 8.4.2
Lack/loss of heating	Loss of power	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15 Technical Appendix 10C - ERP 8.1.2
Lack/loss of potable water	Loss of power; line freezing	1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15 Technical Appendix 10C - ERP 8.1.3
Sewage backup		1	1	1	3	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15 Technical Appendix 10C - ERP 8.1.5

Potential Accidents and Malfunctions	Potential Causes	Consequence: Health and Safety	Consequence: Radiation Exposure	Consequence: Environment	Likeli-hood	Risk Rating- based on highest level consequence	Reference to Assessment/ Controls
Infrastructure damage	Snow loading or extreme weather	2	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15 Technical Appendix 10C - ERP 8.1.1
Food poisoning		2	1	1	3	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15
Food supply disruption	Extreme weather; stranding at site	1	1	1	4	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.15 Technical Appendix 10C - ERP 8.1.4
Other							
Wildlife encounters		4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 6.4 Technical Appendix 6D – Wildlife Mitigation and Monitoring Plan Technical Appendix 10C - ERP 8.3.21
Missing persons		4	1	1	2	3	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.14 Technical Appendix 10C - ERP 8.2.2
Firearm incident	Human error; mental health issues	4	1	1	1	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.13
Stranded at site	Extreme weather; mechanical failure of aircraft	2	1	1	2	2	Tier 2 Volume 10 Environmental Assessment – Accidents & Malfunctions 5.4.10

Attachment B Evaluation of Radiation Exposures Related to Accidents and Malfunctions

B.1 Methodology

Accidents and malfunctions involving radioactive materials may result in incremental radiation exposures to persons involved. An evaluation of potential incremental radiation exposures has been conducted for accident and malfunction scenarios developed in this document. A screening level assessment was conducted to identify those scenarios for which an incremental radiation exposure may be expected. Many identified potential accident or malfunction scenarios do not involve radioactive materials. Where the potential for an incremental exposure was identified, a radiation exposure assessment has been conducted to estimate the incremental dose where appropriate. As the exposure scenarios primarily involve nuclear energy workers at the mine and mill facility, whose annual radiation dose must average less than 20 mSv/year, an incremental dose less than 100 uSv was considered minor for the purposes of risk evaluation in Attachment A.

B.2 Screening Level Assessment

Table B 2-1 presents a screening level assessment to identify accidents and malfunctions which may result in incremental radiation exposure.

Table B-2 1 Screening Level Assessment of Mining and Milling Activities

Category	Accident/Malfunction	Potential For Incremental Exposure			
		Gamma	LLRD	RnP	Rn
Mine Site	Transportation of Ore	✓	✓	✓	✓
	Improper Segregation of Mine Rock and Ore	✓	✓	✓	✓
	Release of Contaminants from Surface Ore Stockpiles	non-radiological accident/malfunction			
	Failure of Slopes and Ground Control	✓	✓	✓	✓
	Falls into Pit	non-radiological accident/malfunction			
	Andrew Lake Dewatering Structure Failure	non-radiological accident/malfunction			
	Pit and Underground Flooding	non-radiological accident/malfunction			
Mill	Ruptures and Spills from Mill and Effluent Treatment Process Tanks and Pipes	✓	✓	✓	✓
	Freezing of Tanks, Site Ponds and Tailings	✓	✓	✓	✓

