TANBREEZ

TANBREEZ MINING GREENLAND A/S

TANBREEZ PROJECT

ENVIRONMENTAL IMPACT ASSESSMENT

DECEMBER 2014

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MAIN REPORT

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List of Acronyms

ABA	Acid Base Accounting
AMP	Act of Mineral Resources
BAT	Best Available Technique
BFS	Bankable Feasibility Study
BMP	Bureau of Minerals and Petroleum
BWM	International Convention for the Control and Management of Ships' Ballast Water and Sediment
CBD	Convention on Biological Diversity
CCP	Conceptual Closure Plan
DWT	Dead Weight Tonnage
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FCP	Final Closure Plan
GEUS	Geological Survey of Denmark and Greenland
GWQG	Greenland Water Quality Guidelines
IMO	International Maritime Organization
IUCN	International Union for Conservation of Nature
MAB	Man and Biosphere Reserve
MARPOL	International Convention for the Prevention of Pollution From Ships
NAG	Net Acid Generation
NERI	National Centre for Environment and Energy, Aarhus University
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
PAG	Potentially Acid Generating
PPM	Parts Per Million
REE	Rare Earth Element
ROM	Run Of Mine
SFE	Shake Flask Extraction
SIA	Social Impact Assessment
TPA	Tonnes Per Annum
UNFCCC	United Nations Framework Convention on Climate Change
VEC	Valued Ecological Component

1 NON TECHNICAL SUMMARY AND CONCLUSION

The TANBREEZ project will extract, process and export mineral concentrates containing Zirconium, Yttrium, Niobium, Hafnium, Tantalum and rare earth elements. The project is located at Killavaat Alannguat (Kringlerne) on the Kangerluarsuk Fjord in South Greenland. The site is about 20 km northeast of Qaqortoq and 12 km southwest of Narsaq. This Environmental Impact Assessment (EIA) assesses the environmental impact of development, operation and closure of the mining project, according to Greenlandic guidelines.

The TANBREEZ project will extract about 500,000 tons of ore per year from two open pit mines. The planned mine operation will have two phases: 1) a pit near the fjord will be excavated for the first five years (Fjord pit site), and 2) a pit on the hill at 450 m will be excavated for the last five years (Hill pit site). A processing facility near the shore will crush and magnetically separate the extracted minerals into mineral concentrates of eudialite and feldspar. About 300,000 tons of mineral concentrates will be shipped from a port facility for further processing outside Greenland. About 200,000 tons per year of tailings (fine material left from processing the ore) will be deposited as slurry in a natural tailings pond (Fostersø a small lake on Killavaat Alannguat at 470 m altitude). The tailings will be transported from the processing plant to Fostersø in a pipeline as slurry. Small amounts of waste rock (low grade rock that cannot be used for processing) will also be deposited in Fostersø.

The project also includes a diesel power plant, storage shed, worker accommodations and other facilities situated. All these facilities will be situated on the shore of the fjord. The area of the mine project will be about 2 x 5 km. A 1 km haul road will lead from the Fjord pit site to the process plant. A 5 km haul road will lead from the mine site on the Hill pit site.

The landscape at Killavaat Alannguat is characterized by relatively high and steep mountains and the long, narrow Kangerluarsuk Fjord. The port and most infrastructures will be located near the head of the fjord close to the outlet of Lakseelv, the largest river in the area. Outflow from the proposed tailings pond (Fostersø) will flow through Laksetværelv to Lakseelv. The ground is rich in minerals which lead to natural high levels of many metals in the soil, sediment and water.

Lakseelv has a large population of fish (Arctic char) while Laksetværelv and Fostersø are fishless. Killavaat Alannguat is almost devoid of vegetation above 50-100 m elevation while dwarf heath vegetation occurs along the shore of the fjord and lower parts of Lakseelv. Wildlife is limited to two terrestrial mammal species (a fox and a hare) and small numbers of marine mammals (seals and whales). The birdlife is limited to a few common and widespread species of South Greenland. No sea bird colonies are found along the fjord. A few species occurring in the study area are listed on the Greenland Red list of threatened species, most notably White-tailed eagle. However, no nesting sites of the eagle are known from the project area.

This EIA report assesses if the planned mine project will have a negative impact on the environment. The Greenlandic guidelines for EIAs require identification of potential pollution and disturbance impacts. A number of specific studies have been carried out to assist the EIA process. These include studies of the tailings material and waste rock to determine if heavy metals would leach out if the materials are deposited in water. A study has tested if the tailings or waste rock could leach toxic substances. Another study has modelled the dispersal of airborne dust and emissions of particulate matter generated from the project. Staff from Nuuk Museum have surveyed the project area for cultural heritage sites and biologists have studied the flora and fauna. Other sources of information for the EIA process include previous studies in the area and studies from other mine projects in the Arctic.

Information about the planned mine project and the project area including its biodiversity and hydrology was compiled and all activities of the mine project that can potentially be a source of disturbance or pollution have been identified. For each potential impact the receptor and potential pathways have been identified.

The deposition of tailings and waste rock in Fostersø can potentially have an impact on the lake itself, Laksetværelv which drains Fostersø and Lakseelv downstream the point where it meets with Laksetværelv (and ultimately the fjord).

The majority of the large Arctic char in Lakseelv occur in the lower part of the river downstream the point where it meets with Laksetværelv. This is also the part of the river where most (if not all) of the Arctic char spend the winter. During summer large numbers of adult Arctic char migrate into the fjord.

A major concern regarding deposition of tailings and waste rock in Fostersø is the potential release of metals and other elements to the lake water. Such releases of contaminants, such as heavy metals, into the water of Fostersø can potentially have effects on the Arctic char population in Lakseelv and key prey organisms for these fish.

To assess to what extent metals and other elements can be released from tailings and waste rock deposited in Fostersø, a number of experiments and tests have been carried out. The tests showed that some metal leaching to the lake water will take place, however for most metals the leaching will result in concentrations below the Greenland Water Quality Guideline (GWQG) values.

Data on the metal leaching to the lake water was subsequently combined with a hydrological model of the Fostersø freshwater system to assess the potential release of metals from the tailings pond over time. The modeling showed that concentrations of metals in Fostersø will increase the first years but then reach a steady-state after about 5 years of operation. Except for lead the modeling predicts that the content of metals will be below GWQG values. The level of lead will after 5 years be elevated to 1.63µg/l and after 10 years reach 1.81µg/l and thereby exceeds the GWQG value of 1 µg/l. However, according to the BMP (2011) the GWQG value has to be met at one or more specified points downstream the mining operation not in Fostersø which as tailings and waste rock pond is part of the mining operation.

A realistic measuring point where the GWQG should be met is just below the point where the outflow of Fostersø blends with Lakseelv. During most of the year the outflow from Fostersø contributes to about 20% of the water in Lakseelv. The water from

Fostersø will therefore be diluted in a short distance from the effluent point (the outlet of Laksetværelv) and the ambient water quality of Lakseelv will not exceed the GWQG.

During mid-winter (January-March) the flow of Lakseelv is much reduced. However, deposition of tailings and waste rock in Fostersø will take place all year and the addition of material to the lake will cause Laksetværelv to flow even during the coldest time of the year (as opposed to the present situation where the flow is very reduced or even stops between early January and late March). In this situation the share of inflow from Laksetværelv to Lakseelv will increase considerably.

This is unlikely to cause lead concentration in excess of the GWAQ value in Lakseelv during the first 3-5 years of mine operation because of the low lead concentrations in the lake water. To what extent the low water flow in Lakseelv during mid-winter will cause the concentration of lead to exceed the GWQG value after 3–5 years of operation is unknown. If a significant increase in the lead concentration is predicted in Lakseelv in mid-winter after 3-5 years of operation there are several ways of preventing the lead concentration to exceed the GWQG value.

One option is to build a dam across the outlet of Fostersø with a throttle valve to prevent outflow during periods of very low flow in Lakseelv. The excess water could then be released in spring when snow melting causes the flow of Lakseelv to be particularly high. Another option is to lower the water level in Fostersø in autumn by pumping water out of the lake into Laksetværelv. The lowering of the water level in the lake would then create room for waste material to be deposited without causing an outflow of water during periods of low flow in Lakseelv. The two options could also be combined.

Similar assessments have been carried out of the entire suite of potential impacts on play in connection with the TANBREEZ project. This includes changes to topography when a significant portion of the outcrop at Killavaat Alannguat is mined as well as the re-profiling of the landscape for infrastructure construction on land and along the shore of the fjord. It also includes the potential increase in dust and emissions generated by trucks and blasting and other project activities and climate change due to the fossil fuel combustion at the diesel power plant and vehicles. The potential disturbance and loss of habitat when for example vegetation is overlaid by buildings has been assessed for marine, freshwater and land animals and plants. Also pollution from other potential sources than tailings and waste has been assessed. This includes accidental release hazardous material such as oil and other hazardous waste.

The conclusion is that if the mitigating measures proposed in this EIA report are implemented and the mining activities are carried out in accordance to good environmental practice then the significance of the impacts on the environment will be low. No significant contamination by toxic materials or other pollutants is expected to take place. Dust dispersal will be small and local and will not contain toxic material. No key animals (such as White-tailed eagle and Arctic char) or rare plants are believed to decline or be displaced because of the mine project.

2 INTRODUCTION

2.1 TANBREEZ Project

The proposed project – the TANBREEZ project - includes the development, operation and ultimate reclamation of an open pit Zirconia, Rare Earth Elements, Yttrium, Niobium, Hafnium and Tantalum mine at Killavaat Alannguat (Kringlerne) in South Greenland. An on-site processing facility will produce mineral concentrates. The concentrates will be transported of-site by ship to a facility abroad for further processing.

2.2 Project setting

The TANBREEZ Project is located about 20 km north-east of Qaqortoq and 12 km south-east of Narsaq (Figure 2.1). The Killavaat Alannguat mineral deposit is situated on the south-east side of the Kangerluarsuk Fjord near the head of the fjord. The fjord is mostly steep sided and surrounded by mountains rising to 700-1,000 m with the Killavaat (Redekammen) mountain to the east rising to 1,200 m.

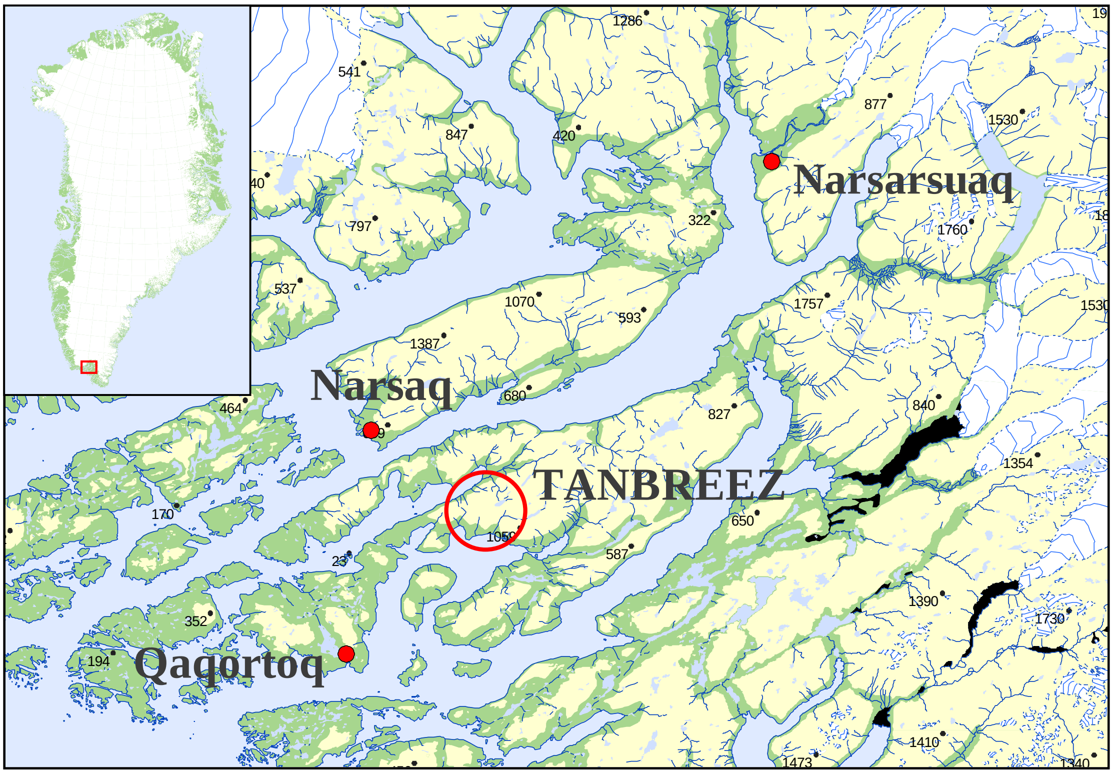

Figure 2.1 Location of TANBREEZ project area in South Greenland

2.3 Environmental Impact Assessment for TANBREEZ project

It is a requirement of the Greenland Self Government that Environmental and Social Impact Assessments are prepared to evaluate the potential impacts on the environment and the community, of proposed developments, such as an open pit mine.

The present Environmental Impact Assessment (EIA) report was prepared in compliance with the official guideline of the BMP, "BMP guidelines – for preparing an Environmental Impact Assessment (EIA) Report for Mineral Exploitation in Greenland" 2nd Edition, January 2011 (Bureau of Minerals and Petroleum 2011).

The EIA has been prepared by the independent consultant Orbicon A/S (Denmark) supported by Orbicon Greenland A/S. Orbicon has been contracted by TANBREEZ Mining PLC. The report is supported by environmental baseline studies carried out by Orbicon in 2007 – 2011.

2.4 Geographical scope of this EIA

The geographical areas assessed in the EIA are defined according to the following terms:

'**Project footprint'** means the area directly influenced by the mine project including the close vicinity to the project components and infrastructure i.e. few hundred meters from the open pit mine area, the process plant facilities and conveyors, the access road, pipeline, port site, etc.

'**Study Area'** means the geographical area where there can be a recognizable or potential impact in terms of disturbances of the natural flora and fauna or from pollutants (noise, dust, water pollution, etc.). In the TANBREEZ project this area is confined to the area seen in Figure 2-2.

"Global Area" Some environmental issues are not confined to geographical areas but has a global perspective e.g. emission of greenhouse gasses.

The EIA is not assessing transport of the product outside the Greenlandic waters or any further processing of the product abroad.

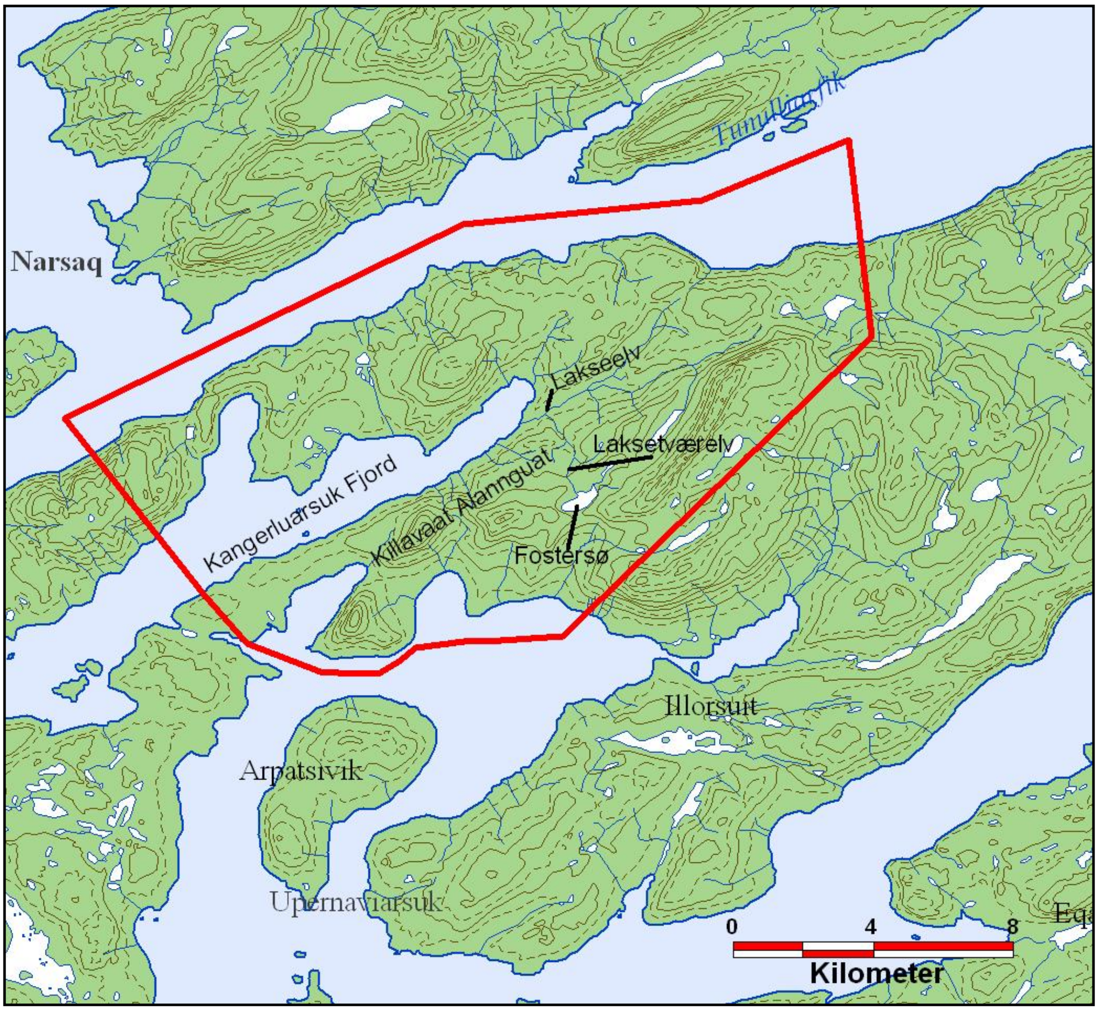

Figure 2.2 Study area in connection with the TANBREEZ project (red marking)

2.5 TANBREEZ Mining Greenland A/S

In 2001 the exploration license for the Killavaat Alannguat area was acquired by Rimbal Pty. Ltd. Exploration at Killavaat Alannguat was initiated in 2007 though the subsidiary Westrip as the TANBREEZ Project. In 2010 the TANBREEZ Mining Greenland A/S, a subsidiary of Rimbal, based in Nuuk was formed.

2.6 Project history

In 1986, the Danish company A/S Carl Nielsen started exploration at Killavaat Alannguat. In 1988, a joint venture between Highwood Resources Ltd. and Platinova Resources Ltd. started exploration in the same area. In 1989 the Ilimassaq Joint Venture was formed between the three companies. Until 1991, at least 60 holes totalling more than 2,500 m were drilled and more than 70 tons of ore were bulk sampled for further studies. The companies explored for zirconia, yttrium, and Rare Earth Elements.

In 1988, the companies aimed at exploitation licensees during 1989 and 1990. Therefore, different environmental investigations were initiated in those years. Ore and tailings from a Highwood Resources Ltd. pilot plant were studied for leaching metals and the toxicity of the produced leachate was tested on rainbow trout.

In the early 1990s, Highwood Resources Ltd. and Platinova A/S investigated the potential to produce sodalite, the raw material for the manufacture of zeolite. Zeolite is a substitute for phosphates in detergents.

Since 1997, the companies have performed no exploration activities in the area, and in 2000, Highwood Resources Ltd. relinquished their exploration license.

In 2001 the exploration license for the Killavaat Alannguat area was acquired by Rimbal Pty. Ltd.

3 ADMINISTRATIVE AND LEGISLATIVE FRAMEWORK AFFECTING THE PROJECT

This section describes the administrative and legislative framework of environment in relation to the project, i.e. an introduction to the key Greenlandic legislation and some of the key international agreements in this regard.

Greenland is part of the Kingdom of Denmark. Autonomous local governance was introduced to Greenland in 1979. On 21 June 2009 a new Act on Greenland Self Government came into force, which states that Greenland could take over the administration of natural resources. Consequently the Naalakkersuisut (Government of Greenland) decided to immediately take control of the mineral resource sector) Environmental issues in relation to mine projects are administrated by:

The Environmental Agency of the Mineral Resources Area - EAMRA (Miljøstyrelsen for Råstofområdet) is the administrative authority for environmental matters relating to mineral resources activities, including protection of the environment and nature, environmental liability and environmental impact assessments (EIA); and

The Mineral Licence and Safety Authority - MLSA (Råstofstyrelsen) is the administrative authority for licence issues and is the authority for safety matters including supervision and inspections.

3.1 Greenlandic legislation

Subsequent to the establishment of Greenlandic responsibility for regulation and management of the mineral sector, a new Act on Mineral Resources in Greenland (AMR), was put into force on 1 January 2010 (Greenland Parliament Act no. 7 - 7 December 2009). This act is the backbone of the legislative regulation of the sector, regulating all matters concerning mineral resource activities, including environmental issues (such as pollution) and nature protection.

3.2 The Mineral Resource Act

The new Mineral Resources Act of 2010 (the Act) is similar to the previous Mineral Resource Act of 1998. However, there are several new provisions including new chapters concerning the environment, nature and the climate. Further, the Act now specifically stipulates that an Environmental Impact Assessment must be prepared before permission to exploit minerals can be granted.

Among the key issues addressed by the provisions are the following:

- Planning and selection of all activities and construction in a manner to cause the least possible pollution, disturbance or other environmental impacts (§ 53);

- Use of best available techniques, including less polluting facilities, machinery, equipment, processes and technologies should be applied (§ 52);

• Avoid impairment or negative impacts on the climate (§ 56);

• Avoid impairment of nature and the habitats of species in designated national and international nature conservation areas and species (§ 60).

In order to conduct mining activities in Greenland, a licensee must first apply for and obtain an exploitation licence for the area. An exploitation licence is granted pursuant to § 29 in the Mineral Resources Act and requires submission to the BMP of the following documents:

• An application with key information on the proposed mining project;

• A Bankable Feasibility Study (BFS);

• An Environmental Impact Assessment (EIA);

• A Social Impact Assessment (SIA).

Provided that the exploitation licence is granted, the licensee needs to apply for and obtain an approval of the exploitation plan from the Greenlandic Government (§ 19) and specifically of the closure plan (§ 43). This approval will typically have to be updated several times during the course of the mine operation.

Provided that the § 19 and § 43 approvals are granted, all specific constructions, processes, vehicles, devices etc. must each have their individual approvals pursuant to § 86 in the Mineral Resources Act. Normally, the BMP will request a single application for all § 86 approvals in order to make a single § 86 approval that in one document specifically approves all these details. This single § 86 approval is to be renewed every year.

3.3 The Mineral Licence and Safety Authorities Guidelines for environmental emission values

The EIA for the TANBREEZ project is prepared to comply with the scope and structure that are specified by the Greenland authorities' Guidelines for preparing an Environmental Impact Assessment Report for Mineral Exploitation in Greenland from 2011 (Guidelines for preparing an Environmental Impact Assessment Report for Mineral Exploitation in Greenland). The guidelines specify the approach to be followed during the EIA process regarding environmental emissions standards. This includes guidelines for discharged water (page 9):

"Greenland authorities have not developed guidelines on acceptable contaminant levels in the environment specific for Greenland. Guidelines must therefore be adopted from other jurisdictions. Greenland is situated in the Arctic and therefore it is natural to adopt guidelines from other Arctic countries or jurisdictions such as Canada. Since Greenland is closely related to Denmark, it is obvious to adopt guidelines from Denmark. Because Denmark is an EU member state, many Danish guidelines have been implemented from EU guidelines. Which guidelines to choose must be agreed upon with the EAMRA".

The Greenland authorities have subsequently published guidelines for some metals in water. These guidelines have been followed in this EIA. When no Greenlandic standard is available the approach suggested above by The Mineral Licence and Safety Authorities has been followed. In many situations have MLSA's suggestions been adopted by changing the design of the mine.

3.4 International obligations

Greenland has ratified a number of international conventions regarding nature and biodiversity, either as a direct member or through its membership of the commonwealth of Denmark and the Faeroe Islands. Of particular relevance to the present project are the following:

- The Convention on Biological Diversity (CBD) on the conservation of biological diversity, sustainable use of its components and fair and equitable sharing of benefits arising from genetic resources. The CBD guides national strategies and policies and implements themes such as sustainable use and precautionary principles. Its application to the Project will be through the implementation of national laws and regulations, in particular the Mineral Resource Act.

- The Ramsar Convention on the protection of wetlands of international importance.

- International Union for Conservation of Nature (IUCN) is an international organization dedicated to natural resource conservation. IUCN publishes a "Red List" compiling information from a network of conservation organizations to rate which species are most endangered.

- UNESCO's World Heritage Convention is a global instrument for the protection of sites of cultural and natural heritage. In 2004 Ilulissat Icefjord was admitted onto UNESCO's World Heritage List.

- UNESCO's World Network of Biosphere Reserves, which covers internationally designated, protected areas, known as biosphere reserves including the Man and Biosphere Reserve programme (MAB). The UNESCO biosphere reserves are found in different countries across all the regions of the world and are meant to demonstrate a balanced relationship between man and nature (e.g. sustainable development). UNESCO's World Network of Biosphere Reserves includes The National Park of North and East Greenland. On behalf of Greenland Denmark has applied the inclusion of the "*Church ruin at Hvalsø, episcopal residence at Gardar, and Brattahlid (A Norse/Eskimo cultural landscape)"* for inclusion in the biosphere reserve network. Hvalsø church ruin is situated close to Killavaat Alannguat.

