

ENVIRONMENTAL IMPACT ASSESSMENT OF NORWEGIAN POLAR INSTITUTE OPERATIONS IN ANTARCTICA



2021-2030

Norwegian Polar Institute



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PREFACE

The following document is a documentation and assessment of Norwegian Polar Institute's operations in Antarctica 2021-2030. It describes the logistical activities associated with the Norwegian Antarctic Operations in respect of their potential impact on the Antarctic environment, including measures to reduce these impacts.

The activities described comprises vessel operations, aircraft and helicopter operations, shelf and traverse operations, field camps, purchasing, training, education and station operations.

The document has been prepared in accordance with § 17 of the Regulations relating to the protection of the environment and safety in Antarctica (2013) ¹. The Regulations relating to the protection of the environment and safety in Antarctica (AER) requires that anyone intending to start a planned activity in Antarctica or is implementing substantial changes to ongoing activities is to prepare an initial environmental evaluation, containing a description of the planned activity. This includes its purpose, location, duration, intensity, use of means of transport and evaluation of impact.

A Multi-year IEE was prepared for Troll Station by Norwegian Polar Institute (NPI) (*Multi-year Initial Environmental Evaluation for the operational aspects of Norwegian Antarctic Research Operations 2000-2010*, B. Njåstad, 2000). In 2004 Troll station upgraded to an all-year station, and a Comprehensive Environmental Evaluation (CEE) was prepared. In 2002 the Troll Runway (now Troll Airfield) was constructed, the IEE (*Construction and operation of Troll Runway*) was prepared for this task. In 2011 the first 10-year environmental assessment was produced covering all aspects of the activity in Dronning Maud Land based on logistic support from Troll station.

Over the past 20 years substantial changes has been implemented in the NPI's operations in Antarctica, and NPI therefore presents this document as a new and updated assessment that covers all activity within the framework of logistic operations at Troll station. The document has been prepared by the Norwegian Polar Institute. The work has been coordinated by Operation and Logistic department and the Environmental Management section. Harvey Goodwin (Operation and Logistics department), Jon Hugo Strømseng (Operation and Logistics department), Stein Ø. Nilsen (Environmental Management Section), Lisa Bjørnsdatter Helgason (Environmental Management Section), and Einar Johansen (Operation and Logistics department) has contributed actively in the process.

¹ <https://lovdata.no/forskrift/2013-04-26-412/§17> og <https://www.regjeringen.no/en/dokumenter/protection-environment-safety-antarctica/id724506/>



Figure 1: A Basler BT67 arrives at Troll Airfield (2008), Photo: Stein Ø. Nilsen / Norwegian Polar Institute

1.0 INTRODUCTION

1.1 History of Norwegian activity in Antarctica

1.1.1 The history of research in Dronning Maud land

Norwegian research activity in Antarctica is rooted in a long tradition. Already in the 1920s and 1930s Norwegian nationals carried through extensive research in Antarctica, most often on expeditions that combined whaling and research activities.

It was the Norwegian-British-Swedish Maudheim Expedition (1949-52) and the activities associated with the International Geophysical Year in 1957-58 that really boosted the level of research effort in Dronning Maud Land. During that time period and the following decades, a number of nations have established and operated research stations in Dronning Maud Land. Currently ten nations operate stations (of which seven are all-year stations), while a number of additional nations are involved in the on-going research activities in the area.



Figure 2: Norwegian-British-Swedish Maudheim Expedition 1949-1952 (Photo: Norwegian Polar Institute)

1.1.2 The Norwegian Antarctic Research Expeditions (NARE)

NARE (Norwegian Antarctic Research Expeditions) was formed as an expedition framework that supported the accomplishment of all Antarctic research funded by the Norwegian government. The modern Norwegian Antarctic Research Expeditions (NARE) commenced in 1976, and expeditions took place regularly. In the period 1990-1997 Norway was part of a Nordic cooperation that entailed that the three Nordic countries active in Antarctica took responsibility for the logistical arrangements of expeditions in turn. Consequently, there was a major Norwegian Antarctic expedition every third or fourth year, with smaller expeditions taking place in the intermittent years when Norway was not responsible for the logistics. The establishment of Troll as an all-year station in 2005 has, together with the change to air transport as main mode of transportation, had significant impact on the form of the Norwegian Antarctic operations. While a relatively small operation in the beginning, the operations are now quite extensive with a continuous presence on the continent.

1.1.3 Establishment of Troll station

The Norwegian summer station Troll was established in 1989/90. This establishment was considered essential in order for Norway to continue to perform modern scientific research in Antarctica. Jutulssessen was selected as the location for Troll because (NPI, 1990b):

1. It was centrally located in relation to Norwegian science priorities.
2. It appeared to have relatively sparse biological activity and therefore environmental impacts would be minimized.

3. It had logistical advantages in terms of no difficult crevasse areas in the vicinity, and there seemed to be possibilities for creating future airstrip.
4. It appeared to have a relatively benign climate.

Since the establishment, the station and its operations have continuously undergone modifications. These have mostly been minor in character and must be considered normal development of a station of this kind. The most substantial changes were described and evaluated in the CEE for upgrading of the Norwegian research station Troll (NPI, 1999).

In 2000 a new era was initiated in Norwegian Antarctic research history when a move was made to make air transport the main mode of personnel transportation. Intercontinental flights were conducted in partnership with other national Antarctic operators with landings at Blue One (Henriksenskjæra) initially, and Novo Airfield later, with onward feeder link operations to Troll. This change in operational mode made it possible to expand the research season significantly and the research potential has become wider. It has led to less travel time and a potential for longer and more flexible research seasons (possibility of shorter field periods and exchange of personnel in the course of the season, for example).

In July 2003 Norway took a further step and announced that Troll was to be upgraded to an all-year station, which was fulfilled in 2005. A blue ice airfield was constructed and opened for use the same year (2005). Troll Runway makes it possible to take down intercontinental flights directly at Troll, providing even further flexibility to the current operations. Since the 2014-15 season main connection to Troll goes directly with chartered flights from Cape Town, South Africa.

There are several institutions running projects within Troll core area, and Norwegian Polar Institute offers services in running and maintenance for these facilities. In the coming years more institutions are expected to establish research infrastructure in the area, and NPI is planning for an increase in use of the facilities at Troll.

In 2014 the Air Monitoring Station operated by NILU (Norwegian Institute for Air Monitoring) was moved from the station area to nearby hill Trollhaugen, due to increase in activity in the Troll station area causing negative influence of the measurements made. In the slope Mimelia and on the hilltops Nonshøgda and Sofietoppen a continuous development of the KSAT activity (downloading of satellite data) have caused an increase of radoms and antenna arrays in these areas.



Figure 3: Map of Dronning Maud Land, Antarctica (Norwegian Polar Institute 2019).

1.2 Current NPI operations in Antarctica

1.2.1 The Norwegian Polar Institute's formal role

The Norwegian Polar Institute is a directorate under the Ministry of Climate and Environment, responsible for scientific research, mapping and environmental monitoring in the Arctic and the Antarctic regions. The institute advises Norwegian authorities on matters concerning polar issues and is Norway's competent environmental authority in Antarctica.

1.2.2 The Norwegian Polar Institute's operations in Antarctica

The Norwegian Polar Institute continues to provide logistic support in Dronning Maud Land (i.e. Norwegian Antarctic operations) to provide support to Antarctic research projects that has Troll as a hub. This entails providing transport to/from and inside the continent, transport/logistics for field operations, operation of the research station Troll as well as the field station Tor. These operations are described and discussed further in this document.

The Norwegian Polar Institute is furthermore one of the main Norwegian institutes conducting research activities in Antarctica. These research activities deliver their own IEE's, and are as such are not described or assessed any further in this document. However, in so far, a research

project utilizes transport/logistics described here, this part of its fieldwork is covered by this assessment.

1.2.3 Geographic area

NPI's operations in Antarctica today are mainly concentrated in Dronning Maud Land, and more specifically in the region around Troll. Troll is the main hub of present day Norwegian activities, and most of the research activities take place at or out from the station.

More extensive field work takes place intermittently, and NPI has in the past amongst other provided logistical support for projects involving ground traverse to/from the South Pole and field work at the Fimbul ice sheet

1.3 Past assessments

The following documents are the major environmental assessments prepared for the Norwegian operations since 2000. Note that separate IEE's have been prepared for all scientific projects that have taken place in this period:

- **Multi-year Initial Environmental Evaluation for the operational aspects of Norwegian Antarctic Research Expeditions 2000-2010.** ²
*This document is the Initial Environmental Evaluation (IEE) for the operational aspects of the Norwegian Antarctic Research Expeditions (NARE) from 2000-2010. The Ministry of Environment made its consideration and approval of the document in 25.10.2000, and has thereafter used it as basis when considering the annual notifications from the Norwegian Polar Institute*³.
- **Initial Environmental Evaluation. Construction and operation of Troll Runway.**
This document is the Initial Environmental Evaluation (IEE) for the construction and operation of Troll Runway (2002). The Ministry of Environment made its consideration and approval of the document 10.09.2003.
 - **FINAL Comprehensive Environmental Evaluation (CEE) for the upgrading of the Norwegian summer station Troll in Dronning Maud Land, Antarctica, to permanent station.**⁴
In January 2004 the Draft Comprehensive Environmental Evaluation (CEE) for the upgrading of the Norwegian summer station Troll in Dronning Maud Land, Antarctica, to permanent station was submitted to the Ministry of Environment. The draft CEE was submitted for CEPs consideration in accordance with Article 3(4) of Annex I of the Environmental protocol. The CEP considered the Draft CEE and reported to Antarctic

² Birgit Njåstad, NPI, 2000

³ The Norwegian Polar Institute submits advance notifications for its operations on an annual basis, providing specific information about the upcoming Norwegian operations and any details about operations that are not assessed in earlier documentations.

⁴ Norwegian Polar Institute, 2004

Treaty Consultative Meeting (ATCM XXVII) held in Cape Town, South Africa in May/June 2004. Based on comments from the meeting the NPI finalized the document, and the Ministry of Environment made its consideration and approval of the document in 19.10.2004. The Final CEE was circulated to Parties 23.01.2004, prior to the start of the activity in accordance with the provisions of the Environmental Protocol.

- **Environmental Impact Assessment of Norwegian Polar Institute Operations in the Antarctic 2011-2020**

In 2010 an EIA was prepared for the operational aspects of the Norwegian Antarctic Research Expeditions (NARE) from 2011-2020. The Ministry of Environment made its consideration and approval of the document in 16.11.2012 and has thereafter used it as basis when considering the annual notifications from the Norwegian Polar Institute.

1.4 Purpose of the assessment: ENVIRONMENTAL IMPACT ASSESSMENT OF NORWEGIAN POLAR INSTITUTE'S OPERATIONS IN ANTARCTICA

The *Multi-year Initial Environmental Evaluation for the operational aspects of Norwegian Antarctic Research Expeditions 2011-2020*⁵ has expired and this assessment replaces this former assessment. The document provides updated background information on the operations of the Norwegian Polar Institute's operational activities based at Troll Station and an assessment of the environmental impacts of these activities.

The assessment answers to the requirements of the *Regulations relating to the protection of the environment and safety in Antarctica*⁶ requiring that all activities be assessed as to any impacts on the environment, including measures that will be taken to limit any harmful effects. The assessment covers all normal NPI ground, marine and air operations in Dronning Maud, as well as the operation of the research station Troll and field station Tor. It does not cover other NPI operations outside Dronning Maud Land. It does not cover specifics associated with research projects requiring field work outside Troll or Tor stations. These operations are required to deliver separate Initial Environmental Evaluations.

Thus, this assessment provides the background for the daily running of NPI operations in Antarctica. The main aspects of the operations are:

- The operation of Troll Station

⁵ Norwegian Polar Institute, NPI, 2012

⁶ The Ministry of Climate and Environment, 2013

- The operation of Troll Airfield
- Operation of Tor Field Station
- Transport of goods and personnel via air, sea and ground operations.
- The operation of field activities including transport, camps and maintenance

2.0 CONSIDERING THE ENVIRONMENT

In order to assess the impacts of the NPI operations in Antarctica the sensitivities and values of the environment in which the activities take place have to be evaluated so that the identified outputs can be considered against the environment they take place in. A summary of this evaluation is presented in Appendix 1, 2 and 3. Three environmental elements of high value have been identified. Three elements of medium value were identified, and a number of elements of low value were however noted, such as flora, fauna, atmosphere, ice, geology and aesthetic values.

3.0. TROLL RESEARCH STATION

3.1 Introduction

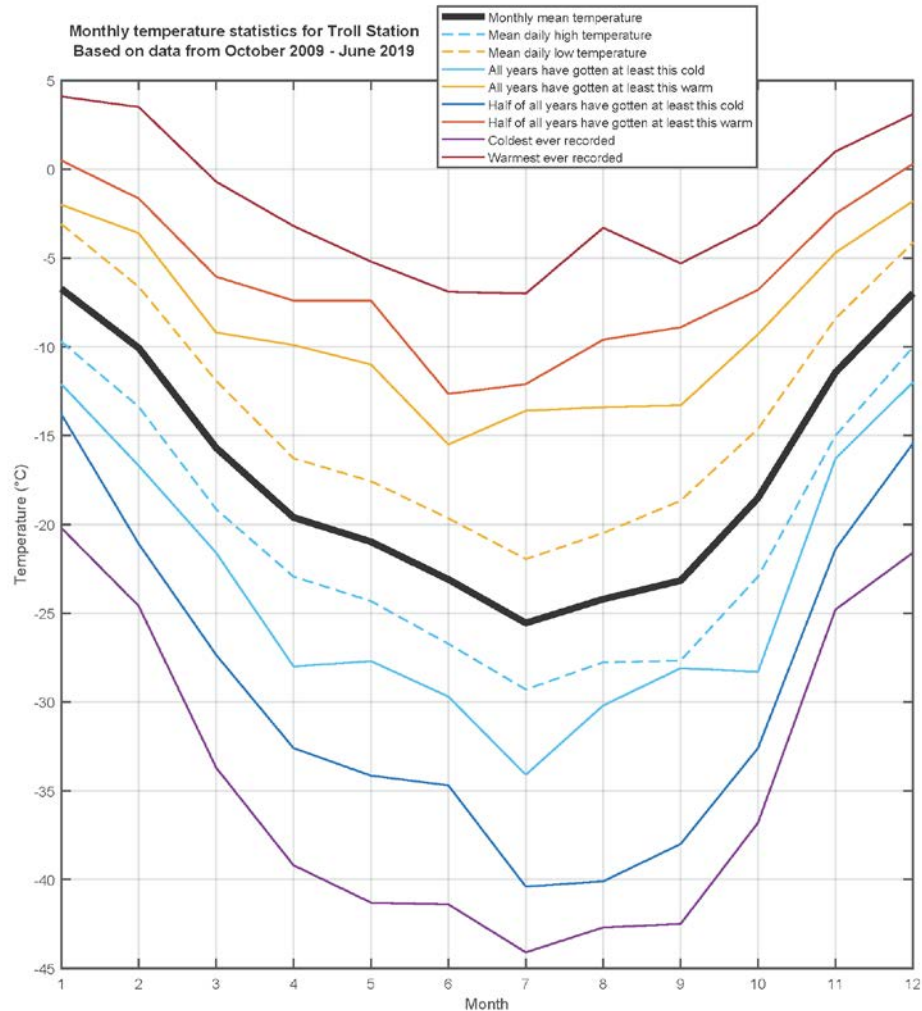
Troll is the main hub of present-day Norwegian activities in Antarctica and has as primary purpose to provide support for high quality national and international research activities. The station is owned by the Norwegian state, while the Norwegian Polar Institute is the state's operator thereby responsible for the daily operation of the station.

The station is located in the Grjotlia nunatak in Jutulsessen (72°00'S, 2°32'E) - for location see Figure 3. Jutulsessen, located 235 km from the coast, is characterized by relatively stable weather conditions. Troll station is placed on ice-free bedrock, 1295 m above sea level and 235 km from nearest open sea in Dronning Maud Land. The nearest neighbor is South Africa's research station SANAE, 200 km away.

Neither wind nor precipitation levels are normally extreme and even temperature is relatively moderate for Antarctica. Wind gusts could though cause dangerous situations due to strong katabatic winds. With an annual average temperature of around - 18°C, temperatures as high as 5°C has been recorded in the summer while the temperature in winter now and then can fall close to -45°C. Average wind speed at Troll station is 4 m/s.

Table 1: Temperature at Troll Station 2007-2019

	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	4.1	3.5	-0.7	-3.2	-5.2	-6.9	-7.0	-3.3	-5.3	-1.3	1.0	3.1
Min	-20.2	-24.6	-33.7	-39.2	-41.3	-41.4	-44.1	-42.7	-42.5	-36.8	-24.8	-21.6
Average	-6.7	-10.1	-15.7	-19.6	-21.0	-23.1	-25.6	-24.2	-23.2	-18.5	-11.4	-7.0

**Table 2. Monthly average temperature at Troll Station 2009-2019 (NPI-data 2019)**

The terrestrial biota in the area is very restricted in species diversity and abundance compared to other areas. No rare species have been registered. Invertebrate fauna is found in association with the vegetated areas. Since the CEE for making Troll a whole year station in 2005, no further investigations nor assessment of the fauna has been performed. It could be a weakness in the environmental assessment the fact it is lacking baseline information of biota like flora and micro-fauna within Troll Core Area.



**Figure 4: The Snow Petrel (*Pagodroma nivea*) is a common seabird species in Jutulsessen area.
(Photo: Stein Ø. Nilsen, Norwegian Polar Institute)**

The vertebrate fauna consists of birds only: Snow petrel (*Pagodroma nivea*), Antarctic petrel (*Thalassoica antarctica*) and South polar skua (*Catharacta maccormicki*). Only a few other species have been observed, Kelp gull (*Larus dominicanus*) has been observed once at Troll station (2008). Two large Antarctic petrel colonies are located in the central parts of Jutulsessen, approximately 10 km from the station area. Breeding south polar skuas are registered in Jutulsessen, while non-breeding young skuas are observed in the vicinity of the petrel colonies. In the station area itself, only a small number of breeding and non-breeding south polar skuas and snow petrels have been observed. The two small Snow Petrel colonies closest to Troll station and the one at Klovningen are monitored annually. There is no evidence so far (2019) that the operation of Troll station affects the breeding birds negatively, but monitoring will be continued.