Category	Accident/Malfunction	Potential For Incremental Exposure			
		Gamma	LLRD	RnP	Rn
	Spills from Tailings Transfer Pipelines	✓	✓	✓	✓
	Overflow of the Tailings Management Facility (TMF) and Sewage, Monitoring and Site Collection Ponds	✓	✓	✓	✓
	Uranium Concentrate Spill within Mill	✓	✓	✓	✓
	Scrubber Stack Failure	non-radiological accident/malfunction			
	Acid Plant Malfunction	non-radiological accident/malfunction			
	Power Failure	✓	✓	✓	✓
	Falls into Lined Ponds	non-radiological accident/malfunction			
General	Spill Risks within Project Footprint	non-radiological accident/malfunction			
	Spills Outside of Project Footprint	non-radiological accident/malfunction; spills of radioactive material outside project footprint discussed in Section 5.5			
	Release of Off-Specification Effluent	non-radiological accident/malfunction			
	Spill of Jet Fuel and De-icing Fluid	non-radiological accident/malfunction			
	Hazardous Substance Storage and Release	non-radiological accident/malfunction			
	Vehicle Collisions	non-radiological accident/malfunction			
	Fire Risks	non-radiological accident/malfunction			
	Explosion Risks	non-radiological accident/malfunction			
	Spill of Exploration Drill Cuttings	✓	✓	✓	✓
	Waste Management	non-radiological accident/malfunction			
	Stranded at Site	non-radiological accident/malfunction			
	Stranded on Road	non-radiological accident/malfunction			
	Fall Through Ice	non-radiological accident/malfunction			
	Firearm Incident	non-radiological accident/malfunction			
	Missing Persons	non-radiological accident/malfunction			
	Disruption of Accommodation Camp	non-radiological accident/malfunction			
	Medical emergency/Medical Conditions	non-radiological accident/malfunction			
	Aircraft Incidents	non-radiological accident/malfunction; aircraft incidents involving yellowcake are evaluated in Section 5. 5			

B.3 Radiation Exposure Assessment

Estimation of worker doses is based on an approximate ore grade of 0.4 %U. A discussion of radiation risk is presented and a scenario developed, where applicable, for the estimation of radiation exposure. Estimations and discussions are intended to inform the evaluation of radiation risk within the risk assessment matrix.

B.3.1 Transport of Ore

Mine workers routinely transport ore from the mine to ore stockpiles or to the mill. Their routine exposure during mining activities has been evaluated in Volume 8, Human Health. Workers transporting radioactive materials are trained in proper personal protective measures in the event of an accident and in mitigation techniques to protect the public and the environment. Spillage of ore along an on-site transportation route would require that the material be excavated and reloaded into a haul truck before continuing. It is conservative to consider that the dose rates encountered during cleanup would be similar to the nominal dose rates encountered in mining operations.

As a limiting ore transport scenario, it is assumed that an entire load from a 100t truck has been spilled. To clean up the spilled ore, a loader operator and a truck driver would be required to excavate and remove the spilled material. A technician would direct the work using radiation detection equipment to ensure complete recovery.

The gamma dose rate from the source material is conservatively estimated using the relationship developed by Chambers et al (Chambers et al. 1981) for a thick, large source:

Gamma Dose Rate, GDR = 45 mGy/h per % U_3O_8 x % U_3O_8/0 85 % U x 0 70 Sv/Gy.

For an ore grade of 0.4% U, the gamma dose rate from a large, thick source is approximately 15 uSv/h.

Attenuation factors for mining equipment have been determined experientially through field testing (COGEMA 1998) and are presented in Table B2-2 below.

Table B 2 2 Equipment Attenuation Field Test Results

	Equipment		Observed Gamma Dose Rate (μSv/h)	Shielding Factors
1	Pit Truck Driver (100 ton trucks)			
		Groundshine at test location	22.5	
		Inside the cab at drivers position (unloaded)	3	
	Shielding provided by truck from ground			0. 133
		Inside the cab at drivers position (fully loaded)	14	
		Ore in load (at contact)	82. 5	
	Shielding provided by truck from load			0. 133
2	Backhoe/Loader Operator*			
		Groundshine at test location	86	
		Inside the cab at drivers position (unloaded)	21	
	Shielding provided by loader from ground			0. 244
		Inside the cab at drivers position (loaded)	25	
		Ore in load (at contact)	85	
	Shielding provided by loader from bucket			0. 047
3	Pit / Mill Truck Drivers (50 ton truck)			
		Groundshine at test location	22. 5	
		Inside the cab at drivers position (unloaded)	6	
	Shielding provided by truck from ground			0. 267
		Inside the cab at drivers position (fully loaded)	12	
		Ore in load (at contact)	85	
	Shielding provided by truck from load			0. 071

The primary source of exposure would be from gamma radiation; radon, radon progeny, and long-lived radioactive dust (LLRD) exposures are typically a fraction of the gamma exposure as this occurs outdoors and operators are within equipment cabs. For purposes of estimation, the radon & radon progeny dose and the LLRD dose are considered to be proportionally similar to that observed in mining operations, i.e. approximately 20% and 15% of gamma dose respectively.