3.5 Shipping regulations

Maritime regulations in Greenland are identical to the Danish regulations and supplemented with specific regulations for navigation in arctic regions. The majority of the regulations are technical oriented and not relevant for the EIA.

Regulations and codes administered by IMO (International Maritime Organization) as well as international conventions adopted by Denmark also apply to Greenland.

Several international rules and conventions are targeting environmental issues and a few shall be highlighted including the MARPOL convention and the annexes (1973/78 International Convention for the Prevention of Pollution From Ships); the BWM convention (2004 - International Convention for the Control and Management of Ships' Ballast Water and Sediments), and the OPRC convention (1990 - International Convention on Oil Pollution Preparedness, Response and Co-operation).

Due to the special navigational conditions in Greenland, a safety package containing special Greenland topics have been issued by the Danish Maritime Authorities (cf. http://www.dma.dk/Ships/Sider/Greenlandwaters.aspx). The safety package includes the following orders and recommendation relevant for the EIA:

- Danish Maritime Authority Order no. 417 of 28. May 2009: "Order on technical regulation on safety of navigation in Greenland territorial waters".

- IMO recommendation A.1024 (26) "Guidelines for ships operating in polar waters".

A special agreement has been entered between the MLSA and the Danish Maritime Authority regarding "Guideline on investigation of navigational safety issues in connection with mineral exploitation projects in Greenland as basis for navigation in the operational phase". The guideline is specifying the contents of a navigational safety investigation to be carried out prior to starting the exploitation activities. The study should be documented in a report submitted to the Greenland authorities (but this is not a part of the EIA).

4 EIA PROCESS

4.1 The aim and purpose of the EIA

The overall aim of this EIA is to identify, predict and evaluate the environmental effects of the planned mine project. The EIA will provide pertinent environmental information about the Project at its inception, identifying the likely impacts, both adverse and beneficial. Key issues associated with the proposed Project will be identified to ensure that potential adverse impacts are addressed before final decisions are made.

4.2 MLSA's guidelines for EIAs for mine operations

The Greenlandic authorities have issued a set of guidelines on preparing an Environmental Impact Assessment (EIA) report for mineral exploitation in Greenland (Bureau of Minerals and Petroleum 2011). The guidelines list a number of topics and issues that must be covered during the EIA process. These are:

- An environmental baseline study which includes collection of 2-3 years pre-mining baseline data.

- Preparation of a detailed plan (Plan of Study) for the EIA process that should be submitted to the authorities prior of start of the process and which includes a table of contents.

The EIA must cover the following issues: non-technical summary, introduction to the project, description of the environment, a description of all phases of the mine project, an assessment of environmental impacts, an environmental management plan, a environmental monitoring plan, comments from the public hearing, conclusions and references.

The EIA should include a description of the chemical composition, acid generation potential and ecological toxicity tests for the ore, waste and tailings.

The chemical concentrations should be compared to international guidelines that are agreed with EAMRA.

Disturbance of the natural environment needs to be assessed.

The public should be involved throughout the process.

4.3 Baseline sampling

EAMRA requires two to three years of environmental baseline studies to adequately characterise an area prior to project start. Such baseline sampling includes collection of lichens, seaweed, mussels, freshwater and marine fish, water and sediment from rivers, lakes and the fjord following a protocol developed by Danish Centre for Environment and Energy - DCE (formerly National Centre for Environment and Energy - NERI), Aarhus University. In addition to sampling in the Project areas, samples have also been collected from a reference area.

Baseline sampling started in the late 1980s when samples were collected by DCE in 1988 and 1989. Between 2007 and 2010 Orbicon carried out further baseline studies. The results of the sampling have been documented in the following reports:

- Grønlands miljøundersøgelser. 1988. Baggrundsundersøgelser ved Narsaq, 1988. Indsamling af prøver til fastlæggelse af baggrundsniveau i forbindelse med A/S Carl Nielsens og Highwood Resources Ltd. efterforsknings-koncessioner. 44 pp.

- Grønlands Miljøundersøgelser. 1989. Baggrundsundersøgelser ved Narsaq 1989. Indsamling af marine, terrestriske og limniske prøver til fastlæggelse af baggrundsniveau i forbindelse med Highwood Resources Ltd., Platinova Resources Ltd. og A/S Carl Nielsens efterforskningskoncessioner. Rapport udarbejdet af Christian Glahder & Marie-Louise Lemgart.

- Orbicon 2007. TANBREEZ project, Greenland; Report on the initial environmental baseline sampling, August 2007. 24 pp.

- Orbicon 2007. TANBREEZ project, Greenland; Report on the extended environmental baseline sampling, September 2007. 21 pp.

- Orbicon 2008. TANBREEZ project, Greenland; report on the environmental baseline sampling in August 2008. 17 pp.

- Orbicon 2010. TANBREEZ project, Greenland; report on the environmental baseline sampling in July 2010.

Except for water samples, the baseline samples have not yet been analysed but are stored at DCE and will be used as reference material once the mine starts operation.

In addition to the baseline studies data observations of mammals, birds, fish, mussels and plants has also been carried out in connection with the baseline sampling in 2007, 2008 and 2010.

A climate station has also been set up on the plateau of Killavaat Alannguat and has since 2010 provided continuous weather data. Finally has discharge of Fostersø been continuously measured since 2010.

4.4 Environmental scoping and Plan of Study

The first stage in the EIA process is a scoping to identify which mine activities could potentially impact the environment. The scoping also helps identify areas where environmental studies are needed to ensure that the information required for the EIA is available

The initial scoping was in Marts 2010 followed by the preparation of a Draft Plan of Study for the TANBREEZ project. The aim of this document was to provide the Greenland authorities with sufficient information to enable it to approve the proposed EIA process for the project as required by the EIA Guidelines. The Plan of Study included a brief description of the mine project, a table of contents for the draft EIA, a list of studies already undertaken in the Killavaat Alannguat area and other studies relevant for the EIA process, a list of studies that would be carried out in 2010 to provide essential information for the EIA report and a technical memorandum describing the planned geochemical testing.

In addition to the studies already undertaken in the Killavaat Alannguat, the Plan of Study proposed that the following additional studies were carried out:

<u>Geochemical studies</u> - a geochemical testing program to determine the potential for acid rock drainage and metal leaching associated with the Project's waste rock, lean ore and tailings.

<u>Toxicological testing</u> - a toxicological testing program to identify the concentration levels of potentially toxic materials within the tailings effluent to aquatic organisms.

<u>Hydrology study</u> - data on the water flow and water chemistry in rivers and streams should be collected in order to calculate the annual run-off. This would make it possible to determine baseline metal concentrations in Fostersø, Laksetværelv and Lakseelv.

<u>Study of Arctic char</u> – mainly the distribution of Arctic char within the project area including Lakseelv, Laksetværelv and Fostersø.

In June 2010 confirmation was received from the BMP that the Plan of Study was approved. The four studies have subsequently been implemented.

Following a review of a draft EIA report by the authorities and there advisor DCE in June 2012 it was required that also a dust dispersal study should be included in the EIA and that there was a need for further geo chemical studies to provider more robust data for the predictions regarding the impact of effluent from tailings and waste rock deposited in the tailings facility, Fostersø. These additional studies have subsequently been implemented and the results are included in this EIA report.

4.5 Public hearing

Following initial approval by EAMRA the report and the supporting technical documents were made available for public hearing by uploading it to the Greenlandic authorities' web site.

During the public hearing period a number of public meetings were held in Nanortalik, Qaqortoq, Narsaq, Alluitsup Paa and Nuuk where the report was presented and discussed.

All questions and answers from the Public Hearing were compiled in a White Book that will be made publically available.

Based on the received comments Orbicon has amended the draft EIA as required and TANBREEZ Mining and subsequently submitted the final version to the authorities.

5 PROJECT DESCRIPTION

This section summarises the proposed mine project. Full technical details of the project can be found in the feasibility study and are not reproduces here. The intention of the chapter is to provide enough information to enable accurate identification and assessment of impacts and other environmental risks. The description follows the basic flow patch of the ore from the mine, through the process and out either as product or mine residue. The supporting infrastructure and labour requirements are also discussed.

The TANBREEZ mine and processing plant will be operated to produce two products of saleable concentrates of feldspar and eudialite. The minecompany’s application and this EIA covers a 10-years production period and a production of 0.5 million tonnes per year.

A key principle when choosing the location of the Project facilities, which potentially may cause pollution of the environment, has been to identify sites where the danger of impact is as small as practically possible. When it comes to the methods of operation of the Project, priority has been given to meet the Best Available Technique (BAT) principle. This include the choice of machinery, processing technology and the handling of waste where emphasis has been placed on pollution prevention techniques, including cleaner technologies and waste minimisation.

5.1 Overall mine design

The overall mine footprint is shown in Figure 5-1. Mining production will occur at a rate of approximately 500,000 Tonnes Per Annum (TPA) extracted from two open pits; Hill site on the plateau of the Killavaat Alannguat mountain and Fjord site at the shore of the Kangerluarsuk Fjord South-west of the port. It is expected that the production will start at the Fjord site and shift to the Hill site after approximately 5 years.

Haul roads will connect the two mining areas with the processing plant which will be located at the shore of the fjord. The concentrates will be stored in buildings next to the processing plant. Except for a shelter near the Hill site, all facilities will be located at the shore of the fjord including the power plant, fuel storage, a workshop, staff accommodations, a heliport and a wharf. Tailings will be pumped through a 7 km pipeline to Fostersø for deposition. A service road will lead from the end of the haul road near the Fjord site to Fostersø. Waste rock will also be deposited in Fostersø.

5.2 Alternatives to the Project

Several alternatives for the location of the various mining facilities were considered:

- It was considered to position the port lower in the fjord to shorten the access road from the mine area but this option was rejected for several reason, for example because the sea was too shallow.

- It was considered to deposit the tailings in the fjord but this was rejected because to assess this solution would require very comprehensive studies of the fjord including the marine ecosystems.

- It was considered to locate the plant and accommodation facilities and power plant next to the mine site but this option was rejected because of the harsh weather conditions with wind speeds regularly exceeding 50 m/s.

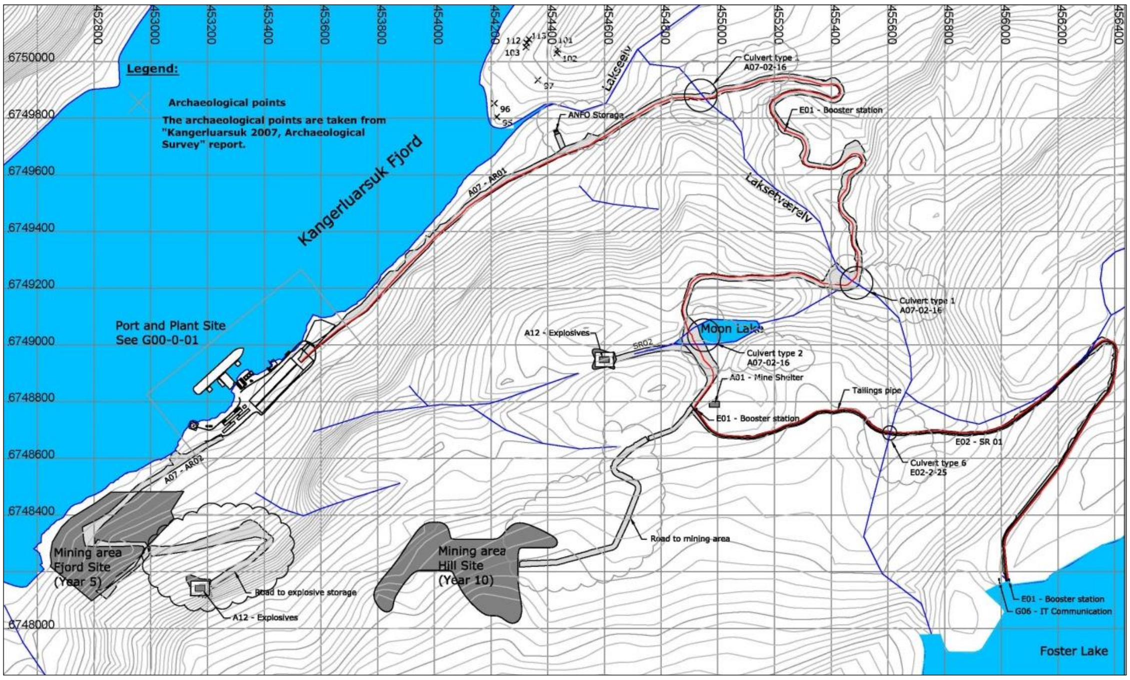

Figure 5.1 Overall mine design with two open pit mining sites, tailings deposition in Fostersø (Foster Lake) and the cruncher, separator and all other facilities located at the fjord

5.3 Processing of ROM

Ore mined at the open pits will be delivered by 35 t payload trucks to the Run Of Mine (ROM) pad for processing at the TANBREEZ plant. The length of the haul road connection Mining Area 1 with the plant will be 4.6 km with the haul road from Mining Area 2 to the plant will be 1.3 km.

Crushing

The primary (coarse) crusher discharges products to a double deck screen. Fine particles are then transported to the fine screen while coarse particles are transferred to a cone crusher. The cone crusher operates in a closed circuit with the coarse screen so that crushed ore is transported back to the double deck screen.

Crushed ore is then passed to a fine screen with screen oversize particles being directed to the high pressure grinding rolls for fine crushing. Product from the grinding rolls is transported back to the screen. Undersize ore from the screen is transferred to the very fine screening system where fines are removed and directed into the tailings deposit area. Ore particles greater than the screen size are transported to the fine ore storage bin located ahead of the magnetic separation plant.

Magnetic separation

The crushed and sized ore in the fine ore storage bin is fed by vibrating feeders to the magnetic separation plant where it is passed through a number of phases of magnetic separation. The three products from the magnetic separation consist of:

- highly magnetic mafic minerals (arfvedsonite)
- weakly magnetic eudialite, and
- non-magnetic feldspar

The eudialite and feldspar are transported onto separate stockpile buildings prior to export shipment, while the mafic minerals are tailings.

5.4 Tailings management

The tailings, fines and dust collected from the plant are piped into the tailings collection box where water is added to form slurry. This slurry will subsequently be pumped to Fostersø (at 470 m altitude) through an insulated 7 km, 11 cm diameter polyethylene pipe where it will be deposited under water. Five electrical booster stations will be constructed along the pipeline. A separate 11 cm diameter pipeline will bring water from the lake to the tailings collection box at the fjord. Both pipelines will be situated on sleepers along a track between the port and the tailings pond.

The slurry will flow at a rate of c. 23 l/s and transport up to 60 tons of tailings to the pond per hour. To avoid the slurry from freezing during winter the pipes will be insulated.

The natural lake Fostersø will be used as tailings pond. The slurry containing the tailings will be released close to the bottom of the lake to minimize the amount of suspended material. In addition a minimum 15 m water depth will be kept to avoid suspended tailings material from reaching the outlet of the lake (Laksetværelv). The volume of Fostersø has been estimated to 3.9 million cubic m with a 15 m water depth. With the planned production rate of 500,000 tons of ore per year, and maintaining a minimum 15 m water depth Fostersø can accommodate tailings for 31 years of production.

5.5 Waste rock

Only very small amounts of waste rock are expected in connecting with the mining. This waste rock will be deposited in the tailings pond (Fostersø).

5.6 Dust management

There are several operational areas where generation of dust has to be managed. The most important are the open pit mine, the haul road, the crusher, and when loading concentrate on to the ship. All storage bins, conveyors, screens, crushers, magnetic separators and transfer points will be fitted with dust extraction arrangements to collect dust and transfer it to the tailings disposal system. Haul road fugitive dust will be suppressed through light wetting with a water truck, but this has to be managed carefully during winter to avoid potential ice build-up.

5.7 Product storage

The concentrate produced is stored within two fully enclosed concentrate shed located adjacent to the export wharf on Kangerluarsuk Fjord (Figure 5-2). The concentrate is therefore kept dry and safely stored prior to shipping to the customer. Entrance to the concentrate shed is via sealed door and the exhaust air from the shed is filtered. It should be noted that storage of the material will require permission from the Greenland authorities.

5.8 Port facility

The port will be located in the Kangerluarsuk Fjord (Figure 5-1, 5-2). The port will be formed by a 15m wide access dike constructed of quarry run/gravel with a compacted wearing course and rock armour to the batters. The pier head will be formed by a rectangular sheet pile cell filled with quarry run/gravel. From the pier head it will be possible to reach the ship for concentrate loading and importing supplies.

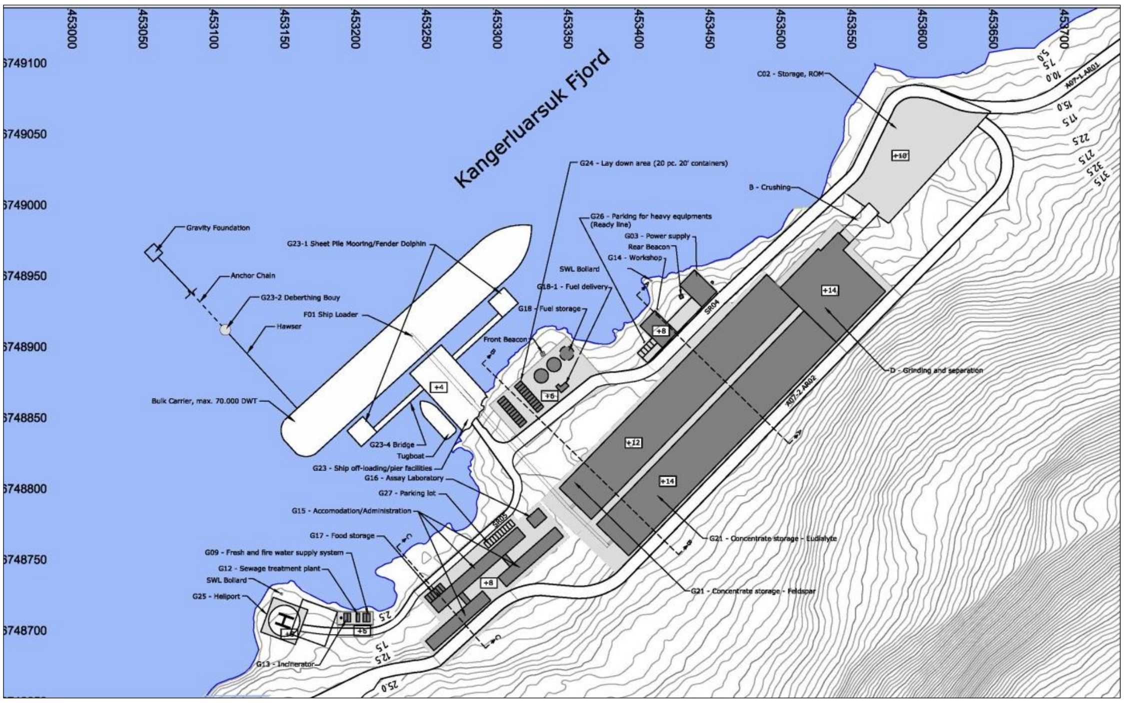

Figure 5.2 Port facilities at the Kangerluarsuk Fjord

5.9 Shipping

Shipping to and from the port at Kangerluarsuk Fjord will use 57,000 Dead Weight Tonnage (DWT) bulk carriers. The bulk carriers are expected to visit the port 6 times a year. In addition, 15,000 DWT Arctic line vessels will visit the port a few times annually with supplies. Finally will fuel be provided 4 times a year by a 2,300 DWT tanker. The vessels that arrives to the port will use light fuels (not HFO) as required by the Greenlandic authorities. In the fjords the ships will follow a route designated by the authorities.

5.10 Supporting infrastructure

Transport to the mine will normally be by boat and occasionally by helicopter. Transport from the port the pits will be by car and truck.

5.11 Energy supply

The power supply will comprise three medium speed 2,636 kW diesel generator units located in a separate building next to the process building. The generator units will be rated 11 kV. Power will be distributed above ground in 12 kV cables.

5.12 Water supply

Water supply is from a desalination plant located in the port area.

5.13 Accommodation

Employees on site will work on a fixed rotation, which will likely be of the order of four weeks on two weeks off. Site personnel will be housed in modern accommodation in the port area. The accommodation will be a 100 person self-contained camp.

5.14 Workshops and warehousing

Site facilities will include a main workshop for maintenance of the mobile equipment fleet including light vehicles. Within the process plant there will be small workshop facilities to enable maintenance to be undertaken.

5.15 Domestic and Industrial Waste Management

Domestic and industrial waste will be disposed of through the use of an incinerator. All non-combustible waste will be removed from site. Domestic waste water will be treated in a sewage plant before discharged to the fjord.

Sanitary waste water at the mine site

The sanitary sewage from the accommodation complex is piped to a treatment unit. After adequate treatment, in accordance with standards as described in the BFS and EAMRA's guidelines the water fraction is discharged to the plant surface drainage system which is discharged toward the fjord. The dewatered sludge is transported to the incinerator. In the mine pits dry toilets will be established.

<u>Combustible solid wastes</u>

The project includes a waste incinerator plant located at the port site. The incinerator plant will be installed as an early priority at the beginning of the construction phase and will have sufficient capacity to handle combustible waste generated during the construction period. It will continue during the operation phase.

When the incinerator plant is constructed and in operation, the waste types suitable for incineration will be handled at the port site:

- Domestic waste produced in the camps
- Sludge cake from the wastewater treatment plant
- All debris suitable for incineration (wood, plastic, paper, packing, etc.)

Incinerator ash will be disposed of according to the requirements by the authorities.

<u>Other categories of waste</u>

Other specific procedures will be applied for waste not suitable for incineration or classified as hazardous waste. The categories include:

- Accumulators, batteries, electronic devices, glass, etc. (all assumed to be small quantities). This fraction will be stored temporary in containers and periodically handed over to Qaqortoq waste handling facility for further disposal according to regulations and after mutual agreement.
- Tires will be temporary stored at the port site and periodically exported to contractors abroad for re-cycling/re-use.
- Iron and metal scrap, etc. will be stored at the port site and periodically exported to contractors abroad for re-cycling/re-use.
- Construction waste (concrete, bricks, wood, etc.) will be re-used as much as possible for other construction purposes e.g. road maintenance.
- Hazardous waste. The handling of these waste fractions is regulated through Kommuneqarfik Kujalleq regulation concerning hazardous waste (Regulations for disposal of hazardous waste /Regulativ for bortskaffelse af miljøfarligt affald, 2009). In general hazardous waste in the municipality is shipped to Denmark and handled in compliance with a comprehensive EU initiated legal framework. Hazardous waste shall be registered and traced using code standards (EC waste list / EAK koder / Europæiske Affalds Koder).

The waste handling procedures described above will be detailed in a waste management manual to become part of the EMP for the construction phase and later detailed for the operational phase. The procedures specific to handling hazardous wastes will be detailed in collaboration with the Qaqortoq waste handling facility under the Kommuneqarfik Kujalleq

5.16 Construction work

The construction work will consist two phases;

<u>Phase one</u>
During the first nine months a tented camp will be set up, a ware house will be constructed and a lay down area build in the port area. In addition, the bulk of the earth work in the port area will be done. During the first year only portable water will be used. Furthermore, a temporary sewage treatment plant will be installed that meets the EU requirements for wastewater. Waste will be collected in big bags and shipped off site.

<u>Phase two</u>
The second phase comprises the remaining construction works. This includes the construction of the haul roads to the two mine sites, the building of the grinding facility and separation plant, the construction of the tailings pipeline and the completion of the port.

5.17 Alternatives considered

EAMRA's guidelines require that an EIA describe the key alternatives considered and the reasoning behind the choices made.

5.17.1 Zero alternative

The "*zero-alternative*" is that the TANBREEZ mining project is not implemented and that the impacts discussed in this report will not occur. Similarly will social and economic impacts and opportunities such as job-creation, income generation, etc. for the Greenlandic society not occur. The social impacts are further described in the SIA report.

5.17.2 Process technology and location of process plant

Ore samples have been carefully analyzed from different parts of the ore body and pilot production tests have been carried out for design of the process plant. There are no practical and economical alternatives to the basic crushing and magnetic separation process which have been tailored for the TANBREEZ ore to meet market demands and to minimize energy consumption, use of reagents, dust, noise and other environmental impacts.

The process plant location has been selected for its location close to the port and mine sites and a downhill path for product delivery.

5.17.3 Energy supply alternatives

The proposed energy supply is based on 100% fossil fuel diesel generators. Hydropower and combinations of hydropower and diesel power were also considered. The electric-power transmission line connecting the 7.2 MW Qorlortorsuaq hydropower plant with Narsaq passes close to the proposed site for the processing plant and it has been considered that the hydropower plant should supply power to the project. However, this is not possible since Qorlortorsuaq hydropower plant has no excess electric production.

5.17.4 Methodology of tailings deposition

The EU Reference Document on Best Available Techniques for Management of Tailings and Waste-Rock in Mining Activities (January 2009) recommends considering alternative utilizations etc. of the tailings, such as using the material as an aggregate in constructions, restoration of other mines or backfilling into the mine site proper. These methodologies have been considered, but none of them are applicable in the TANBREEZ Mining Project. This is because it will be an open pit mine where tailings cannot be deposited because of risk for dispersal due to the strong winds in the area.

Instead, as described, tailings will be pumped to and disposed in Fostersø (the tailings pond facility), where it will remain, submerged, non-visible, non-dusting and essentially non-leaching, due to its composition and the climate conditions of the region.

Fostersø is located near the process plant and it has sufficient storage capacity to hold the expected volume of tailings during the planned 31 years of production. Alternative locations (other lakes, the fjord) and alternative uses of the tailings are not considered technically or environmentally feasible.

