4.4.2 Wind speed and direction

Utsteinen ridge benefits from the protection of the mountains and is, due to its position at the western side of the range, less influenced by high katabatic wind speeds. Nevertheless, the site is not over-protected as it protrudes northwards from the northern rim of nunataks and therefore benefits from a more constant wind flow that might be useful from an energetic point of view. The mean wind speed recorded at Utsteinen amounts to 6 m/s, which is half the value of the mean wind speed recorded at Asuka Station, situated at 55 km to the Northeast. Mean summer wind speeds are around 4.5 m/s (**Fig. 4.3**).

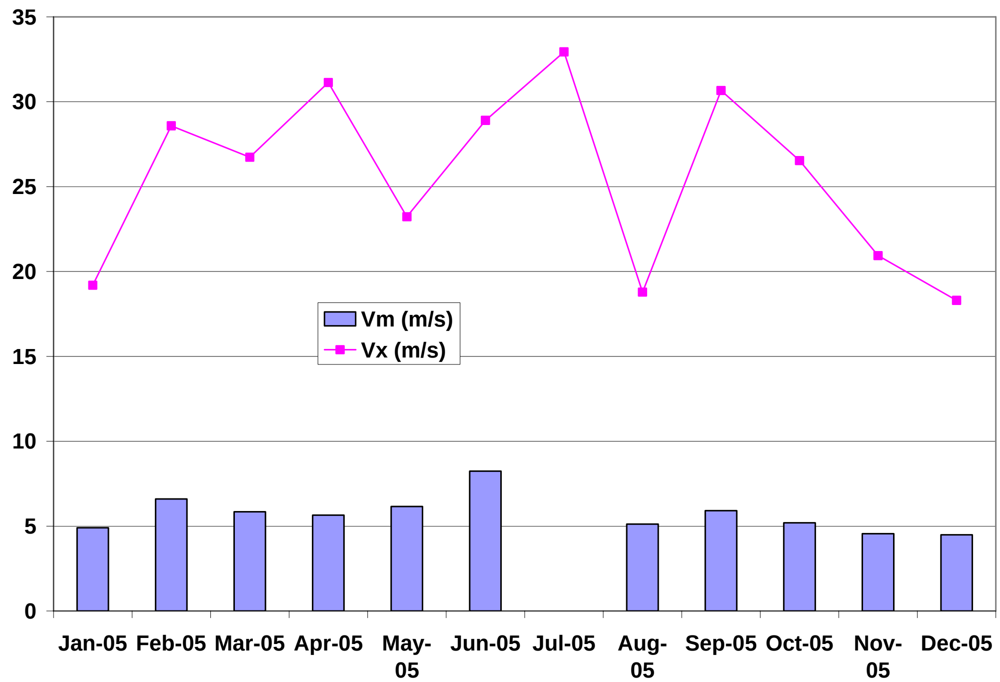

Fig 4.4: Monthly mean wind speed (Vm) at the Utsteinen site in 2005. Maximum recorded wind gusts (Vx) are given as well.

The main wind direction at Utsteinen is from the East, which is a katabatic wind regime coming from Jenningsbreen, one of the major outlet glaciers that cut through the range. Somewhat less frequent are winds from the SE direction, coming from Gunnestadbreen, the outlet glacier that lies closest to the site (**Fig. 4.5**). The whole sector E to SSE accounts for more than 90% of winds at Utsteinen. More variable winds occur only at very low wind speeds, which shows that the katabatic wind regime is dominant. Higher wind speeds (> 15 m/s) mostly come form the E and ESE (80%) The near absence of a northerly component indicates that near the surface the climate is seldom reached by cyclones or air masses associated with the low pressure trough bordering Antarctica.