Position	Time (hrs)	Unshielded Dose Rate @ 0. 4%U (μSv/hr)	Shielding Factor	Gamma Dose (uSv)	LLRD (uSv)	RnP & Rn (uSv)	Total Dose (uSv)
RP Technician	1	15	1	15	2. 3	3	20. 3
Loader Operator	1	15	0. 133	2	0. 3	0. 4	2. 7
Truck Operator	1	15	0. 047	0. 7	0. 1	0. 1	0. 9

Conclusion: Incremental radiological exposure would be minor.

B.3.2 Improper Segregation of Mine Rock and Ore

If a full load of ore (100 tonnes) were to be dumped mistakenly on the temporary stockpile instead of the ore stockpile the material would be cleaned-up and properly placed. A truck operator, equipment operator and either a geology or RP technician would be involved in the clean-up and transfer of material. The scenario is identical to the scenario considered for the spillage of ore.

Conclusion: Incremental radiological exposure would be minor.

B.3.3 Failure of Slopes and Ground Control

A failure of a slope or ground control may result in additional excavation in order to continue mine development. The events do not generally result in an increase in exposure rates, however, the extension of the mining period could result in an increment in the cumulative dose over the life of the mine. The incremental dose would occur nominally at the annual rates estimated in Volume 8, Section 6, and deemed to be acceptable.

Conclusion: Incremental radiological exposure would be minor.

B.3.4 Ruptures and Spills from Mill and Effluent Treatment Process Tanks, Pipes and Freezing of Tanks, Site Ponds and Tailings, and Spills from Tailings Transfer Pipelines

The rupture of a process vessel or piping within the mill or external to the mill results in similar exposure scenarios, i. e. operators and maintenance personnel are exposed to a quantity of spilled material for a period while the situation is remedied.

Vessels containing uranium bearing materials are designed with secondary containment measures in the event of an incident to contain materials and facilitate cleanup. Inside the mill, upset ventilation systems quickly reduce exposures to airborne contaminants; outdoors, airborne contaminants dissipate quickly.

A conservative exposure scenario considers the upset of a large vessel into an enclosed space. In this scenario, a 20 m^3 vessel releases its contents into secondary containment, requiring an operator to pump the material to another vessel, and a repair to be conducted by maintenance personnel. The exposure period is conservatively considered to be 5 hours. Again, consider the spilled material a large, thick source. The unshielded dose rate from run-of-mine ore estimated above is approximately 15 uSv/h. Process vessels typically contain materials which are less than 50% solids so the dose rate from the slurry material is approximately 50% of the run-of-mill dose rate (Chambers et al. 1981), resulting in a dose rate of 7.5 uSv/h. To estimate radon emissions, consider a 20 m^3 slurry volume of 0.4 % ore at 50% solids covering an area of 20 m^2 .in a building that is 1000 m^3 in volume, with an air exchange rate of 4 exchanges per hour. Radon emissions, $E_{Rn\text{-}222}$, can be estimated as follows:

E_{Rn222} = Ra-226 content (Bq/g) x Radon generation rate (Bq Rn-222/m^2/s/Bq Ra-226/g)

= 0.004 g U/g ore x 50% x 1.22×10^4 Bq Ra-226/g U x 1 Bq Rn-222/m^2/s/Bq Ra-226/g x 20 m^2

= 490 Bq/s

Estimated radon concentration at equilibrium in the room using a single chamber model (EIC 2014) is approximately 440 Bq/m^3 with a corresponding radon progeny concentration of 0.02 WL. The combined effective dose rate from exposure to radon and radon progeny at these levels is given by:

Effective Dose Rate (uSv/h) = Rn (Bq/m^3) x breathing rate (m^3/h) x DCF_{Rn} + RnP (WL) x DCF_{RnP}

= 440 Bq/m^3 x 1.2 m^3/h x 20 mSv/1.6 $\times10^8$ Bq + 0.026 WL x 5 mSv/WLM x 1 month/170 h

= 6.6×10^{-5} mSv/h + 7.6×10^{-4} mSv/h

= 0.83 uSv/h

For LLRD exposure estimates, the nominal workplace exposure rate objective of 0.01 DAC will be used though the generation of airborne dusts are generally eliminated by keep materials wet, which would be a necessity for cleanup.