6 EXISTING ENVIRONMENT

6.1 Physical setting

The landscape in South Greenland is characterized by relatively high and steep mountains inland and low islands and peninsulas in the coastal area. This landscape is largely formed by the ice, which has also carved the long, narrow fjords. The entire area was covered by ice during the last glaciations (the Weichel/Wisconsin) until about 11000 years ago and the landscape is therefore highly influenced the glacial processes such as erosion, transport and sedimentation (Langager & Lemgart 1988).

The Killavaat Alannguat is a mountainous area along the south-eastern shore of the Kangerluarsuk Fjord (Figure 6.1). The mountains rises from the fjord to 400-500 m altitude and form a plateau further inland where several lakes are situated including Fostersø (470 m altitude). Fostersø is drained by the stream Laksetværelv which connects with the river Lakseelv 600 meters before it discharges into the fjord.

Figure 6.1 Killavaat Alannguat and the Kangerluarsuk Fjord. The Ivaangiusaq Kangileq (top centre) behind Killavaat Alannguat rises to 805 m altitude

6.2 Geology

Killavaat Alannguat is part of the Illímaussaq intrusion. This 8 x 17 km intrusion in the Gardar Igneous Province developed in a failed rift zone in late Mesoproterozoic some 1 160 million years ago and also includes Kvanefjeldet North-east of Narsaq.

It is the type locality for agpaitic nepheline syenites and represents an enormous concentration of a number of rare elements particularly Li, Be, Nb, Zr, Rare Earth Elements (REE), Y, U and Th. This explains the presence of about 220 minerals, 27 of these discovered in and first described from the complex, and nine only found there. It should be noted that the content of Uranium and Thorium at Killavaat Alannguat is low and below that background level. Radon is a gas that is generated when Uranium-238 decays. The low content of Uranium at Killavaat Alannguat means that Radon will occur in low concentrations only.

The Illimaussaq intrusion is surrounded by granite. While the granites surrounding the intrusion are relatively unaffected by weathering, the intrusion is covered by loose debris of syenitic material.

Of particular interest in the Killavaat Alannguat area is the presence of the rare intrusive igneous rock Kakortokite, a eudialytic nepheline syenites with accumulated Zirconium, Yttrium and REEs.

The Kakortokite in principally contains three minerals: whitish nepheline ((Na,K)AlSiO4), blackish arfvedsonite (NaNa2((Fe+2)4Fe+3)Si8O22(OH)2), and reddish eudialyte (Na4(Ca,Ce)2(Fe,Mn,Y) ZrSi8O22(OH,Cl)2) which are the focus of the proposed mining activities.

Occasionally, Kakortokite also contain the uncommon mineral Villiaumite. This is for example the case at the Kvanefjeld. Villiaumite is composed of sodium fluoride NaF and is soluble in water. The Geological Survey of Denmark and Greenland (GEUS) has carried out a literature study to determine if villiaumite has been documented from kakortokit at Killavaat Alannguat. The search has been fruitless which means that there is no documentation that villiaumite occurs in kakortokit at Killavaat Alannguat (GEUS 2014).

6.3 Water ressources

The hills and mountains that surround the Kangerluarsuk Fjord are crisscrossed by small streams and also have a high number of lakes. Some of the streams dry out in periods with low precipitation while others flow from spring to autumn.

Lakseelv is the main river in the study area. This river discharges into Kangerluarsuk Fjord near the planned position for the port. Due to the water exchange mechanism of sill fjords, the inflow of this river can be described as the engine that drives large-scale circulation in this part of part of the Kangerluarsuk Fjord (see Section 6.6).

Lakseelv drains a number of small lakes in the study area. This includes Fostersø which is connected to Lakseelv via Laksetværelv (Figure 6.2). Fostersø is the proposed tailings pond for the TANBREEZ project.

Fostersø is situated at 470 m altitude about 2 km north-east of the Mine site 1. The lake is about 1 km long, 250 m wide and c. 40 m deep.

Figure 6.2 Lakseelv (top) is the main river in the area. Lake 470 is Fostersø which connects to Lakseelv via Laksetværelv. Red lines indicate the catchment areas

Figure 6.3 Lakseelv and the Kangerluarsuk Fjord in the distance

Figure 6.4 Fostersø

Figure 6.5 Laksetværelv

Based on discharge measurements at the outlet of Fostersø it has been calculated that the average annual discharge from the lake through Laksetværelv is 0.145 m^3/s (Orbicon 2013b). Most of the year the water level and amount of out flow follows the rain fall pattern (Figure 6-6). In some years, such as in 2011, the outlet was blocked by ice and no discharge took place from mid-January 2011 until end of March 2011. During this winter period the water level in Fostersø steadily increased (Figure 6-6 top). This is most likely due to an inflow of groundwater/soil water to the lake. Following a very warm period in late March 2011 (Figure 6-6 bottom) the ice that blocked the outlet melted resulting in a major flush of water through Laksetværelv and a subsequent drop in the water level of Fostersø.

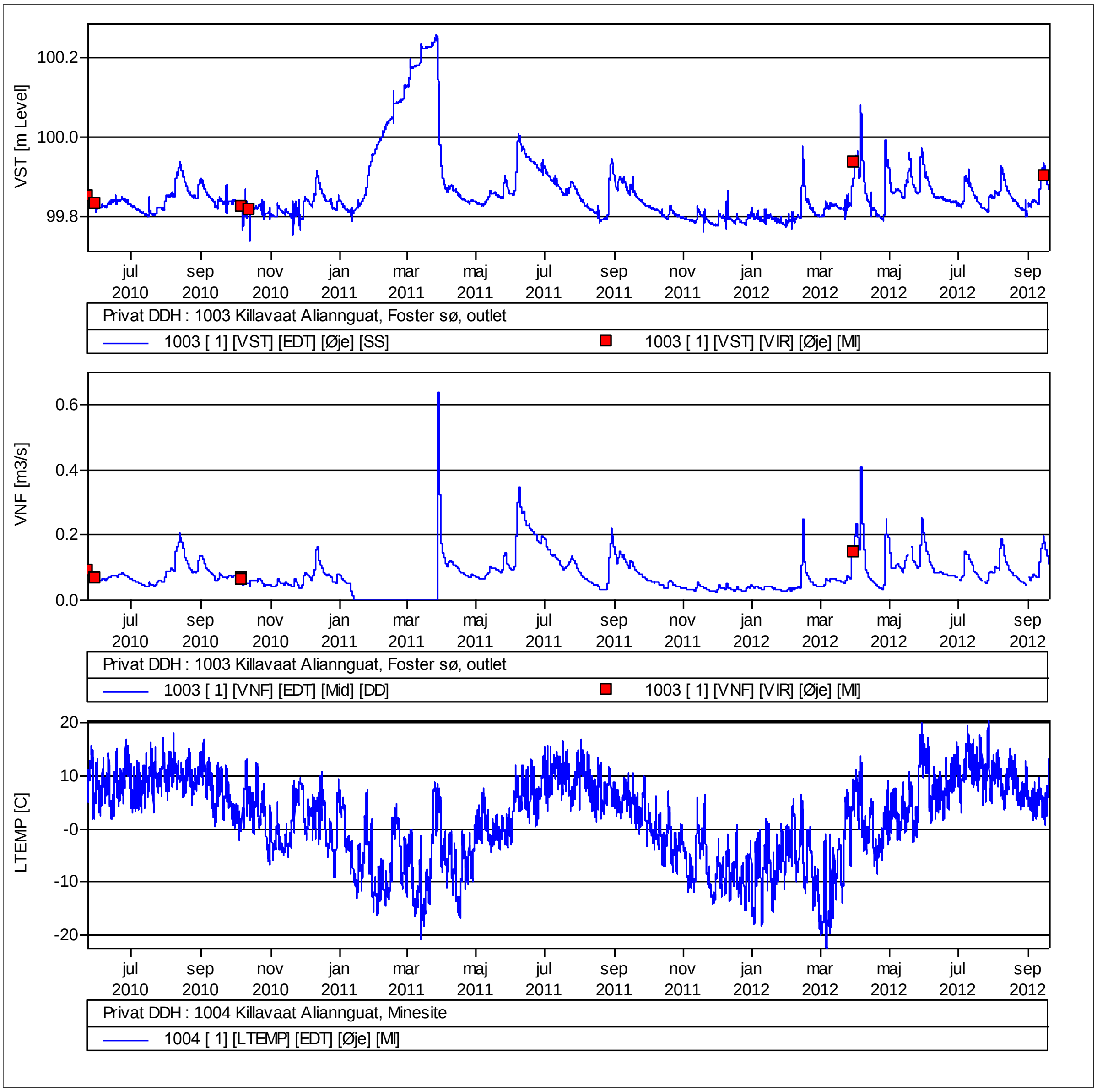

Figure 6.6 *Water level in meter in Fostersø from June 2010 to September 2012 (top), discharge from Fostersø in m^3/s (middle) and air temperature in degree Celsius (bottom). The red dots mark time when manual control readings were carried out (see text for further explanation)*

In other years the outlet is not blocked by ice during winter and a flow out of the lake takes place throughout the year, even in periods when the lake is mostly covered by ice. In periods with heavy rainfall during winter (for example in mid-February 2012 – see Figure 6.6), the water level of the lake increases briefly and the flow increased significantly for a couple of days.

Measurements of the temperature profile in Fostersø in June 2010 are shown in Figure 6-7. Stratification in the water column is noted between 10 and 15 m depth. Above this depth the water is well mixed. This is probably because of the regular strong winds in the area that enhance circulation of the water.

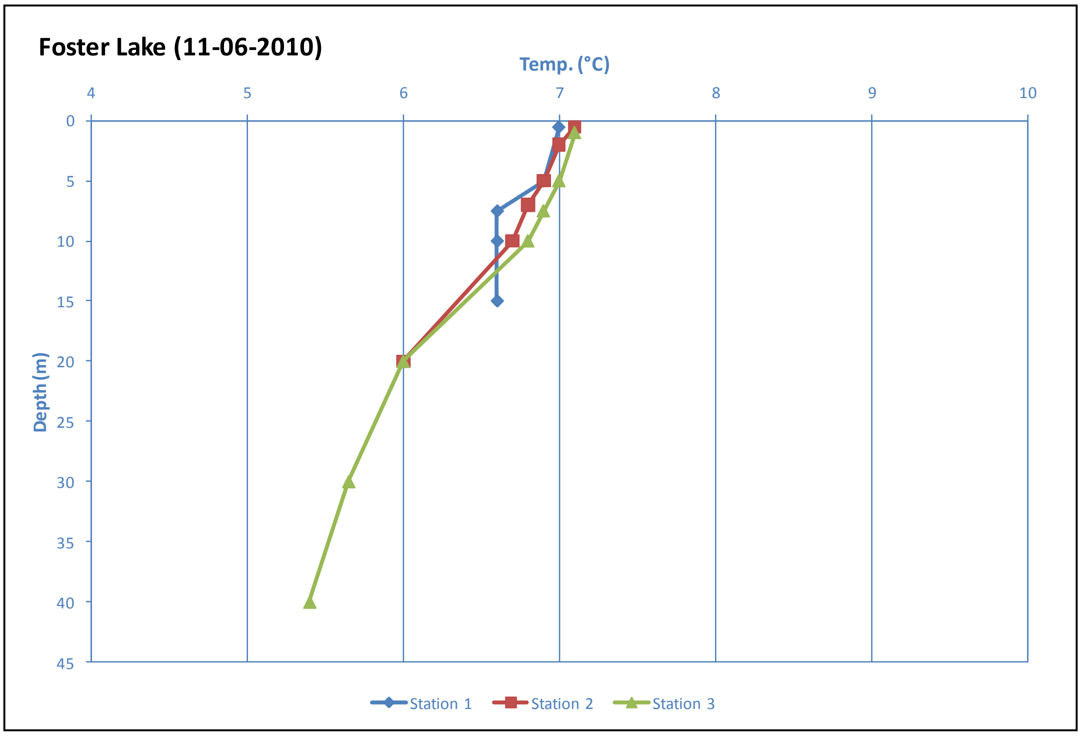

Figure 6.7 Temperature profile at three stations in Fostersø (Foster Lake) measured the 11 June 2010

6.4 Water Quality in Lakes and Rivers

The lakes and rivers in the study area are typically clear water bodies with very low turbidity, low level of nutrients and high levels of metals. The high transparency of the water facilitates biological production but the low nutrient levels are a determining factor.

The content of metals is generally high in the Killavaat Alannguat area and mineralization has released large amounts of metals to the surroundings. This includes soil, water and sediment in lakes and streams. Table 6-1 show the contents of a collection of metals in river sediment from Lakseelv and Laksetværelv.

Locality	As (ppm)	Co pmm	Cr (ppm)	Cu (ppm)	Hg	Mo	Ni (ppm)	Pb (ppm)	Zn (ppm)
Lakseelv (upper)	2	17	23	19	0	0	20	14	111
Lakseelv (lower)	-	-	50	75	-	-	84	188	703
Laksetværelv	5	10	9	47	0	0	31	23	286

Table 6-1 Contents of selected metals (in ppm – parts per million) from stream sediment at Killavaat Alannguat (collected and analyses by Geological Survey of Denmark and Greenland GEUS)

The content of metals in streams and rivers in the Killavaat Alannguat area was investigated as part of the baseline studies. In June 2010 water samples were collected from a number of stations along the Lakseelv and Laksetværelv (see Figure 6.8). The content of a selection of metals is shown in Table 6.2.

		Fe	As	Cd	Co	Cr	Cu	Hg	Mo	Ni	Pb	Zn
Detection limit		***4.92***	***0.14***	***0.034***	***0.043***	***0.036***	***0.04***	***0.003***	***0.056***	***0.047***	***0.029***	***0.11***
Lakseelv	L1	24.35	0.29	<dl	<dl	0.10	0.74	<dl	3.64	0.11	0.29	4.82
	L2	10.35	2.83	0.075	<dl	0.04	0.45	<dl	4.51	0.07	0.25	12.81
	L3	15.73	0.21	<dl	<dl	0.15	11.58	<dl	3.7	0.34	0.49	3.11
	L4	11.98	1.51	<dl	<dl	0.04	0.44	<dl	4.5	<dl	0.27	2.45
	L5	<dl	1.84	0.038	<dl	<dl	0.24	<dl	5.84	<dl	0.18	4.25
	L6	14.68	1.62	<dl	<dl	0.08	0.96	<dl	5.34	0.06	0.21	3.04
Lakse-tværelv	L7	<dl	0.19	<dl	<dl	0.05	0.10	<dl	2.52	0.05	0.07	3.19
	L8	<dl	<dl	<dl	<dl	<dl	0.07	<dl	2.03	<dl	0.09	1.63

Table 6-2 *Content of a selection of metals (microgram/L) in water samples collected along Lakseelv and Laksetværelv. Position of stations is shown in Figure 6.8*

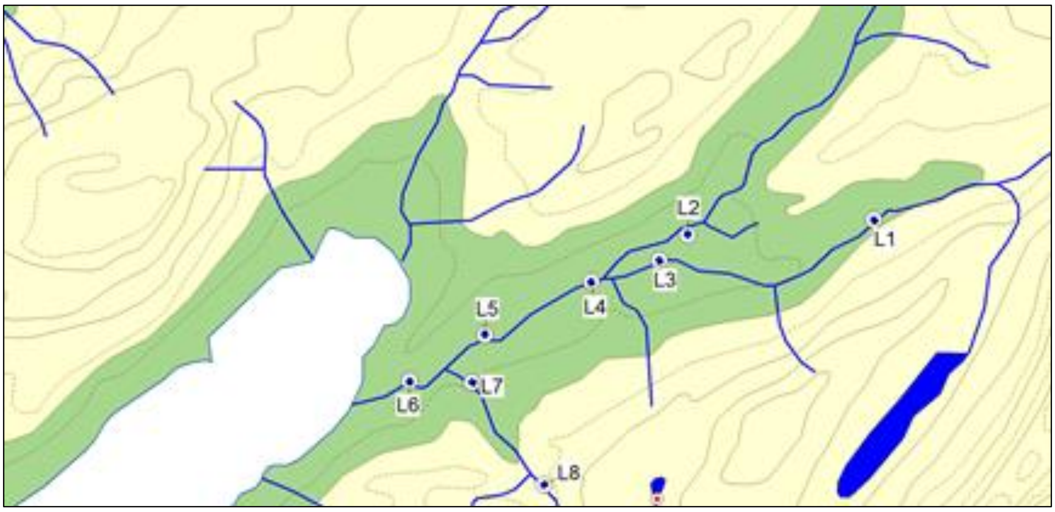

Figure 6.8 *Position of stations along Lakseelv and Laksetværelv where water samples were collected in June 2010 (content of various metals are listed in Table 6.2)*

The content of various metals in the water from Fostersø are summarised in Table 6-3. A high content of lead (1.14 µg/l) was recorded from station 2 at 20 m (near the bottom).

Sediment cores from Fostersø contained little organic matter and minerals represent almost all the lake sediment.

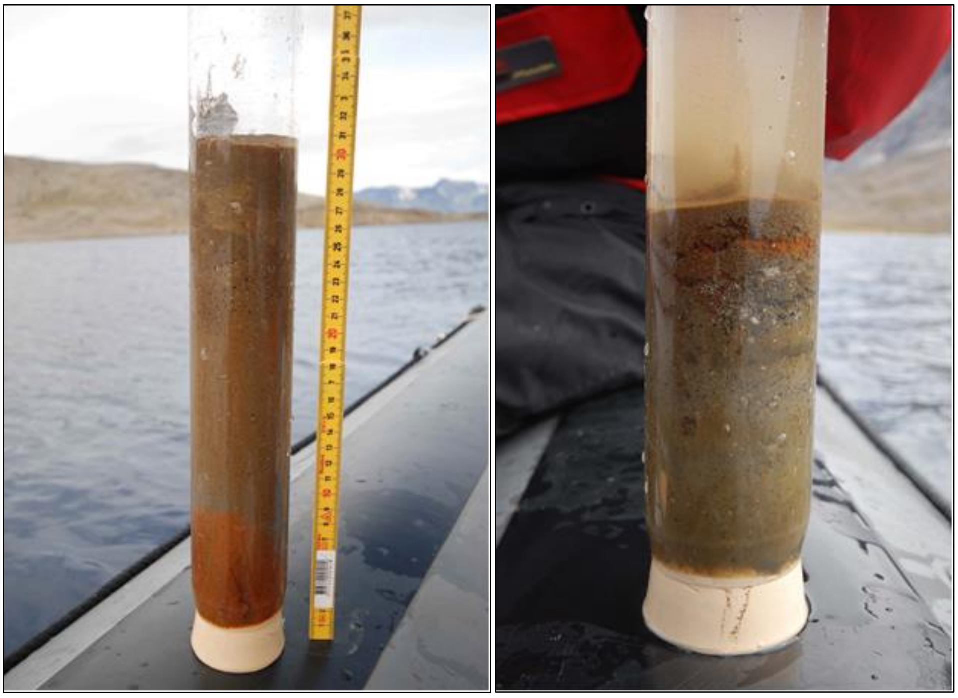

Figure 6.9 Sediment cores from Fostersø (station 1 to the right and station 2 to the left)

Sample nr. Depth (meters)		44071 1 m	44072 7 m	44073 15 m	44062 1 m	44063 10 m	44064 20 m	44079 1 m	44080 15 m	44081 35 m
Position (map 2)		Foster_Lake_1			Foster_Lake_2			Foster_Lake_3		
	Filtrerad	No	No	No	No	No	No	No	No	No
Ca	mg/l	1,51	1,4	1,44	1,41	1,44	1,43	1,41	1,44	1,47
Fe	mg/l	0,0028	0,0012	0,0022	0,0013	0,0031	0,0012	0,0017	0,0015	0,0164
K	mg/l	0,423	<0,4	<0,4	<0,4	<0,4	<0,4	<0,4	<0,4	<0,4
Mg	mg/l	0,457	0,453	0,463	0,458	0,459	0,45	0,452	0,454	0,46
Na	mg/l	3,41	3,29	3,41	3,4	3,4	3,38	3,32	3,4	3,42
Si	mg/l	1,32	1,32	1,27	1,29	1,32	1,3	1,33	1,28	1,32
Al	µg/l	6,7	4,64	6,62	5,28	17,3	4,69	8,24	6,26	57,5
As	µg/l	<0,1	<0,1	0,148	<0,1	0,128	<0,1	<0,1	<0,1	<0,1
Ba	µg/l	6,94	2,07	2,13	2,11	2,12	2,04	2,08	2,17	2,5
Be	µg/l	0,0059	0,0058	0,0053	0,005	0,0161	0,0044	0,0042	0,0097	0,0223
Ce	µg/l	0,0397	0,0261	0,0562	0,0279	0,114	0,0278	0,352	0,0587	0,922
Cd	µg/l	0,0068	<0,002	<0,002	<0,002	0,0022	<0,002	<0,002	0,0039	0,005
Co	µg/l	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	0,0109
Cr	µg/l	<0,01	0,021	<0,01	0,0138	0,0115	0,0324	<0,01	<0,01	0,0246
Cu	µg/l	0,585	0,501	0,351	0,217	0,537	1,38	0,14	0,299	0,531
Dy	µg/l	<0,005	<0,005	0,0061	<0,005	0,0106	<0,005	0,0142	<0,005	0,0683
Ga	µg/l	0,0144	0,0159	0,0059	0,0221	0,0277	0,0175	0,0044	0,0149	0,0483
Gd	µg/l	<0,005	<0,005	0,0056	<0,005	0,0116	<0,005	0,019	0,0054	0,0757
Eu	µg/l	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	0,0092
Er	µg/l	<0,005	<0,005	<0,005	<0,005	0,0063	<0,005	0,0067	<0,005	0,0418
Hf	µg/l	<0,005	<0,005	<0,005	<0,005	0,0081	<0,005	<0,005	<0,005	0,0255
Ho	µg/l	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	0,0147
Hg	µg/l	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002	<0,002
La	µg/l	0,0441	0,0395	0,0615	0,0359	0,0936	0,039	0,207	0,0556	0,591
Lu	µg/l	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005
Mn	µg/l	0,586	0,485	1,62	0,646	0,966	0,593	2,97	0,779	26,1
Mo	µg/l	0,805	0,796	0,843	0,811	0,817	0,833	0,815	0,842	0,784
Nb	µg/l	0,0026	0,0032	0,0063	0,0036	0,0394	0,0025	0,0152	0,0136	0,117
Nd	µg/l	0,0327	0,0262	0,0422	0,0233	0,0714	0,0243	0,161	0,0338	0,456
Ni	µg/l	<0,05	<0,05	0,136	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05
P	µg/l	1,45	<1	<1	<1	1,14	<1	<1	<1	3,94
Pb	µg/l	0,266	0,335	0,269	0,175	0,408	1,14	0,103	0,308	0,515
Pr	µg/l	0,0081	0,0073	0,0119	0,0074	0,0188	0,0071	0,0468	0,009	0,127
Rb	µg/l	0,92	0,923	0,915	0,911	0,921	0,96	0,955	0,914	0,99
Sc	µg/l	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05
Sm	µg/l	<0,005	<0,005	0,0065	<0,005	0,0122	<0,005	0,0237	0,0064	0,0818
Sn	µg/l	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05
Sr	µg/l	8,5	8,21	8,44	8,27	8,41	8,16	8,11	8,38	8,55
Ta	µg/l	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	0,007
Tb	µg/l	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	0,0112
Tm	µg/l	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	<0,004	0,0053
Th	µg/l	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	0,0242
U	µg/l	0,0849	0,0842	0,0975	0,0917	0,1	0,0922	0,101	0,0932	0,208
V	µg/l	0,0155	0,0194	0,0161	0,0166	0,0151	0,007	0,0193	0,0074	0,044
W	µg/l	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05
Y	µg/l	0,027	0,022	0,035	0,0226	0,0655	0,022	0,0744	0,0308	0,403
Yb	µg/l	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	<0,005	0,0318
Zn	µg/l	1,32	0,777	0,675	0,636	0,792	1,01	0,474	0,82	1,83

Table 6-3 Metal content in water samples from three depths at three stations in Fostersø collected 11 June 2010.

6.5 Sea ice

Three types of sea ice occur in Kangerluarsuk Fjord:

Fast ice may occur in parts of Kangerluarsuk Fjord. Most winters the inner third of the fjord has ice cover between October-November and May (Langager & Lemgart 1988) but this type of ice cover is extremely variable both during the winter period and between winters. In recent years fast ice has mostly been limited to the heads of fjords in South Greenland with the fjords otherwise ice-free during winter.

Depending on the wind and current icebergs and growlers originating from glaciers in Ikersuaq/ Brede Fjord and Tunulliarfik/Eriks Fjord sometimes enter Kangerluarsuk Fjord. However, they only occasionally reach the head of the fjord at Killavaat Alannguat.

Multi-year sea ice / drift ice (Storis) flows southwards along the East cost of Greenland with the East Greenland current, turns westwards at Cap Farewell and then northward along the West Coast of Greenland. In some years "Storis" fill up the mouths of the larger fjords of South Greenland during March and April (Glahder 2001), but only in south winds does the ice enter the fjord. Drift ice may also occasionally block the entrance to Kangerluarsuk Fjord during short periods.

6.6 Fjord oceanography

Like most fjords in South and West Greenland Kangerluarsuk Fjord is an old glacial valley with water depths up to 400 m (Langager & Lemgart 1988). It is also a "sill fjord" where low water depths at the mouth of the fjord prevent oceanic water to freely enter. In Kangerluarsuk Fjord the inner part of the fjord has depth around 100 – 200 m, but south of Argat Qaqqaat the depth is only 40m (Rose-Hansen et al. 1977, Langager & Lemgart 1988).