Figure 5: Troll station, Core operational area in 2018 (Photo: Harald Faste Aas / Norwegian Polar Institute)

Originally, the Troll station was set up by NPI during the NARE (Norwegian Antarctic Research Expedition) of 1989-1990. With its 100 square meters and light construction it was describes as a small summer station. This meant that NPI personnel could only be there during the austral summer from November to February. Troll was opened as a year-round station by HM Queen Sonja on 12 February 2005 and is now (2020) an internationally important all-year station that functions as a hub for aerial transport between Dronning Maud Land and South Africa, and the adjacent stations in Dronning Maud Land. Several large joint expeditions have been arranged with Troll as starting point.

The station is also important due to its medical facilities which is an important safety factor for conducting expeditions in the area.

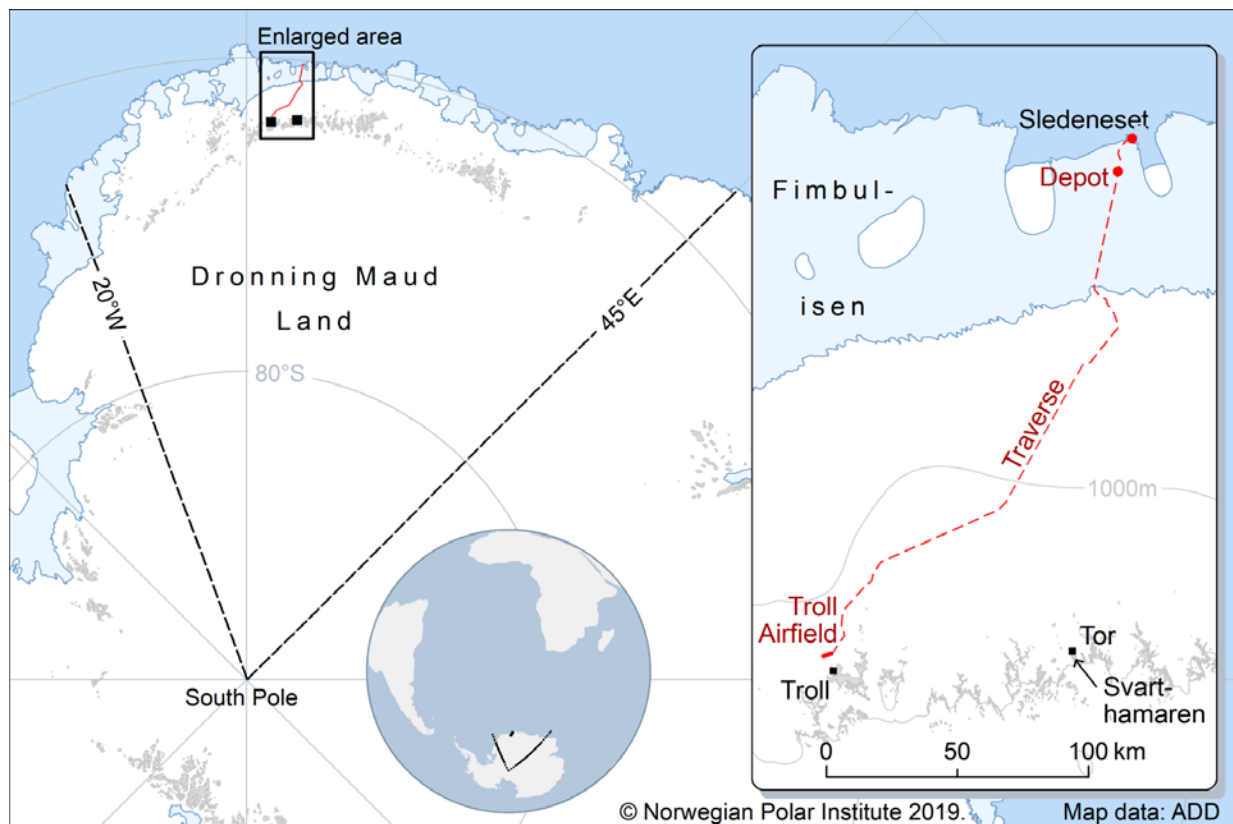


Figure 6: Map of Dronning Maud Land showing the location of Troll and Tor stations, Sledeneset and the depot (Troll Cargo Site) with ca 260 km traverse route (NPI 2019).

3.2. Land use and footprint

3.2.1 Description

- The assessment covers land use and footprint considerations related to the core infrastructure and operations at Troll⁷.
- The extent of the station area is defined by outer boundaries of the Troll land use plan (2011), see Appendix 4. The plan is under revision and will be made available when the work is completed.
- Most of current station infrastructure is located on ice-free ground although some structures are located on the blue ice near the station.
- The core operational area⁸ covers an area of approximately 50 000 m², plus the airfield and outlying cargo lines. Troll station consists of several structures like the main building, generator buildings, visitor housing, garages and storage facilities and more.

⁷ Core infrastructure is defined as all facilities related to accommodation, hygiene, health, energy etc. which any person staying at Troll depends on having access to.

⁸ The core operational area is defined in the land use plan for Troll Station, marked as Core Operational Area (cf. Appendix 4)

Scientific infrastructure has been established throughout the area. See Table 2 for details of station building details. Total amount of gravel roads constructed is ca. 5.7 kilometer (2019).

- Currently two other operators have established infrastructure within the boundaries of the Troll station land use plan area. NILU operates an air monitoring station on Trollhaugen above the station and KSAT operates a satellite ground station⁹. These installations are not considered in detail in this document, although considered with respect to the cumulative impacts in the area.
- The aesthetic values in the station area have been diminished by the placement of structures on top of mountains/hillsides or on the blue ice. The station area as such is not very visible due to the placement in the valley between the hills Trollhaugen and Sofietoppen/Nonshøgda. Being a remote station, the reduction of esthetic values will only be of concern for the personnel/visitors at Troll.
- The wilderness values near Troll are high. The wilderness values are however diminished due to infrastructure like the airstrip, gravel roads, buildings and antennas, but also noise from airplanes, vehicles and generators contributes to reduce the values of the station area.

Table 2: Buildings at Troll Station 2019 (all measurements in meters)

Name	Length	Width	Area m²
Main station	42	17	727
Cold garage	30	19	570
Emergency station	6	5	30
Carpenters workshop	5	3	15
Emergency generator (2000)	6	2.5	15
Sleeping module (1-5)	80	7.5	600
Container platform 1 (Blåmyra)	71	6	428
Container platform 2 (gravitasjoncont.)	2,5	2.5	6
Mechanical Workshop	21	12	252
Power plant 2005	14	6	84
Power plant 2007	12	10	120
Fuel container platform and pumphouse	15	6.5	98
Recycling facility/Environmental station	30	6.5	1995

- NPI will ensure that further development of the station will fulfill the below minimum requirements and thereby be covered by this assessment:

⁹ Kongsberg Satellite Services AS (KSAT) has established and operates Troll Satellite Station (TrollSat), a satellite reception, control and command station. The company is owned by Norwegian Space Centre (a government organisation reporting to the Ministry of Trade and Industry) and Kongsberg Defence and Aerospace AS with 50% of the shares each..

- **Strategic development:** Further development of the Troll station will be in line with the NPI strategic plan for Troll Station¹⁰. The plan will provide a strategic framework ensuring that, logistics and other external activities at Troll are in line with the primary purpose of the station, i.e. a platform for high quality national and international research based on an environmentally sound foundation.
- **Land use plan:** Further development of the Troll station will be in line with the land use strategy outlined in the Troll land use plan, which provides a zoning scheme that ensures that environmental and scientific values of the area have the highest priority in further development of the area. See Appendix 5.
- **Aesthetic values and wilderness:** Further devaluation of the aesthetic and wilderness values at the site will be avoided by strictly planning according to strategic plans and the land use plan.



Figure 7: Troll Station, Core operational area (2019)

¹⁰ NPI Strategic plan 2019-2024

Table 3: Legend, Troll Core Operational Area

Number/Letter	Description
B	Barrels with Petrol, Jet fuel, engine oil and lubricants storage ca. 300 meter South
D	Fuel storage; approx. 500 meter West, placed on blue ice
1	Main building
2	Carpenter workshop
3	Emergency Power station
4	Environmental station
5	Garage
6	Garage
7	Fuel tanks
8	Power station, Backup
9	Power station, Main
10	KSAT Antenna
11	Emergency Station
12	Antenna array
13	Container storage area: 25 pcs. 20' containers
14	Sleeping module/ visitor housing
15	UiO Gravity Project - instrument container

3.2.2 Alternatives

As activity at and associated with Troll increases, the potential for an expansion of land use and thereby an increased footprint is large. Having clear strategic framework (including land use plan) provides a useful tool to avoid unplanned growth. An alternative to allowing for planned/strategic growth would be to set a clear limit to number of buildings, extent of land use, etc. (Including no further growth). However, this would by no means enable the freedom necessary to make resources and area available for important and prioritized research.

There are plans for relatively large increase in infrastructure at Troll, and the area in Mimelia slope North-East of today's Troll Core Area have areas available for such future development. It is very likely that the establishment of such buildings and other infrastructure as roads, cables and pipelines will be within the timeframe of this EIA. The size and reach of such an increase would possibly be considered so large that a separate IEE will be made.

3.2.3 Impacts

Potential Environmental Impacts from land use and footprint at Troll station

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
<ul style="list-style-type: none"> Physical footprint 	<p>Aesthetic values: Buildings, roads, infrastructure, fuel spill remains, and waste introduce visible human elements into the natural landscape and may change the emotional experience for visitors. Visitors in the area are normally associated with research expeditions and will normally expect human elements in environment</p> <p>Wilderness: Troll station occupies ca. 2 % of the total ice-free areas of Jutulsessen and is a factor in reducing the wilderness value of the area. Nonetheless visitors in the area are normally associated with research expeditions and will normally expect human elements in environment.</p> <p>Flora: Construction of new station elements and associated use of vehicles may disturb small vegetation patches in the station areas. Increased pedestrian traffic in the station area (radius 500 meters) will likewise have such effect (Komarkova, 1983). Re-growth in damaged areas will be slow. Vegetation patches occur only sporadically in the area, and no unique assemblages have been recorded.</p>	<p>Extent: Local to regional Duration: Permanent Significance: Low</p>	<p>Strategic plan: The NPI Strategic plan will be used as a guidance for reducing the total physical footprint at Troll station.</p> <p>Land use plan: The document will be used actively in planning future activity and constructions within the designated area to keep the physical footprint as small as possible.</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
<ul style="list-style-type: none"> Physical footprint 	<p>Fauna: Nest sites of snow petrel can be disturbed or destroyed due to construction work.</p> <p>Snow petrel tend to return to original nests but will normally find alternatives if nest is not available. The number of nests that would be disturbed in this manner is likely to be small and have minimal impact on individuals and no impact on population.</p>		<p>Construction guidance: Construction work will as far as possible be carried out before or after the snow petrels arrive/leave the area. Before construction work is undertaken the affected area will be investigated for nest sites. All attempts will be made to ensure that no nest sites that are in active use will be destroyed in connection with the construction of roads and foundations for buildings. Efforts will also be initiated to limit the number of affected inactive nest sites.</p>
<ul style="list-style-type: none"> Noise 	<p>Fauna: Noise may disturb birds in a manner so that they leave their nests (and expose eggs/chicks to environment and predators), raise stress level and increase metabolism, all which could affect the fine tuned balance of energy intake and energy use (see CAFF (1998) and Giese & Riddle (1999)).</p> <p>It is expected that the limited exposure to output will be too low for any significant impact. The noise from the generators will be a part of the environment when the birds arrive at the start of the breeding season and will likely therefore be of little concern.</p>	<p>Extent: Local Duration: Permanent Significance: Low</p>	<p>Noise reduction: Efforts to minimize generator need during summer season by focus on alternative energy.</p> <p>Noise issues will always be considered when establishing new infrastructure at the station.</p>

3.3 Use of vehicles

3.3.1 Description

- The assessment covers vehicle use needed to support normal day to day operations at Troll and support to field parties
- A variety of different vehicles are used at Troll, see table 4. The vehicle park is upgraded when needed, which leads to investment in new types of vehicles necessary.
- NPI will ensure that vehicle use at the station will fulfill the below minimum requirements and thereby be covered by this assessment:
 - **Controlled use:** Unnecessary use of vehicles at Troll will be avoided.
 - **Recreational traffic:** All recreational traffic will be carried out on marked (on maps) areas to ensure safety of the personnel. Areas with crevices will be avoided. Outside the mountainous areas around Troll, the recreational hut in Vassdalen and the Jutulsessen area are destinations for recreational purposes.
 - **Registration of traffic:** All traffic in the clean air zone (cf. land use plan) will be logged. This is due to the air monitoring activity at Troll (Performed by NILU), and the operations conflicting with these measurements should be correlated.
 - **Use of established tracks:** In general, there will be no traffic outside established tracks within the station area. All use of vehicles, with the exception of snow mobiles, occurs on established tracks.
 - **Establishment of new tracks:** New tracks shall only be constructed if there is a permanent use for the track. If not, consideration will be given to make a preliminary track/construction road. If there are exceptions to this, actions will as far as possible be taken to avoid interference with wildlife or leaving footprints in the landscape. As far as possible new tracks should avoid passing within the Clean Air Zones.
 - **Investment in environmentally friendly vehicles:** The environmental aspect of vehicles will be considered when purchasing new vehicles¹¹. Consumption, CO2 emission and possibilities for reuse of materials will be considered before purchasing. NPI will as far as possible request the use of environmentally friendly production methods, retrograding routines and reuse of materials in vehicles purchased for use in fragile areas. Electrical vehicles (EV) are used for transport in Clean Air Zones within Troll Core Area.

¹¹ See further discussions relating to purchasing in chapter 9.1



Figure 8: Electric ATV used at Troll station in 2020. Photo: Einar Johansen/Norwegian Polar institute (2020)

Table 4: Vehicles at Troll in 2020

Type of vehicle	Number of vehicles	Purpose	Fuel
SCANIA P 550 Truck	1	Fire truck	Diesel
Hägglund BV206: Tracked vehicle	4	Transport	Diesel / Jet-A1
CAT 908: Front-end loader	1	Station maintenance	Diesel
CAT D8T Bulldozer	1	Airfield maintenance	Diesel
JCB 2140 Tractor	1	Station maintenance	Diesel
ABS TB145 Excavator	1	Station maintenance	Diesel
Prinoth Everest: Tracked vehicle	6	Transport cargo	Diesel / Jet-A1
Prinoth Panther Troll: Tracked vehicle	1	Transport cargo	Diesel
Berco TL6: Tracked vehicle	3	Expedition vehicle	Diesel / Jet-A1
Toyota Hi Lux	3	Station / airfield	Diesel
VOLVO L110: Front-end loader	1	Station maintenance	Diesel
VOLVO EC240: Excavator	1	Station maintenance	Diesel
ØVERAASEN UTV 430 MK II: Snowblower	1	Airfield maintenance	Diesel
Polaris Ranger Electric ATV	2	Station maintenance	Electric
Yamaha VK540III: snow mobile	11	Expedition / transport	Petrol
Genie Z80-60: Personnel lift	1	Station maintenance	Diesel
Hammar side-loader 25 tons	2	Transport	Diesel
Polaris 6-wheel ATV	3	KSAT	Petrol
Toyota Hi Lux	1	KSAT	Diesel
Electric ATV	1	KSAT	Electric
Mobile crane 40 ton	1	KSAT	Diesel
Drill rig	1	KSAT	Diesel
Electric ATV	1	NILU	Electric

3.3.2 Alternatives

Due to the size of the Norwegian operations taking place in Antarctica there are no alternatives to using vehicles. However, using modern technology as often as possible, such as electrical or hybrid powered vehicles within the station area to reduce emissions will contribute to a decreased impact.



Figure 9: Prinoth Panther T16 is one of the vehicles used for heavy transport in Dronning Maud Land (2019)
(Photo: Svein Sørly / Norwegian Polar Institute)

3.3.3 Impacts

Potential Environmental Impacts from use of vehicles at Troll station

Output	Description of potential impact	Evaluation of impact	Measures to reduce impact
Emission	<p>Exhaust emission: Air in local area around station will be exposed to exhaust emission. This will affect the air monitoring program at Troll Station negatively. Wind and pollution combined render a relatively large amount of the monitoring data unusable.</p> <p>Dust: Dust from operating vehicles on established roads and tracks will affect the air quality in the local area of the station. This could have an effect on air monitoring performed at Troll Station. Wind and pollution combined render a relatively large amount of the monitoring data less usable</p>	<p>Extent: Local to regional</p> <p>Duration: Permanent</p> <p>Significance: Low/Medium</p>	<p>Vehicle control: Driving will be limited to that which is necessary. Electric powered vehicles are used in those areas that are most sensitive to air pollution (i.e. clean air zone) and noise. Only clean unleaded fuels will be used. Since 2014 the NILU instruments were moved 1.5 km away from the station to diminish the effects of generator use, and traffic on roads and tracks.</p>
Noise	<p>Fauna: Noise from operating vehicles in the station area could affect breeding birds. Noise may disturb birds in a manner so that they leave their nests (and expose eggs/chicks to environment and predators), raise stress level and increase metabolism, all which could affect the fine tuned balance of energy intake and energy use (see e.g. CAFF (1998) and Giese and Riddle (1999)).</p> <p>It is expected that the limited exposure to output will be too low for any significant impact.</p>	<p>Extent: Local</p> <p>Duration: Permanent</p> <p>Significance: Medium</p>	

3.4 Waste

3.4.1 Description

- This assessment covers waste management resulting from normal day-to-day operations at Troll.
- Currently approximately 153 m³ of waste is produced annually at Troll (2019). An overview of types of waste is given in Table 6. NPI currently has contract with the company Marineslops (SA), Cape Town, South Africa) who ensures that South African national regulations are followed. A detailed *Certificate of safe disposal* is issued for deliverances made for recycling in Cape Town, South Africa. The general principles and certificates will be upheld independently of contractor in the Republic of South Africa.
- The key principle of the waste management at the stations is established in the national Regulations relating to the protection of the environment and safety in Antarctica (2013). In short, this entails that all waste, except wastewater, is collected, separated

and brought out of Antarctica for appropriate disposal and recycling. **Regulations relating to the protection of the environment and safety in Antarctica§ 21-25.**

- The following elements of the waste management procedures should be noted:
 - **Waste compressors:** Waste compressors are used to reduce waste volume of general waste, plastics and paper significantly. Also, another compressor is used to compress empty fuel drums to 20% of full size.
 - **Toilet waste:** Vacuum toilets (Jets system, Norway) and a diaphragm cleansing system for black and grey water (Martin Systems AG, Germany) have been in use since 2008. See Table 5 for amount of wastewater and solid waste produced by the system.