LLRD Effective Dose Rate (uSv/h) = 0.01 DAC x 20 mSv/DAC x 1year/1800 hours = 0.1 uSv/h

Position	Time (hrs)	Unshielded Dose Rate @ 0. 4%U (µSv/hr)	Shielding Factor	Gamma Dose (uSv/h)	LLRD (uSv/h)	RnP & Rn (uSv/h)	Total Dose (uSv)
Mill Operator	5	7. 5	1	7. 5	0. 1	0. 83	42
Maintenance	5	7. 5	1	7. 5	0. 1	0. 83	42

Conclusion: Incremental radiological exposure from the scenario would be minor.

B.3.5 Uranium Concentrate Spill within the Mill

Uranium ore concentrates are packaged using an automated system by operators wearing protective clothing. Handling of yellowcake drums is similarly conducted within the facility under controlled conditions. The most likely scenario resulting in the spillage of uranium concentrates within the mill involves the accidental puncturing of a drum by a fork lift. Events involving drum puncture involve small quantities of materials within facilities designed for easy clean up. Gamma radiation levels in the vicinity of a spill of yellowcake within a mill facility remain unchanged by minor spillage due to the source material in the area. The primary risk of exposure will be from long lived radioactive dust (LLRD) however personal protective equipment worn to mitigate internal exposure during the clean-up of the spill and when transferring the remaining drum contents is effective at eliminating incremental exposure.

Conclusion: Spillage of uranium concentrate within the mill is unlikely to result in incremental radiation exposure.

B.3.6 Power Failure

In the event of a power failure at either the underground mine or the mill, the primary radiological concern is the absence of operating ventilation systems which reduce airborne radiological levels. Typically, with generated power on the mine site, power interruptions are short lived because there are multiple generators, and the operation of ventilation systems is a priority, interruption affecting workplace radiological exposure rates is rare. The mill design calls for both process exhaust systems and general area ventilation. With process ventilation systems, radon generated from mill processes remains isolated from the general work environment. In the absence of robust, well monitored ventilation systems with a defence-in-depth strategy, radon and radon progeny levels can rise to unacceptable levels.

Conclusion: Power failure can have a major impact on radon and radon progeny exposures.

B.3.7 Spill of Exploration Drill Cuttings

During exploration drilling, mineralized drill cuttings are packaged into tote bags and transferred for storage or disposal. A slinging operation mishap could result in the need for cleanup. A mishap would be confined to a single tote volume of approximately 1 m^3. For this scenario consideration was given to a clean-up involving a tote of mineralized drill cuttings accidentally spilled onto an area of land during a slinging operation mishap. The primary source of exposure would be from gamma radiation; doses due to LLRD, radon, and radon progeny are negligible in the outdoor environment. Doses received by workers, would be related to the grade and dispersal of the drill cuttings, how close the workers are to the dispersed cuttings and the amount of time involved in the clean-up. The exposure scenario resembles that of spilled ore, discussed above, however, the cleanup would likely be conducted by hand, using shovels, rather than using equipment. It is estimated to take approximately 4 hours for a 2 person crew to shovel the dispersed material into a new tote for transport. The source material in this case would be neither large nor thick so the unshielded dose rate calculated above will significantly overestimate the gamma dose rate and should therefore compensate for any minor underestimation created by ignoring contributions from LLRD, Rn and RnP.

Position	Time (hrs)	Unshielded Dose Rate @ 0.4 %U (µSv/hr)	Shielding Factor	Total Dose (uSv)
Cleanup Crew	4	15	1	60

Conclusion: Incremental radiological exposure from the scenario would be minor.

B.3.8 Summary

All accident and malfunction scenarios evaluated resulted in estimated radiation doses which are a fraction of the the annual dose limit for a nuclear energy worker.