As the sill strongly limits the exchange of water between the deeper parts of the fjord and the open sea, the large scale circulation of water in the fjord mostly depend on the supply of freshwater that runs into it. The freshwater input to the inner part of Kangerluarsuk Fjord comes mainly from Lakseelv but also from a number of other smaller streams (Langager & Lemgart 1988).

This inflow of freshwater form a surface layer of brackish water in Kangerluarsuk Fjord and causes a higher water level in the fjords than outside (Mosbech et al. 2004). This difference in water level forces the brackish surface water out of the fjords. On its way towards the mouth of the fjord the brackish water becomes increasingly saline since the surface water mixes with the underlying water. In order to replace the water entrained into the surface current an undercurrent of more saline water is flowing into the fjords at intermediate depth levels (Mosbech et al. 2004).

The limited exchange of bottom water in Kangerluarsuk Fjord with the ocean also leads constant low water temperatures in the deeper parts. In July 1974 temperatures close to 0 degree Centigrade were measured at depths between 40 and 90 meters in the inner part of Kangerluarsuk Fjord.

During winter the fresh water inflow to the fjords is reduced because lakes and rivers freeze and the precipitation on land falls as snow. The surface salinity in the fjord therefore increases to the level found in the coastal waters outside the fjord, and the circulation in the fjord decreases to a minimum. This condition will further facilitate development of convection in the fjord.

The water at the bottom of sill fjords, such as Kangerluarsuk Fjord is renewed through two different mechanisms (from Mosbech et al. 2004):

- Inflow of water from the ocean with higher density that the deep water of the fjords. This requires strong winds, which will cause high density water to rise above sill level outside the fjord.

- Vertical convection during autumn and winter cooling and freezing of the surface water causing salt rejection from the freezing water.

Figure 6.10 Inner section of Kangerluarsuk Fjord and the outlet of Lakseelv

6.7 Atmospheric setting

6.7.1 Climate

At a regional scale the weather in South Greenland is mainly influenced by the North American continent and the North Atlantic Ocean. But the local climate is also heavily influenced by the Greenland Inland Ice. Another key factor is the all year round low sea surface temperature which is causing the South Greenland waters and coasts to be part of the arctic zone with summer temperatures below 10^0C.

Qaqortoq, 20 km south-west of Killavaat Alannguat, is situated close to the open coast and is under influence by an oceanic weather type with cool summers and relatively mild summers. The average January temperature in Qaqortoq is – 5.5^0C, while the average temperature in the warmest months (July and August) is 7.2^0C (DMI 2012).

Further inland, the weather type is more of a continental type and in South Greenland average summer temperatures can locally exceed the 10 degree threshold, which limit the arctic region. For instance the average January temperature in Narsarsuaq, 35 km northeast of Killavaat Alannguat, is – 6.8^0C, but 10.3^0C in July (DMI 2012).

Since May 2010 a weather station has been running at Killavaat Alannguat. Preliminary temperature data is shown in Figure 6-11 while the measured precipitation is shown in Table 6-4.

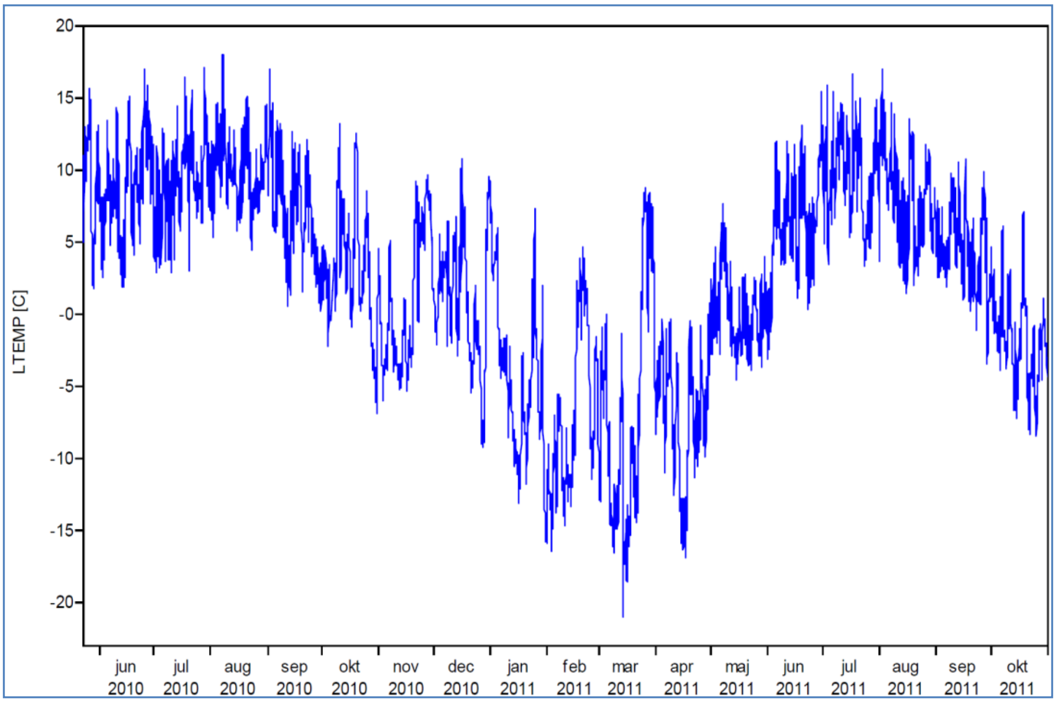

Figure 6.11 Air temperate (degree centigrade) measured at climate station on Killavaat Alannguat from June 2010 to October 2011. The weather station is at 450 m altitude

	Air Temperature			Humidity	Wind speed			Precipitation
Measuring Seqence	1. hour			1. Hour	1. Hour avg	1 hour max	10. min avg	
Period value	Avg	Min	Max	Avg	Avg	Max	Max	Total
Year/Month	C°	C°	C°	%	m/s	m/s	m/s	mm
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-
5	9.3	1.8	15.7	47	4.6	29.1	27.4	-
6	8.5	1.9	17.0	70	2.9	28.3	20.7	65
7	9.0	2.9	17.1	77	2.6	27.0	21.4	80
8	10.1	4.4	18.0	84	2.3	25.8	17.9	174
9	7.2	0.2	17.0	68	3.4	52.4	30.4	98
10	3.1	-6.9	13.2	64	4.6	52.1	31.7	51
11	0.8	-6.0	9.6	60	5.9	43.9	30.9	125
12	1.1	-9.2	10.8	60	3.2	39.1	32.1	100
2010	**5.8**	**-9.2**	**18.0**	**68**	**3.6**	**52.4**	**32.1**	**691**
1	-4.6	-15.9	7.5	60	3.1	26.2	20.1	71
2	-7.0	-16.4	4.7	66	5.0	41.0	22.7	71
3	-7.0	-21.0	8.8	60	4.9	33.7	27.1	40
4	-6.8	-16.8	0.8	66	3.5	20.7	16.7	48
5	0.1	-4.6	7.6	74	2.3	15.9	12.3	66
6	6.3	-3.1	15.4	69	2.8	36.0	23.3	17
7	9.7	3.3	16.6	68	2.7	27.5	18.3	64
8	8.0	1.4	17.0	76	2.5	33.4	21.1	122
9	4.5	-3.4	10.7	64	2.4	35.0	23.6	72
10	-1.8	-8.4	7.1	60	2.2	32.3	24.1	43
11	-	-	-	-	-	-	-	-
12	-	-	-	-	-	-	-	-
2011	**0.2**	**-21.0**	**17.0**	**66**	**3.1**	**41.0**	**27.1**	**614**

Table 6-4 Data from climate station at Killavaat Alannguat recorded between May 2010 and October 2011

The weather regime in the Killavaat Alannguat area clearly takes an intermediate position between Qaqortoq and Narsarsuaq. This means that Killavaat Alannguat lies within the Arctic climate zone, with cool summers and cold winters. The annual precipitation from November 2010 to October 2011 at Killavaat Alannguat was 840 mm while only 660 mm was recorded in Qaqortoq during the same period. Since a 5% increase in precipitation for every 100 altitude is often recorded in coastal Greenland, the higher precipitation measured at Killavaat Alannguat is most likely due to the fact that the station at Killavaat Alannguat is at 450 m altitude while the weather station at Qaqortoq is at 100 m.

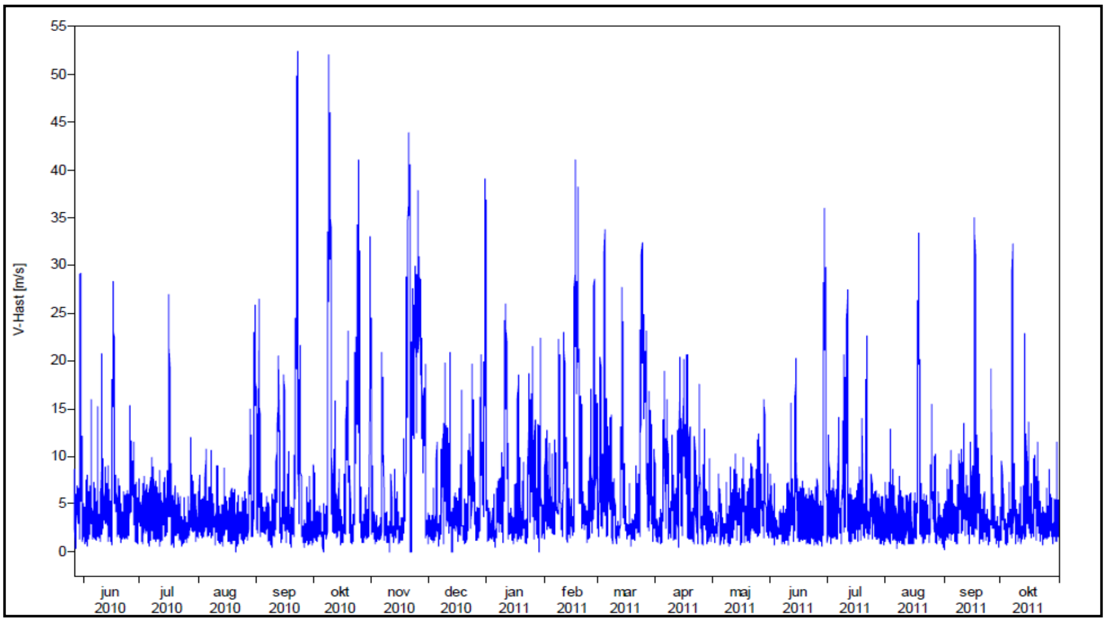

Figure 6.12 Wind speed (m/s) measured at climate station on Killavaat Alannguat from June 2010 to October 2011

Gale force winds (above 13.8 m/s) are common in South Greenland in particular in winter. Furthermore, down directed offshore winds may reach sea level as outbursts of dry and relatively warm air (a foehn wind). This is a warm dry wind arising through adiabatic compression of the air sweeping down from the inland ice cap. Its relative humidity drops to 30-40% and the temperatures rises up to 15-20^{0}C within an hour and remains very high for up to a day or two. The effect of the foehn wind is particularly marked in winter, when it results in rapid melting of the snow. Foehn winds are quite common at Killavaat Alannguat (see Figure Figure 6-11 and 6-12).

Very high wind speeds have also been recorded at Killavaat Alannguat with a maximum wind speed of 52.4 m/s in September 2010 but many incidences with wind speeds over 30 m/s (Table 6-12).

6.7.2 Air quality

No investigations are available of the project area as such, but a survey of air quality and air pollutants of the Nuuk area was published by NERI in 2005 (Skov et al. 2005). Although Nuuk is situated very far from the project area this study probably gives an indication of the general air quality in west-south Greenland. The survey focused on the monitoring of heavy metals including mercury, NOx and sulphate.

In general, this survey registered insignificant or low levels of pollutants, the overall conclusion being that the atmosphere at Nuuk is generally very clean, apart from a small local pollution and a small contribution by long-range transport of distant anthropogenic sources located in North America (Skov et al. 2005).

6.8 Natural environment

6.8.1 Vegetation

In South Greenland the vegetation is largely determined by temperature and precipitation which generally follows an oceanic-inland/continental gradient and an altitude gradient. Along long and narrow fjords, such as the Kangerluarsuk Fjord, this is very obvious as one moves from the outer fjord where vegetation growth is suppressed by cold ocean currents, drift ice, salt spray, and wind to the head of the fjord far inland where the vegetation below 200 m altitude, with south-facing exposure, locally develop into dense one meter high birch and willow scrub.

A survey of the distribution of plant communities of the study area was carried out in 1974 (Rose-Hansen et al. 1977). In 1977 – 1981 further studies of the vegetation were published in Thorsteinsson (1983). Although these studies were carried out several decades ago it is believed that the general distribution of plant species and communities including the occurrence of vulnerable species has not changes significantly over the years. Studies of the biodiversity in the study area between 2007 and 2010 by Orbicon staff points in the same direction.

The Ilímaussaq intrusion at Killavaat Alannguat is unusual in having almost no vegetation at all. Large expanses of the terrain above c. 200 altitude have no plant cover and only very few widely scattered plants exist. Only in the lowlands (below c. 100 m altitude) close to the fjord and along the lower part of the river is a shallow band of vegetation.

Vegetation below 200 m altitude

Around the head of the fjord and along the lower section of Lakseelv at altitudes below 200 m the vegetation is dominated by different types of dwarf shrub heath and grasslands.

Dense vegetation is limited to a narrow band along the shore of the Kangerluarsuk Fjord and on both sides of Lakseelv below 50 – 100 m altitude (see Figure 6.13). In this area the following plant communities have been identified (from Rose-Hansen et al. 1977 and observations by Orbicon staff (Orbicon 2013a)):

- Dwarf shrub heath is found along Lakseelv and the shore of the head of the fjord dominated by Crowberry *Empetrum nigrum*, Glandular birch *Betula glandulosa* and Northern willow *Salix glauca*. On dry exposed slopes Common juniper *Juniperus communis* is widespread.

- At protected and moist sites along the northwest shore near the head of the fjord (that is opposite the planned port facility) and along the lower part of Lakseelv small patches of richer vegetation is found with Alpine bartsia *Bartsia alpine*, Viviparous knotweed *Polygonum viviparum*, Flame-tipped lousewort *Pedicularis flammea*, Angelica *Angelica archangelica,* Moonwort *Botrychium lunaria* and Small-white orchids *Leucorchis albida*.

- Close to the shore of the fjord north of the outlet of Lakseelv grows Scottish lovage *Ligusticum scoticum* and Beach pea *Lathyrus maritimus.*

- Up to one meter tall copses of Northern willow occur along some of the small watercourses and scattered along Lakseelv.

- Above 50-100 m altitude the dwarf shrub heath grades into a mossy heath with some Northern willow and Glandular birch. Over 100 m altitude this vegetation gradually becomes patchier.

Figure 6.13 Vegetation at the eastern shore of the fjord consists mainly on patches of willow and beach shrub and grasses

Vegetation above 200 m altitude

Above *c*. 200 m altitude the Killavaat Alannguat mountain has almost no vegetation at all. This includes the slopes facing the fjord, the plateau on top of the mountain and the land surrounding Fostersø, Månesø and the river Laksetværelv that drains these lakes.

In this area the plant cover is estimated to cover less than 2% of the land (see Figure 6.14). The plants that do exist at Killavaat Alannguat include Arctic marsh willow *Salix arctophila*, Lapland diapensia *Diapensia lapponica*, Moss campion *Silena acaulis* and Purple saxifrage *Saxifraga oppositifolia.* Along watercourses - including Laksetværelv - grow few scattered and small examples of Glandular birch, Northern willow and Mountain sorrel *Oxyria digyna*.

Figure 6.14 Almost no vegetation exists on Killavaat Alannguat plateau at 400 – 500 m altitude

6.8.2 *Fauna*

Little specific knowledge is available about most groups of animals in the project area. This includes for example invertebrates (such as insects and spiders) while birds, mammals and freshwater fish are relatively well known. The following description of the fauna in the Killavaat Alannguat area therefore focuses on these last groups. These animal groups are often also considered as good indicators of the overall biodiversity of an area.

Terrestrial mammals

Arctic fox and Arctic hare are the only terrestrial mammals in the Project area.

<u>Arctic fox *Alopex lagopus*</u>

The fox is the only terrestrial carnivore in South Greenland. In spite of massive persecution it is still common and widespread and has also been recorded from Killavaat Alannguat. The Arctic fox is a very opportunistic feeder. In the project area birds (especially young) probably make up an important part of the diet during summer while fish found along the shore of the fjord are important during winter. Foxes are present in the project area throughout the year.

Arctic hare *Lepus arcticus*

This is a relatively uncommon mammal in South Greenland most years but the population show large fluctuations in numbers. It has been recorded in small numbers in the project area, mostly at high altitude. Little seems to be known about the general life history Arctic hare in Greenland. However, hares are generally considered resident and sedges, grasses, willow and other plants are believed to be the primary food items.

Marine mammals

Ringed seal seems to be the only marine mammal that regularly occurs in the Kangerluarsuk Fjord. Other species of seals, such as Hooded seal (*Crystophora cristata*) and Harp seal (*Phoca groenlandica*) might also occasionally occur (Orbicon 2013a). Whales appear to be rare in the Kangerluarsuk Fjord.

Ringed seal *Phoca hispida*

This rather small seal has a circumpolar distribution and occurs in all waters surrounding Greenland. It is generally common in Greenland waters but less so along the south-western coastline (Glahder 2001). It is believed to be mainly stationary in South Greenland where it favours fjords with ice (Mosbech et al. 2004). Ringed seal also occurs in small numbers in Kangerluarsuk Fjord.

Ringed seals haul-out and moult exclusively on fast-ice. During winter they maintain several breathing holes in ice. Ringed seals breed at the head of fjords where fast ice is formed during winter. Breeding takes place from March-April to mid-May when the pups are born in snow dens on the sea ice.

It feed on a broad range of pelagic prey items, including fish and crustaceans (Siegstad et al. 1998, Mosbech et al. 2004). Ringed seal is subject to large scale unregulated hunting and is regularly on sale at the local markets “brættet” in Narsaq and Qaqortoq. The take of Ringed seal has been more or less stable since the 1960’ies at about 60-70 000 individuals (Bugge and Christensen 2003). It is listed as “least concern” on the Greenland Red List of threatened species (Boertmann 2007).

6.8.3 Birds

The bird fauna at Killavaat Alannguat is relatively species poor and consist almost exclusively of species that are common and widespread in South Greenland (Orbicon 2013a). The most diverse bird fauna is found along the shore of the fjord and associated with the dense vegetation of the lower parts of Lakseelv. The almost barren land above 400 m altitude includes Mine Site 1 and at Fostersø and Lille Månesø has almost no birds. The key bird species associated with the project area are discussed below.

Raven (*Corvus corax*), Snow bunting (*Plectrophenax nivalis*), Common Wheatear (*Oenanthe oenanthe*), Redpoll (*Carduelis flammea*) and Lapland bunting (*Calcarius lapponicus*) are common breeders at low to medium altitude along the Kangerluarsuk Fjord and the lower section of Lakseelv. These birds are common and widespread throughout south and west Greenland. A small population of Redwing thrush (*Turdus iliacus*) occur in connection with the dense shrub along the shore of Qaqortukulooq close to Hvalsø Church ruin. This is an uncommon breeding bird in Greenland limited to a few sites in South Greenland.

Snow bunting is the only passerine bird that seems to breed in the almost barred land above 400 m close to Mine Site 1 and Fostersø. Snow buntings are mainly migratory but small numbers remain all year in South Greenland.

Ptarmigan (*Lagopus mutus*) is widespread and common throughout South Greenland but subject to marked annual fluctuations in numbers. Ptarmigans have been regularly observed in the project area and it is one of the only breeding birds observed in the barren country above 400 m. The Ptarmigan is sedentary in South Greenland.

Harlequin Duck (*Histrionicus histrionicus*) is a potential low density breeding bird along clear, clean streams of the study area. However, during baseline field work in 2007 and 2008 and in connection with a specific survey for this species in 2010 no Harlequin ducks were observed.

Common eider (*Somateria mollissima*) has a widespread but fragmented breeding population in Greenland, typically breeding on small islets and skerries along the coast. It has declined dramatically during the last 50-100 years due to intensive unsustainable hunting, and the West Greenland population is now listed “Vulnerable” in the regional Greenland red list (Boertmann 2007). No breeding colonies of eiders are known from the Study area but large numbers winter off shore South Greenland and flocks also regularly occur in the fjords. Small number probably also enter Kangerluarsuk Fjord.

Glaucous Gull (*Larus hyperboreus)*, Iceland Gull (*L. glaucoides*) and Great Black-backed Gull (*L. marinus*) are regularly encountered in Kangerluarsuk Fjord, but no breeding sites are known from this fjord (Boertmann 2004, Orbicon 2013a). Other seabirds such as Common eider (*Somateria mollissima),* Brünnich’s Guillemot (*Uria lomvia*) and Black Guillemot (*Cephus grylle*) appear to be uncommon visitors to the inner parts of the fjord. None of these seabirds breed along the shore of Kangerluarsuk Fjord.

Purple sandpiper (*Calidris maritime*) is the only species of wader which occur regularly in the project area. Although no sign of nesting has been observed during the field work in 2007, 2008 and 2010 one or two pair might occasional breed in dwarf shrub heath in association with Lakseelv. The Purple sandpiper is migratory that arrive to the breeding site during late May and early June and leave in August – beginning of September.

Peregrine (*Falco peregrinus*) is quite common in South Greenland where it typically nests on ledges on steep cliffs in the inland. One or two pairs probably nest near the mine site as Peregrine Falcons has been observed on several occasions. Peregrine Falcons mainly feed on medium-size birds. It is a migrant that arrive in May and depart in August-November. It is listed as “least concern” on the Greenland Red List of threatened species (Boertmann 2007).

The large Gyrfalcon (*Falco rusticolus*) occurs throughout Greenland, but is nowhere common. Gyrfalcon nests on ledges on steep cliff sides and primarily feeds on large birds such as gulls.The population in South Greenland is mainly sedentary. The size of the Greenland breeding population is estimated to c. 500 pairs. Due to the small population Gyrfalcon is listed as “Near Threatened” in the regional Greenland red list (Boertmann 2007). No breeding sites of this falcon are known from the Study area (K. Falk pers. com) but single birds have been observed in at Killavaat Alannguat a few times during field work between 2007 and 2010.

The White-tailed Eagle (*Haliaetus albicilla*) is confined to Greenland’s south and west coasts north to Upernavik and belongs to an endemic subspecies. During the 20th century many White-tailed Eagles were shot by sheep farmers and the population declined to app. 50 pairs. In recent decades it has partly recovered as the hunting pressure has eased, and the population is now estimated to 150-200 pairs (Boertmann 2007). Due to the small population size the Greenland White-tailed Eagle is listed as “vulnerable” on the regional Greenland red list (Boertmann 2007).

Greenland White-tailed Eagles are mainly found in coastal areas where they feed on fish. The nest is typically placed on ledges on steep cliffs. The adults normally remain within the breeding areas throughout the year while the young birds move to the outer coastal areas during winter. Breeding White-tailed eagles are present at the nest from around 1. March to early September. Egg-laying typically takes place at around 1. April. During breeding the eagles are known to be very sensitive to disturbance.

Figure 6.15 Adult Greenlandic White-tailed eagle (Haliaetus albicilla groenlandicus)

White-tailed Eagles are commonly observed throughout the Study area and one or two pairs probably breed in this area. However, no signs of breeding have been observed near the proposed mine sites at Killavaat Alannguat or near the port site (Orbicon 2013a).

6.8.4 *Aquatic ecology*

Studies in streams and rivers in the Project area have shown that the freshwater fauna is dominated by crustaceans, insect larvae and very few adult insects (such as the beetle *Colymbetes dolabratus*) (Figure 6-16). The highest diversity and density are usually found in the sections of rivers and streams with no fish (predation).

	Trichoptera	Chironomidae spp.	Simuliidae spp.	Tipulidae spp.	Nematode spp.
		Lakseelven			
L1 (no fish)	+++	+++	+++	++	-
L2 (fish)	-	++	++	-	-
L3 (fish)	-	++	+	+	+
L4 (fish)	-	++	+	-	-
L5 (fish)	+	++	+	+	+
L6 (fish)	-	++	+	+	-
		Laksetværelven			
L7 (no fish)	-	-	-	-	-
L8 (no fish)	+	+++	++	-	-

Figure 6.16 Occurrence of freshwater insects groups in the Lakseelv and Laksetværelv. The position of the stations is shown in Figure 6.17

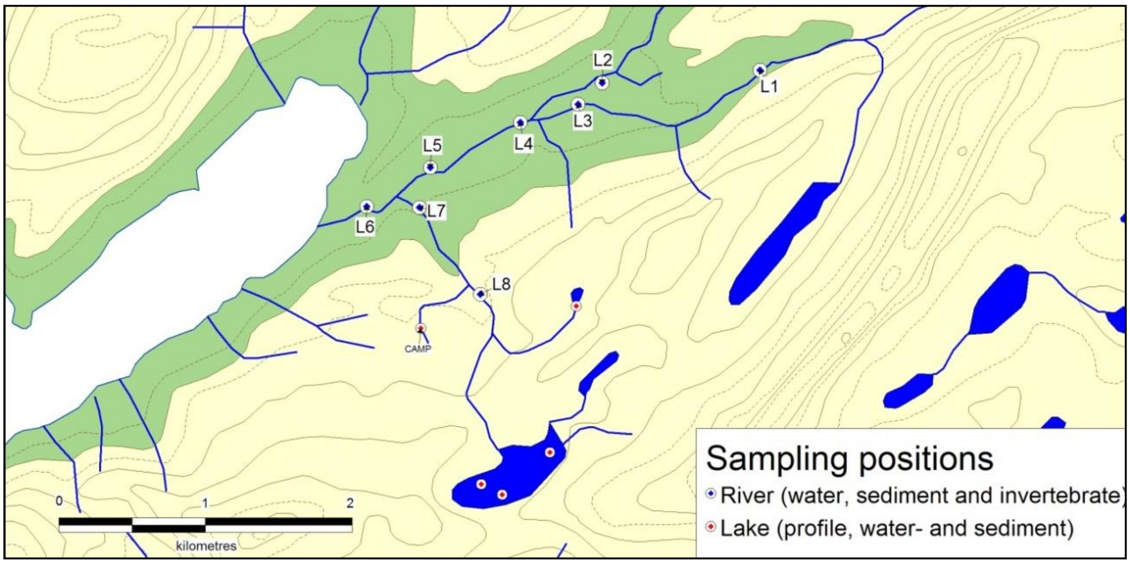

Figure 6.17 Position of the stations in Lakseelv (Station L1 – L6) and Laksetværelv (L7 & L8)

6.8.5 Arctic char

The Arctic char (*Salvelinus alpines*) is a habitat generalist like no other northern fish found in streams, at sea and in all habitats of oligotrophic lakes throughout Greenland. Some populations are stationary and remain in fresh water while in others the adult fish conducts feeding movements along the coast.