Table 5: Amount of annually produced cleansed wastewater and solid waste (in Kg) at Troll station (2018)

Description	Amount
Total grey water discharged:	Ca. 450 m ³
Solid toilet waste (Annual: From Diaphragm Filter System)	Ca. 7.5 m ³
Urine	0.4 m ³

- **Food waste:** A grinder/decomposer is used to reduce food waste volumes to 10% of the original amount. The machinery is made by *Global Enviro International AS*, Norway and has a capacity of decomposing 50 tons of food waste per year. Fat is excreted and is delivered separately as toilet waste in South Africa. The remaining solids is packed in 60-liter barrels and shipped to South Africa.
- **Waste collection routines:** All waste is sorted in to 30 different categories. This complies with the demands of the South African company *Marineslops (SA)*, so that waste from Troll can be delivered in accordance with South African laws and regulations ¹².
- **Waste retrograding routines:** All waste is prepared and stored in containers at Troll station before shipment to South Africa. Containers with waste can be secured and stored ca. 600 meter away from ice shelf for maximum 4 weeks prior to arrival of the vessel. The waste is delivered in South Africa in containers. The company *Marineslops*, Cape Town ensures correct reporting, treatment, reuse and disposal in accordance with the provisions of the South African laws. ¹²

¹² National Environmental Management Act No. 73 of 1989, National Environmental Management Act No. 107 of 1998, National Water Act No. 73 of 1998, The Health Act No. 63 of 1977, The Occupational Health and Safety Act of

- **Waste responsibility:** The overwintering team is responsible for waste management at the station. **Regulations relating to the protection of the environment and safety in Antarctica § 21.**¹³
- Wastewater is discharged in a rocky outcrops ca. 150 meters south of the main building at the Troll station. Currently approximately 450 m³ of filtered grey water is discharged on an annual basis (See table 5). A new diaphragm system for wastewater treatment was installed in 2008 and when operating correctly this ensures high level of treatment of the wastewater before it is discharged. Regular samples of the wastewater are taken to ensure that the treatment plant is working satisfactory. Discharge of wastewater on ice-free ground is in contradiction with the provisions of the **Environmental Protocol Article Annex III Art. 4** and dispensation from the Norwegian Antarctic Regulations is required **Regulations relating to the protection of the environment and safety in Antarctica § 21-25, cf § 36**. The Ministry of Climate and the Environment has provided such dispensation in the period 2011-2020.
- NPI will ensure that waste management will fulfill the below minimum requirements and thereby be covered by this assessment:
 - **Disposal of waste:** All waste will be shipped out of Antarctica and deposited in South Africa. Records and documentation will be kept as to the amount of waste that has been delivered and treated in South Africa in accordance with relevant South African national¹⁰ and international agreements.
 - **Storage:** All waste to be removed will be stored in such a way so their dispersal is prevented. Storage will take place in tethered cargo containers or indoor in designated area for storage of waste. Waste will be stored at Troll station and at the permanent depot in safe distance from the ice shelf during austral winter.¹⁴ **Environmental protocol, Annex III, Article 6, Regulations relating to the protection of the environment and safety in Antarctica § 23.**
 - **Recording:** All figures on amount, type and weight of produced, shipped and disposed waste will be recorded annually **Regulations relating to the protection of the environment and safety in Antarctica § 25. Environmental Protocol, Article 4**. The overwintering team is responsible for keeping record books.

1993, The National Road Traffic Act No. 93 of 1996 and Transport of dangerous substances by road – Chapter 8 of National Road Act.

¹³ Routines and procedures for waste management at Troll is further specified in the Troll Operation Routines (OVERSIKT KATEGORIER AVFALL PÅ TROLL(NPI 2019) in Norwegian).

¹⁴ Permission in letter from The Ministry of Climate and Environment 02.07.2018: Norwegian Antarctic Research Expedition (NARE) 2017-2018 – Melding om etablering av omlastningsområde og lager for drivstoff

- **Waste minimization:** The waste volume will be reduced by focusing on purchase, packing, reuse and recycling. **Environmental Protocol, Article 1**
 - **Packing:** All shredded paper, polystyrene beads, chips or similar forms of loose packaging will be replaced with bubble wrap, cardboard or paper as far as possible. **Environmental Protocol, Article 2**
 - **Reuse:** There is no waste that can be reused at Troll presently; waste delivered in South Africa will be recycled and reused as far as possible.
 - **Purchasing:** See chapter 9.1.
- **Littering:** Storage containers will be constructed and maintained in a manner that no littering will take place. In case of an accident or an unforeseen event all litter will be removed immediately.
- **Training:** The person responsible for waste management, and other key personnel, will receive necessary training related to waste management issues **Regulations relating to the protection of the environment and safety in Antarctica § 10.**
- **Wastewater treatment:** All efforts will be made to ensure appropriate operations of the wastewater treatment system. Water released shall not exceed the limits for the selected indicators as listed in Table 7.
- **Wastewater reuse:** Wastewater will to the largest extent possible be reused for household washing and in the toilet system. The vacuum toilets use only ab. 0.5 – 0.75 liters for flushing so the gain is relatively minor. The wastewater cleansing system requires a certain minimum amount of water to be efficient, so especially during winter season it is not possible to substantially reduce the amount of water used.

Table 6: Waste categories at Troll station (2019). ¹⁵

Nr.	Category
1	WOOD
2	CARDBOARD/PAPER
3	PLASTICS
4	ELECTRICAL DEVICES
5	CABLES
6	GLASS
7	LEAD BATTERIES
8	SMALL BATTERIES
9	GENERAL WASTE
10	AIRFILTERS
11	POLYSTYRENE/FOAM RUBBER/GLASS WOOL
12	DANGEROUS WASTE
13	SPRAY CANS
14	LIGHTBULBS/TUBES
15	SPILL OIL
16	RAGS CONTAMINATED WITH OIL/ABSORBENTS
17	CONTAMINATED FUEL
18	URINE
19	TOILET WASTE
19	COMPOST
20	FOOD/KITCHEN WASTE
21	METAL

Table 7, Wastewater treatment requirements (maximum levels) ¹⁶

Substance	Manufacturer's specification	Maximum level
Suspended matter (TSS):	5 mg/l	10 mg/l
Organic pollution (COD)	1 mg/l	15 mg/l
Total Phosphate (Ptotal)	1 mg/l	3 mg/l

3.4.2 Alternatives

Waste is an unavoidable consequence of operating in Antarctica. Retrograding of all waste is the alternative with least impact on the environment. Incineration is a potential alternative. However, this treatment form is highly dependent on large amounts of fuel in order to ensure

¹⁵ Rutinebeskrivelse: Avfallshåndtering på Trollstasjonen (veier, losseplass på isen, containerekke og KSAT anlegg) NPI 2019 (In Norwegian)

¹⁶ Based on advice from Miljødirektoratet (Norwegian Environment Agency) and specifications provided by system manufacturer, Martins AG, Germany.

acceptable temperature levels and thereby minimize harmful emissions. Due to research activities such as continuous air monitoring at Troll station it is furthermore desirable to minimize the emissions as much as possible. Incineration is therefore not considered a viable alternative at Troll. It is not considered an alternative to ship out the filtered grey water due to the amount of fuel used this would cause, as long as the quality of the grey water is considered acceptable to the levels set. Mechanical chiseling of the ice-block has proved effective to increase ablation. Drainage of cleaned grey water into the environment could have an impact, technological solutions to reduce or even make this action redundant should be a future priority for NPI.

3.4.3 Impacts

Potential Environmental Impacts from waste management

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Emission	<p>Wastewater: Wastewater may affect micro-flora potentially present in discharge area. Increase due to expanded season and expected higher wastewater discharge. Wastewater is likely to ablate (cf. experience from the area) to a large degree, although ice build-up may be expected during winter season. Wastewater treatment system will ensure minimal pollution in discharged water and thereby exposure to pollution.</p>	<p>Extent: Local Duration: long Significance: Low</p>	<p>Technology: Best available technology will be used for cleansing wastewater (greywater).</p> <p>Monitoring: The wastewater will be monitored on monthly basis to ensure that acceptable discharge quality is maintained (cf. table 7). Discharge of water will be stopped if failure to comply with wastewater quality (cf. Table 7) consistently over a longer time period.</p> <p>To increase ablation the ice formed by wastewater outlet will be chopped into smaller pieces once yearly.</p> <p>Education: Due care and attention, use of appropriate procedures and equipment when managing waste, reinforced by education and training.</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Littering	<p>Waste littering. Waste could be spread in adverse weather, or if waste is inadequately handled or secured. Associated impacts are mainly of an aesthetic nature but could have a pollution effect if chemicals are involved. Break-down of litter is slow, and litter will remain. Contributes to overall contamination of environment.</p> <p>Due to strong winds empty steel containers has shone prone to be drifted away.</p>	<p>Extent: Local to regional</p> <p>Duration: Transitory to Permanent</p> <p>Significance: Low</p>	<p>Avoidance: How to ensure that littering is avoided and that all litter is taken care of immediately is specified in Troll Station Waste Procedures. Steel containers should be secured in safe areas to ensure not being taken away by adverse weather.</p> <p>Handling: If unintentionally littering happens action will be taken to collect litter as soon as possible.</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Non-native organisms and disease	<p>There is a risk of spreading bacteria or possible diseases with wastewater and/or contaminated foodstuff.</p> <p>Human activity can be the cause of disease outbreaks, bringing pathogens unintentionally into Antarctica. So far few, if any, disease outbreaks are however known to have been introduced to Antarctica as a result of human activity. Disease could be detrimental to populations (Hughes & Convey, 2010, Knowles, Riddle & Clarke, 1999 and Gardner et al., 1997).</p>	<p>Extent: Local Duration: Short Significance: Medium</p>	<p>Avoidance: Food wastes will be stored in a secure manner to ensure avoiding contact with wildlife, disallowing littering into the environment. All waste is stored securely before shipped in containers to South-Africa for further treatment. Special care will be given to poultry or other foodstuff that has a potential to inflict diseases to birdlife in the region. Procedures are specified in Troll Station Waste Procedures.</p> <p>Relevant material in the Non-native Species Manual¹⁷ will be used as guidance, e.g. the “Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species” developed by Comnap/Scar (2011)</p>

3.5 Management of fuel and hazardous substances

3.5.1 Description

This assessment covers management of hazardous substances, including fuel, in the context of the normal day-to-day operations at Troll.

¹⁷ Cf. ATCM Resolution 6 (2011) available at http://www.ats.aq/documents/recatt%5Catt486_e.pdf

- Currently approximately 400,000 liters of fuel is used for power production at Troll annually (2019), and typically up to 800,000 liters of various types of fuel are stored at the station at any one time. An overview of hazardous substances (and approximate maximum amounts) is given in Table 8. The key principle relating to management of hazardous substances is laid out in the Norway's *Antarctic Environmental Regulations*. In short, no harmful products/substances shall be disposed/emitted during operation¹⁸
Regulations relating to the protection of the environment and safety in Antarctica §§ 21-22.
- The following additional aspects with respect to fuel and pollution management should be noted:
 - **Fuel depot:** *The Polar Diesel* fuel depot at Troll consists of large containers (Maximum 24, 000 liters/container) located on the ice ca. 600 meters from the station. Total amount stored in 2019 was ca. 650,000 liters. Up to 200,000 liters of Jet fuel A-1 is stored in sealed 200-liter barrels in locked containers. In addition, a total of 20000 liters unleaded petrol 95 octane is stored in sealed 200 liter barrels in locked containers. Additionally, in 2018 there's established a fuel depot ca. 10 Kms from Sledeneset (Troll Cargo Site) with a maximum allowance from The Ministry of Climate and Environment to store 400.000 liters of polar diesel, 10 20' containers with waste and up till 15 empty 20' containers.¹⁹
 - **Fuel transport:** All fuel and chemicals are brought to Troll from the cargo vessel (at Troll Cargo Site) in containers or sleds with 200 liter barrels to Troll station. Polar diesel is transported in 11,000 liters tanks within 20' containers and in 23000 liters double walled tankcontainers. See Chapter 3.
 - **Monitoring:** All fuel depots are monitored visually regularly to ensure that no barrels or tanks are leaking liquids to the environment.

Table 8; Fuel and other substances stored at Troll station (all numbers showing maximum amounts 2019)

Substance	Amount
Polar Diesel	700 m ³
Jet Fuel A-1	500 barrels (100,000 liters)
Petrol 95 octane (unleaded)	100 barrels (20 000 liters)
Glycol	8 barrels (1600 liter)
Battery acid	50 liter
Cleansing liquid for waste treatment (Caustic Soda 50%, Chlorine cleaner 13%, Citric Acid 50%)	70 liter
Propane gas	500 kg

¹⁸ This does not preclude combustion from generators, vehicles and the like.

¹⁹ Permission in letter from The Ministry of Climate and Environment 02.07.2018: Norwegian Antarctic Research Expedition (NARE) 2017-2018 – Melding om etablering av omlastningsområde og lager for drivstoff

- NPI will ensure that management of hazardous substances will fulfill the below minimum requirements and thereby be covered by this assessment
 - **Prohibited products:** No polychlorinated biphenyls (PCBs), non-sterile soil, polystyrene beads, chips or similar form of packaging or pesticides (other than those required for scientific, medical or hygienic purposes) will be taken into or used at Troll **Environmental Protocol, Article 7.**
 - **Storage:** All fuel depots within Troll Core Area will be inspected regularly during both summer and winter season.
 - **Spill equipment:** Spill material such as spill mats and absorbents will be available for fuel or dangerous substances operations. The person in charge of the operations will be responsible for having the right type of equipment on site before the operation starts.
 - **Spill handling:** All small and large fuel spills will be handled in accordance with routines specified in the Troll Station Waste Procedures. In the event of an oil spill incident in excess of 200 liters (and for oil spills less than 200 liters, if considered significant) a full Oil Spill Report will be prepared.

3.5.2 Alternatives

As long as fuel is used for generators and vehicles there are no alternative to not using fuel. There are a variety of available technologies available for fuel storage and transport, and best practice is evolving over time to ensure as little as possible environmental impact. NPI considers alternatives continuously, in order to reduce both costs and environmental impacts from fuel transport/storage. Use of sun energy is a future alternative for the running of the station for long periods during Austral summer period, but it is considered still too little cost-effective.

3.5.3 Impacts

Potential Environmental Impacts from management of fuel and hazardous substances.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Emission	<p>Ground: Fuel spills can be released into the ground during filling or operation. Jet A-1 and Polar Diesel are relatively volatile, and a large portion of a spill is likely to evaporate instead of migrating into ice/ground. Contaminants that migrate into the ice will be encapsulated and remain in the ice for an indefinite period. Impacts at release time depend on point of release but could affect biota or quality of receiving environment. Such spills will contribute to overall contamination of environment and may have bearings on future ice related research. Limited ice related research is currently ongoing in the area.</p> <p>Fauna: Fuel spills may occur and could produce numerous health concerns to any animal that comes into direct or indirect contact with the substance. Birds and humans that come in direct physical contact with the chemicals can suffer skin and eye lesions or chemical burns. Fuel spills at Troll have so far been few and small due to proper handling routines, and exposure is expected to be small with little impact.</p> <p>During the more than 15 years of operation no birds are reported contaminated with oil spills during the operations.</p>	<p>Extent: Local Duration: Permanent Significance: Low</p>	<p>Avoidance: Spill equipment will be during filling operations Procedures will be specified in Troll Station Regulations.</p> <p>Education: Personnel shall receive adequate environmental information, fuel handling procedures and waste handling procedures.</p>
Waste	<p>Litter: Waste as empty oil drums, contaminated spill equipment, containment mats and straps do occur during filling during ground operations. These will be handled as contaminated waste at the Environmental station and are not expected to affect the environment. Some unintentional littering could occur during field operations. Associated impacts are mainly of an aesthetic nature. Break-down of litter is slow, and litter will remain. Contributes to overall contamination of environment.</p>	<p>Extent: Local Duration: Short Significance: Low</p>	<p>Handling: If unintentionally littering happens action will be taken to collect litter as soon as possible. Litter will be brought to Environmental station at Troll for further treatment.</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Non-native organisms and disease	<p>In the case of fuel handling, introductions may take place via equipment/cargo carried into Antarctica. It is to be expected that establishment of non-native species will only be possible for those species that can tolerate the conditions of the Antarctic environment. Containers used in the Arctic regions could possibly bring arthropods, seeds and/or plants of alien species to Antarctica.</p> <p>There are well-known examples of experimental and accidental introductions of non-native organisms in Antarctica. It is, however, considered likely that most non-native organisms will not find suitable environment to thrive in the Troll area (due to climatic and other environmental factors). Non-native organisms can displace existing vegetation and micro-flora/fauna (Smith, 1996).</p>	<p>Extent: Local Duration: Short Significance: Low</p>	<p>Avoidance: Relevant material in the Non-native Species Manual will be used as guidance, e.g. the “Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species” developed by COMNAP & SCAR (2011)</p>

3.6 Power supply

3.6.1 Description

- This assessment covers power generation, in the context of the normal day-to-day station operations at Troll.
- Currently power supply at the station is mainly based on conventional generators and Polar Diesel consumption.
- The amount of energy produced annually is ca. 1 300 000 Kwh (2019). Of the core infrastructure the main station building requires most energy. However, it is the external activity (TrollSat) that consumes most of the energy produced at Troll.
- The following aspects related to power supply and energy production should be noted:
 - **Maximum capacity:** The main generator can produce a maximum of 240 KVA, the current energy consumption is currently at approx. 70 % (2019).
 - **Fuel consumption:** The generators at Troll are running 24/7 due to the satellite services and instruments operating full time all year. The annual consumption for operating the generators is currently at ca. 420 000 liters of Polar Diesel (2019).
 - **Utilization of waste heat:** At Troll waste heat from the generators is used for melting of ice for drinking water, heating of tap water and for the heating of the larger buildings such as garages, main building and generator buildings. The water is led by pipelines from the generator building.

- **Energy savings:** To reduce the use of energy, lighting has been changed to the use of LED-technology (Light Emitting Diodes). Procedures has been implemented to switch of lights and unnecessary equipment when not needed. The amount of energy used for the buildings has been reduced significantly due to the increased education and awareness.
- **Solar panels:** There's established a small installation of solar panels at the summer barracks called "Blåbo". The summer barracks are only operational during the summer season. The solar panels produce enough electrical power to supply "Blåbo". Any surplus power is distributed to the electrical grid at the station which decrease the load from the fuel supplied generators.