Figure 6.18 Arctic char in pool in Lakseelv

<u>Distribution of Arctic char in the Lakseelv</u>

The distribution of Arctic char in Lakseelv and its tributary and connected lakes were mapped in mid-June 2010. Lakseelv, Laksetværelv and other tributaries were survey with electro-fishing equipment. Fostersø and Månesø were survey with electro-fishing equipment and fishing rods.

Arctic char was only recorded in the lower and middle section of Lakseelv and in a branch of this river (stream section with fish marked with red in Figure 6.19) where a large population is present. A waterfall about 5 km from the outlet of the river excludes further movements upstream and no fish were recorded from the upper section of the river. No fish were found in Laksetværelv. This small stream drains Fostersø and connects with Lakseelv about 600 m from its outlet to the fjord. A c. 75 cm high “waterfall” close to where it meets Lakseelv is probably the reason that no Arctic char were recorded from this stream in mid-June. In winter Laksetværelv regularly runs dry preventing a stable fish population to be established. All the survey lakes were fishless.

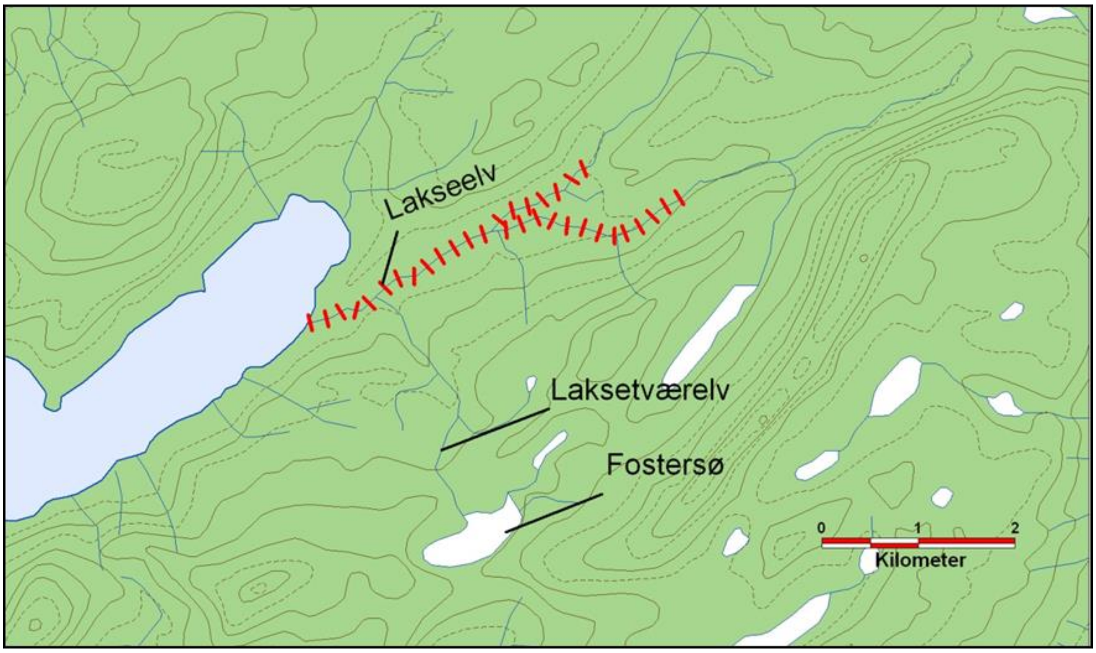

Figure 6.19 Distribution of Arctic char in Lakseelv and its tributaries

In addition to the mapping study in 2010, a survey of the char population of Lakseelv was carried out by staff from Grønlands Fiskeri- og Miljøundersøgelser in August 1985 (Boje 1985). This team noted a waterfall, just a few hundred meters upstream from the fjord which was believed to present a barrier for the fish and therefore effectively separating the population into two. In June 2010, where the discharge of Lakseelv probably was considerable higher than in August 1985, this waterfall seemed to be less of a barrier to the fish and at least some fish were probably able to pass it and move further upstream.

The life cycle of Arctic char in South Greenland

The Arctic char population in rivers typically consists of resident fish (non-anadromous) and anadromous fish that migrate to the sea during summer when they have reached a certain age. The migrating fish usually stay relatively close to their natal river. For example was the average maximum distance travelled by Arctic char from a sea-going population at Baffin Island only 40-50 km (Moore 1975). The seaward migration probably stars at ice break-up in the river and the fish return in mid-summer or autumn.

The anadromous Arctic char in South Greenland start to migrate into the fjord when they around 4 years old and c. 15 cm long (Christensen & Mortensen 1982, Boje 1985). During the period of saltwater residence, Arctic chars frequently move into the intertidal zone and freshwater (Moore 1975). Returning fish have been recorded in other South Greenland rivers as early as mid-July (Christensen & Mortensen 1982) but most seemed to move back to the river in late July and in August. This is probably also the case in Lakseelv where small dark and spotted non- anadromous fish (parr) dominated in mid-June as opposed to the sea-going silver Arctic char (smolts).

The Arctic char in South Greenland rivers typically reached sexual maturity when they were around 5 years old that is after their first sea run (Christensen & Mortensen 1982).

The Arctic char in South Greenland spawn from late August to beginning of October. In Narsaq elv, which is only 12 km from Lakseelv, the char mostly spawn in the main stream on sites with gravel bottom, 30-35 cm depth and not too strong current (Christensen & Mortensen 1982). The female dig a depression before laying the eggs and cover the eggs with gravel by tail beats after fertilization. The eggs hatch the following spring. In Narsaq elv by far the majority of females that spawn have spent the summer in salt water (Christensen & Mortensen 1982).

During winter most of the Greenland's rivers are covered by thick ice and the water flow is very restricted. This time of the year the char spend in the deepest parts of the rivers. In Lakseelv most char probably winter in the deep pools near the outlet of the river (Figure 6.20). In spring the fish spread out to utilize all water-covered areas below the rapid 5 km upstream.

Figure 6.20 Deep pool in Lakseelv a few hundred meters from the outlet in the fjord where large numbers of Arctic char spent the winter months

Food

The first weeks the fish larvae feed on yolk which they carry in a sac underneath their belly. About a month after hatching the fry begins to feed on plankton. Later they start to take insect larvae, in particular Chironomidae (non-biting midges), Trichoptera (caddis flies) and Simuliidae (black flies). Insect larvae are also the main food of the larger fish when they are in fresh water.

A study of the density of insect larvae in the Lakseelv and tributaries by Orbicon in June 2010 showed much higher densities of Chironomidae and Trichoptera just above the waterfall that limited the Arctic char distribution in Lakseelv and low densities below the waterfall (Table 6.16), suggesting that char predation of these insect larvae in Lakseelv is significant. Cannibalisms probably also takes place. Arctic char generally exhibited a very slow growth rate while in rivers where the main foot is insect larvae. During winter they probably eat nothing. The char that move into saltwater during summer fed on planktonic amphipods, copepods and fish and their food intake rates and growth is much higher than in resident char.

Population size

The August 1985 study included an attempt to assess the density and number of char in Lakseelv. The stock of anadromous char in August was estimated to be 800 - 900 fish (Boje 1985). No estimate of the non-anadromous population is given but the density of fish was found to be 0.1 fish per sq. m, which is comparable to other rivers in South Greenland (Boje 1985).

6.8.6 Marine fish

A large number of fish species occur in South Greenland fjords but generally little is known about the species that are not utilized commercially or in connection with local subsistence fishery (Pedersen and Kannewolf 1995).

The most important in connection with commercial and subsistence fishery in Kangerluarsuk Fjord are Atlantic Cod (*Gadus morhua*), Spotted Wolffish (*Anarhichas minor*), Greenland Halibut (*Reinhardtius hippoglossoides*) and Lumpsucker (*Cyclopterus lumpus*)(Orbicon 2013a). The Lumpsucker also have important spawning grounds along the shoreline of Kangerluarsuk Fjord (Mosbech et al. 2004).

6.8.7 Marine invertebrates

Little is known about the occurrence of marine invertebrates – such as mussels. However it is known that for example blue mussels occur in large numbers along the coast.

6.8.8 Protected areas and threatened species

Three species – all birds - listed on the regional Greenland red list as Vulnerable or near Threatened (Boertmann 2007) occur regularly in the Study area, see Table 6-5.

Species	Status	Period of occurrence	Main habitat	Greenland red-list status	Importance of Study area to population
Common Eider	Visitor	Year round	Coastal and in fjords	Vulnerable	Low
White-tailed Eagle	Breeding	Year round	Coastal and in fjords	Vulnerable	Medium
Gyrfalcon	Visitor (breeding)	Year round	Throughout	Near Threatened	Low

Table 6-5 Species on the regional Greenland red list of threatened species occurring in the Killavaat Alannguat area

Common eider is on the Greenland Red list because of the large decline in West Greenland over very long time (the population appears now to be recovering slowly). This sea duck is not breeding in the project area but small number probably winter in Kangerluarsuk Fjord.

White-tailed Eagle is on the Red list because of the small population following decades of persecution. The population is now recovering. One or two pars probably breed in or near the project area. The eagles are particularly sensitive to disturbance near the nest.

Gyrfalcon is on the Red list because the Greenland population is small. This bird of prey is mainly sensitive to disturbance near the nest. No nesting sites are known in or near the project area.

No protected areas or areas of particular conservation concerns (such as sea bird colonies, breeding areas for seals and wintering areas for sea duck) are known from the Project area or it’s near vicinity.

6.8.9 Summary of biodiversity in the project area

The area that surrounds the planned pit site and tailings pond (Fostersø) is almost completely without vegetation and also has a very limited fauna. Only two species of birds (Ptarmigan and Snow Bunting) appear to breed, in very small numbers, in this area. At Fostersø and the ponds to the north of the lake, no nesting water birds have been recorded during the field work in July 2010 although a few might occasionally breed. Arctic fox and Arctic hare were observed in the area in small numbers although little define information exist on their status.

In a narrow zone along the shore of the fjord and around the lower part of Lakseelv is more developed vegetation that mainly consists of dwarf-shrub heaths. The common passerine birds in Greenland breed in this area.

The number of marine mammals and seabirds that occur at the head of the Kangerluarsuk Fjord seems low.

The lower part of the Lakseelv has a large Arctic char population. The upper part of this river, Laksetværelv and the lakes on the plateau including Fostersø is fishless. Many of the Arctic char in Lakseelv move into the fjord during summer but return to spend the winter in the deep parts of the river.

Three birds listed on the Greenland Red List of threatened species have been recorded from the Project area: Common eider, White-tailed eagle and Gyrfalcon.

No protected areas or areas of particular conservation concerns (such as sea bird colonies, breeding areas for seals and wintering areas for sea duck) are known from the Project area or its vicinity.

7 SOCIO AND ECONOMIC SETTING

7.1 Population and local use of the area

Southern Greenland has been populated for at least two long periods, c. 2 400 BC to 200 AD and from c. 980 AD to present. Previous to the coming of the Norse in AD 985, Greenland had been inhabited by various Inuit cultures including the Dorset culture and the later Thule culture. Interaction between the Thule Eskimos and the newly arrived Norse appears to have begun shortly after the Norse landnam (pioneer settlement) in the Western Settlement of Greenland, near modern Nuuk.

Killavaat Alannguat is almost at the centre of the largest Norse settlement – the Eastern Settlement, which established farms in virtually all areas with good pastureland inside the deep fjords of what is now Narsaq and Qaqortoq municipalities. During the Norse period the settlement Igaliku about 25 km northeast of Killavaat Alannguat – at that time called Gardar - was the religious centre of the Eastern Settlement.

Today, the population mainly live in the towns Narsaq (1,750 inhabitants) and Qaqortoq (3 200 inhabitants) and in a few settlements. The main occupations now are fishing, hunting and sheep farming. The settlement Igaliku today has a population of c. 60 who are mainly occupied with sheep farming. No settlements are found at or near the project area.

Modern sheep breeders arrived to south Greenland in 1924 and today 50-60 families have sheep breeding as their main occupation. During summer the sheep feed on the natural vegetation while they are kept in stalls during winter and fed with locally grown grass. During summer sheep from the farms at Igaliku moves southwards on the Qaqortoq peninsula to feed on the natural vegetation. Small numbers of sheep reach Killavaat Alannguat during this time of the year. Within the proposed footprint of the TANBREEZ mine project, sheep will be limited to the narrow green belt along the shore of the fjord since no plant cover exist on the slopes and plateau Killavaat Alannguat.

The natural resources of the area are also utilized by the local population. This includes the Arctic char in Lakseelv, different marine fish and seals in the fjords and hare and ptarmigan in the mountains (Orbicon 2013d).

7.2 Archaeology and cultural heritage

I 2007 an archaeological survey was carried out to assess if sites of cultural heritage are found in the Project area. The archaeologists visited a number of known sites in the area but also discovered several previously unknown. This includes Norse as well as Thule-Inuit sites.

Figure 7-1 shows the position of the known sites along the shore of the inner fjord (no other sites were located in the Study area). Most of the sites are situated north of the outlet of Lakseelv – that outside the Project area (Greenland National Museum and Archives 2013). A single 17- 19th century Thule-Inuit 4 x 3.5 m tent ruin with remains of the bench was also located (yellow spot on figure)(Greenland National Museum and Archives 2013). Prior to any disturbance of this site, a staff of the Greenland National Museum and Archives must first photograph and measure the structure as part of the archaeological registration and documentation of the site.

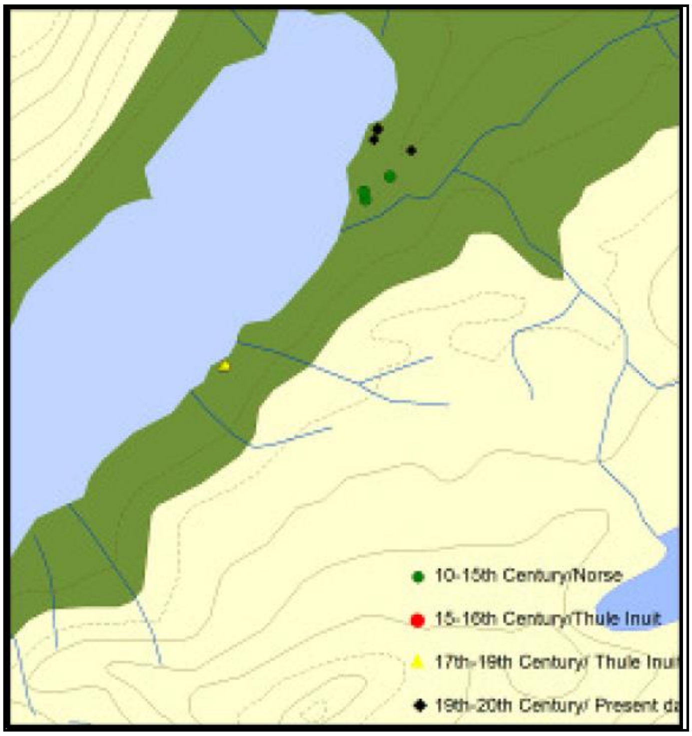

Figure 7.1 Position of cultural heritage sites in the Study area

8 IMPACT ASSESSMENT METHODOLOGY

This section considers the methodology used to assess, and where possible, mitigate potential environmental impacts from the proposed Project. As stated in the BMP (now EAMRA) guidelines particular focus is on identifying potential pollution and disturbance impacts. The identification of impacts is based on the assumption that there is a source (from the mine project), a pathway and a receptor. The main receptors are considered to be land, air and water and the associated flora and fauna of these elements. Human receptors are not discussed due to the minimal number of people in the project area (other than the staff of the Project) and the significant distance to the nearest population (at least 12 km).

Consequently the impact assessment considers:

- the activities related to the proposed TANBREEZ mine that are the source of emissions, disturbances or other effects;
- the likely emissions, disturbances or other effects;
- the receptors that can be impacted by these effects;
- the pathways between the sources and the receptors;
- the potential impact to the receptors and how they may vary for the different stages of the mine life; and
- ways to mitigate the impacts.

This has been done in the following way:

Mine activities that could potentially cause an impact have been identified from the project description of the new mine (Chapter 5). This was done by systematically looking at each project element or activity in all stages of the mine life (construction, operation, closure and post-closure).

The potential impacts – emissions, disturbances or other effects – induced by mine activities were identified through consideration of the information presented in Chapter 5 and 6.

The receptors considered susceptible to impact were sourced from the environmental baseline description in Chapter 6 and further information presented in Annexes.

The pathways between the sources and the receptors

Overall there are two types of impacts to consider;

(1) Direct impacts where the source can immediately effect the receptor e.g. noise (such as blasting) at the mine site affecting birds and mammals; and

(2) Indirect impacts which occur when one medium is affected which then affects the eventual receptor e.g. contamination of river which eventually impact upon fish and seals in fjord.

Particular attention has been on Valued Ecological Components (VECs) which are the particularly sensitive and/or important elements of the ecosystem of the project area. This includes species of commercial value as well as species of conservation concern in Greenland. For the purpose of this study White-tailed eagle and Arctic char were identified as VECs.

In chapter 9 each of the identified mine activities that could lead to a potential impact of the physical, air, water and natural environment are discussed. If a mine activity can potentially impact for example both the physical and natural environment it is discussed under each of these headings.

For each impacts there is first a brief description of the type (e.g. noise from blasting, land clearance etc.) and when during the phases in the life of the mine the impact could be relevant. This is followed by a description of the potential pathways and receptors of the impact. If possible, proposals to mitigation are given. The passage is completed by an assessment of the severity of the impact to specific receptors.

The information is then summarized in an Impact Assessment Table (see Table 8-1).

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Regional	Short term	Medium	Definite	High
Mitigation measures • During detailed design and sighting of infrastructure avoid as far as possible areas with continuous vegetation. This can be done by fine-scale mapping of sensitive areas around the power plant, access roads and port.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Local	Short term	Low	Possible	High

Table 8-1 *In this example, the dark shaded bar would indicate that the impact is mainly applicable to the construction phase of the mine project with minor applicability during operation (light shading) and no applicability at closure and post-closure (no shading). Without mitigating the activity will have a Regional impact, short term duration and have Medium impact on the environment. It is further definitive that the impact will take place and the confidence of this assessment is high*

i.e. it is based on robust data. With mitigating in place the activity will have only Local impact, short term duration and have Low impact

The impact table identifies (1) the phase of the mine operation in which the impact could occur, (2) the spatial extent (size of area) of the impact, (3) the duration of the impact, (4) the significance to the environment, (5) the probability that the impact will occur, and (6) the confidence by which the assessment has been made. This is followed by a list of proposed mitigating measures (if relevant) and a bar with an assessment of the spatial extent, duration, significance, probability and confidence when mitigation has been taken into account.

For the purpose of this EIA study the following terminologies are used in the Impact Assessment Table:

Spatial scale of the impact:

- *Project footprint*; that is within the footprint of the mine project, i.e. confined to the activities per see, the infrastructure itself and the very close vicinity hereof (few hundreds of meters away);
- *Project area*; within a few km from the activity (about 0- 5 km);
- *Regional*; within a distance up to 50 – 75 km from the project area;
- *Global.*

Duration (reversibility)
Duration means the time horizon for the impact. The term also includes the degree of reversibility, i.e. to what extent the impact is temporary or permanent (i.e. irreversible).

- *Short term;* the impact last for a short period without any irreversible effects;
- *Medium Term;* the impact will last for a period of months or years but without permanent effects or definitely without irreversible effects;
- *Long term;* the impact will be long lasting (> 15 years) e.g. cover the entire lifetime of the operational phase. Permanent and close to irreversible effects might be ascertained;
- *Permanent;* the impact will last for many decades and have irreversible character.

Significance of the impact:

- *Very low;* very small/brief elevation of contaminates in local air/terrestrial/freshwater/marine environment by non-toxic substances (when concerning emissions) and decline/displacement of a few (non-key) animal and plant species from mine site and/or loss of habitat in the mine area (when concerning disturbance);
- *Low*: small elevation of contaminates in local air/terrestrial/freshwater/marine environment by non-toxic substances and/or very small temporary elevations of toxic substances (when concerning emissions) and decline/displacement of a

Valued Ecosystem Components (VEC) that is a key animal and/or plant species and/or loss of habitat in the project area (when concerning disturbance);

- *Medium*: some elevation (above baseline, national or international guidelines) of contaminates in local or regional air/terrestrial/freshwater/marine environment including toxic substances or decline/displacement of VECs such as key animal and/or plant species and/or loss of habitat at local level;
- *High*; significant elevation of contaminates (above baseline, national or international guidelines) in local and regional air/terrestrial/freshwater/marine environment including toxic substances or decline/displacement of VECs such as key animal and/or plant species and/or loss of habitat at regional level.

Probability that the impact will occur:

- *Improbable;*
- *Possible;*
- *Probable;*
- *Definite.*

Confidence that the assessment is correct:

- *Low* - data are weak;
- *Medium* - data from Greenland or other parts of the Arctic (in particular Canada) points to the conclusion;
- *High* – data from the Study area or neighbouring parts of South Greenland are conclusive.

9 IMPACT ASSESSMENT AND IDENTIFICATION OF MITIGATION MEASURES

This impact assessment chapter is divided into six sections:

- Section 9.1 evaluates the consequences of the project on the **physical environment** that is the landscape;

- Section 9.2 focuses on the impacts the project might have on the **air environment** in terms of airborne pollution and climate change (from carbon dioxide emissions);

- Section 9.3 looks at the potential impact on the **water environment** (lakes, streams, rivers and the fjord) in terms of potential pollution and changes of flow pattern. This section includes an assessment of using Fostersø for deposition of tailings and waste rock[1] and the potential impact on the Arctic char population in Lakseelv (which is connected to Fostersø);

- Section 9.4 looks at the potential impacts on the **ecological environment** that is the animals and plants of the study area and their habitats. This assessment looks at both the potential direct disturbances and loss of habitat;

- Section 9.5 deals specifically with the **waste** issue including the potential impact of hazardous waste from the project; and

- Section 9.6 contains an evaluation of any impact of **cultural heritage** sites.

9.1 Physical Environment

Changes to topography (landscape) are generally experienced either as a physical disturbance affecting the natural flora and fauna (and humans) or as an aesthetic disturbance to the scenic beauty of the land. This section focuses on assessing the impact of the mine activities on the landscape.

9.1.1 Removal of ore and waste rock

The process of open pit mining will remove a significant proportion of the outcrop at Killavaat Alannguat, leaving open pits. The material removed from the ore body is either deposited in Fostersø as waste rock or taken away for further processing. The change to the topography of the pit areas is permanent.

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[1] Tailings refer the materials left over after the process of separating the valuable fraction from the uneconomic fraction of an ore while waste rock refers to rock material with no significant REE content and which is progressively removed from the pit areas to give access to ore body. Only very small amounts of waste rock are expected in connection with the TANBREEZ project.

Due to the geology and the climatic forces Killavaat Alannguat is mostly characterized by almost bare ground with loose rubble and broken slopes with no or very little vegetation. Changes to the topography due to mining will therefore have relatively little visible impact and the areas to be disturbed are also small in relation to surrounding available land. The significance of the permanent changes to the topography at the open pits is therefore considered Low.

The removal of ore is taking away a non-renewable resource. However, that is the specific intention of the project and there will be a number of positive impacts associated with this process (discussed in Social Impact Assessment report).

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Low	Definite	High
Mitigation measures • Limited mitigation possible; however the aesthetic impact can be lowered by planning open pits to blend as far as practical with the surrounding landscape.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Low	Definite	High

Table 9-1 Assessment summary of removal of ore and waste rock

9.1.2 *The use of Fostersø as tailings pond and waste rock dump*

Tailings separated from the saleable concentrates at the processing plant will be mixed with dust from the filters in the processing plant building and water to form slurry which will be pumped through a pipeline to Fostersø where it will be deposited. Waste rock will also be deposited in Fostersø. This change to Fostersø is permanent.

The use of Fostersø as tailings pond and waste rock dump will not require any significant re-profiling of the area round the lake. Since the tailings and waste rock will be covered by water it will have little or no visual impact.