3.6.2 Alternatives

Use of alternative energy/fuels could be considered in order to reduce the impact (and costs) associated with conventional energy production. The following are under consideration:

- **Solar power:** The 24-hour daylight during the austral summer makes use of solar power a potential additional power supply. A test plant was mounted and tested since 2015. High specific yield due to high irradiance, low temperatures and high albedo shows potential for future use. Hourly / daily storage (battery) allows solar energy to meet up to 50% of the annual demand. This alternative will be considered further. It has so far proved difficult to invest in this kind of technology, but descending prices globally for this kind of equipment should make it more likely in near future. The amount of fuel used at the station and the amount of fuel used for transport of fuel will reduce the environmental footprint significantly.
- **Wind power:** This alternative was tested at Troll, but due to irregular wind force it proved unusable for this location.

3.6.3 Impacts

Potential Environmental Impacts from power supply

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Combustion emission	<p>Air: Combustion gases released into the atmosphere can contribute to the greenhouse effect both directly and indirectly. However, in the overall emission picture (both in the Antarctic context and the global context) the contribution from the activity is relatively minor.</p> <p>Air quality in general may be affected by releasing combustion compounds into the atmosphere. Since atmospheric research is one of the main elements of the all-year activity at the station, such emission may have undesirable effects and should be minimized.</p> <p>Ground. Soot emissions from exhaust outlet could contaminate ice and snow and affect the albedo locally, which with time could lead to further alterations of the physical environment and ablation rates. Soot deposition has been shown to cause no measurable changes of snow albedo at the South Pole Station where there is higher and more constant emission (see e.g. Warren and Clarke (1990), Wolff (1992) and Suttie and Wolff (1993)). Ice quality in general may be affected by deposited combustion compounds. This could have bearings on ice related research (e.g. climate research). No ice related research is on-going or planned in the area.</p> <p>Fauna: Soot and combustion products can be potentially harmful if birds get in direct contact with the substances. Although combustion products can affect birds (habitat and health), the exposure is limited due to relatively low emission levels from Troll.</p> <p>Ingestion through food not likely due to marine diet. Inhalation low due to distance from source. Exposure could in the long run affect respiratory system and other vital functions (see e.g. Maniero (1996)).</p>	<p>Extent: Local to regional</p> <p>Duration: Very long</p> <p>Significance: Medium</p>	<p>Technology: Well-maintained generators and equipment will be used, and generators will not be left idling unnecessary. High energy efficient fuel will be used. Continued consideration will be given to potential mechanisms to cleansing of combustion gases.</p> <p>Reduction: Further efforts will be instituted to identify and implement use of alternative energy sources such as sun energy in future. NPI will continue to focus on energy efficiency measures to reduce energy needs.</p>

3.7 Water supply

3.7.1 Description

- Fresh water at Troll station is made from blue ice taken from nearby the station. The ice is melted in a melting-tank heated by waste-heat from the generators.
- The melted ice is cleansed with particle filter and UV-filter.
- The freshwater quality is tested sporadically, and the equipment and melting tank is cleansed at least once annually. The quality complies with Norwegian national drinking water regulations.

3.7.2 Alternatives

There are no alternatives to using melted ice or snow for fresh water supply at Troll.

3.7.3 Impacts

Potential Environmental Impacts from water supply

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Disturbance in landscape	Wilderness: Wilderness and aesthetic values could be affected by taking of ice in a single location. Annual snowfall, wind driven snow and movement of glaciers will obliterate traces from the taking of ice.	Extent: Local Duration: Temporary to short Significance: Low	Avoidance. to avoid visible abrasion snow/ice will be taken over a larger area.

3.8 Recreational activities

3.8.1 Introduction

Being physically active is considered positive for the general health for the personnel at remote stations like Troll. Skiing, hiking in the mountains, running and shorter trips with snowmobiles and Band wagons are typical activities for the personnel at Troll. General and specific guidance provides the necessary safety/environmental measures and restrictions for recreational activities. In 2018 the use of a small recreational hut at Vassdalen was approved by The Ministry of Climate and Environment. The hut is around 25 square meters and is located 3,2 kilometers from Troll Station. The use of the hut calculated to 50 days a year with 2 guests on each visit. It is heated by a kerosene (Jet A-1) stove. The transport is mainly carried out with snow mobiles on a well-known route for the visitors. After a visit the garbage is transported back to environmental station at Troll.

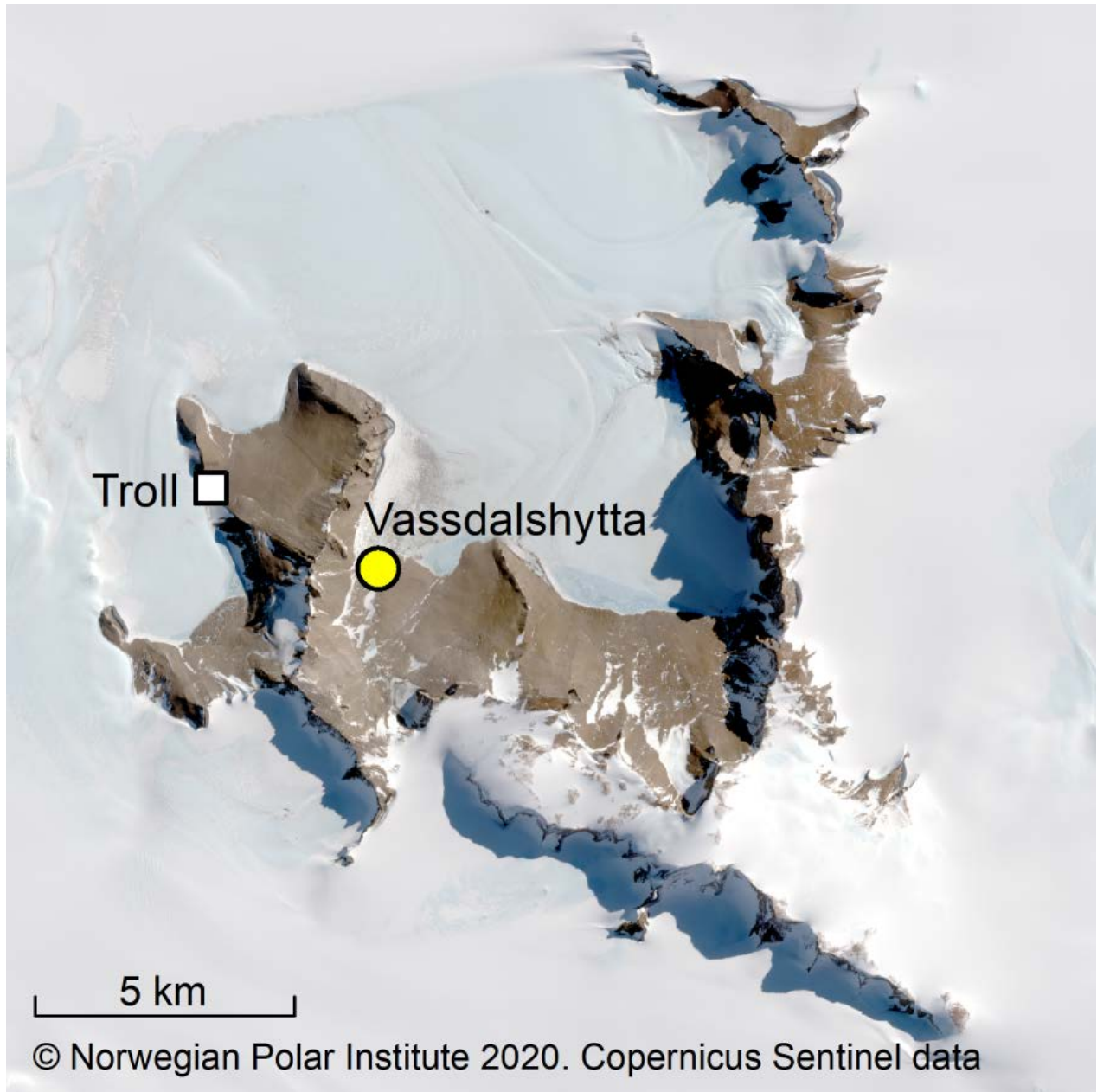


Figure 10: The location of the recreational hut in Vassdalen

Personnel at Troll could have a need from time to time to get away from the surroundings at Troll. The recreational hut and daytrips around Troll are considered adequate for such a purpose. For safety reason any longer trips should be avoided.

3.8.3 Impact

Recreational activity would be considered positive with little or no environmental impact. Use of fuel for vehicles and heating of huts would create pollution in form of exhaust gases. All wastes are brought back to Troll for further treatment.

4.0 TOR FIELD STATION

The station Tor is located at Svarthamaren nunatak, at 71°53'S, 5°10'E. Svarthamaren is an Antarctic Special Protected Area (ASPA 142) (See figure 11 for the station location).

Tor is NPI's only field station in Dronning Maud Land. The purpose of establishing Tor was maintaining the monitoring and research activities in the bird colonies at Svarthamaren (ASPA 142).

The vegetation at Svarthamaren is sparse compared to western parts of the Mühlig-Hofmanfjella. There is rich micro fauna consisting of mids (Eupodes angardi, Tydeus erebus), protozoa, nematodes and rotifers, as well as one insect species (Cryptopygus sverdrupi). No rare species have been identified.

There are large colonies of Antarctic petrel (*Thalassoica antarctica*), ab. 250.000 pairs (2018) in the northeastern slopes of the mountains. This is south of the area of the station. Additionally, there are 500-1000 breeding pairs of snow petrel (*Pagadroma nivea*) and approximately 50 pairs of south polar skua (*Catharacta maccormicki*). There are large numbers of non-breeding petrels and skuas located in the area. Wilson's storm petrel (*Oceanites oceanicus*) has been sighted near Tor on rare occasions.



Figure 11: Tor Field station (Photo: Sebastien Descamps / Norwegian Polar Institute, 2018)

4.1. Land use and footprint

4.1.1 Description

- The assessment covers land use and footprint considerations related to the infrastructure and operations at Tor.
- Tor station consists of a main building, and a small hut which is used for storage, a generator building and a field toilet. The Norwegian field station Tor is located on the edge of Svarthamaren nunatak at lat. 71°53'22"S, 5°9'34"E, immediately outside the protected area. All the buildings are constructed on gravel and rocks. The area used as shown on Figure 10.
- The aesthetic values in the station area have been somewhat diminished by the structures. However, the station as such is not very visible due its size. Being a remote station, the reduction of aesthetic values will mainly be of concern for the personnel/visitors at Tor.
- The wilderness values near Tor are high. The wilderness values are somewhat diminished due to infrastructure and noise, but due to low occupancy rate and limited activity the devaluation of the wilderness value is considered low.

4.1.2 Alternatives

Mobile field camps have been used during many large-scale field activities throughout Dronning Maud Land (e.g. operations at Fimbul Ice Shelf) and could be an alternative to fixed field camps. The monitoring and research operations in the Svarthamaren bird colonies are of such a scale that having a fixed field station is considered the best option.

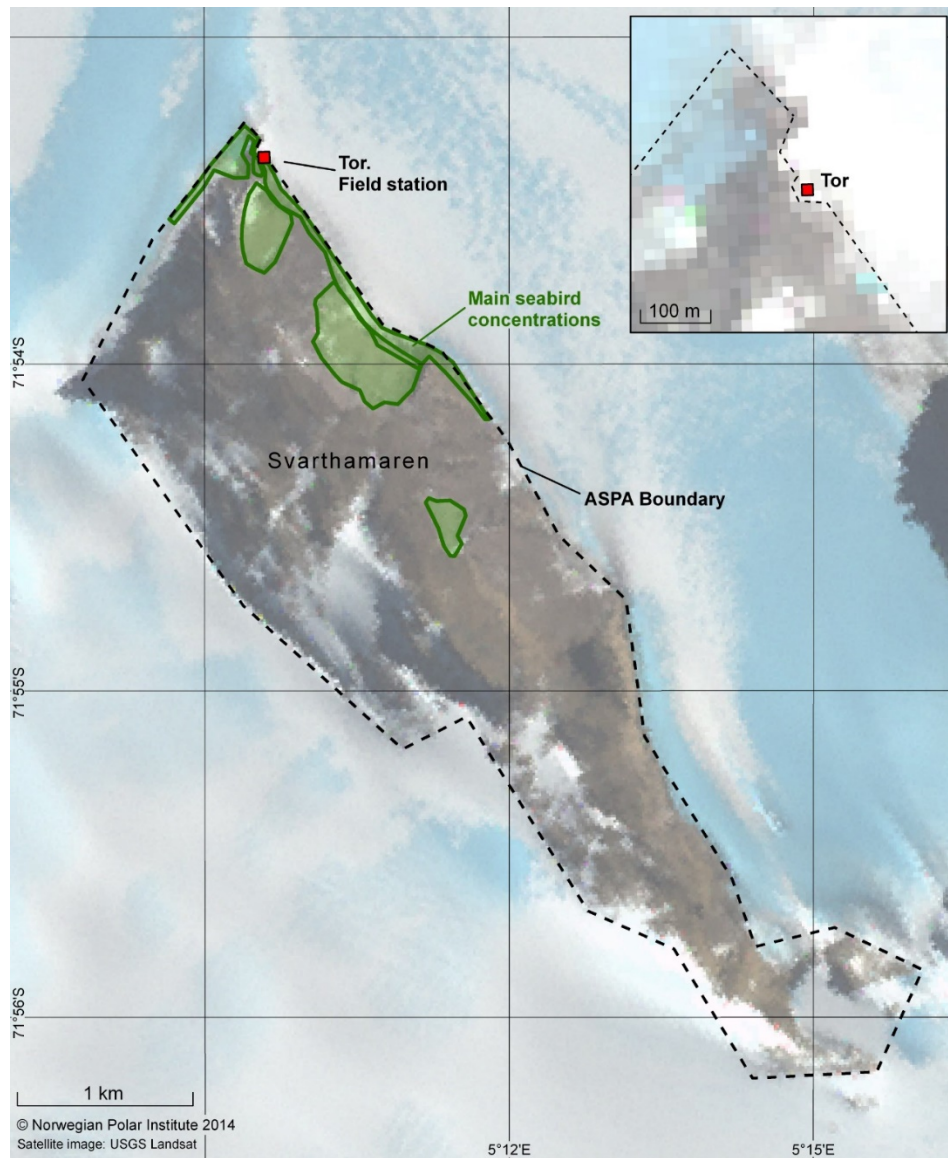


Figure 12: Svarthamaren – Antarctic Special Protected Area (ASP) 142 with placement of field station Tor. Field station Tor is not a part of the protected area (Norwegian Polar Institute 2014).

4.2 Waste at Tor field station

4.2.1 Description

- This assessment covers waste management resulting from normal day-to-day operations at Tor.
- Waste management at the stations is in accordance with national *Antarctic Environmental Regulations (2013)*. In short, this entails that all waste is collected, separated and brought out of Antarctica for appropriate disposal and recycling. The following elements of the waste management procedures should be noted:

- **Waste:** All waste, garbage, food waste, wastewater (in 200 liter barrels) and toilet waste is brought back to Troll station and shipped out of Antarctica for disposal.
- **Toilet system:** Tor station uses field toilets. All waste is brought back to Troll station and shipped in 200-liter drums out of Antarctica for disposal.
- **Waste responsibility:** The leader of the field activity is responsible for waste management at the field station. **Regulations relating to the protection of the environment and safety in Antarctica § 21.**
- NPI will ensure that waste management will fulfill the below minimum requirements and thereby be covered by this assessment. NPI will institute procedures to ensure compliance/implementation during operations:
 - **Disposal of waste:** All waste from Tor will be brought to Troll station for further treatment (cf. Troll Station Waste Procedures). All figures on amount and type will be recorded together with waste from Troll station on an annual basis when delivered to Cape Town, South Africa **Antarctic Environmental Regulations § 21. Environmental Protocol, Annex III, Article 4**
 - **Storage:** All waste to be removed will be stored in such a way to prevent their dispersal into the environment. **Environmental protocol, Annex III, Article 6, Regulations relating to the protection of the environment and safety in Antarctica §§ 21-23**
 - **Waste minimization:** The waste volume will be reduced by focusing on purchase, packing, reuse and recycling. **Environmental Protocol, Article 1**
 - **Packing:** All shredded paper, polystyrene beads, chips or similar forms of loose packaging will be replaced with bubble wrap, cardboard or paper as far as possible. **Environmental Protocol, Annex III, Article 2**
 - **Purchasing:** See chapter 9.1.
 - **Littering:** Storage will be constructed and maintained so that no littering will take place. In case of an accident or an unforeseen event all litter will be removed immediately.
 - **Training:** The person responsible for waste management, and other key personnel, will receive necessary training related to waste management issues. **Regulations relating to the protection of the environment and safety in Antarctica § 21**

4.2.2 Alternatives

Incineration of waste is a method used by several stations in Antarctica. NPI has concluded the best option is to bring all waste out of Antarctica and thereby minimizing harmful emissions. Incineration will not be a method used at Tor station. Use of open burning is not allowed in Antarctica **Environmental Protocol, Annex III, Article 3**

4.3 Fuel and hazardous substances at Tor station

- This assessment covers management of hazardous substances, including fuel, in the context of the normal day-to-day operations at Tor. All fuel is brought to Tor station in Jerry cans (20 liters) or drums (200 liters).
- NPI will ensure that management of hazardous substances will fulfill the below minimum requirements and thereby be covered by this assessment
 - **Spill avoidance.** When refueling vehicles, generator or refilling kerosene spill kits shall be available.
 - **Fuel storage:** Fuel will be stored so not unintentionally spill occurs.
 - **Spill handling:** All small and large fuel spills will be handled in accordance with routines specified in the Troll Station Regulations. In the event of an oil spill incident in excess of 200 liters (and for oil spills less than 200 liters, if considered significant) a full Oil Spill Report will be prepared.

4.4 Water use and foodstuff

Water for drinking, washing and cooking at Tor station is made from melting of snow or ice. Due to the high amount of birds in the vicinity of Tor, all drinking water must be boiled for disinfection. The use of local snow and ice are considered having little effect on the environment.

It is not allowed to bring any foodstuff containing traces of eggs, poultry meat or other articles originating from other bird species than those already present at Troll. This must be taken into planning of future fieldwork at Tor and Svarthamaren ASPA.

4.5 Energy use and electrical power

- This assessment covers power generation, in the context of the normal day-to-day station operations at Tor.
- Electricity is provided by 3 solar panels producing a total of 750W; and a battery bank consisting of 6 batteries and an inverter which delivers 240V for lighting and charging of electrical equipment.
- A Honda 4-stroke generator 2KW is available for backup. The generator runs on 95-octane petrol. Electrical power is only used for computers and electronic equipment; maximum estimated consumption of petrol is ab. 4 liters/day.

- Tor station uses propane gas for cooking, and Jet A-1 for heating of the 20' containers. There is no filtering of the combustion from the kerosene oven. The other building has no heating devices.

4.6 Impacts

Potential Environmental Impacts from operations at station Tor

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Combustion emission	<p>Air: Combustion gases released into the atmosphere can contribute to the greenhouse effect both directly and indirectly. However, in the overall emission picture (both in the Antarctic context and the global context) the contribution from the activity is relatively minor.</p> <p>Fauna: Soot and combustion products can be potentially harmful if birds get in direct contact with the substances. Although combustion products can affect birds (habitat and health), the exposure is limited due to low emission levels from Tor.</p> <p>Ingestion through food not likely due to marine diet. Inhalation low due to distance from source. Exposure could in the long run affect respiratory system and other vital functions (see e.g. Maniero (1996)).</p>	<p>Extent: Local Duration: Short Significance: Low</p>	<p>Technology: Use of solar energy for the running of computers and electrical equipment is reducing the need for fuel. Well maintained generators and equipment will be used, and generators will not be left idling unnecessary. High energy efficient fuel will be used.</p> <p>Reduction: Continued use of alternative energy sources such as sun energy, see figure 9.</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Emission to ground	<p>Ground: Fuel spills can be released into the ground during filling or operation. The fuels used are relatively volatile and a large portion of a spill is likely to evaporate instead of migrating into ice/ground. Contaminants that migrate into the ice will be encapsulated and remain in the ice for an indefinite period. Impacts at release time depend on point of release but could affect biota or quality of receiving environment. Such spills will contribute to overall contamination of environment and may have bearings on future ice related research. No ice related research is currently ongoing in the area.</p> <p>Fauna: Fuel spills may occur and could produce numerous health concerns to any animal that comes into direct or indirect contact with the substance. Birds and humans that come in direct physical contact with the chemicals can suffer skin and eye lesions or chemical burns. Fuel spills at Tor have so far been few and small due to proper handling routines, and exposure is expected to be small with little impact.</p>	<p>Extent: Local Duration: Long Significance: Low</p>	<p>Avoidance: Spill equipment will be used during filling operations. Procedures for cleaning fuel and oil spills is following Troll Station Waste Procedures. All fuel spills on ice and snow shall be taken back to Troll Station for further treatment.</p>
Littering	<p>Waste littering. Waste could be spread in adverse weather, or if waste is inadequately handled or secured. Associated impacts are mainly of an aesthetic nature. Break-down of litter is slow, and litter will remain. Contributes to overall contamination of environment.</p>	<p>Extent: Local Duration: Short Significance: Low</p>	<p>Avoidance: Procedures to ensure that littering is avoided and that all litter is taken care of immediately will be instituted. All waste is brought back to Troll Station for further treatment.</p> <p>Handling: If unintentionally littering happens action will be taken to collect litter as soon as possible.</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Noise	<p>Fauna: Noise from helicopters or vehicles could disturb and chase away breeding birds. Noise from operating vehicles in the station area could affect breeding birds. Noise may disturb birds in a manner so that they leave their nests (and expose eggs/chicks to environment and predators), raise stress level and increase metabolism, all which could affect the fine-tuned balance of energy intake and energy use (see e.g. CAFF (1998) and Giese and Riddle (1999)).</p> <p>It is expected that the limited exposure to output will be too low for any significant impact.</p>	<p>Extent: Local Duration: Short Significance: High</p>	<p>Vehicle/aircraft control: Driving/flying will be limited to that which is necessary. CEP guidelines for the operation of Aircraft near concentrations of birds in Antarctica²⁰ will be used as guidance.</p> <p>Education: Field party shall receive adequate environmental information</p>
Non-native organisms and disease	<p>All equipment brought into Antarctica can transfer non-native species. It is to be expected that establishment of non-native species will only be possible for those species that can tolerate the conditions of the Antarctic environment. Human activity can be the cause of disease outbreaks, bringing pathogens unintentionally into Antarctica. So far few, if any, disease outbreaks are however known to have been introduced to Antarctica as a result of human activity. Disease could be detrimental to populations (Hughes, Kevin A.; Convey, Pete. 2010, Knowles et al., 1999 and Gardner et al., 1997).</p>	<p>Extent: Local Duration: Short Significance: Medium</p>	<p>Avoidance: Food wastes will be stored in a secure manner, disallowing littering into the environment. Poultry products and eggs from species other than those already occurring in the Svarthamaren is strictly forbidden to avoid diseases.</p> <p>Relevant material in the Non-native Species Manual will be used as guidance, e.g. the "Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species" developed by COMNAP/SCAR (2011).</p>

²⁰ Cf. ATCM Resolution 2 (2004), available at http://www.ats.aq/documents/recatt/Att224_e.pdf

5.0 FIELD CAMPS

Field camps are likely to be established for shorter or longer periods when research is performed outside Troll and/or Tor stations.

Field camps can be placed on ice, snow or gravel/rock surfaces depending on the area where the field work will be conducted. Due to different locations and environmental conditions, remote field activities will require submission of a separate Initial Environmental Evaluation (IEE)²¹, and only the general aspects of field camps are covered in this assessment.



Figure 13: 2007-2009 Norway – USA Scientific traverse (Troll – South Pole return). Photo: Norwegian Polar Institute

5.1. Land use and footprint

Field camps often consist of module containers which provide shelter for personnel and facilities for cooking and dining.

²¹ Environmental Protocol, Annex I, Article 2; Regulations relating to the protection of the environment and safety in Antarctica § 16

The area extent used in these camps is quite limited, and most often the camps are established on snow or ice surface.

Field camps are temporary in nature, and as such requires no permanent land use and leaves no permanent footprint.

5.2 Waste from field camps

This assessment covers waste management resulting from normal day-to-day operations at field camps established by NPI.

- Waste management at the camps are in accordance with Norwegian national regulations relating to the protection of the environment and safety in Antarctica (2013) §§ 20-25. In short, this entails that all waste, including wastewater, is collected, separated and brought out of Antarctica for appropriate disposal and recycling. The following elements of the waste management procedures should be noted:
 - **Waste:** All waste, garbage, food waste, wastewater and human waste will be brought back to Troll station and shipped out of Antarctica for disposal.
 - **Toilet system:** In field camps field toilets are used. All toilet waste is brought back to Troll or Troll Cargo point and shipped out of Antarctica for disposal.
 - **Waste responsibility:** Leader of the field activity is responsible for waste management in field camps. **Regulations relating to the protection of the environment and safety in Antarctica §25.**
- NPI will ensure that waste management will fulfill the below minimum requirements and thereby be covered by this assessment:
 - **Disposal of waste:** All waste from field camps will be transported to Troll for further treatment. Grey water could be filtered through the sewage system in main building at Troll. (cf. **Troll Station Waste Procedures**).
 - **Storage:** All waste to be removed will be stored in locked containers to prevent their dispersal into the environment. The waste will be secured to prevent flying debris. **Environmental protocol, Annex III, Article 6, Regulations relating to the protection of the environment and safety in Antarctica § 23.**
 - **Waste minimization:** The waste volume will be reduced by focusing on purchase, packing, reuse and recycling. **Environmental Protocol, Annex III, Article 1, point 2.**
 - **Packing:** All shredded paper, polystyrene beads, chips or similar forms of loose packaging will be replaced with bubble wrap, cardboard or

paper as far as possible. **Environmental Protocol, Annex III, Article 7, Regulations relating to the protection of the environment and safety in Antarctica § 22.**

- **Purchasing:** See chapter 9.1.
- **Littering:** All litter will be recovered immediately and handled in accordance with given procedures (**cf. Troll Station Waste Procedures**)
- **Training:** The person responsible for waste management (i.e. leader of the field activity) and other key personnel will receive necessary training related to waste management issues. This is part of the training program for the embarking over-winter team²². **Regulations relating to the protection of the environment and safety in Antarctica § 25**

5.3 Fuel in field camps

- This assessment covers management of hazardous substances, including fuel, in the context of the normal day-to-day operations of field camps.
- Fuel in field camps is mainly for generators and vehicles. Depending on what kind of project and the size of the expedition, the amount and type of fuel will vary. All fuel in field camps is brought in Jerry cans (20 liters) or drums (200 liters).
- NPI will ensure that management of hazardous substances will fulfill the below minimum requirements and thereby be covered by this assessment
 - **Spill avoidance:** When refueling vehicles or generators, spill kits shall be available. Fuel will be stored to limit unintentional spills.
 - **Spill handling:** All small and large fuel spills will be handled in accordance with routines specified in the Procedure: BEREDSKAPSPLAN FOR AKUTT FORURENSNING (NPI 2013 in Norwegian). In the event of an oil spill incident in excess of 200 liters (and for oil spills less than 200 liters, if considered significant) a full Oil Spill Report will be prepared.

5.4 Water use

Water for drinking, washing and cooking in field camps is made from melted snow or ice. Melting for water is done on kerosene (Jet A-1) or a gas stove.

5.5 Energy use and electrical power

- This assessment covers power generation, in the context of the normal day-to-day field camp operations.
- Normally electricity is produced from portable generators. The generator runs on 95-octane petrol or jet A-1. Electric power is only used for computers and electronic

²² Opplæring(2019)NPI Environmental Education (nilsen v1_2019) Presentation in Norwegian

equipment. Field camps uses propane gas or kerosene/Jet A-1 for cooking, and Jet A-1 for heating of the living quarters (container). There is no filtering of the combustion from the kerosene oven. Tents normally have no heating devices.

5.6 Impacts

Potential Environmental Impacts from operations at field camps.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Combustion emission	<p>Air: Combustion gases released into the atmosphere can contribute to the greenhouse effect both directly and indirectly. However, in the overall emission picture (both in the Antarctic context and the global context) the contribution from the activity is minor.</p> <p>Fauna: Soot and combustion products can be potentially harmful if animals get in direct contact with the substances. Although combustion products can affect animals (habitat and health), the exposure is limited due to low emission levels from field camps</p>	<p>Extent: Local Duration: Short Significance: Low</p>	<p>Technology: Well-maintained 4-stroke generators and equipment will be used, and generators will not be left idling unnecessary. High energy efficient fuel will be used. Continued consideration will be given to potential mechanisms to cleansing of combustion gases.</p>
Emission to ground	<p>Ground: Fuel spills can be released into the ground during filling or operation. The fuels used are relatively volatile and a large portion of a spill is likely to evaporate instead of migrating into ice/ground. Contaminants that migrate into the ice will be encapsulated and remain in the ice for an indefinite period. Impacts at release time depend on point of release but could affect biota or quality of receiving environment. Such spills will contribute to overall contamination of environment and may have bearings on future ice related research.</p> <p>Fauna: Fuel spills may occur and could produce numerous health concerns to any animal that comes into direct or indirect contact with the substance. Animals and humans that come in direct physical contact with the chemicals can suffer skin and eye lesions or chemical burns. Fuel spills in field camps have so far been few and small due to proper handling routines, and exposure is expected to be small with little impact.</p>	<p>Extent: Local Duration: long Significance: Low</p>	<p>Avoidance: Spill equipment will be available during filling operations. Procedures will be instituted: BEREDSKAPSPLAN FOR AKUTT FORURENSNING (NPI 2013 in Norwegian)</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Littering	<p>Waste littering: Waste could be spread in adverse weather, or if waste is inadequately handled or secured. Littering causes pollution, and could be harmful to animals, in addition to detract the aesthetic quality of the Antarctic environment.</p>	<p>Extent: Local Duration: Short Significance: Low</p>	<p>Avoidance: Procedures to ensure that littering is avoided and that all litter is taken care of immediately will be instituted and be part of operational procedures in field camps.</p> <p>Handling: If unintentionally littering happens action will be taken to collect litter as soon as possible.</p>
Noise	<p>Fauna: Noise from helicopters or vehicles could disturb and chase away animals. Noise may disturb birds in a manner so that they leave their nests (and expose eggs/chicks to environment and predators), raise stress level and increase metabolism, all which could affect the fine-tuned balance of energy intake and energy use (see e.g. CAFF (1998) and Giese and Riddle (1999)).</p> <p>It is expected that the limited exposure to output will be too low for any significant impact.</p>	<p>Probability: Low Extent: Local Duration: Short Significance: High</p>	<p>Vehicle/aircraft control: Driving/flying will be limited to that which is necessary. CEP guidelines for the operation of Aircraft near concentrations of birds in Antarctica will be used as guidance.</p> <p>Education: Field parties shall receive adequate environmental information</p>

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Non-native organisms and disease	All equipment brought into Antarctica can transfer non-native species. It is to be expected that establishment of non-native species will only be possible in those species that can tolerate the conditions of the Antarctic environment. Human activity can be the cause of disease outbreaks, bringing pathogens unintentionally into Antarctica. So far few, if any, disease outbreaks are however known to have been introduced to Antarctica as a result of human activity. Disease could be detrimental to populations (Hughes, Kevin A.; Convey, Pete. 2010 Knowles et al., 1999 and Gardner et al., 1997). In order to prevent unintentional disease outbreaks and spread of non-native organisms and diseases, all travelers to Troll are sent the document "Don't Pack a Pest" from IAATO before they travel to Troll. A reference to the brochure "Checklists for supply chain managers for the National Antarctic Programmes for the reduction in risk of transfer of non-native species" will be made available.	Extent: Local Duration: Short Significance: Medium to High	Avoidance: Food wastes will be stored in a secure manner, disallowing littering into the environment. Special care will be given to poultry or other foodstuff that has a potential to inflict diseases to birdlife in the region. Procedures will be instituted and be part of operational procedures in field camps. Relevant material in the Non-native Species Manual will be used as guidance, e.g. the "Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species" developed by COMNAP/SCAR (2011).

6.0 MARINE VESSEL SUPPLY OPERATIONS

6.1 Description

- The activity consists of normal vessel operations associated with transport of equipment/personnel.
- The Norwegian Polar Institute's marine operations normally take place in the South Atlantic sector of the Southern Ocean, in the area between South Africa and Dronning Maud Land. The area of interest is illustrated in Figure 6.

- The marine operations normally take place in the period primo December to primo March when the ice conditions are considered the least complicated. Ice conditions will generally be no worse than occurrence of broken up 1-year sea ice.
- Currently NPI charters a ship (in DROMSHIP²³ context) for cargo. For the period 2018 – 2028 a contract has been drawn up with Royal Arctic Line (Denmark). Other charters may be contracted after this contract has been terminated.
- The contract between the ship owner and Norwegian Polar Institute ensures that Norwegian law and all relevant international obligations made by the Norwegian State are followed.
- NPI will ensure that any vessel chartered by NPI or used by NPI in its operations will fulfill the below minimum requirements and thereby be covered by this assessment. If these requirements are not followed during operation, it will be regarded as a breach of contract. NPI will institute procedures²⁴ to ensure vessel compliance/implementation during operations, preferably through onboard representation during the operation:
 - **Vessel type:** Vessels used during Norwegian operations are classified as cargo ships and/or research vessels suitable for polar operations. They follow the International maritime Organization (IMO)'s International Code for Ships Operating in Polar Waters (Polar code) under the International Convention for the Safety of Life at Sea (SOLAS) and the International Convention for the Prevention of Pollution from Ships (MARPOL).
 - **Vessel flag:** NPI strives to charter vessels flagged by IMO states in order to ensure compliance with IMO regulatory framework aiming at protecting the environment. If this is not possible the Norwegian Polar Institute will oblige the vessel owners through the contract to see that relevant provisions in the following agreements are fulfilled:
 - SOLAS
 - MARPOL
 - Other relevant conventions, protocols, codes and recommendations adopted by IMO
 - **Ice class:** Vessels shall be ice strengthened and certified in accordance with the Polar Code. The vessels are to be classified to a minimum of DNV ICE 1A Super or similar for operations in severe ice conditions.
 - **Fuel type:** No heavy fuel oils will be *used* or *carried* onboard the vessels south of 60°S. **Amendment to MARPOL Annex I (Regulations for the prevention of**

²³ The Dronning Maud Land Shipping network (DROMSHIP) is a non-profit, international co-operation formed by the national Antarctic operators of Norway, Germany, Belgium, Finland and Sweden to arrange joint ship transport in support of their Antarctic operations

²⁴ Sailing instructions, MV Mary Arctica 2019- 20, NPI

pollution by oil) on Special requirements for the use or carriage of oils in the Antarctic area²⁵. MGO or similar light marine diesel fuel with reduced sulfur content will be utilized. **MARPOL Annex VI Regulations for the Prevention of Air Pollution from Ships²⁶.**

- **Design:** NPI will charter vessels as described in IMO guidelines for ship operating in polar waters (Polar Code).
- **Ballast water:** In order to maintain ship stability ballast water may be taken onboard to compensate for fuel used and cargo unloaded. All ballast water exchange shall be conducted in accordance with adopted Antarctic Treaty system guidelines (**ATCM Resolution 3 (2006) on Ballast Water Exchange²⁷**).
- **Garbage:** No garbage will be disposed into the sea in Antarctica (south of 60°S). No waste will, unless it cannot be avoided due to unexpected circumstances, be disposed into the sea north of 60°S. Food waste might, if no option for storage exists, be disposed into the sea, although no closer than 12 nautical miles of land or ice shelf, and only after being passed through a comminutor or a grinder²⁸. The vessels utilized shall have sufficient capacity to store waste (with possible exception of food waste) while operating in the area, and there shall be arrangements for transfer of such waste to appropriate reception facilities.

Annex VI to the Environmental Protocol, article 5 and 9.

- **Sewage:** Sewage will not be discharged into the sea within 12 nautical miles of land or ice shelves. Sewage which is discharged beyond this distance shall only be discharged gradually while the ship is maintaining a speed of at least 4 knots.

Annex VI to the Environmental Protocol, article 6.