The use of Fostersø as tailings pond and waste rock dump is assessed to have Very Low impact on the landscape (note that the impact on water chemistry and freshwater ecology is dealt with in Section 9.3 and 9.4, respectively).

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Very Low	Definite	High
Mitigation measures • Limited mitigation is possible other than planning the equipment at the tailings pond to blend as far as practical with the surrounding landscape; • Remove buildings and other equipment next to the lake at the end of mine life.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Very Low	Definite	High

Table 9-2 Assessment summary of landscape changes if Fostersø is used for tailings pond and waste rock deposition

9.1.3 Re-profiling of the landscape for infrastructure construction at the plateau of Killavaat Alannguat

A five km haul road will be constructed between the Hill pit site and the crusher at the port. Another c. 1 km haul road will be built between Fjord site and the crusher. In addition, a service road will connect the tailings management facility at Fostersø with the haul road. A pipeline will be built from the crusher to the tailings facility. A number of buildings (explosive magazine, emergency staff building) will also be constructed between Fostersø and the Hill site. The construction of the roads, pipeline and buildings will cause some re-profiling of the terrain, in particular in connection with the haul road. These topographical changes are permanent except for the buildings which will be removed during mine closure.

The road alignments of the project will be permanent changes to the landscape of Killavaat Alannguat plateau within an area of app. 2 x 5 km. The disturbed area is therefore small in relation to surrounding available land. In addition, away from the fjord and the Lakseelv, the land is almost without vegetation and it is expected that the gravel roads will to a large extent blend into the surrounding landscape. For this reason the significance of the physical and aesthetic disturbances of infrastructure on the Killavaat Alannguat plateau are assessed as Low.

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Low	Definite	High
Mitigation measures • Limited mitigation is possible, however the aesthetic impact can be lowered by planning roads to blend as far as practicable with the surrounding landscape; • The haul road and service roads will be left in place after the closure of the mine, however to encourage re-vegetation it is proposed to rip the road surfaces.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Low	Definite	High

Table 9-3 Assessment summary of re-profiling of the landscape for infrastructure construction on the Killavaat Alannguat plateau

9.1.4 Changes in the topography arising from the construction of port and other facilities along the shore of the fjord

Re-profiling of the land along the shore of the fjord will take place where the port and other facilities including the crusher, magnetic separator and staff buildings will be constructed. The changes to the topography are permanent. The re-profiling for the facilities at the fjord will lead to loss of the soil layer.

The re-profiling to accommodate buildings along the fjord will also lead to loss of natural vegetation. However, since mine facilities at the fjord are limited to an area of app. 0.5 km^2 only an insignificant area will be disturbed.

Following the decommissioning of buildings and machines at mine closure natural vegetation re-growth will take place through natural plant succession and restore the plant cover. This will be facilitated if soil resource can be conserved and subsequently put back in place at the end of the life of the mine.

The impact on the landscape from facilities at the fjord during the operation of the mine is considered Low due to the relatively small footprint of the facilities. With soil conserved and put back in place after buildings have been removed at mine closure to facilitate vegetation re-growth, the significance of the impact is further lowered and assessed as Very Low.

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Long term	Low	Definite	High
Mitigation measures • Minimize the area to be disturbed by planning infrastructure to have as small a footprint as possible; • Conserve topsoil for use in progressive and end of life mine rehabilitation.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Long term	Very Low	Possible	Medium

Table 9-4 Assessment summary of changes in the topography arising from the construction of port and other facilities along the shore of the fjord

9.2 Air environment

This section relates the potential direct impact arising from air born pollutants (dust and emissions) and the indirect impact which includes contribution to the greenhouse gas emissions from Greenland causing increased climate change.

9.2.1 Increase in concentrations and deposition of dust and emissions of particulate matter from Project operation

This impact relates to the airborne dust and emissions of particulate matter generated from the Project. The Project will generate dust emissions during operation of the open pit mines, including drilling and blasting, excavation, hauling, stockpiling, crushing and processing of ore, road maintenance and the storage and ship loading of the Eudialyte and Feldspar products. Particulate emissions will also come from the diesel power plant, mobile equipment engines and the incinerator.

Since the planned mine operation will have two phases (a pit near Kangerluarsuk Fjord will be excavated for the first five years (Fjord site), and a pit on the hill will be excavated for the last five years (Hill site)) these two separate scenarios are assessed. AirQuality.dk (2013) details the potential dust dispersal and deposition. The most important results of the study are summarized below.

Dust Emission

Emissions of particulate matter are calculated for two particulate size classes: total suspended particulate matter (TSP) and particulate matter less than 10 µm in diameter (PM_{10}). The maximum daily emission rate and annual average emission rate are calculated for both parameters. PM_{10} ambient concentrations, TSP dust fall rates and metal loads in dust fall are compared to international standards.

Emission calculations for both scenarios are based on the design production rate for the processing plant of 2400 tons of ore per day. The mine is assumed to operate 248 days per year (80% availability and 85% utilization). This gives an annual production of 595,200 tons of ore per year, which is 19% more than the design basis of 500,000 tons per year but well within the planned capacity of the facility. The estimated concentrate yield for both scenarios is 101,184 tons/year Eudialyte (17% of ore) and 202,368 tons/year Feldspar (34% of ore).

Emission estimation takes into account dust control measures planned in the design, including watering and/or chemical dust suppression on haul roads, enclosed processing plant with dust filtration system, and enclosed ship loading conveyor system.

The total annual TSP emission is estimated at 318 tons TSP/year for the Fjord site scenario and 631 tons TSP/year for the Hill site scenario. PM_{10} emissions are 102 and 191 tons PM_{10}/year for the two scenarios. The overall annual emission rates for the Fjord site scenario are 0.53 kg TSP per ton ore and 0.17 kg PM_{10} per ton ore. For the Hill site scenario the overall emission rates are 1.06 kg TSP/ton and 0.32 kg PM_{10}/ton.

Dust generated by haul trucks and other vehicles on unpaved roads accounts for the largest share of the total dust emission in both scenarios – 83% for the fjord pit scenario and 91% for the hill pit scenario. The power plant accounts for 2% and 1% of particulate emissions and mobile equipment diesel engines account for only about 0.1%.

Dust Deposition

Annual total dust deposition was calculated by the CALPUFF dispersion model based on emission of TSP. Isoline maps of annual TSP deposition in kg/ha/year are shown in Figure 9.1 for the Fjord site scenario and in Figure 9.2 for Hill site scenario. The peak values of calculated annual dust deposition are labeled in the figures: 51 kg/ha/year for the Fjord site scenario and 72 kg/ha/year for the Hill site scenario. These peak values correspond to 14 $mg/m^2/day$ and 20 $mg/m^2/day$ respectively.

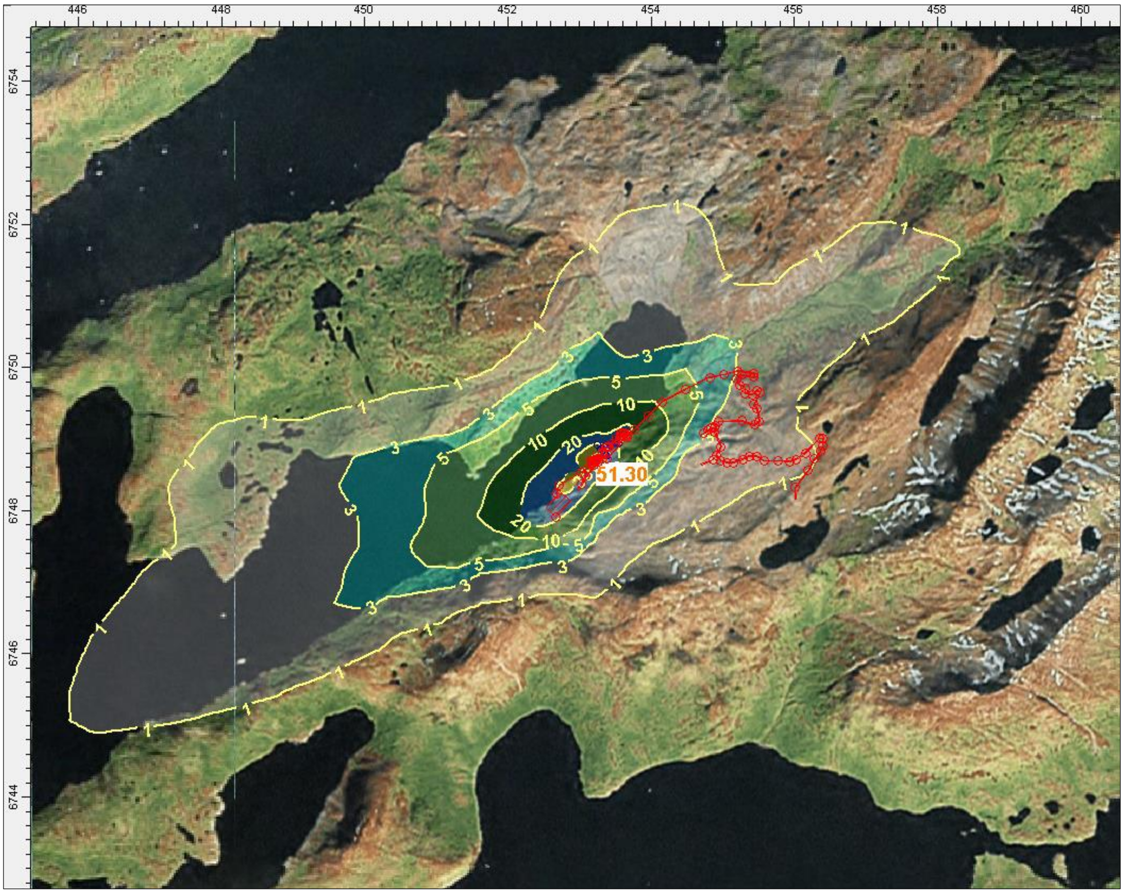

Figure 9.1 Isoline map of annual dust deposition for the Fjord pit site scenario in kg/ha/year. The highest value is labeled 51.30 kg/ha/year (equivalent to 14 mg/ m^2/day)

Most of the dust from the Project will come from travel on gravel roads. This dust will come from gravel made from the local Kakortokite bedrock exposed throughout the project area. Dust falling on the land surface will therefore be the same material as the surface itself, and will not change the chemical composition of the surface or runoff. Dust particles falling directly on streams, lakes and fjords will mostly settle to the bottom, where it will have the same mineral composition as the bottom material. The natural water quality will not be altered by dust.

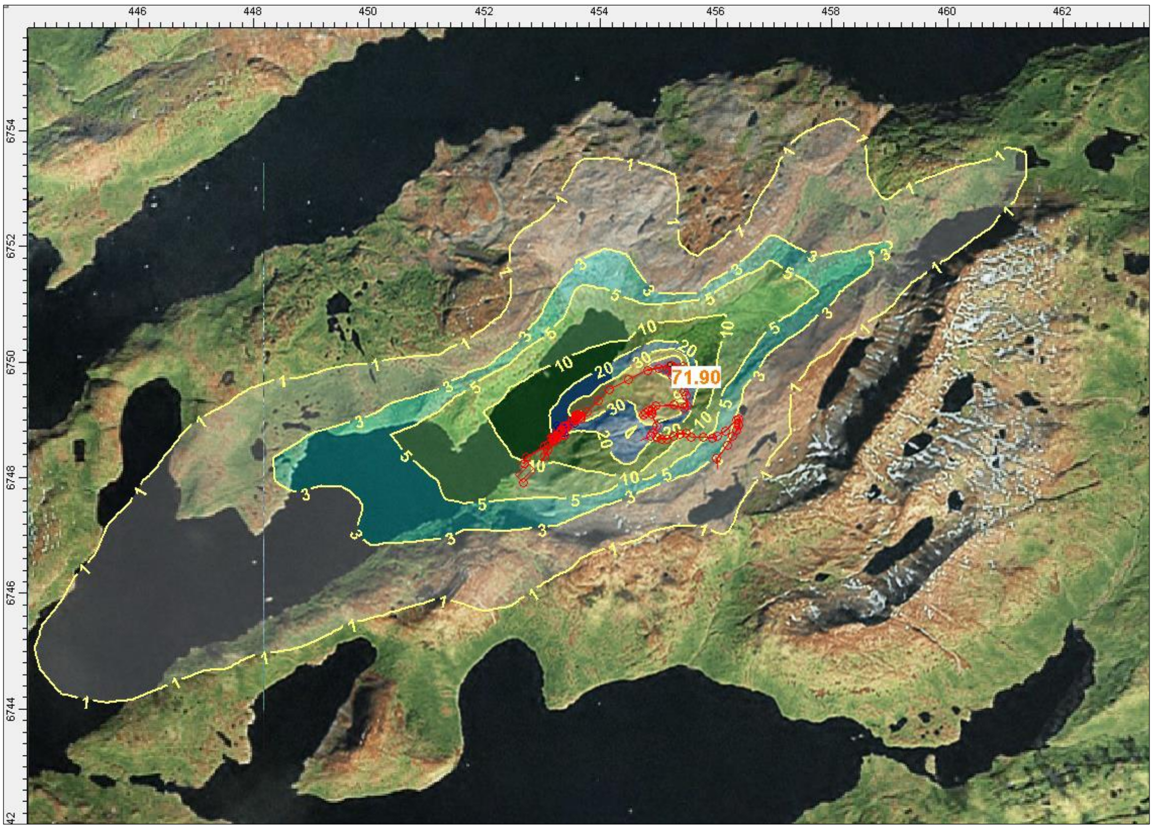

Figure 9.2 Isoline map of annual dust deposition for the Hill pit site scenario in kg/ha/year. The highest value is labeled 71.90 kg/ha/year (equivalent to 20 mg/ m²/day)

Dust generation will increase ambient particulate matter concentrations close to mine activity and haul roads. EU limit values for ambient concentrations of inhalable particles (PM_{10}) apply to populated and publically accessible areas and not in industrial areas. The EU limit values have not been formally adopted in Greenland, but are used for comparison. The EU annual PM_{10} limit value (40 µg/m³) will be exceeded only in a few small areas within the mining site itself. The EU short-term 24-hour PM_{10} limit value (50 µg/m³), reflecting occasional adverse dispersion conditions, will be exceeded no more than 500 m from the active mine pit and haul roads.

In comparison to the Norwegian nuisance limit value for dust deposition of 5 g/m²/30 days (167 mg/m²/day), dust deposition is at most 0.6 g/m²/30 days (20 mg/m²/day) or 12% of the nuisance limit value – and that occurs at the dustiest location within the mine site. Dust deposition rates decline rapidly from the maximum level – to less than 2% of the Norwegian limit value within about 500 m of the pits and haul roads.

There is no vegetation over most of the project area, but where vegetation occurs, plant communities could be affected up to a few tens of meters from the mine pit, haul roads and crusher area.

The area where dust deposition is more than 20 kg/ha/year (5.5 mg/m²/day) – a level suggested by Canadian research as a lower threshold for caribou avoidance due to dust on edible vegetation – is limited to within about 500 m from the mine pits and haul roads, similar to the 500 m buffer area suggested by the 24-hour ambient PM_{10} concentrations. Caribou are not found in the area, but this threshold might also be relevant for Arctic hare and bird such as Ptarmigan where there is vegetation for forage.

Metal Deposition

Mineral dust is expected to have the same chemical composition as the natural Kakortokite bedrock used for gravel, or the Eudialyte and Feldspar minerals being mined (see table 9.5).

		Maximum concentrations		
		Eudialyte	Waste rock	Worst Case
Metals		µg/g (ppm)	µg/g (ppm)	µg/g (ppm)
Aluminium	Al	81800	78300	81800
Iron	Fe	70200	101000	101000
Cobber	Cu	40.0	20.0	40.0
Zink	Zn	410	1240	1240
Arsenic	As	30.0	62.0	62.0
Cadmium	Cd	0.25	4.5	4.5
Lead	Pb	124	933	933

Tabel 9-5 ”Worst case” concentrations of metals in dust (ppm) based on the highest measured concentrations in eudialyt and waste rock.

Heavy metal loads in dust fall can be compared to German limit values for deposition of arsenic, cadmium and lead: 4 µg As/m^2/day, 2 µg Cd/m^2/day and 100 µg Pb/m^2/day. Based on the maximum calculated dust deposition rate (71.9 kg/ha/year, Hill Pit scenario), and the highest concentrations measured in ore and waste rock samples, the maximum loads of arsenic, cadmium and lead in dust fall are 1.2 µg As/m^2/day, 0.09 µg Cd/m^2/day and 18.4 µg Pb/m^2/day. These are 31%, 5% and 18% of the German limit values, respectively. Dust deposition rates decline rapidly from the maximum in the mine site, further reducing the loads in comparison to the German standards.

The entire load of arsenic, copper, cadmium and zinc in emitted dust is no greater than the dissolved amount naturally flowing into Kangerluarsuk Fjord from a single stream (Lakseelv). Only a fraction of the total dust load will fall on the fjord and most of this will settle to the bottom without significant leaching of metals. Since the chemical composition of the dust is similar to the composition of the exposed bedrock on the land surface and under the fjord, changes to water quality would be very small and difficult to detect.

Conclusion

The dust study shows that by far de majority of the dust deposition will take place within 500 m of the pit and haul roads. The dust consists of the same material as the surrounding rocks and will therefore not alter the chemical position of the soil, freshwater or the fjord. The overall impact of dust emission, dispersion and deposition is assessed to be Low.

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Low	Definite	High
Mitigation measures • Use Best Available Technique filters in crusher building to minimise the dust emissions; • Choose vehicles and other equipment based on energy efficiency technologies to optimise emissions rates; • Water gravel roads to reduce dust generation(not when frost); and • Maintain diesel power plant, vehicles and other fuel powered equipment in accordance with manufacture's specifications to minimise on emissions.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Low	Probable	High

Table 9-6 Assessment summary of dispersal and deposition of dust and emissions of particulate matter from Project activities

9.2.2 Greenhouse gas emissions

The TANBREEZ project will have its energy consumption based on fossil fuel combustion, with associated emissions of carbon dioxide (CO_2). CO_2 is a greenhouse gas that contributes to global warming and climate change.

The expected fuel consumption during construction and operation of the project is 7.8 million liters per year. Arctic diesel fuel will mainly be used. A very small fraction of the fuel is jet fuel for helicopters. Fuel consumption by ships calling at the port are not included.

CO_2 emissions are estimated by multiplying annual fuel consumption amounts by an emission factor. Emission factors are based on the carbon content of the fuel. The emission factor for diesel oil is 74 kg CO_2 per MJ of gas oil. Arctic diesel has a density of 850 kg/m^3 and a lower calorific value of 42.56 MJ/kg. These figures enable the CO_2 emission factor to be expressed as 2677 tons CO_2 per million liters of arctic diesel fuel. The very small difference in the emission factor for jet fuel is neglected for this calculation. This corresponds to 20 881 tons of CO_2 per year.

The above figures can be compared to the present Greenlandic import of liquid fuels and CO_2 emission and to international figures. The annual import of liquid fuel to Greenland has varied between 221 and 276 million liters in the period 2002 – 2009 with an annual average of 251 million liters of fuel per year (data source: Statistics Greenland). The equivalent CO_2 emission is estimated to between 0.58 and 0.65 million tons of CO_2 with an annual average in the period 2002 – 2009 of 0.63 million tons per year. Taking these figures as baseline, the TANBREEZ project increases the import of fuel to Greenland as well as the CO_2 emission by 3.3 %.

9.3 Water environment

The TANBREEZ Project can have an impact on the water environment, that is lakes and streams in the study area and the marine environment of the fjord. The potential impacts are:

1. Changes to the freshwater quality;

2. Changes to the flow pattern; and

3. Oil and chemical spill into fresh water or the fjord.

9.3.1 Freshwater quality

A number of project activities can potentially have an impact on the water quality of lakes and streams in the study area:

1. Deposition of tailings and waste rock in Fostersø can lead to changes to the water quality and changes in flow patterns;

2. Blasting at the pits can increase nitrogen load in surrounding water bodies; and

3. Excavations of the mine pits can lead to erosion and leaching of substances into water bodies.

In addition, accidents in connection with the construction and operation of the mine can lead to spill and contamination of freshwater. This includes accidents in connection with transport, storage and handling on land.[2]

1. The potential impact of tailings and waste rock deposition in Fostersø

The deposition of tailings and waste rock in Fostersø can potentially have an impact on the lake itself, Laksetværelv which drains Fostersø and Lakseelv downstream the point where it meets with Laksetværelv (and ultimately the fjord). Tailings refer to the materials left over after the process of separating the valuable fraction from the uneconomic fraction of an ore while waste rock refers to rock material with no significant REE content and which is progressively removed from the pit areas to give access to ore body. Only very small amounts of waste rock are expected in connection with the TANBREEZ project.

Lakseelv has a large and important population of Arctic char. Most of the large specimens that belong to this fish population occur in the lower part of the river downstream the point where it meets with Laksetværelv. This is also the part of the river where most (if not all) of the Arctic char spent the winter. During summer large numbers of adult Arctic char migrate into the fjord.

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[2] Note that a potentially increase the turbidity of lake and stream water is discussed under 9.4.5

A major concern regarding deposition of tailings and waste rock in Fostersø is the potential release of metals and other elements to the lake water. Releases of contaminants, such as heavy metals, into the water of Fostersø can potentially have effects on the Arctic char population in Lakseelv and to the bentic macroinvertebrate which are key prey organisms for these fish.

The arctic fishes, including Arctic char are known to be very sensitive to heavy metals, trace elements, and other contaminants in mine wastes (Lemly 1994). Exposure to metals is believed to potentially affect char feeding habits, bioaccumulation, and general condition. Uptake of metals from water is usually considered to be the predominant route of exposure but dietary accumulation, where also cannibalisms can be a driving force, may also contribute significantly to the total body burden of heavy metals (Dallinger and Kautzky 1985, Hatakeyama and Yasuno 1987; Dallinger et al. 1987; Harrison and Klaverkamp 1989; Douben 1989).

Also altered prey communities may have a significant impact if important metal-sensitive prey species are replaced by less attractive metal-tolerant species (Clementsa & Reesa 1997).

Some fish species appear to be able to regulate metal concentrations in critical organs using metal-binding proteins such as metallothionein (Roch et al. 1982). Since production of these proteins comes at some metabolic cost to the organism, fish in an environment with high levels of metals must divert energy from other important physiological processes (e.g. growth, reproduction) to metal regulation.

Geochemical analyses

To assess to what extent metals and other elements can be released from tailings and waste rock if these materials are deposited in Fostersø the chemical composition of the ore, tailings and waste rock has been analyzed. A number of experiments have also been carried out to determine if metal leaching to the lake water can potentially take place. Finally, have potential changes in the concentration of metals in Fostersø over time been modeled in a situation where the lake is used for deposition of mine waste. The test work and modeling was carried out by Golder (Sweden) and described in Golder (2013a). The key results are summarized in the following.

Two tailings samples and two samples of waste rock representative of the operation of the TANBREEZ project have been subjected to environmental test work. For comparison one ore sample and two samples of concentrate were also included in the test work.

Initially a semi-quantitative screening of the samples was carried out to identify if metals known potentially to be toxic to humans and the environment were present in the samples. Potentially elevated concentrations of six metals were identified: arsenic, cadmium, chromium, lead, copper and zinc (the elevated chromium content is most probably a contamination from the milling process).

To determine the acid generating potential of tailings and waste rock an Acid Base Accounting test was carried out. An acid producing material can, when exposed to weathering and water, contribute to lowering the pH of downstream water and cause release of metals ions in for example stream sediment. The test work showed that neither tailings nor waste rock is acid producing.

To assess if the tailings or waste rock could potentially contain other toxic substances than the known metals, a specific eco-toxicity test was carried out. Samples of tailings and waste rock material were placed in water tanks with daphnia and trout to test for unexpected mortality. The tests recorded no unexpected mortality among the daphnia or fish[3].

In order to clarify the geochemical processes that could take place between tailings, waste rock and the environment a sequential extraction test was carried out. This test indicates if metals are readily mobilized in various geochemical settings and thus become available to be up taken into the environment. The conclusion of the tests is that there is low likelihood of mobilization of sulphide-bound or metals retained in the residual phase in case of an underwater storage of tailings and waste rock. Exceptions are one of the tailings samples and the waste rock samples where lead potentially might become mobile during underwater storage. Also arsenic in one of the waste rock samples showed potential signs of mobility in case of an underwater deposition. The actual scale of such mobilization depends on a number of ambient conditions in the lake, such as pH of the water.

To provide information on the potential (short term) metal leaching of tailings and waste rock in water a “shake flask” test was carried out. The results of these tests suggest that arsenic and lead potentially can leach from tailings and waste rock if deposited in water.

An important concern when storing tailing and waste rock at the bottom of lakes is if anoxic conditions will develop in the deposited material and the lake bottom water. Such conditions can greatly increase the mobility and transport of metals, in particular arsenic and iron, and potentially lead to high concentrations of these elements in the lake water.

To test if such condition could develop in Fostersø a sub-aqueous column (long term) test was carried out using tailings and waste rock material from the TANBREEZ project. Three replicates containing tailings and waste rock material was submerged in a container with water for seven weeks[4]. Subsequently water samples were collected and analyzed for metal contents, pH and electric conductivity. The result showed that some metal leaching to the lake water will take place, however for most metals the leaching will result in low concentrations only.

Modeling the leaching of metals

Although the tests work suggest a potential for metal leaching of lead and arsenics if the tailings and waste rock from the TANBREEZ project is deposited in water, the actual amount of leaching and to what extent it will lead to elevated metal concentrations in the lake depend on a number of factors. This includes how the deposition is carried out, the

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[3] In the first round of testing an unexpected 60% mortality was recorded among trout in the tank with one of the tailings samples. Since this result could not be correlated with the analytical data from the sample an external factor was suspected to have caused the high mortality. The test was subsequently repeated and zero mortality was recorded.