- **Air Pollution:** No incineration of the following products will take place: PCBs, waste with traces of heavy metals, refined petroleum products with halogen compounds or PVC products. **MARPOL Annex VI Regulations for the Prevention of Air Pollution from Ships²⁹**
- **Oil Pollution:** No oil-contaminated water will be discharged into the sea south of 60°S. **MARPOL Annex I on Regulations for the Prevention of Pollution by Oil³⁰**
- **Anti-fouling Paint:** Only non-toxic antifouling paint will be used on vessels contracted by NPI. The international convention on the control of harmful antifouling

²⁵ The amendment prohibits the carriage, in bulk as cargo, or carriage and use as fuel, of: crude oils having a density, at 15°C, higher than 900 kg/m³; oils, other than crude oils, having a density, at 15°C, higher than 900 kg/m³ or a kinematic viscosity, at 50°C, higher than 180 mm²/s; or bitumen, tar and their emulsions

²⁶ Cf. Regulation 14 on Sulphur Oxides (SO_x)

²⁷ http://www.ats.aq/documents/recatt/att345_e.pdf

²⁸ MARPOL Annex V www.imo.org

²⁹ Cf. Regulation 16 on Shipboard Incineration

³⁰ Cf. Regulation 15 B on Control of discharge of oil in special areas

systems on ships, are banning globally both the application and presence on ships hulls of TBT-based antifouling. NPI will ask for documentation that non-toxic antifouling is used in the vessels contracted.³¹

- **Noxious substances:** No noxious substances carried in packages (marine pollutants according to the IMDG code) will be disposed into the sea. **MARPOL Annex II on Regulations for the Prevention of Pollution by Noxious Liquid Substances in Bulk**³²
- **Contingency plans and environmental procedures training:** Vessels utilized shall have in place reasonable preventative measures that are designed to reduce the risk of environmental emergencies and their potential adverse impact, i.e. equipment, procedures, training. **Regulations relating to the protection of the environment and safety in Antarctica § 10, Annex IV to the Environmental Protocol**³³. Vessels shall have available Antarctic specific contingency plans for responses to incidents with potential adverse impacts on the Antarctic environment, normally as an addition to the ship oil pollution emergency plan (SOPEP) plan that the vessel normally will carry **MARPOL Annex I on Regulations for the Prevention of Pollution by Oil**³⁴
- **Information to the crew:** The crew members on the ships contracted by Norwegian Polar Institute will receive adequate environmental information before travelling into Antarctic waters.
- **Fuel handling at ice shelf:** In order to reduce oil spills during loading of fuel at the ice shelf, all handling of fuel should be made onboard the ship into large tanks or barrels. No use of pipelines from the ship to ice shelf will be utilized during Norwegian Polar Institute operations.

6.2 Alternatives

- Not using vessel for the national Antarctic supply operations is not considered a viable alternative if Norway is to continue to conduct its program in Antarctica. Supply operations are required for transportation of equipment for the research station Troll and other terrestrial operations. Cooperation with other countries operating in Dronning Maud Land will be strived for in order to see that vessel operations are conducted in an efficient manner.

³¹ Sailing instructions, MV Mary Arctica 2019- 20 pp 4-5

³² Cf. Regulation 13, point 8 on Discharges in the Antarctic Area

³³ Cf. Article 12

³⁴ Cf. Article 37

- Other timing of marine operations will increase the risk of accidents and emergency situations due to higher risk of incidents in ice covered waters. This is not considered a viable alternative.

6.3 Impacts

The table indicates potential impacts and provide a summary of measures that will be instituted to minimize these impacts.

Potential Environmental Impacts from vessel operations

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Combustion emission	Combustion gases released into the atmosphere can contribute to the greenhouse effect both directly and indirectly. Operations can vary from 60 to 150 days between years. However, in the overall emission picture (both in the Antarctic context and the global context) the contribution from the activity is relatively minor.	Extent: Local to global Duration: Periodical Impact: Low	<ul style="list-style-type: none"> • Use of “clean” fuels. • Shared logistics will minimize total emission in area. Continue co-operation within DROMSHIP.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Fuel spill and chemicals	Fuel spills may occur and could produce numerous health concerns to any animal that comes into direct or indirect contact with the substance. Mammals (whales, fur seals), reptiles (sea turtles), and various species of birds that come in direct physical contact with the chemicals can suffer skin and eye lesions or chemical burns. Fish and other invertebrates may experience fin erosion in addition to other ailments. Direct ingestion by any wildlife species commonly results in ulcers, organ damage, immune deficiency, and reproductive failure. Toxic waste and chemicals could have high impact on living organisms in Polar regions.	Probability: Nil to very low Duration: Periodical Impact: Medium	<ul style="list-style-type: none"> Oil spill contingency plans and equipment and training (cf. vessel requirements). Use of environmentally friendly ship coating/paint. Minimum class ICE-1A (or corresponding). Navigation equipment appropriate to the circumstances to reduce the risk of failure. Emergency equipment adapted for use in cold climates. Ship should have the capability to contain and clean up minor deck and over side spills. Documented expertise / experience in sailing in ice-filled waters. Strive to charter boats with double hull. Use of light marine diesel oils (spills will in these cases likely disperse fairly quickly due to wave and wind action).
Waste	Waste spill may occur due to adverse weather or an accident. This could have great consequences for sea mammals and birdlife of the region. Birds and animals are subjected to pollution, strangulation or starvation due to this kind of pollution	Extent: Local to regional Duration: Periodical Impact: Medium	<ul style="list-style-type: none"> - Securing waste in locked containers. - No garbage to be discharged from the ship. - Food waste to be discharged no closer than 12 nautical miles from shore or ice shelf. - Sewage will not be discharged closer than 12 nautical miles from shore or ice shelf.
Noise	Disturbance due to load noise/sounds has shown to have an adverse effect on breeding birds and sea mammals. This is mostly due to exposing eggs and small chicks/cubs to predators when the adult individuals are scared off their territories. Juvenile birds and eggs are likely to freeze to death due to the harsh conditions in Antarctic waters.	Extent: Local to global Duration: Periodical Impact: Medium	<ul style="list-style-type: none"> - The use of sirens, fog horns, load radio communication or other form of unnatural load noise/sounds should not occur near sea mammals and seabirds.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Light	<p>Birds attracted to ships by light can be injured or risks oiling by emissions from cranes and wires etc.</p> <p>Due to light conditions in the area during relevant operating season this impact is not an immediate concern for the activity described in this document.</p>	<p>Extent: Local</p> <p>Duration: Periodical</p> <p>Impact: Low</p>	<ul style="list-style-type: none"> - The use of light when operating in darkness/dusk should be made with caution. This applies to attracting birds and sea mammals to the ship during darkness.³⁵ - Record all incidents of bird strikes through appropriate internal reporting mechanisms. Consideration might be given to training programmes for members of the ship's crew to deal with bird strikes. - Institute appropriate cautionary procedures if there is an increase in observed incidents involving bird strikes.
Non-native organisms and disease	<p>In the case of ships, introductions may take place via ballast water exchange or by fouling of the hull and sea chests (recessed intake areas for seawater used in the ship's operation). The physiology of typical fouling organisms from various parts of the world is a neglected research area.</p> <p>The only non-native marine species that are likely to become established are those that can tolerate Antarctic conditions. However, since many marine environments are similar, e.g., in terms of temperature and salinity, the possibility must be taken seriously.</p>	<p>Extent: Local to regional</p> <p>Duration: Long</p> <p>Impact: Medium to high</p>	<p>Hull fouling will be cleaned from mussels and other alien species attached to cavities in the construction before entering Antarctic waters. (i.e. Sailing instructions, MV Mary Arctica 2019- 20 or similar for other contracted ships)</p> <p>Measures will be taken to avoid spreading alien species from north to south. Special attention will be given to ships operating in Arctic oceans not to spread species that could survive in Antarctic waters.</p> <p>Ballast water exchange in accordance with guidance in ballast water guidelines. (RESOLUTION MEPC.163(56) (2007) GUIDELINES FOR BALLAST WATER EXCHANGE IN THE ANTARCTIC TREATY AREA)</p>

³⁵ http://www.ats.aq/documents/ATCM33/wp/ATCM33_wp012_e.doc

7.0 AIRCRAFT, HELICOPTER AND RPAS OPERATIONS

7.1 Aircraft operations

7.1.1 Description

- The assessment covers aircraft operations for the purpose of transport of personnel and equipment to/from the continent, normally to Troll airfield. Novolazarevskaya (Russia)³⁶ is the backup airfield for Norwegian operations and part of the Dromlan network. Novolazarevskaya operations is not covered by this EIA.
- The assessment further covers helicopter operations for the purpose of transport of equipment to/from supply vessel, for transport of research parties to field operations and for implementing fieldwork in areas where ground transport is difficult or dangerous.
- When aircraft or helicopters are to be used as a main component in field activities or construction work this activity should be covered by the environmental assessment required for the project. If on-going projects are hindered by dangerous conditions due to ice crevasses or similar, use of helicopter can be a part of the transport to maintain personnel health and safety at the highest level possible. The route chosen must follow procedures stated in the Antarctic Flight Information Manual (AFIM) and be in accordance with helicopter guidelines for Antarctica, *"Guidelines for the Operation of Aircraft near Concentrations of Birds in Antarctica"*.³⁷
- Flight operations normally take place during late October/early November to late February/early March. Flights outside this period will only be considered if an emergency situation occurs, this due to lack of SAR capacity in the area and adverse climate/weather conditions.
- NPI charters air support directly to Troll Airfield or through the DROMLAN network. The contract between with the aircraft operators and Norwegian Polar Institute ensures that all relevant national and international obligations made by the Norwegian State are met.
- All flights between Cape Town and Troll Airfield are well planned in due time before the start of the season to avoid unnecessary traffic.

³⁶ These two airfields are part of a hub connecting the other international research stations in Dronning Maud Land. These are part of the DROMLAN "Dronning Maud Land Air Network Project" cooperation.

³⁷ http://www.ats.aq/documents/recatt/Att224_e.pdf

- NPI will ensure that any aircraft chartered by NPI or used by NPI in its operations will fulfill the below minimum requirements and thereby be covered by this assessment. If these requirements are not followed during operation, it will be regarded as a breach of contract. NPI will institute procedures to ensure aircraft compliance/implementation during operations:
 - **Aircraft type:** Aircrafts used during Norwegian operations are suitable for polar operations.
 - **Emission to air:** Combustion gases will be reduced to a minimum by using latest possible technology in aviation, i.e. engines, propellers and turbines to the greatest extent possible.
 - **Noise:** The noise level will be minimized by using modern aircrafts with less noise and by flying at altitudes that ensures no disturbance on bird, animals or personnel.
 - **Protected areas:** No aircraft will land in a protected area unless special permission has been granted. The only Antarctic Specially Protected Area located in the area of normal Norwegian operations is ASPA No. 142 (Svarthamaren). No flying of aircraft is allowed over, and no landings are allowed within the boundaries of this area³⁸.
 - **General flight conduct:** All flights will be conducted in accordance with Guidelines for the operation of aircraft near concentration of birds in Antarctica³⁹. Flights in the vicinity of seabird colonies or congregations of mammals will be avoided.
 - **On-ground facilities:** All on-ground infrastructures in Antarctica utilized by aircraft operators/supporters shall be run in accordance with the **Protocol on Environmental Protection to the Antarctic Treaty**.
 - **Risk reduction:** To reduce the risk of aircraft accidents the pilots should have experience from operating in polar regions or similar conditions. All air operations to/from and within Antarctica should follow international safety demands (i.e. the International Civil Aviation Organization (ICAO)) and follow procedures stated in the Antarctic Flight Information Manual (AFIM)⁴⁰.
 - **Contingency plans and environmental procedures training:** Air operators shall have in place reasonable preventative measures that are designed to reduce the risk of environmental emergencies and their potential adverse impact, i.e. equipment, procedures, training.

³⁸ Management plan (2019) available at https://documents.ats.aq/recatt/att650_e.pdf

³⁹ ATCM Resolution 2 (2004), available at http://www.ats.aq/documents/recatt/Att224_e.pdf.

⁴⁰ Published by COMNAP as a tool towards safe air operations in Antarctica as per Antarctic Treaty Consultative Meeting (ATCM) recommendation XV-20 (Paris 1989)

- **Environmental information:** Crew members shall receive adequate environmental information before entering Antarctic air space.
- **RPAS (Remotely Piloted Aircraft Systems) in Dronning Maud Land**
 If RPAS (drones) are used within the Troll Core Area as defined by Troll Land Use Plan it should be done in cooperation with operations coordinator or expedition leader to ensure that the flight planned does not interfere with wildlife concentrations (100 meters from bird colonies⁴¹), human activity nor operation of vital instruments. It should also be assured that all use of drones within the Troll Core Area are operated as VLOS - Visual Line of Sight, this means the pilot should have visual contact with the RPAS at all times of the operation and height above ground should not exceed 120 meters. The RPAS's used in Antarctica should have a GPS/tracking device to ensure recovery of environmentally dangerous materials as batteries and plastics if for some reason the operations fails.
 RPAS could be used for inspection of infrastructure, buildings and constructions, and for dissemination measures in purpose of showing Norwegian activities at Troll and in Antarctica.
 RPAS could also be used for safety purposes to register and identify dangerous crevices on the traverse to Sledeneset or other operations on glaciers and ice shelves. This use must not conflict with animal concentrations or disturb wildlife in any sense. Operation should be performed as VLOS – Visual Line of Sight and height above ground should not exceed 120 meters.
 For safety reasons shall RPAS not be operated outside Troll station area closer than 5 Kms from Troll Airfield, if drones are used for safety reasons at the airport (inspection of runway etc.), operations should be cleared by the operations coordinator or expedition leader ahead of operating the RPAS.
 Use of larger drones BLOS – Beyond Line of Sight must be assessed by an Initial Environmental Evaluation 1-one year ahead of the operation.⁴²
 Use of RPAS within the borders of an ASPA (Antarctic Special Protected Area) is not allowed.

⁴¹ State of knowledge of Wildlife Responses to Remotely Piloted Aircraft Systems (RPAS), SCAR, ATCM 13, CEP 10c (2017)

⁴² §9 Duty to give notice of activity in Antarctica <https://www.regjeringen.no/en/dokumenter/protection-environment-safety-antarctica/id724506/>

7.1.2 Alternatives

7.1.2.1 Not using aircraft, helicopters or RPAS for operations

Up until the 2000-2001 season, Norwegian operations relied solely on seaborne transport of personnel. Since the 2008-2009 season all personnel transport has been airborne, arranged through the DROMLAN Network. In future only personnel doing marine research or research along the ice sheet can reasonably be transported by vessel. The flexibility gained by using aircraft is considered essential. Air transport reduces the length of time personnel are on site, thus limiting the pressure on the stations and the surrounding environment. Efficient transport to and from the continent reduces the amount of time personnel are unable to carry out their ordinary duties. Efficient transport within the continent means that less time and fewer resources are spent on ground transport of personnel to and from the place of arrival/departure. Flexibility as to when the personnel arrive on the continent helps accommodate the needs of research projects, and that personnel do not have to spend more time on the continent than necessary.

Flying personnel to the continent entails less combustion than if they are transported by ship. International cooperation to coordinate transport of equipment on a single vessel per season also reduces the total combustion for all operations in Dronning Maud Land.

RPAS are since 2014 used as a tool by the national Antarctic programs in support of science, logistics and operations. They are low-cost platforms that can dramatically reduce the use of personnel aircraft and land-based vehicles. Use of RPAS could reduce the use of fossil fuels and in some cases reduce risk for injuries in human personnel in the Antarctic Treaty area. The RPAS in use today are typically electrically powered, are low decibel and reduce environmental impact from activities that would otherwise be carried out using manned aircraft or vehicles.

7.1.2.2 Different temporal framework

A different timing of flight operations would increase the risk of accidents and emergency situations due to difficult flight conditions. Moreover, the discussion in the previous paragraph shows that timing issues generally favour flying over seaborne transport. This is not considered a viable alternative⁴³.

7.1.2.3 Different geographic region

Norway's primary research interests in Antarctica have traditionally been in the area around and in Dronning Maud Land. This is likely to continue to be the main area of focus. Increased Norwegian activity in marine research as in Kong Haakon VII Hav and research on tourism at the

⁴³ In 2008 one staff member was transported from Troll Airfield one month earlier than flights normally take place in Dronning Maud Land. This was due to an emergency situation.

Antarctic Peninsula could make use of both helicopter operations and RPAS. Aircraft and helicopter operations in other areas would not satisfy the national strategy for Antarctic research. In certain cooperative projects with other nations outside Dronning Maud Land, NPI has used aircraft operations for transporting equipment and personnel (i.e. IPY 2007-2008). This could also be considered likely in the future.

7.2 Troll Airfield operations

- During the period 2011-2019 an average of 6 Intercontinental flights were performed annually. In addition, on average, there were another 15 intra continental flights by smaller airplanes and helicopters.
- The Troll Airfield was established in 2003. This was due to an increased need for several large runways in Dronning Maud Land. This improved aviation safety in the area and supported the increased activity at Troll Station. The timeframe for using the airfield is the austral summer October – March. The airfield is situated at the northern part of Jutulsessen Mountains at 71°57'42"S, 2°27'35"E. Closest ice-free area is approx. 6 km from the runway.
- The airfield is established to accommodate aircrafts operated by all the national programs in DML. Troll Airfield is used for direct flights between Cape Town and Troll and occasionally for flights with stopover at Novolazarevskaya. It is also a back-up runway for the runway at Novolazarevskaya which increases the safety for intercontinental flights.
- Due to its location Troll Airfield has been used as a base for scientific flights and there is an interest from several national programs to continue to use it in the future. A number of different aircraft types are able to utilize the Troll Airfield. Airplanes on both wheels and ski that do not need more than 3000 meters for landing are capable to utilize Troll Airfield. NPI will ensure that all aircraft that utilize Troll Airfield adhere to the same rules/requirements
- Approximately 10-15 intercontinental flights per season is the result of Troll Airfield becoming the primary hub for flights associated with the Norwegian Antarctic program. The number of intercontinental flights depends on how much through-traffic spins off the intercontinental traffic. This is likely to vary widely between flights and seasons.
- Fuel is stored in drums which are stored in 20-foot containers (40 drums per container) at Troll station and transported to the airfield when needed. The fuel is transferred from drums to a larger fuel tank as needed in preparation for intercontinental flights. For

intra continental flights, fuel is pumped directly from drums.

- Due to the proximity of Troll station there is only a minimal of ground facilities at the runway. Services necessary to operate the runway include a weather station and a couple of 20-foot containers containing a workshop, generator, equipment and fuel storage, as well as storage of emergency equipment in case of a mass casualty incident.
- For night and low light flight, the Troll airfield operates a Runway Lighting System.
- The airfield is supported by a CAT 5 fire truck manned by 4 firefighters. In addition, there are variety of fire extinguishers and an extra water tank at the airfield.
- There are oil spill kits available if needed.
- Due to the nearby location of Troll Station any accommodation and meals for transfer passengers will take place there. A Weatherhaven expandable MECC container acts as a passenger transit hall. The container is set up in 20 minutes.
- Transport to Troll Station is performed by 4WD car or by bandwagon depending on the amount of passengers/crew. The procedures during landing and take-off adhere to the current contingency plan for Troll Station⁴⁴.
- Runway grooming is done with a heavy-duty snow and ice grinder/blower. Several snow groomers are used for preparation and maintenance. Grooming of the airstrip adhere to the contingency plan for Troll Station.
- NPI will ensure that operation of the Troll Airfield will fulfill the below minimum requirements and thereby be covered by this assessment:
 - **Fuel handling:** No fueling of aircrafts or helicopters will normally take place outside Troll Airfield. Larger aircraft as refueled with a pressurized fuel system. Spill kits are available during operations if needed. The personnel at Troll station are responsible for refueling aircrafts at Troll airfield, and to ensure that the necessary precautionary and mitigation measures are taken during operations.
 - **Waste treatment:** All waste generated at the airfield will be secured and transported to Troll station for further treatment and storage.⁴⁵
 - **Tourism:** Troll Airfield will not be utilized for purposes other than governmental activities. NPI do not have the capacity or resources to support tourist activities and there are no plans or wishes to build such capacity in future. (i.e. the airfield will not be utilized for tourism and other non-governmental activities).

⁴⁴ Updated on an annual basis.

⁴⁵ Rutinebeskrivelse: Avfallshåndtering Troll Airfield (TAF) NPI 2019 (In Norwegian)

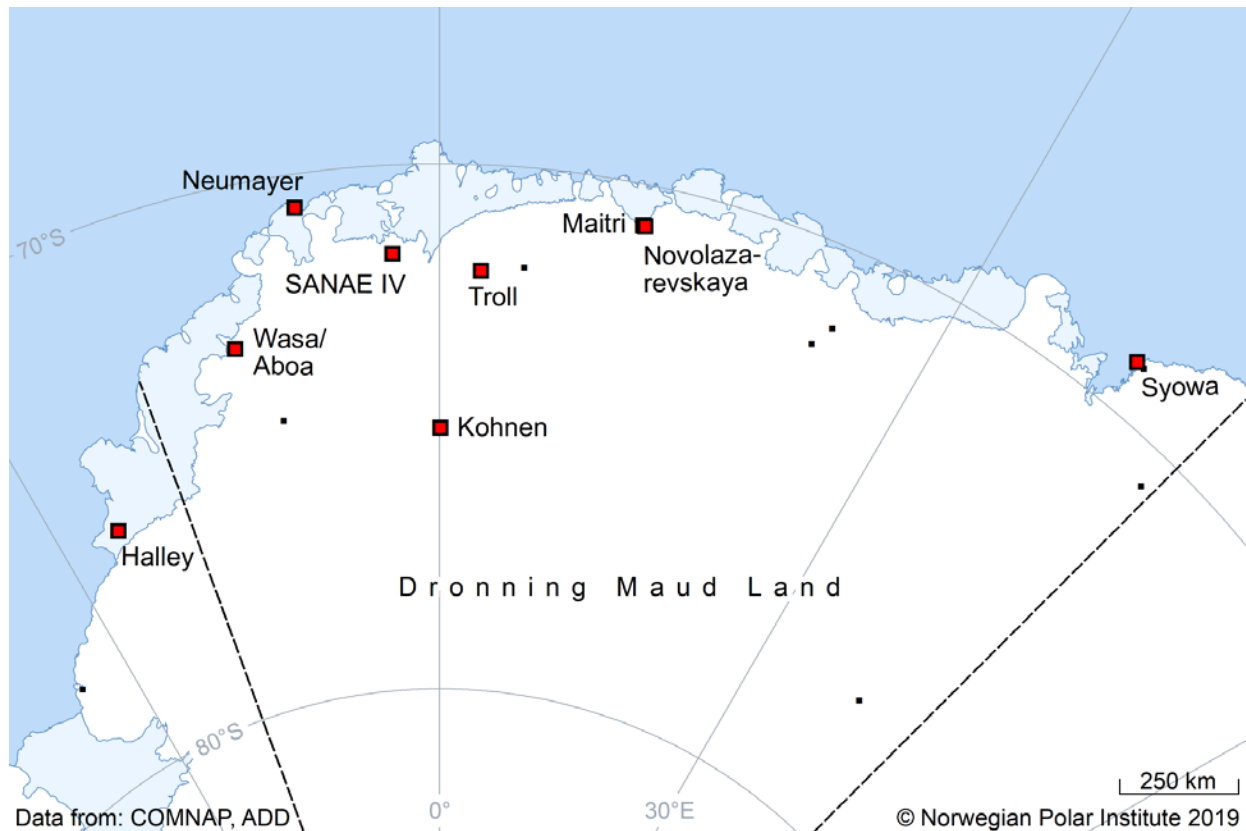


Figure 14: Map of Dromlan network (Norwegian Polar Institute 2019)

7.3 Alternatives to activity

- The only true alternative to using the Troll Airfield is using Novolazarevskaya Airfield as the main landing site in DML. This alternative will still entail the need to maintain and operate a small runway for flight operations (from Novolazarevskaya) to support the Norwegian operations.
- There is a risk that Novolazarevskaya Airfield will not be available during periods with extensive melting during midsummer.
- It is a matter of safety to be able to receive aircraft directly to Troll from Cape Town in case of emergency.
- It is also a matter of safety to be able to have intercontinental flights directly to Troll outside the normal season for medical evacuations. Having an airfield able to receive large intercontinental cargo aircraft has proven very valuable in maintaining and upgrading the infrastructure at Troll.

7.4 Impacts

Potential Environmental Impacts from aircraft, helicopter and runway operations

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Combustion emission	<p>Combustion gases released into the atmosphere can contribute to the greenhouse effect both directly and indirectly.</p> <p>Air quality in general may be affected by releasing combustion compounds into the atmosphere. Could affect atmospheric research in the region.</p>	<p>Probability: Certain</p> <p>Extent: Local to global</p> <p>Duration: Very long</p> <p>Significance: Low</p>	<ul style="list-style-type: none"> Emissions are inevitable but will be minimized by well-planned logistics to reduce flights. Use of high energy efficient fuel Shared logistics will minimize total emission in area. Continue co-operation within DROMLAN with this in mind. Well maintained aircrafts will be used and not left idling unnecessary.
Fuel spill	<p>Fuel spills may occur and could produce numerous health concerns to any animal that comes into direct or indirect contact with the substance. Birds and humans that come in direct physical contact with the chemicals can suffer skin and eye lesions or chemical burns. Direct ingestion by any wildlife species commonly results in ulcers, organ damage, immune deficiency, and reproductive failure. Toxic waste and chemicals could have high impact on living organisms in Polar regions.</p>	<p>Probability: Low</p> <p>Extent: Local</p> <p>Duration: Long</p> <p>Significance: Low</p>	<ul style="list-style-type: none"> Oil spill contingency plans and equipment and training (cf. aircraft requirements) Due care and attention, use of appropriate spill prevention material when refueling, reinforced by education and training.
Littering	<p>No garbage is to be discharged during flight operations or operations at Troll.</p> <p>No sewage should be discharged on ice or snow.</p> <p>Strong winds could cause discharge of litter</p>	<p>Probability: Low</p> <p>Extent: Local</p> <p>Duration: Short</p> <p>Significance: Low</p>	<ul style="list-style-type: none"> All waste should be brought back to Troll station for further treatment or airport outside Antarctica.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Noise	Noise from aircrafts could disturb and chase away breeding birds, with great impact on eggs and chicks due to the extreme conditions in Antarctica.	Probability: Low Extent: Local Duration: Short Significance: High	Adhere to AFIM and CEP guidelines. Pilots and crew shall receive environmental information before entering Antarctic airspace.
Non-native organisms and disease	<p>In the case of aircrafts, introductions may take place via the landing wheels/skis or via equipment/cargo carried into Antarctica. It is to be expected that establishment of non-native species will only be possible in those species that can tolerate the conditions of the Antarctic environment.</p> <p>Helicopters used in the Arctic regions could possibly bring arthropods, seeds and/or plants of alien species to Antarctica.</p>	Probability: Medium Extent: Local Duration: Short Significance: Low to medium	<p>Measures will be taken to avoid spreading alien species from north to south. Special attention will be given to aircrafts operating in Arctic areas not to spread species that could survive in Antarctica.</p> <p>Relevant material in the Non-native Species Manual will be used as guidance, e.g. the "Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species" developed by COMNAP/SCAR (2011)</p>

8.0 SHELF AND TRAVERSE OPERATIONS

8.1 Description

All fuel, foodstuff and building materials for Troll station and the Norwegian operations in Dronning Maud Land are delivered to Troll Cargo Site (Sledeneset) by ship, see Figure 6. The goods are transported to Troll on sleds pulled by tracked vehicles. The distance from Troll to Sledeneset is approximately 260 Km (2019). The trip takes ca. 2.5 days utilizing 12-hour shifts; normally the convoy takes 5 days back and forth. The vessel arrives at the ice shelf between

mid-December and mid-January and all the on/offloading of cargo is done within 5 days. The 7-person team that handle operations on the shelf uses the toilet and washing facilities aboard the ship during the operation.

8.2 Land use and footprint

The traverse is performed on snow and ice from Troll to the ice shelf, Sledeneset. The distance is ca. 260 km (2019). No part of the traverse involves ice free ground.

8.2.1 Alternatives

Due to the amount of cargo delivered annually there is no alternative to ice shelf operations. Small amounts of fresh food and delicate equipment are brought by air cargo to Troll Airfield.

8.3 Use of vehicles

The cargo is currently transported by 6 tracked vehicles operating 10-12 trips back and forth from Troll Station to the ice shelf every season.

8.4 Waste

All waste produced during transport shall be returned to Troll station for further treatment in accordance with Troll Station Waste Procedures. During the traverses, field toilets are used, and all waste is brought back to Troll station for further storage and transport out of Antarctica.

Waste containers are brought to the shelf during the austral summer a few weeks before back loading to the ship. Containers are secured, interlocked and stored approx. 600 meters from the edge of the ice shelf awaiting back loading for transport out of Antarctica. No waste is stored on the shelf during the austral winter season. Fuel containers are stored at storage area established in 2018 south of Sledeneset throughout the austral winter^{46, 47}

8.5 Management of fuel and hazardous substances

All fuel handling and refueling during the transport between Troll and the ice shelf, is in accordance with Procedure for filling operations.

Fueling of fuel containers (11,000 litre and 24,000 litres) is normally done onboard the ship. Full fuel containers are craned directly on to sleds. This is the best practice to avoid possible oil spill connections or fuel lines. If fuel lines are pulled over the edge of the ice shelf, strict routines are followed to avoid any possible oil spill into the environment.⁴⁸

⁴⁶ Norwegian Antarctic Research Expedition (NARE) 2017-2018 – Melding om etablering av omlastningsområde og lager for drivstoff 2. July 2018, Permission to establish storage area from Ministry of Climate and the Environment.

⁴⁷ Rutinebeskrivelse: Avfallshåndtering i felt, Antarktis, NPI 2019 (In Norwegian)

⁴⁸ Rutine: Fylling av dieseltanker fra skip til barriere (In Norwegian) Norwegian Polar Institute

8.6 Power supply

12V electrical power is normally utilized during transport.

8.7 Water supply

All drinking water during transport operations is brought from Troll station.

8.8 Impacts

Potential Environmental Impacts from shelf and traverse operations.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Combustion emissions	<p>Combustion gases released into the atmosphere can contribute to the greenhouse effect both directly and indirectly.</p> <p>Air quality in general may be affected by releasing combustion compounds into the atmosphere. Could affect atmospheric research in the region.</p> <p>Use of kerosene or Jet A-1 for heating the field camp releases combustion gases. Use of kerosene for cooking will release combustion gases.</p>	<p>Probability: Certain Extent: Local to regional Duration: Short Significance: Low</p>	<ul style="list-style-type: none">• Well maintained vehicles will be used and not left idling unnecessary• Use of high energy efficient fuel• Make use of more powerful pull-wagons to increase load per trip performed
Fuel spills	<p>Fuel spills may occur and could produce numerous health concerns to any animal that comes into direct or indirect contact with the substance. Birds and humans that come in direct physical contact with the chemicals can suffer skin and eye lesions or chemical burns. Direct ingestion by any wildlife species commonly results in ulcers, organ damage, immune deficiency, and reproductive failure. Toxic waste and chemicals could have high impact on living organisms in Polar regions.</p> <p>Transport with bandwagons or snowmobiles is performed on ice or snow and the footprint on these surfaces is minimal.</p>	<p>Probability: Low Extent: Local Duration: Long Significance: Low</p>	<ul style="list-style-type: none">• Oil spill contingency plans and equipment and training (cf. station contingency plans)• Due care and attention, use of appropriate spill prevention material when refueling, reinforced by education and training.• Due care and attention when unloading fuel from the ship to the ice shelf.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Waste	Waste spill may occur due to an accident during ground operations. Strong winds could move garbage large distances away from field camps.	Probability: Low Extent: Local to regional Duration: Short Significance: Low	<p>No garbage is to be discharged during flight or ground operations in field. All waste is stored in secured containers during the operation.</p> <p>No sewage should be expelled on ice or snow. Field camps uses field toilets, and the human waste is brought back to Troll and shipped out of Antarctica for disposal.</p> <p>Due care and attention, reinforced by education and training</p>
Noise	Noise from vehicles could disturb and chase away breeding birds, with great impact on eggs and chicks due to the extreme conditions in Antarctica.	Probability: Low Extent: Local Duration: Short Significance: High	Field crew and scientists shall receive adequate environmental information.

Output	Description and evaluation of potential impact	Summary of impact	Measures to reduce impact
Non-native organisms and disease	<p>Equipment used in the Arctic regions could possibly bring arthropods, seeds and/or plants of alien species to Antarctica.</p> <p>Field equipment used in the Arctic region can transfer non-native species to Antarctica.⁴⁹ It is to be expected that establishment of non-native species will only be possible in those species that can tolerate the conditions of the Antarctic environment.</p>	<p>Probability: Medium</p> <p>Extent: Local to regional</p> <p>Duration: Short</p> <p>Significance: Medium</p>	<p>Measures should be taken to avoid spreading alien species from north to south. Special attention will be given to vehicles and equipment operating in Arctic areas not to spread species that could survive in Antarctica.</p> <p>Relevant material in the Non-native Species Manual will be used as guidance, e.g. the “Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species” developed by COMNAP/SCAR (2011)</p>

9.0 OTHER ISSUES

9.1 Purchasing

Certification of products and services is based on compliance with stringent environmental criteria that are established in consultation with industry, environmental groups, and independent experts and are based on research into the lifecycle impacts of a product or service.

In order to decrease human impacts on the Antarctic environment it is important to minimise the environmental effects stemming from the daily use of material and equipment. One way of encouraging this is to use green procurement, i.e. take into account and compare environmental considerations when purchasing goods, services or works. By purchasing wisely, you can save materials and energy and reduce waste and pollution.

⁴⁹ “Checklists for supply chain managers of National Antarctic Programmes for the reduction in risk of transfer of non-native species” developed by COMNAP/SCAR (2011)

In practice this means that the person responsible for procurement in NPI will emphasize pollution prevention as a natural part of the purchasing process. Some general examples are;

- Products manufactured from recycled materials
- Environmentally preferable products
- Energy efficient products
- Bio based products
- Alternative fuels and fuel-efficient vehicles
- Non-ozone depleting substances
- Products complying with state-of-the-art environmental solutions.

9.2 Training and education

All NPI personnel receive adequate environmental training and education before entering Antarctica. This to ensure they have the knowledge needed and the attitude required for operating according to the national Regulations relating to the protection of the environment and safety (2013).

“Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture and his biophysical surroundings. This also entails practice in decision-making and self-formulation of a code of behavior about issues concerning environmental quality” (IUCN, 1970)

9.3 Removal of the station

Removal of Troll and/or Tor stations are not part of the Multi-year Initial Environmental Evaluation for the operational aspects of Norwegian Antarctic Research Expeditions 2000-2010 (NPI, 2000) nor FINAL Comprehensive Environmental Evaluation (CEE) for the upgrading of the Norwegian summer station Troll in Dronning Maud Land, Antarctica, to permanent station (NPI, 2004). A separate IEE for the removal of either of the stations must be prepared in accordance with Regulations relating to the protection of the environment and safety in Antarctica § 16.

10 MONITORING

Environmental impacts are monitored and reported.

The aim of the monitoring program is to:

- assess whether the actual impacts from the activity are as anticipated
- establish the geographic extent of impact, and assess any changes to this "footprint"
- provide a basis on which to initiate processes to mitigate and minimize impacts
- assess changes in intensity of activity

- ensure that the activity is carried out in accordance with international agreements and national legislation

Currently (2019) the monitoring program include bird monitoring, visual control of the sewage water (smell and color) and monthly analyses of the sewage water. The goals of the monitoring program will remain the same, but an updated practical monitoring plan is under development in order to take into account the new operational framework as well as take advantage of the opportunities the all-year presence gives for more specific and analytic monitoring.

11 CUMULATIVE IMPACTS

The Jutulsessen area is a relatively pristine and untouched area, with the exception of the impact created by the Norwegian station facilities at Troll. Although some research has taken place in the local area, most activities that use Troll as logistical hub has in fact been conducted in more remote areas. The Jutulsessen area has consequently mostly been visited only for recreational purposes by the core personnel at Troll station.

Increase in air traffic and upgrading of Troll to an all-year station, the related influx of national program personnel and the potential increase in non-governmental activities will all have bearings on the level of activity in the area. It must be expected that the Jutulsessen area will experience a higher intensity with respect to use of the area, be it recreational activities performed by NPI staff, expansion of existing facilities, establishment of new facilities, etc. The following may be noted in this respect:

- The activity in the area continues to grow with respect to fuel combustion and thereby a higher level of emission to air. The total level of emission is still relatively low, compared both to global values and to comparable operations in Antarctica, and relative to levels considered harmful to the environment. The cumulative consequences for the local environment are therefore not considered significant. Stress for the seabirds in the Jutulsessen area may increase due to the increased activity level, but overall impacts on fauna are expected to be quite limited. Two colonies of Snow Petrels have been monitored since 2008, with addition of one more colony at Klovningen near Troll in 2017. Results from this monitoring are internally reported annually by the Research Department at NPI. There is no other monitoring of birds outside Svarthamaren (ASPA 142) in Dronning Maud Land.
- The ice-free areas in the interior of Antarctica are relatively rare and are as such vulnerable. All the on-going activity in the Troll area adds pressure on the land use. Although the station building mass has expanded and continues to expand with the upgrading to an all-year station, the area affected by the building mass will remain relatively constant, as expansion will occur within the perimeters of the already affected station area (cf. land use plan). The

Troll Airfield is prepared on the blue-ice and does not as such directly affect the ice-free areas. An unknown, and somewhat unpredictable factor is the future potential addition of research and monitoring facilities associated with the station. Stipulating that a total area of 5 km² would be impacted directly by station and facility operations in the future, less than 2% of the ice-free ground in the Jutulsessen area would be affected.