[4] A seven week study of the metal release will normally provide data that enable robust modelling of the metal release over much longer time.

volume of water and the retention time of water in the lake as well as the chemical-physical parameters in the lake water (such as pH and temperature stratification).

To assess the actual amount of metal leaching to the lake water of Fostersø the results of the metal concentrations measured in connection with the seven weeks sub-aqueous column test were combined with a hydrological model of the Fostersø freshwater system to assess the potential release of metals from the tailings pond over time.

Golder (Sweden) carried out the modeling, which is described in Golder (2013a & 2013b). The results are summarized in the following:

The model is based on the following key assumptions:

- Volume of water in Fostersø: 8,408,000 m^3
- Annual waste rock deposition 50,000 metric tonnes composed of:
    - 32,500 tonnes of massive green syenite, and
    - 15,500 tonnes of green syenitic pegmatite
- Annual tailings deposition: 200,000 tonnes composed of:
    - 136,000 tonnes of magnetically-separated material, and
    - 64,000 tonnes of fines.
- Operational lifetime of mine: 10 years
- Average outflow from Fostersø: 0.145 m^3/s

The results are presented in Table 9-7. The concentrations of metals in Fostersø will increase the first years but then reach a steady-state after about 5 years of operation as the pond fills with tailings and waste rock. This is because:

(1) The amount of metals that releases from the tailings to the lake water is constant, because metals only dissolve from the top layer of tailings in direct contact with the water. Further down in the tailings the material is packed so tight together that it almost excluding water movements and dissolved metals here will therefore not reach the lake water.

(2) Although the volume of lake water is reduced as more and more tailings is deposited, the water flow through the lake (from rain, snow and springs) remains the same. This means that the dilution of the metal dissolved in the lake water increases as the water volume of the lake decreases.

Modelling show that a steady state will be reached after about five years, where the amount of metals from tailings equals the amount of dissolved metals that is discharged from the lake.

Except for lead the modeling, predict that the content of metals will be below the Greenland Water Quality Guideline (GWQG) values. The level of lead will after 5 years be elevated to1.63µg/l and after 10 years to 1.81µg/l. However, the GWQG value has to be met at one or more specified points downstream the mining operation (BMP 2011) not in Fostersø which as tailings and waste rock pond is part of the mining operation.

A realistic measuring point where the GWQG should be met is just below the point where the outflow of Fostersø blends with Lakseelv. During most of the year, the outflow from Fostersø contributes to about 20% of the water in Lakseelv (Orbicon 2013c). The water from Fostersø will therefore be diluted in a short distance from the effluent point (the outlet of Laksetværelv) and the ambient water quality of Lakseelv will not exceed the GWQG.

Elements	**Year 1** (µg/l)	**Year 5** (µg/l)	**Year 10** (µg/l)	**Greenland Water Guideline** (µg/l)
Iron (Fe)	0.005	0.010	0.011	0.3
Aluminium (Al)	32	81	90	NA
Arsenic (As)	0.28	0.72	0.80	4.0
Cadmium (Cd)	0.003	0.007	0.008	0.1
Cobalt (Co)	0.002	0.006	0.007	NA
Chromium (Cr)	0.01	0.02	0.02	3
Copper (Cu)	0.45	1.13	1.26	2
Mercury (Hg)	< 0.002	< 0.002	< 0.002	0.05
Molybdenum (Mo)	1.96	4.91	5.44	NA
Nickel (Ni)	0.004	0.01	0.01	5
Lead (Pb)	0.65	1.63	1.81	1
Zinc (Zn)	0.28	0.67	0.75	10

Table 9-7 Calculated content of metals (µg/l) in Fostersø after 1, 5 and 10 years of deposition of tailings and waste rock. The values are average concentrations from three sub-aqueous column tests (see text). Greenlandic guideline values (dissolved values) are shown to the right

During mid-winter (January-March) the flow of Lakseelv is much reduced. Deposition of tailings and waste rock in Fostersø will take place all year and the addition of material to the lake will cause Laksetværelv to flow even during the coldest time of the year (as opposed to the present situation where the flow is very reduced or even stops between early January and late March). This will cause the share of inflow from Laksetværelv to Lakseelv to increase above 20%.

This is unlikely to cause lead concentration in excess of the GWAQ value in Lakseelv during the first years of mine operation because of the low lead concentrations in the lake water. To what extent the low water flow in Lakseelv during mid-winter will cause the concentration of lead to exceed the GWQG value after 3 – 5 years of operation is unknown. If a significant increase in the lead concentration is recorded in Lakseelv in mid-winter during operation there are (at least) two ways of preventing the lead concentration to exceed the GWQG value.

One option is to build a low dam across the outlet of Fostersø with a throttle valve to prevent outflow during period of very low flow in Lakseelv. The excess water would then be released in spring when snow melting causes the flow of Lakseelv to be particularly high.

Another option is to lower the water level in Fostersø in late autumn by pumping water out of the lake into Laksetværelv. The lowering of the water level in the lake would then create room for waste material to be deposited without causing an outflow of water during periods of low flow in Lakseelv. The two options could also be combined.

In conclusion, the ambient water quality of Lakseelv will not exceed the GWQG during the first years of operation due to metal leaching from tailings and waste rock deposition in Fostersø. After 3-5 years the low water flow in Lakseelv during mid-winter could potentially cause the concentration of lead to exceed the GWQG value. However, this can be prevented by controlling the outflow of water from Fostersø. This can either be done by constructing a low dam at the outlet and blocking the outflow during mid-winter or by pumping water out of the lake during autumn and thereby lowering the water level to accommodate the waste material deposition during mid-winter without causing an outflow of water from the lake.

When the mine closes and deposition of tailings and waste rock in Fostersø ends, the concentration of lead in the lake is expected to drop below the 1 µg/l Greenlandic guideline value within a few years.

2. Nitrogen load from blasting

During operation of the mine, additional nitrogen can come from residues of nitrogen-based explosives used in the mine pits. Blasting in connection with the construction works will also cause nitrogen dispersal within the Project area. Nitrogen leached from blasting residues will flow in runoff water into Fostersø and other fresh water bodies and ultimately into the fjord.

Due to the relatively small amounts of nitrogen-based explosives expected to be used no significant increase in the nitrogen concentration in the outflow from Fostersø or in other water bodies (including the fjord) are expected.

3. Erosion and leaching of substances from pit excavation

The existing landscape at Killavaat Alannguat undergoes natural erosion every summer due to snowmelt, melt water runoff and stream flow.

Construction work and in particular the building of the haul road to the hill pit and the pipeline to Fostersø could potentially increase erosion due to surface runoff. However, such erosion will be temporary and a very local phenomenon.

Excavation of the mine pits is not expected to contribute to erosion. Leaching of substances from excavation surfaces is deemed not to be an issue.

<u>In conclusion</u>

If mitigated properly, deposition of tailings and waste rock in Fostersø and residues of nitrogen-based explosives will lead to no measurable impact on the water quality outside the mine area. Erosion from excavation of the mine pits and leaching of substances from excavation activities are deemed not to be an issue. All in all pollution of freshwater due to mine activities is assessed as Low provided that the proposed mitigating measures are completed (if necessary).

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Medium	Probably	High
Mitigation measures • Control outlet of Fostersø in periods with low water flow in Lakseelv (during winter) if lead concentrations exceeding the GWQG value is recorded in Fostersø				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Low	Definite	High

Table 9-5 Assessment summary of contamination of freshwater resources

9.3.2 Changes to the flow pattern

The deposition of tailings and waste rock in Fostersø will gradually reduce the volume of the lake and potentially change the flow pattern of the outlet, Laksetværelv (which connects with Lakseelv). This change is permanent. Culverts will be put in place to permit the haul road to cross the Laksetværelv two times. The culverts will be removed at mine closure.

The Arctic char that spend the winter in deep pools at the lowermost section of Lakseelv are dependent on a (small) steady flow of clean water to survive under the ice cover. Any significant change in the flow pattern during this critical period can have severe impact on the Arctic char population.

Measurements of the flow pattern in Laksetværelv show that most of the year this stream contributes with about 20% of the water in Lakseelv. However, Laksetværelv sometimes freezes up in winter and stop flowing. In 2011 Laksetværelv was dry from the beginning of January till the end of March (Figure 6.6).

Since Laksetværelv sometimes stop flowing during mid-winter the contribution of water from this stream is not essential for the survival of the Arctic char during this period of the year.

The culverts for the haul road will be sized according to flow measurements made at the outlet at Fostersø. The culverts will also be constructed and sized to handle freezing conditions and in particular the break-up when blocks of ice are washed down the river in spring. The culverts should therefore not cause any significant flow constrictions to the Laksetværelv or lead to erosion along the banks of the river.

Overall the impact of deposition of the tailings and waste rock in Fostersø and the construction of culverts is assessed to have Very Low significance for the flow pattern of water resources in the area. Also the hydrological changes and impact on fish populations downstream of Fostersø will be insignificant.

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Permanent/Long term	Very Low	Definite	High
Mitigation measures • No mitigating possible other that removing the culverts where feasible at mine closure				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Permanent/Long term	Very Low	Definite	High

Table 9-6 Assessment summary of changes in flow patterns and capacity of freshwater resources

9.3.3 Oil and chemical spill into fresh water or the fjord

Accidents in connection with transport, storage and handling of hazardous materials on land such as fuel, grease, paint and chemicals can potentially cause contamination of nearby freshwater bodies. Contamination of the lakes and streams by oil or other hazardous materials from project activities could potentially pose a risk to animals, plants and their habitats. Hydro-carbons, such as jet fuel and Arctic diesel, can have toxic effects. Pollution in for example Fostersø can potentially have significant negative impact on aquatic life in a large area, since streams connect the lake with the fjord.

Building material, fuel, machines and other cargo will be shipped to the port during the construction phase. During operation, fuel will arrive to the port site each year in 2,300 DWT tankers and products will be exported in vessels up to 57,000 tons. The ships that call at the port will also be carrying large quantities of fuel oil for their own use[5]. A major shipping accident or spill during unloading of oil at the port site could contaminate the Kangerluarsuk Fjord marine environment with oil or chemicals. Oil spills caused by operational events – human failures, malfunctions of valves, rupture of hoses, etc. – are more likely than a ship accident, but the quantities of spilled oil are usually much smaller.

The minor volumes of individual fuel tanks used during construction on land and the location of oil tanks for the operation of the TANBREEZ project will limit the potential impacts of accidents. Only small quantities of hazardous materials will be used during construction and operation and with strict procedures for their handling the risk of a significant spill is considered low.

A large oil spill in Kangerluarsuk Fjord could have significant consequences for marine life. Tidal currents in the fjord could spread oily surface layers over considerable distances and shoreline contamination would be likely. Birds are probably the animal group most sensitive to oil. Marine mammals such as whales and seals are generally less sensitive to oiling, except for seal pups which are sensitive to direct oiling. Many species of fish appear to be able to detect and avoid oil. Fish eggs and larvae are more sensitive to oil than adult fish so an oil spill may significantly reduce recruitment (survival of offspring) from spawning fish for a year or more. Lumpsucker spawning grounds along the shipping route are extremely sensitive. The toxicity of oil combined with the smothering effect will eliminate macro algae and benthic invertebrates on oiled shores and shallow fjords.

If all maritime regulations are followed, and shipping lanes are well placed, the likelihood of a full scale accident happening during construction or operation is deemed to be very low and phrased as ‘improbable’. Although the consequence of a major oil spill in the fjord during operation of the mine is severe, the likelihood of such is considered to be low. With well-rehearsed contingency plans and equipment in place to combat oil spills in all seasons, the potential impact on the marine life of the fjord from an oil spill accident is assessed as Low.

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[5] Due to the substantial emissions of black carbon and SO2 and higher impact on the marine environment in case of a spill the use of heavy fuel oil will be prohibited in connection with shipping to mines in Greenland according to DCE/BMP

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Regional	Short/long term	Medium	Probable	High
Mitigation measures • Prepare contingency plans for oil and chemical spills including efficient combat readiness training; • Allocate properly dimensioned equipment to cope with operational spills from unloading operations at the port area.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area/footprint	Short term	Low	Probable	High

Table 9-7 Assessment summary of impacts on plants, animals and habitats caused by oil or chemical spill

9.4 Ecological environment

The identified potential sources of impacts on the ecological environment (flora, fauna and their habitats) are mainly disturbance effects. The effects of pollution of terrestrial habitats, road kills and introduction of alien species with ballast water are also covered in this section.

Disturbance of wildlife

For the purpose of this EIA “disturbance” includes (1) the active scaring of animals, for example noise from blasting and a mine truck, (2) when a habitat becomes unavailable to animals, for example if Arctic hares are excluded for utilising an area with vegetation because it is close to a haul road and (3) when a habitat is lost for example if Arctic char is excluded from a stream because the water becomes silted due to project activities or terrestrial habitat is lost when an area with vegetation is over-layed by infrastructure. In this section the following potential disturbance impact are discussed:

- Disturbance of terrestrial mammals and birds (disturbance type 1 & 2);
- Disturbance of marine animals (disturbance type 1 & 2);
- Disturbance of freshwater fish (disturbance type 2);
- Loss of terrestrial habitat (disturbance type 3);
- Loss of freshwater habitat (disturbance type 3); and
- Loss of marine habitat (disturbance type 3).

Other potential impact

- Contamination of terrestrial habitats;
- Road kills; and
- Introduction of invasive non-indigenous species with ballast water.

9.4.1 Disturbance of terrestrial mammals and birds (disturbance type 1 & 2)

A number of mining activities can potentially disturb animals, and in particular mammals and birds in the mine area:

- Noise and vibrations during the construction phase;

- Noise and vibrations during operation of the open pit mines, ore processing, shipping and road and auxiliary services. In particular the intermittent blasting noise, which can be heard at a significant distance from the mine, has the potential of scaring mammals and birds; and

- Visual disturbances from personnel, vehicles, buildings and other project structures which might cause mammals and birds to avoid utilising habitat in and near the mine area.

Bird and mammal species react very differently to noise and visual disturbances. Among the birds that regularly occur at Killavaat Alannguat, White-tailed eagles must generally be considered the potentially most sensitive to disturbance from project activities. In particular, the eagles are sensitive to disturbance at the nest during breeding. Although White-tailed eagle is common in the Narsaq-Qaqortoq area no nest sites are known close to the Project area.

Among the birds that breed in the project area, none except for the Raven are known to be particularly sensitive to noise or visual disturbance and will most likely avoid breeding within 1-2 kilometres from the mine area. Ravens are generally low density breeding birds in Greenland and the mine project is not believed to have a major impact on the distribution of nesting pairs in the region.

The two terrestrial mammals that occur in the mine area, Arctic fox and Arctic hare usually habituate well to human activities where they are not hunted. However, since the hunting pressure in South Greenland is generally high, foxes and hares will probably stay well clear of the project facilities.

All in all the mining activities will cause localised disturbance of birds and terrestrial mammals. Since no breeding sites for White-tailed eagles are known in or near the planned mine area, the disturbance impact of terrestrial mammals and birds is assessed as Low.

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Low	Definite	High
Mitigation measures • Restrict the movement of staff members outside the Project area during spring and summer to minimize the general disturbance of wildlife • Ensure that helicopters follow designated corridors to and from the mine heliport to minimize disturbance of wildlife				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Low	Definite	High

Table 9-8 Assessment summary of disturbance of birds and terrestrial mammals and birds

9.4.2 Disturbance of marine animals

The construction of the port facility at the fjord will cause temporary underwater noise and increase turbidity of the sea water. Shipping during the construction- and operational phase can potential disturb marine animals.

The existing data suggest that the only very few marine mammals occur regularly in the Kangerluarsuk Fjord. The most common is believed to be Ringed seal. Very few sea birds have been recorded from the fjord and no sea bird colonies exist. Arctic char migrate into the fjord from Lakseelv during summer.

Ringed seals are most at risk from March-April to mid-May when the pups are born in snow dens on the sea ice, typically at the head of fjords where the ice is most stable. Outside this period Ringed seals are not known to be particularly sensitive to shipping and is common and widespread throughout Greenland water including areas where frequent shipping (and large scale hunting) takes place. Shipping in the fjords should therefore not adversely affect Ringed seals since shipping will not affect the potential breeding area.

With ships arriving to the project port on average once a month the disturbance of sea birds (mainly gulls) and fish (including Arctic char from Lakseelv) is considered insignificant.

Overall are activities in connection with the TANBREEZ project assessed to have Very Low disturbance impact on marine animals in Kangerluarsuk Fjord.

Impact during phases of the life of mine			
Construction	Operation	Closure	Post-closure

Importance of impact without mitigation

Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Very Low	Improbable	High

Mitigation measures

- No mitigating possible other than ensuring that shipping contractors are made aware of the presence of marine mammals in the fjord and asked to approach the port site with caution

Importance of impact with mitigation

Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Very Low	Improbable	High

Table 9-9 Assessment summary of disturbance of marine animals due to project activities

9.4.3 Disturbance of freshwater fish (disturbance type 2)

The construction of the mine project can potentially lead to disturbance of the freshwater fauna of the project area. In particular activities in connection with preparing the tailings facilities at Fostersø can potentially lead to disturbance of freshwater organisms in and downstream the lake.

Lakseelv has a large population of Arctic char. The lower part of the river with the majority of the fish population is situated close to some of the construction areas.

The construction works include the building of a pipeline and service track from the project site at the shore fjord to the hill mine site and to Fostersø. The pipeline/service track will cross Laksetværelv three times (where culvers will be installed) and the eastern corner of Månesø (Moon Lake) where culvers also will be fitted (Figure 5.1)

The construction works – in particular the installation of the culvers at Laksetværelv – can cause a short-term increase in the turbidity of the stream. The turbid water will reach Lakseelv downstream. Laksetværelv and Månesø (Moon Lake) are fishless but the turbid water will potentially disturb the Arctic char in Lakseelv. However, since any rise in turbidity due to construction works will be temporary (and short) and Laksetværelv only contribute with 20% of the water in Lakseelv, the disturbance of the Arctic char from the construction works are accessed as of low importance.

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Short term	Low	Definite	Medium
Mitigation measures • Minimise the disturbance of the water in Laksetværelv when installing culvers by keeping the construction period as short as practically possible				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Short term	Low	Definite	Medium

Table 9-10 Assessment summary of disturbance of freshwater fish

9.4.4 Loss of terrestrial habitat

The re-profiling to accommodate buildings along the fjord as part of the construction works will lead to loss of natural vegetation and displacement of most terrestrial animals from the area.

The mine facilities at the fjord will cover app. 0.5 km^2 of land. The habitat types in question are widespread and common in South Greenland and include no known rare or endangered plant species. Typically low densities of animals occur in these habitats none of which are known to be rare or threatened in Greenland. The significance of terrestrial habitat loss in connection with the TANBREEZ project is therefore assessed as Low.

Following the decommissioning of buildings and machines natural vegetation re-growth will take place through natural plant succession. This will be facilitated further if soil resource can be (partly) conserved and subsequently put back in place at the end of the life of the mine. With such mitigation is place the overall impact of terrestrial habitat loss will be Very Low.

Impact during phases of the life of mine			
Construction	Operation	Closure	Post-closure

Importance of impact without mitigation

Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Long term	Low	Definite	High

Mitigation measures

- Minimize the area to be disturbed by planning infrastructure to have as small a footprint as possible;
- Conserve topsoil for use in progressive and end of life mine rehabilitation.

Importance of impact with mitigation

Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Long term	Very Low	Probably	Medium

Table 9-11 Assessment summary of loss of terrestrial habitat

9.4.5 Loss of freshwater habitat

Deposition of tailings in Fostersø will permanently change the lake. At mine closure the water depth will be reduces from c. 40 m to about 15 m. Such a major change in water depth will potentially have significant impact on the aquatic organisms in the lake.

Deposition of fine material in Fostersø can potentially increase the turbidity of the lake water and the water in the outlet Laksetværelv during operation. If such silted water subsequently reaches the clear water of Lakseelv with its large Arctic char population, it could potentially have a devastating effect on the char habitat.

Studies of the freshwater ecology of Fostersø have shown that no fish are found in the lake and that it is only inhabited by a species poor invertebrate fauna consisting of species which are common and widespread in South Greenland. Almost no vegetation is found along the shore or in the lake. The loss of freshwater habitat if Fostersø is used for deposition of mine residuals will therefore be limited, and the significance is assessed as Low.

The release of tailings material into Fostersø will be through a pipe near the bottom of the lake at depths ranging from 40 to 20 m. This is well below a marked stratification recorded between -10 and -15 m measured from the water surface. Since the discharged medium has a higher density that the receiving water the plume of fine material that develops where the material is discharged from the pipe will remain below the stratification. During the operation of the mine the water depth in Fostersø will be kept at 15 m to avoid suspended solids from reaching the surface and the outlet. It is therefore assessed as unlikely that the deposition of mine residual in Fostersø will lead to a significant increase in the turbidity in the upper layers of Fostersø or in the outlet Laksetværelv. Further downstream in Lakseelv no measurable increase in the turbidity is expected.

The installation of culvers at the eastern end of Månesø (Moon Lake) in connection with the construction of the service road between the port and the hill mine site will lead to a marginal loss of freshwater habitat. Since the lake is fishless and without vegetation the impact is small and the significance is assessed as very low.

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Low	Definite	High
Mitigation measures • Design the tailings deposition procedure at Fostersø so that the material will be stored at the lake floor as quickly as possible.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Low	Definite	High

Table 9-12 Assessment summary of loss of freshwater habitat

9.4.6 *Loss of marine habitat*

A pier head and a 15 m wide access dike and some associated infrastructure facilities will be constructed at the shore of Kangerluarsuk Fjord. This will require re-profiling of a section of the shore. The re-profiling will be permanent.

The re-profiling will lead to loss of inter-tidal habitat and could potentially impact populations of marine animals and plants. This includes Arctic char from the Lakseelv population that migrates into the fjord during the summer months.

Little specific knowledge exists about the marine flora and fauna of Kangerluarsuk Fjord except that Lumpsucker spawning takes place along the coastline (Mosbech et al. 2004). Observations during the ecological baseline sampling suggest that no marine mammals or sea birds are specifically associated with this part of the fjord. The loss of foraging ground for Arctic char and spawning grounds for Lumpfish due to the construction of the port is believed to be insignificant since very large areas of similar rocky habitat type is very common and widespread along the shore of Kangerluarsuk Fjord (and other fjords in the region). The loss of marine habitat at the port site is therefore assessed to have Very Low significance.

Impact during phases of the life of mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Very Low	Definite	High
Mitigation measures • No mitigating possible other than limiting the impact area as much as possible				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Permanent	Very Low	Definite	High

Table 9-13 Assessment summary of loss of marine habitat

9.4.7 Contamination of terrestrial habitats[6]

A number of project activities can potentially cause contamination of terrestrial habitats:

- Accidents in connection with transport, storage and handling of hazardous materials such as fuel, grease, paint and chemicals; and
- Blasting for construction can cause elevated levels of nitrates.

Contamination of the surface soil and the vegetation by oil or other hazardous materials from project activities could potentially pose a risk to animals, plants and their habitats. Hydrocarbons, such as jet fuel and Arctic diesel, can have toxic effects. Due to their organic nature, small spills of hydrocarbons are generally broken down by bacteria in the soil, however this process is much slower in the arctic climate and even small oil spills can kill the vegetation which subsequently requires decades to re-establish.

Blasting in connection with the construction works and the associated ammonia contamination from the explosives is difficult to mitigate. The blasting could therefore lead to a local nutrient enrichment.

The most serious contamination of terrestrial habitats would probably be an oil spill. However, the minor volumes of individual tanks used during construction and operation will limit the potential impacts of accidents.

The likelihood of a major spill occurring on land is low, but contingencies need to be worked out. Lesser operational spills are more likely to occur, but the effects are likely to be localized, and comparatively easy to combat. The small amounts of explosive to be used will only cause insignificant increases in ammonia levels.

[6] Contamination of freshwater and marine habitats is dealt with in section 9.3.

In conclusion: The environmental impacts of fuel and chemical spills on land are assessed to be confined to the project area (i.e. local scale). The potential loss or depletion of terrestrial habitat due to contamination is consequently assessed as Low.

Impact during phases of the life of the mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Medium term	Low	Possible	High
Mitigation measures • Install equipment to capture oil spill from oil tanks and pumps and determine rigid procedures for pumping oil between tanks; • Prepare contingency plans in collaboration with appropriate authorities. Efficient combat organization in place. • Ensure the staff is well trained and equipment readily available to combat oil spill on land				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Medium term	Low	Possible	High

Table 9-14 Assessment summary of impacts on terrestrial habitats from pollution caused by the Project

9.4.8 Road kills

The Project could potentially lead to increased direct mortally among animals and birds due to road kills.

The movement of trucks and other vehicles along the haul and service roads represents a risk for road kills of animals. However, given the lay-out of the road system within the project area this is unlikely to be a major danger for the wildlife. Furthermore, if reasonable speed limits are introduces and drivers are instructed to be aware of animals moving close to roads this risk of roads kills is considered to be Very Low.