Figure 15: Wilderness is associated with the concept of no physical human presence. View from Troll Station towards the vast glaciers of Hellehallet stretching all the way to the coast 26 km further North.

- With the upgrading of Troll to an all-year station in 2005, atmospheric research and monitoring are important elements of the research established. This requires a clean environment (pollutants/noise), and continued efforts will therefore be made to ensure limited impact on the science, which also will have positive consequences with regard to environmental impacts. NILU – Norwegian Institute for Air Research is in charge of the monitoring and the reporting of these results.⁵⁰
- Wilderness and aesthetic values will be affected by the new elements introduced into the environment. However, since this is an area that is already affected by ongoing activity, the cumulative impact is expected to be quite limited.

⁵⁰ Kallenborn, R., Breivik, K., Eckhardt, S., Lunder, C. R., Manø, S., Schlabach, M., and Stohl, A.: Long-term monitoring of persistent organic pollutants (POPs) at the Norwegian Troll station in Dronning Maud Land, Antarctica, *Atmos. Chem. Phys.*, 13, 6983–6992, <https://doi.org/10.5194/acp-13-6983-2013>, 2013.

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13 APPENDIXES

Appendix 1: Considering the Environment: Troll

In considering the value of an environmental element the following terms have been used:

- N/A:** Values not present.
- Low:** The loss of the environmental elements would at the most have bearings on the local environment, in this instance the Troll station area and the immediate surrounding area.
- Medium:** The loss of the environmental elements could have bearings on the regional environment, in this instance Jutulsessen area, or could affect science or station operations.
- High:** The loss of the environmental elements could have significant bearings for the overall environment in Antarctica.

Environmental Element	Description	Value
Flora	<p>Elements:</p> <ul style="list-style-type: none"> - Limited flora is present on location. - Sparse occurrences in the Jutulsessen mountains (lichens and algae) <p>Consideration of values:</p> <ul style="list-style-type: none"> - No unique occurrences/assemblages have been registered in the local area. - Relatively undisturbed outside the local area 	Low

Environmental Element	Description	Value
	<p>Background information:</p> <ul style="list-style-type: none"> - NPI (1990) - Ohta (1993) - NIVA (1991) 	
Fauna	<p>Elements:</p> <ul style="list-style-type: none"> - Micro-fauna is present on location in limited amounts. - Two small snow petrel colonies in the vicinity of Troll – Nonshøgda to the north and an area just south of the station. One larger colony of snow petrel in the Klovningen area north of Troll station. Sporadic occurrences of skua in station area and Jutulsessen in general. - A number of larger seabird colonies are located in the more remote and inaccessible parts of Jutulsessen <p>Consideration of values:</p> <ul style="list-style-type: none"> - No unique occurrences registered. - Relatively undisturbed outside the local area. <p>Background information:</p> <ul style="list-style-type: none"> - NPI (1990) - Bye (1993) - Ohta (1993) - Harris et.al. (2015) 	Low
Freshwater	<p>Elements:</p> <ul style="list-style-type: none"> - Freshwater reservoir in the blue ice in the station area <p>Consideration of values:</p> <ul style="list-style-type: none"> - Was formerly valuable to operations (as drinking water), but not considered environmentally unique. <p>Background information:</p> <ul style="list-style-type: none"> - NPI 	Low

Environmental Element	Description	Value
Sea water	Not present on location.	N/A
Soil	<p>Elements:</p> <ul style="list-style-type: none"> - Ground cover in station area <p>Consideration of values:</p> <ul style="list-style-type: none"> - Ground cover in station area affected by near 25 years of operations at Troll station. - No unique occurrence. <p>Background information:</p> <ul style="list-style-type: none"> - Ohta (1993) 	Low
Air	<p>Elements:</p> <ul style="list-style-type: none"> - Air <p>Consideration of values:</p> <ul style="list-style-type: none"> - Air is relatively pristine as only affected by operations at Troll - Atmospheric research currently on-going in the area, this is important in the context of the all-year station using 24/7 Diesel generators. <p>Background information:</p> <ul style="list-style-type: none"> - Njåstad (2000) - Kallenborn et al. (2013) 	<p>Medium</p> <p>(pollution will affect research)</p>
Ice	<p>Elements:</p> <ul style="list-style-type: none"> - Blue ice area next to station. 	Low

Environmental Element	Description	Value
	Consideration of values: <ul style="list-style-type: none"> - Not significantly affected by earlier activity. - No unique ice conditions registered in the area. - Blue ice covers only 1% of Antarctica – relatively rare type of surface. - Common surface condition in the region Background information: <ul style="list-style-type: none"> - Bintanja, R (1999) - Winther, Jespersen & Liston (2001) 	
Geology	Elements: <ul style="list-style-type: none"> - The Troll station is located in the Jutulsessen nunataqs (description provided in chapter 3.1) Consideration of values: <ul style="list-style-type: none"> - No unique geologic elements registered in association with the Jutulsessen mountains. - Area interesting for geological research due to good exposure of elements Background information: <ul style="list-style-type: none"> - Dallman et al. (1990) - Ohta (1993) 	Low

Environmental Element	Description	Value
Wilderness	Wilderness is associated with the concept of no physical human presence. As this is an area with station facilities and associated activities, it is considered that wilderness is not present in the station area.	N/A
Aesthetics and intrinsic values⁵¹	Elements:	Low

⁵¹ Aesthetic value can for example be defined as "the response derived from the experience of the environment or particular natural and cultural attributes within it. This response can be to either visual or non-visual elements and can embrace emotional response, sense of place, sound, smell and any other factors having a strong impact on

Environmental Element	Description	Value
	<ul style="list-style-type: none"> - Isolated and visually pleasing area, although obstructed by existing station facilities. <p>Consideration of value:</p> <ul style="list-style-type: none"> - The Jutulsessen Mountains are not very high, steep or unique in any manner and other areas of the DML nunataqs are more spectacular and are likely to be considered of higher aesthetic and intrinsic value. 	
History	No historic sites or monuments (HSM).	N/A

Appendix 2: Considering the Environment: Tor

In considering the value of an environmental element the following terms have been used:

N/A: Values not present.

Low: The loss of the environmental elements would at the most have bearings on the local environment, in this instance the Tor station area and the immediate surrounding area.

Medium: The loss of the environmental elements could have bearings on the regional environment, in this instance Jutulsessen area, or could affect science or station operations.

High: The loss of the environmental elements could have significant bearings for the overall environment in Antarctica.

human thought, feelings and attitudes” (Australian Heritage Commission & Department of Conservation and Natural Resources 1994, p. 5).

Environmental Element	Description	Value
Flora	<p>Elements:</p> <p>-Flora</p> <ul style="list-style-type: none"> - The flora and vegetation at Svarthamaren are sparse compared with other area in Mühlig-Hofmannfjella and Gjelsvikfjella to the west of the site. The only abundant plant species is the green algae, <i>Prasiola crispa</i>. There are few lichen species on glacier-borne erratics 1-2 km away from the bird colonies: <i>Candelariella hellettensis</i> (<i>C. antarctica</i>), <i>Rhizoplaca malanophthalma</i>, <i>umbilicaria</i> spp. and <i>Xanthoria</i> spp. A melting dam below the bird colonies supports strong growth of the yellowish-green unicellular algae <i>Chlamydomonas</i> sp. <p>Background information: Management plan for ASPA No. 142 Svarthamaren (2019)</p>	Low
Fauna	<p>Elements:</p> <p>-Seabirds</p> <ul style="list-style-type: none"> - The nunatak holds the largest known seabird colony in Antarctica. More than 250.000 pairs of Antarctic petrels (<i>Thalassoica antarctica</i>) are breeding annually (2018), and about 500.000 non-breeding birds are present during breeding season. In addition, there are ca. 500-1.000 pairs of snow petrel (<i>Pagodroma nivea</i>) and 50-100 pairs of South Polar skua (<i>Catharacta maccormicki</i>) - -Invertebrates -Large amounts of collembola (<i>Cryptopygus sverdrupi</i>) and a rich fauna of mites (<i>Eupodes anghardi</i>, <i>Tydeus erebus</i>) protozoan, nematodes and rotifers are described from Svarthamaren. No unique species are found. - Background information: Management plan for ASPA No. 142 Svarthamaren (2019) Sømme, L. (1986) 	<p>High</p> <p>Low</p>

Environmental Element	Description	Value
Freshwater	<ul style="list-style-type: none"> - There is no source of freshwater at Tor station. A ca. 10 meter wide melted pond near the station is heavily polluted by wind-blown petrel carcasses and is covered with yellowish-green algae <i>Chlamydomonas sp.</i> 	Low
Sea water	Not present on location.	N/A
Soil	<p>Elements:</p> <ul style="list-style-type: none"> - Soil <p>Consideration of value: The slopes are covered by decomposed felspathic sand. No unique type of soil is found at Tor.</p>	Low
Air	<p>Elements:</p> <ul style="list-style-type: none"> - Air <p>Consideration of value:</p> <ul style="list-style-type: none"> - Air is relatively pristine as only affected by small scale operations at Tor 	Low
Ice	<p>Elements:</p> <ul style="list-style-type: none"> - Blue ice areas next to station <p>Consideration of value:</p> <ul style="list-style-type: none"> - No unique ice conditions registered in the area <p>Background information:</p> <ul style="list-style-type: none"> - Bintaja, R. (1999) - Winther, Jespersen & Liston et al. (2001) 	Low
Geology	<p>Elements: Geology</p> <p>Consideration of value:</p> <ul style="list-style-type: none"> - The main rock types in the area are coarse and medium grained charnockites with small amounts of xenoliths. Included in the charnockitoids are banded gneisses, amphibolites and granites of the amphibolite facies mineralogy. 	Low

Environmental Element	Description	Value
	Background information: <ul style="list-style-type: none"> - Management plan for ASPA No. 142 Svarthamaren (2019) - Ohta, Y et al. 1990 	
Environmental Element	Description	Value
Wilderness	<p>Wilderness is associated with the concept of no physical human presence.</p> <p>Consideration of value:</p> <p>Due to small size of Tor the wilderness value as such is present in the area outside the station.</p>	Medium
Aesthetics and intrinsic values⁵²	<p>Elements:</p> <ul style="list-style-type: none"> - Isolated and visually pleasing area, although obstructed by existing station facilities. <p>Consideration of value:</p> <p>The size and magnitude of the sea bird colonies and the birdlife makes Svarthamaren an special area in Antarctica.</p>	High
History	No historic sites or monuments (HSM).	N/A

⁵² Aesthetic value can for example be defined as "the response derived from the experience of the environment or particular natural and cultural attributes within it. This response can be to either visual or non-visual elements and can embrace emotional response, sense of place, sound, smell and any other factors having a strong impact on human thought, feelings and attitudes" (Australian Heritage Commission & Department of Conservation and Natural Resources 1994, p. 5).

Appendix 3: Considering the Environment: Sledeneset (Troll Cargo Site) and Traverse Route

In considering the value of an environmental element the following terms have been used:

- N/A:** Values not present.
- Low:** The loss of the environmental element would at the most have bearing on the local environment, in this instance the Troll Station area, the traverse route to the cargo site and the areas immediately surrounding these.
- Medium:** The loss of the environmental elements could have bearings on the regional environment, in this instance Jutulsessen and the area surrounding the traverse route or, could affect science or station operations.
- High:** The loss of the environmental elements could have significant bearings for the overall environment in Antarctica.

Environmental Element	Description	Value
Flora	- Not present	N/A
Fauna	Elements: -Seabirds Individuals of Adelie Penguin (<i>Pygoscelis adeliae</i>) are found breeding in low numbers at Sledeneset (Troll Cargo Site). Several petrel spp. is feeding in open water adjacent to the site. -Mammals Furred seals can be observed near Sledeneset (Troll Cargo Site).	Low
Freshwater	- Not present	Low
Sea water	Elements: Sea water is pristine in Antarctic waters. Consideration of value: The value of clean sea water is high. The vessel used in the marine operations shall not release any ballast	Low

Environmental Element	Description	Value
	water, wastewater, fuel spills or food waste into the sea during operation in Antarctic waters (South of 60° S).	
Soil	Not present	N/A
Air	<p>Elements:</p> <ul style="list-style-type: none"> - Air <p>Consideration of values:</p> <ul style="list-style-type: none"> - Air is relatively pristine as only affected by small scale operations in area - 	Low
Ice	<p>Elements:</p> <ul style="list-style-type: none"> - Blue ice <p>Consideration of values:</p> <ul style="list-style-type: none"> - Not significantly affected by earlier activity. - No unique ice conditions registered in the area. - Common surface condition in the region 	Low
Geology	<ul style="list-style-type: none"> - Not present 	N/A

Environmental Element	Description	Value
Wilderness	Wilderness is associated with the concept of no physical human presence.	High
Aesthetics and intrinsic values⁵³	<p>Elements:</p> <ul style="list-style-type: none"> - Isolated and visually pleasing area <p>Consideration of value:</p> <ul style="list-style-type: none"> - Clean ice sheets with no traces of human activity is present in the area and do have an aesthetic value, but no unique structures for Antarctica are found. 	Low
History	No historic sites or monuments (HSM).	N/A

⁵³ Aesthetic value can for example be defined as "the response derived from the experience of the environment or particular natural and cultural attributes within it. This response can be to either visual or non-visual elements and can embrace emotional response, sense of place, sound, smell and any other factors having a strong impact on human thought, feelings and attitudes" (Australian Heritage Commission & Department of Conservation and Natural Resources 1994, p. 5).

Appendix 4: Land Use Plan 2011



Figure 16: Land Use Plan, Troll Station 2011

Land-use plan for Troll: description

This land-use plan specifies the areal limits of the Norwegian Troll Research Station. The plan is intended to constitute some of the framework conditions controlling the development at Troll as regards research, logistics and other activities linked with the research station.

The basis for the land-use plan is a simple division of the area into zones. Instructions are given below for development and/or environmental protection within each zone. The zones and instructions must be complied with when implementing new measures or activities at Troll.

In the area beyond the applicability of the land-use plan, all activity must accord with the framework conditions stated in the requirements and provisions of the Environmental regulations ^[1]. To the extent that such activity is linked with what is taking place at Troll and occurs near the station, its influence on the area surrounding the station (the land-use plan area) must be assessed in an overall perspective.

Environmental zone 1 (Nonshøgda)

The zone is designated to safeguard a nesting site for birds. The following instructions apply to the zone:

- No installations or infrastructure may be built unless they are intended for invaluable, approved and prioritized research.
- Consequences for the environment and other activities in the area must be investigated before new activity takes place or new installations or infrastructure are built. If the proposed activity is likely to have more than a transitory or minor impact, a comprehensive environmental evaluation must be prepared in accordance with § 11 of the *Regulations relating to the protection of the environment and safety in Antarctica*.
- Motorized traffic must not occur within the area unless it is absolutely essential in connection with construction work and approved and prioritized research, perhaps in connection with the establishment of approved installations on the summit of Nonshøgda.

Environmental zone 2 (Trollhaugen)

The zone is designated to safeguard a nesting site for birds. The following instructions apply to the zone:

- No installations or infrastructure may be built unless they are intended for invaluable, approved and prioritized research.

Consequences for the environment and other activities in the area must be investigated before new activity takes place or new installations or infrastructure are built. If the proposed activity is likely to have more than a transitory or minor impact, a comprehensive environmental

^[1] Regulations relating to the protection of the environment and safety in Antarctica (2013)

evaluation must be prepared in accordance with § 17 of the *Regulations relating to the protection of the environment and safety in Antarctica*.

- Motorized traffic must not occur within the area, unless it is absolutely essential in connection with construction work and approved and prioritized research.

Environmental zone 3 (Klovningen)

The zone is designated to safeguard a nesting site for birds. The following instructions apply to the zone:

- No installations or infrastructure may be built unless they are intended for invaluable, approved and prioritized research.
- Consequences for the environment and other activities in the area must be investigated before new activity takes place or new installations or infrastructure are built. If the proposed activity is likely to have more than a transitory or minor impact, a comprehensive environmental evaluation must be prepared in accordance with § 11 of the *Regulations relating to protection of the environment in Antarctica*.
- Motorized traffic must not occur within the area unless it is absolutely essential in connection with construction work, clean-up operations and approved prioritized research as monitoring breeding snow petrels.

Environmental zone 4 (clean air zone)

The zone has been designated to ensure that the air is as little as possible affected by local activity, which is, among other things, essential to safeguard the requirements of the Troll Observatory, which monitors the air and atmosphere. The following instructions apply to the area:

- No installations or infrastructure may be built that result in polluting emissions.
- Consequences for the environment and other activities in the area must be investigated before new activity takes place or new installations or infrastructure are built. If the proposed activity is likely to have more than a transitory or minor impact, a comprehensive environmental evaluation must be prepared in accordance with § 11 of the *Regulations relating to protection of the environment in Antarctica*.
- When any new installations or infrastructure are to be established in the area, this must be done in such a way that emissions in connection with the construction work are as limited as possible and are accommodated to the requirements of the Troll Observatory.
- Motorized traffic must be as limited as possible and is only permitted in connection with construction and maintenance work that requires heavy and/or cumbersome equipment. Demands may be laid down regarding the type of vehicle. All motorized traffic must be logged and reported at an appointed place at Troll.

Operational zone for the station

This zone has been established to ensure adequate space for the operational running of the Troll Research Station, including preparations and logistic support for research projects in the Antarctic. The following instructions apply to the area:

- Basically, no installations or infrastructure may be set up in this zone that are not related to the purpose of establishing the zones. Should this be done, it must not be a hindrance for maintaining the purpose of the zones.
- Consequences for the environment and other activities in the area must be evaluated before new activity takes place or new installations or infrastructure are built. If the proposed activity is likely to have more than a transitory or minor impact, a comprehensive environmental evaluation must be prepared in accordance with § 17 of the *Regulations relating to protection of the environment in Antarctica*.

Other areas

The following instructions apply to other areas within the boundary of the land-use plan:

- Consequences for the environment and other activities in the area must be investigated before new activity takes place or new installations or infrastructure are built. If the proposed activity is likely to have more than a transitory or minor impact, a comprehensive environmental evaluation must be prepared in accordance with § 17 of the *Regulations relating to protection of the environment in Antarctica*.
- Before new activity is established, clearance must be obtained from other scientists in the region to ensure that it does not clash with ongoing activity.



Figure 17: Troll Station 72°S 02°E. (Photo: Stein Ø. Nilsen, Norwegian Polar Institute)