Impact during phases of the life of mine				
Construction	Operation	Closure	Post-closure	
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Long term	Low	Possible	High
Mitigation measures • Ensure stipulated speed limits are enforced along roads to minimize the risk of road kills and that truck drivers and other staff are trained to be aware of animal hazards and how to minimize any negative consequences.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Long term	Very Low	Possible	High

Table 9-15 Assessment summary of the danger of road kills

9.4.9 *Introduction of invasive non-indigenous species with ballast water*

Ships calling in at the port site will discharge ballast water before loading cargo. The ballast water can contain non-indigenous species that could potentially establish themselves in the fjord. When introduced in new areas, these species could thrive and become a threat to indigenous species and the local ecosystem.

In 2004, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted. It is a new international convention to prevent the potentially devastating effects of spreading of harmful aquatic organisms carried by ships' ballast water. The convention will come into force 12 months after ratification by 30 States, representing 35 per cent of world merchant shipping tonnage. As of October 2012, 35 States have ratified the convention, including Denmark, while the per cent of world merchant shipping tonnage is 28. The convention is expected to come into force in 2015.

The BWM will require all ships to implement a Ballast Water and Sediments Management Plan. All ships are required to carry out ballast water management procedures to a given standard. The IMO Marine Environment Protection Committee (MEPC) has already adopted guidelines, which are part of a series developed to assist in the implementation of the BWM Convention.

To minimize a potential introduction of non-indigenous species, regulations of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM) should be followed.

Provided that vessels that call in at the TANBREEZ port follow the BWM regulations, the risk of introducing invasive non-indigenous species with ballast water is assessed as Very Low.

Table 9-16 Assessment summary of risk for introducing invasive non-indigenous species with ballast water

Impact during phases of the life of the mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Regional	Long term/Permanent	Medium	Possible	High
Mitigation measures • Follow regulations of the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM)				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
-	-	Very Low	Improbable	High

9.5 Waste

Waste produced during the construction and operation periods includes domestic waste, construction waste, tires from mobile equipment, and various types of hazardous waste (such as oily waste, chemical waste, batteries).

Such waste – and in particular hazardous waste - can lead to significant contamination of the environment.

To minimize this TANBREEZ Mining Greenland will take a number of measures. Domestic waste water will be treated in a sewage plant at the port site before discharged to the fjord. A waste incinerator plant will be constructed in the port area early in the construction phase. All combustible waste suitable for incineration (wood, paper, packing, etc.) will be incinerated.

Waste not suitable for incineration or considered as hazardous waste including accumulators, batteries, electronic devices, glass, etc. will be stored temporary in containers and periodically handed over to Qaqortoq waste handling facility for further disposal according to regulations and after mutual agreement. Tires and metal scrap, etc. will be temporarily stored at the port site and periodically exported to contractors abroad for re-cycling.

Hazardous waste is regulated by the Kommuneqarfik Kujalleq regulation on hazardous waste. Hazardous waste will be registered and shipped to Denmark for treatment and disposal in compliance with Danish and EU requirements.

The waste handling procedures described above will be further detailed in a waste management manual to become part of the Environment Management Plan (EMP) (see Chapter 10) for the construction phase and later detailed for the operational phase.

With proper waste handling procedures in place that are carried out according to good environmental practice, high degree of re-use and re-cycling of the waste, the impact of waste production to the environment is assessed to be Very Low.

Impact during phases of the life of the mine				
Construction	Operation		Closure	Post-closure
Importance of impact without mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project area	Long term	Medium	Possible	High
Mitigation measures • Strict enforcement of waste handling procedures; and • Continues update waste management manual.				
Importance of impact with mitigation				
Spatial extent	*Duration*	*Significance*	*Probability*	*Confidence*
Project footprint	Short term	Very Low	Improbable	High

Table 9-17 Assessment summary of contamination of environment from waste

9.6 Cultural heritage

A number of Norse and Thule-Inuit archaeological sites are known along the head of the Kangerluarsuk Fjord. Construction works in connection with the TANBREEZ project could potentially damage or destroy these cultural heritage sites.

Greenland National Museum has been contracted by TANBREEZ Mining Greenland to survey and pin point the exact location of all archaeological sites in the Project area (Greenland National Museum and Archives 2013). All known sites are found along the shore of the fjord with the majority situated north of the outlet of Lakseelv – that is outside the Project footprint. A single 17- 19th century Thule-Inuit tent ruin was located further south on the coast in an area close to the proposed port site.

To avoid damaging this site before it is documented in detail, a staff member of the Greenland National Museum and Archives must first photograph and measure the structure as part of the archaeological registration before any construction works are initiated.

With this arrangement in place any loss of cultural heritage sites due to activities in connection with the TANBREEZ Project is considered unlikely.

On behalf of Greenland Denmark has applied the inclusion of the “Church ruin at Hvalsø, episcopal residence at Gardar, and Brattahlid (A Norse/Eskimo cultural landscape)” in the UNESCO’s World Network of Biosphere Reserves.

The church ruin is situated about 6 km southeast of the TANBREEZ Project. Between the mine area (at c. 400-450 m altitude) and the church ruin at the shore of the fjord is high ground raising to over 600 m. This excludes that mine facilities are visible from the church area.

Except, perhaps for blasting at the hill pit site under certain wind conditions, the distance and the high ground is believed to prevent noise, dust or other impacts from the mine project to reach the Hvalsø church area.

10 FRAMEWORK ENVIRONMENTAL MANAGEMENT PLAN

This Environmental Management Plan (EMP) to manage impacts for construction, operation, closure and post-closure is developed to outline measures to be implemented in order to minimize adverse environmental impact and risks from the TANBREEZ Project. The EMP provides the linkage between each potential impact identified in Chapter 9 of this EIA report, the proposed mitigation measure and the monitoring approach (Chapter 11). The EMP will serve as a guide for the management, contractor(s) and the workforce on their roles and responsibilities concerning environmental management on site.

The EMP presented below is a framework which consists of the following key elements:

A management program that specifies the activities to be performed in order to minimize disturbance of the natural environment and prevent or minimize all forms of pollution

A definition of the roles, responsibilities and authority to implement the management program

The EMP is tabulated in spreadsheets (Table 10-1 – 10-6) which are laid out with the following divisions:

Project activity – the activity associated with the mining project which has been identified to possess a potential impact or risk to the environment. Each project activity has a reference number which correspond to the activity number in Chapter 9.

Environmental impact – description of the negative impact of the activity (such as pollution or disturbance of natural environment).

Action – the mitigating measure or actions identified to prevent or minimize the adverse environmental impact.

Project stage - the stage in the life of the mine where the measures, actions, or principles have effects e.g. construction (C), operation (O) and decommissioning and closure (D).

Frequency and/or timing – the frequency or timing when the action should take place.

Responsibility – party/ies responsible for ensuring the action, measure, or principle is done.

It is important to bear in mind that alternative actions or measures may be identified during the life of the Project and can be used to ensure the management objectives are met.

Initial responsibility for meeting some of the management commitments in the tables will be transferred to TANBREEZ's contractors. TANBREEZ Mining Greenland will commit the contractors to meeting the relevant management responsibilities. This will be done by developing a code of responsible environmental practice that will be included in tender documents and contracts. TANBREEZ Mining Greenland fully recognizes that it is not absolved from those management responsibilities. Ultimate responsibility for meeting all commitments in this section lies with TANBREEZ Mining Greenland.

In most cases the person (or persons) assigned responsibility for a certain commitment is seen as the driver of the requirement. This will typically be the mine manager and/or the company biologist.

Table 10-1 Physical environment

Ref. no.	Project activity	Environmental impact	Action	Project stage	Frequency/timing	Responsibility
9.1.1	Removal of ore and waste rock	The mining activities can have aesthetic impact	Plan open pit mining to blend as far as practicable possible with surrounding landscape	O	Regular throughout operation	Mine manager
9.1.2	The use of Fostersø as tailings pond and waste rock dump	The activities at Fostersø can have aesthetic impact	Plan equipment to blend as far as practical possible with the surrounding landscape Remove buildings and other equipment at the end of mine life	C/D	During construction and during decommissioning	Mine manager
9.1.3	Re-profiling of the landscape for infrastructure construction at Killavaay Alannguat plateau	Re-profiling of terrain for infrastructure can have aesthetic impact	Plan road to blend as far as practicable with the surrounding landscape Rip the road surface after the closure of the mine to encourage re-vegetation	C/D	During construction and during decommissioning	Mine manager
9.1.4	Changes in topography from construction of port and other facilities along the shore of the fjord	Re-profiling of coast line for infrastructure can have aesthetic impact	Minimize the area to be disturbed by planning infrastructure to have as small a footprint as possible Conserve topsoil if available for use in progressive and end of life mine rehabilitation	C/(O)/D	During construction (and if new facilities are to be built during operation) and during decommissioning	Mine manager

Table 10-2 Air environment

Ref. no.	Project activity	Environmental impact	Action	Project stage	Frequency/timing	Responsibility
9.2.1	Air borne dust and emissions generated by mine activities	Potential pollution of water and land	Use BAT filters in crusher building Chose vehicles and other equipment based on low emission rates Maintain diesel power plant and other fuel powered equipment in accordance with specifications to minimise on emissions	C/O	During start up and regular throughout operation	Mine manager
9.2.2	Energy generation based on fossil fuels	Climate change	Reduce energy use through deployment of BAT Reduce energy use through energy efficient practices	C/O	During construction and throughout operation	Mine manager

Table 10-3 Water environment

Ref. no.	Project activity	Environmental impact	Action	Project stage	Frequency/timing	Responsibility
9.3.1	Deposition of tailings and waste rock in Fostersø, blasting and excavation at mine sites and accidental oil and chemical spills	Pollution of lakes, streams, rivers and fjord	Design tailings deposition equipment to facilitate quick storage of material at lake floor Prepare contingency plans for oil and chemical spills including efficient combat readiness training	C/O/D	During start up and regular throughout operation and during decommissioning	Mine manager
9.3.2	Construction of infrastructure and deposition of tailings and waste rock in Fostersø	Changes to natural flow pattern and capacity of freshwater resources	Remove culverts at the end of mine operation	C/O	During construction and operation	Mine manager
9.3.3	Accidental oil and chemical spills	Pollution of land and fjord	Prepare contingency plans for oil and chemical spills including efficient combat readiness training Allocate properly dimensioned equipment to cope with operational spills from unloading operations at the port area	C/O/D	During start up and regular throughout operation and during decommissioning	Mine manager

Table 10-4 Ecological environment

Ref. no.	Project activity	Environmental impact	Action	Project stage	Frequency/timing	Responsibility
9.4.1	Noise of visual disturbance from personnel and equipment	Disturbance of terrestrial mammals and birds	Restrict movements of people outside project footprint during spring and summer to minimize disturbance of wildlife	C/O/D	Throughout during construction, operation and decommissioning	Mine manager/ company biologist
9.4.2	Shipping in Kangerluarsuk Fjord	Disturbance of marine mammals and sea birds	Ensure that shipping contractors are aware of presence of marine mammals and asked to approach port site with caution	C/O/D	Throughout during construction, operation and decommissioning	Mine manager/ company biologist
9.4.3	Installation of culvers at Laksetværelv	Disturbance of freshwater fish due to increased turbidity in streams	Keep construction as short as possible when installing culverts at Laksetværelv	C	During construction	Mine manager/ company biologist
9.4.4	Re-profiling to infrastructure along fjord	Loss of terrestrial habitat	Minimize the area to be disturbed by planning infrastructure to has as small footprint as possible Conserve topsoil for use in progressive and end of life mine rehabilitation.	C	During construction	Mine manager/ company biologist
9.4.5	Deposition of tailings in Fostersø	Loss of freshwater habitat due to increased turbidity	Design deposition of tailings so that material will be stored at lake bottom as quickly as possible	O	During operation	Mine manager/ company biologist
9.4.6	Re-profiling for shore to accommodate port	Loss of marine habitat	Minimize the area to be disturbed	C	During construction	Mine manager
9.4.7	Accidental spill of oil or other hazardous materials	Contamination of terrestrial habitats	Prepare contingency plans, have effective combat organisation in place and proper equipment ready	C/O/D	Throughout during construction, operation and decommissioning	Mine manager

9.4.8	Traffic	Road kills of animals	Ensure speed limits are enforced and that all staff are aware of animal hazards	C/O/D	Throughout during construction, operation and decommissioning	Mine manager
9.4.9	Shipping	Introduction of alien species with ballast water	Follow regulations of the International Convention for the Control and Management of Ships' ballast water and Sediments	C/O/D	Throughout all states of mine project	Mine manager

Table 10-5 Waste

Ref. no.	**Project activity**	**Environmental impact**	**Action**	**Project stage**	**Frequency/timing**	**Responsibility**
9.5.1	During construction and operation domestic waste, construction waste, tires from mobile equipment, and various types of hazardous waste will be produced	Waste – and in particular hazardous waste - can lead to significant contamination of the environment	Handle waste according to procedure detailed in waste management manual and according to good environmental practice, with high degree of re-use and re-cycling	C/O/D	Throughout all states of mine project	Mine manager

Table 10-6   Cultural heritage

Ref. no.	Project activity	Environmental impact	Action	Project stage	Frequency/timing	Responsibility
9.6.1	Photograph and measure17- 19^{th} century Thule-Inuit tent ruin on coast of fjord near proposed port site.	Damage and potential destruction of cultural heritage site	Contact staff member of the Greenland National Museum and Archives	C	Before construction works along shore of fjord starts	Mine manager

11 ENVIRONMENTAL MONITORING PLAN

11.1 Conceptual Monitoring Plan

TANBREEZ Mining Greenland will implement a monitoring programme which will aim to (1) provide measurements of the effects and impacts of the Project on the environment; (2) demonstrate compliance with license conditions and statutory requirements; and (3) ensure any claims made against the Project in respect of alleged deterioration of the environment can be defended with confidence.

It is therefore proposed that monitoring of the following environmental aspects will be undertaken:

- Fresh water;
- Metal contamination of flora and fauna;
- Climate;
- Dust emissions; and
- Flora and fauna.

In Table 11-1 a framework for the monitoring parameters and sampling locations are proposed. The suggested sampling frequency for each parameter should ensure validity of actual environmental conditions at the Project site and surroundings, and the defined monitoring duration identifies which phases of the mining project will generate the potential impact that requires sampling and monitoring. Where relevant the programme includes control sites where no expected Project impacts are likely to be experienced.

Wherever possible, the sampling stations used in the baseline studies should be retained to provide data continuity. Also the sample types (including species of lichens and animals) should be the same as during the baseline sampling. Routine monitoring should commence before constructions begins to ensure maximum provisions of pre-development baseline data.

It is expected that the appointed company biologist will need to further refine this monitoring program in dialog with the Greenlandic authorities before project commencement. During this process definition of assessment criteria should also be agree.

Table 11-1 Framework monitoring program

Monitoring aspect	**Sites/activities to be monitored**	**Parameter to be monitored**	**Frequency**	**Duration**	**Assessment criteria**[7]	**Reporting**
River flows	Lakseelv; Laksetværelv	Water flow	Continual during flow period	Life of mine	To be defined in cooperation with BMP	Annual Monitoring Report
Metal concentrations in rivers, streams and lake	Fostersø, Lakseelv and Laksetværelv (baseline stations)	Metals in water	Fostersø/Laksetværelv: one station weekly during flow; Lakseelv weekly during flow period; other stations at least annually (August)	Life of mine plus three years post closure	To be defined in cooperation with BMP	Annual Monitoring Report
Metal contents in higher plants	Baseline stations in mine area and reference stations	Metals in Snow Lichens	Annually (August)	Life of mine plus three years post closure	To be defined in cooperation with BMP	Annual Monitoring Report
Metal contents in soil	Baseline stations in mine area and reference stations	Metals in soil	Annually (August)	Life of mine	To be defined in cooperation with BMP	Annual Monitoring Report
Metal contents in marine fish	Kangerluarsuk Fjord (baseline stations) and reference stations	Metals in sculpins	Annually (August)	Life of mine	To be defined in cooperation with BMP	Annual Monitoring Report

[7] The assessment criteria will be based on the water quality criteria for Greenland and on the dust model results.

Metal contents in mussels	Kangerluarsuk Fjord (baseline stations) and reference stations	Metals in blue mussels	Annually (August)	Life of mine	To be defined data in cooperation with BMP	Annual Monitoring Report
Metal contents in seaweed	Kangerluarsuk Fjord (baseline stations) and reference stations	Metals in *Fucus*	Annually (August)	Life of mine	To be defined in cooperation with BMP	Annual Monitoring Report
Local climate	Weather station	Precipitation, wind speed and direction and temperature	Continual	Life of mine	None	Annual Monitoring Report
Higher fauna	Mine area and near surroundings	Ad hoc observations of birds and mammals in connection with other monitoring activities	Annually (August)	Life of mine	To be defined in cooperation with BMP	Annual Monitoring Report

12 CONCEPTUAL DECOMMISSIONING AND CLOSURE PLAN

Once the end of mine life has been reached, it is TANBREEZ mining's goal to restore the land to an environmental acceptable state and manage the environment through a program of post-closure care and maintenance (if needed).

The closure process that TANBREEZ Mining Greenland proposes to adopt is a phased approach. At this stage a preliminary plan is provided (Table 12-1). This plan will subsequently be developed. Near the end of mine life a final Decommissioning and Closure Plan (DCP) will be developed. Therefore, the closure planning at TANBREEZ will be an active and continuous process that will be constantly evolving.

The overall objectives of the decommissioning and closure plan are the following:

<u>Physically safe</u> so that the site is left safe for any users (people and wildlife).

<u>Physical stable</u> ensuring that the site can be considered safe from excessive slumping and erosion.

<u>Chemical stable</u> meaning that any deposits remaining on the surface will not release substances at a concentration that would significantly harm the environment.

A preliminary decommissioning and closure plan is proposed in Table 12-1. TANBREEZ mining's propose that this is used as the basis for the on-going decommissioning and closure process described above. It is based on the DCP developed by MTHøjgaard Greenland (document REP001, rev1).

Table 12-1 Conceptual decommissioning and closure plan for the TANBREEZ mining project

Mine facility	Decommissioning and closure plan measures
Surface facilities and infrastructure	• Salvage buildings and remove these with ships • Demolish remaining buildings with demolition equipment and remove it by ship • Salvage equipment and remove it by ship • Remove culverts and formal drainage systems and re-establish original drainage • Cover concrete foundations with rock fill and soil from deposit • Rip gravel pad, internal roads at port and plant site to encourage re-vegetation • Reshape to restore natural slope and drainage

Port facilities (sheet pile quay and dolphins)	• Leave all port facilities as constructed except light poles, electrical cables etc.
Haul roads and service roads	• Remove culverts and re-establish original drainage • Leave road in place but rip surface to encourage re-vegetation
Pipelines	• Decommission pipelines supporting structure for pipes, booster stations and pump station, remove all pipes and equipment
Tailings Management Facility	• Remove construction facilities next to the lake and ship these out • Remove pipes in lake • Leave Fostersø as is
Open pit	• Remove equipment and ship it out • Allow the pit to ne naturally filled with water

In addition, site services and structures will be decommissioned where possible and the materials disposed of to landfill, incinerated or shipped off site depending on their inherent properties. The process and power plants will be decommissioned. Mobile equipment where of value will be re-sale otherwise it will be decommissioned in the decline prior to closure of the mine.

Active re-vegetation is not proposed. This means that vegetation will come back by natural succession.

13 REFERENCES

AirQuality.dk. 2013. TANBREEZ Project. Dust Dispersion Study. 43 pp.

Boertmann, D. 2004: Seabird colonies and moulting harlequin ducks in South Greenland. Results of a survey in July 2003. National Environmental Research Institute, Denmark. 34 pp.- Research Notes from NERI No. 191. http://research-notes.dmu.dk

Boertmann, D. 2007. Grønlands Rødliste, 2007. Direktoratet for Miljø og Natur, Grønlands Hjemmestyre. 152s.

Boje, J. 1985. Miljø-rekognoscering ved Lakseelv for vandkraftprojekt Killavaat/Redekammen, Qaqortoq/Julianehåb, 1983. Grønlands Fiskeri- og Miljøundersøgelser. 28 pp.

Bugge Jensen, D. and Christensen, K. D. 2003. The Biodiversity of Greenland – a country study. Technical Report No 55, Pinngortitalerifik, Grønlands Naturinstitut. 210 pp.

Bureau of Minerals and Petroleum. 2011. BMP guidelines – for preparing an Environmental Impact Assessment (EIA) Report for Mineral Exploitation in Greenland. 20 pp.

Christensen & Mortensen 1982. Fjeldørredundersøgelser i Narssaq Elv, 1981. Grønlands Fiskeriundersøgelser. 36 pp.

Clementsa, W.H. & Reesa, D.E. 1997. Effects of Heavy Metals on Prey Abundance, Feeding habits, and Metal Uptake of Brown Trout in the Arkansas River, Colorado. Transactions of the American Fisheries Society 126: Issue 5.

Danish Meteorological Institute (2012), homepage assessed in March 2012.

Dallinger, R. & Kautzky, H. 1985. The importance of contaminated food uptake for the heavy metals by rainbow trout (*Salmo gairdneri*): a field study. Oecologia (Berl.) 67: 82 – 89.

Dallinger, R., Prosi, F. & Back, H. 1987. Contaminated food and uptake of heavy metals by fish: a review and a proposal for future research. Oecologia (Berl.) 73: 91 – 98.

Douben, P.E.T. 1989. Metabolic rate and uptake and loss of cadmium from food by the fish Noemaccheilus barbatulus (stone loach) Environ Pollut. 59: 177 – 202.

GEUS 2014. Vurdering af mulig tilstedeværelse af villiaumit i kakortokit fra Kringlerne. GEUS notat nr. 11-MI14-03. 2 pp.

Glahder, C. M. 2001. Natural resources in the Nanortalik district. An interview study on fishing, hunting and tourism in the area around the Nalunaq gold project. National Environmental Research Institute, Technical Report No. 384: 81 pp.

Golder Associates, Sweden. 2013a. TANBREEZ Project. GEOCHEMICAL SPECIATION RESULTS. 175 pp.

Golder Associates, Sweden. 2013b. GEOCHEMICAL INTERPRETATION. 30 pp.

Greenland National Museum and Archives. 2013. TANBREEZ Project. Archaeological survey. 28pp.

Harrison, S.E. & Klaverkamp, J.F. 1989. Uptake, elemination and tissue distribution of dietary and aqueous cadmium by rainbow trout (*Salmo gairdneri*) and lake whitefish (*Coregonus clupeaformis*). Environ. Tox. Chem. 8: 87 – 97.

Hatakeyama, S. & Yasuno, M. 1987. Cronic effects of Cd on the reproduction of the guppy (*Poecilia reticulate*) through Cd-accumulated midge larvae (*Chironomus yoshimatsue*). Ecotox. Environ. Saf. 14: 191 – 207.

Langager, H.K. & Lemgart, M.L. 1988. Baggrundsundersøgelser 1988. Highwood-gruppens koncessionsområde øst for Narsaq, Sydgrønland. Nuna-Tek Forundersøgelser.

Lemly, A.D. 1994. Mining in northern Canada: Expanding the industry while protecting arctic dishes – A review. Ecotoxicology and Environmental Safety 29: 229 – 242.

Moore, J.W. 1975. Distribution, movements, and mortality of anadromous arctic char, Salvelinus alpinus L., in the Cumberland Sound of Baffin Island. Journal of Fish Biology 7: 339 – 348.

Mosbech, A., Boertmann, D., Olsen, B.Ø., Olsvig, S., von Platen, F., Buch, E., hansen, K.Q., Rash, M., Nielsen, N., Møller, H.S., Potter, S., Andreasen, C., Berglund, J. & Myrup, M. 2004. Environmental Oil Spill Sensivity Atlas for South Greenland Coastal

Zone. National Environmental Research Institute, Denmark. 341 pp. - NERI Technical Report No. 493.

Orbicon. 2013a. TANBREEZ Project. The natural environment of the study area. 54 pp.

Orbicon 2013b. TANBREEZ Project. Forstersø study. 17 pp.

Orbicon. 2013c. TANBREEZ. Climate and Hydrology. 32 pp.

Orbicon. 2013d. TANBREEZ Project. Local Use Study. 51 pp.

Pedersen, S.A. and Kannewolf, P. 1995. Fish on the West Greenland shrimp grounds, 1988 – 1992. - ICES Journal of Marine Science 52: 165 – 182.

Roch, M., McCarter, J.A., Matheson, A.T., Clark, M.J.R. & Olafson, R.W. 1982. Hepatic metallothionein in rainbow trout (Salmo gairdneri) as an indicator of heavy metal pollution in the Campbell River system. Can J. Fish. Aquat. Sci. 39: 1596 – 1601.

Rose-Hansen, J., Nielsen, C.O. & Sørensen, H. (eds) 1977: The Narsaq Project. A geochemical-ecological research project. Progress Report No. 1 (vol. 1: 82 pp., vol. 2: 49 + 40 pp.). The 1974 field season. Unpublished report, Institute of Petrology, University of Copenhagen, Denmark.

Rosing-Asvid, A. 2010. Grønlands sæler. Ilinniusiorfik Undervisningsmiddelforlag.

Thorsteinsson, I. 1983. Undersøgelser af de naturlige græsgange i Syd-Grønland 1977-1981. Landbrugets Forskningsinstitut Island & Forsøgsstationen Upernaviarsuk Grønland. 223 pp.

Skov, H., Bossi, R., Wåhlin,P., Vikelsøe, J., Christensen, J., Egeløv, A. H.,Heidam, N.Z., Jensen, B., Ahleson, H.P., Stausgård, L., Jensen, I. & Petersen, D. 2005: Contaminants in the Atmosphere. AMAP- Nuuk, Westgreenland 2002-2004. National Envitonmental Research Institute, Denmark. 45pp. NERI Technical Report No. 547. http://technical-reports.dmu.dk