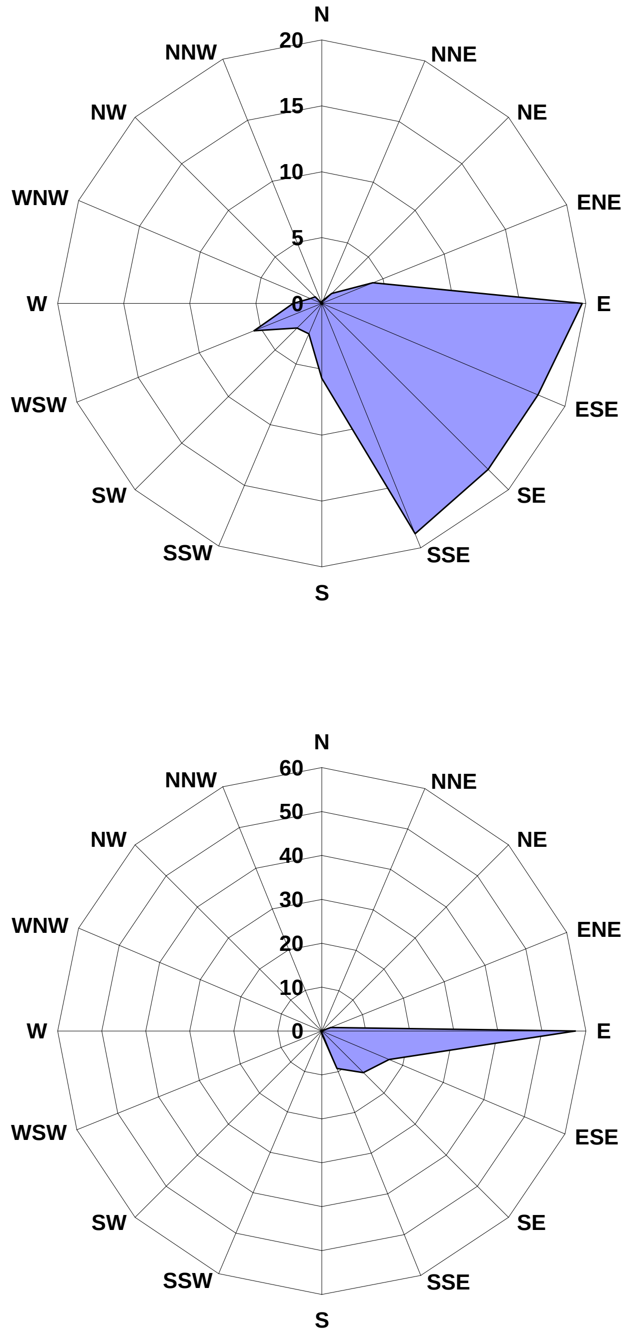

Fig 4.5: Frequency of winds (upper panel) and winds stronger than 15 m/s (bottom panel). Values are given in %.

4.4.3 Atmospheric pressure

Atmospheric pressure variations at Utsteinen are relatively constant in time while oscillating around a mean value of 827 hPa, which underscores the fact that coastal cyclonic activity hardly influences the site. With exception of low pressure values in August and September, all variations are within 20 hPa. The yearly pressure curve lacks the double minima observed at most coastal stations.

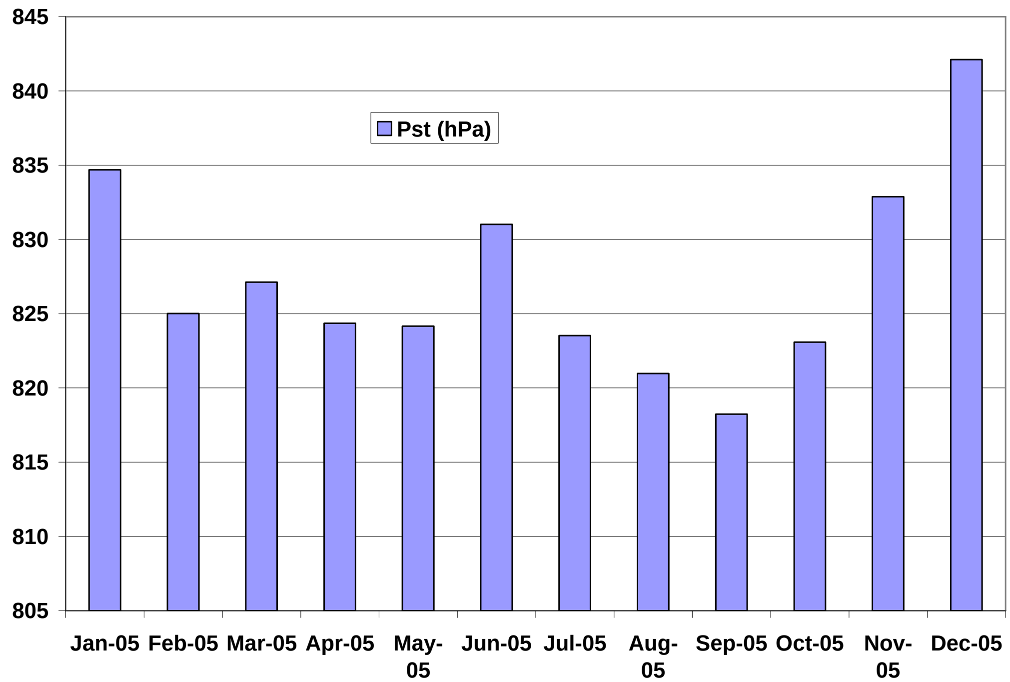

Fig 4.6: Monthly mean atmospheric pressure observed at Utsteinen during 2005.

4.4.4 Conclusion:

The one year record of the AWS at Utsteinen confirms what was already known from reports of field parties in the past, i.e. the relative mild climate (high temperature and low wind speed) of the Western part of the Sør Rondane, being optimal for field work in summertime. The yearly variation of the climatic elements on the other hand points towards the continental character of the climate. Considering the very few stations in the continental interior, the climatic record of the new Belgian station will contribute to a better understanding of the East Antarctic climate.

4.5 Baseline monitoring information

The Environmental Protocol includes requirements to undertake regular and effective monitoring of the impacts of ongoing activities and verification of the predicted impacts. Environmental monitoring is also required to facilitate early detection of possible unforeseen effects of activities.

A baseline study was performed on soil, snow/ice and lichen samples taken from the Utsteinen Ridge during the Belare 2004 and Belare 2005 site survey expeditions, in order to obtain reliable data about the initial clean state of the environment and to establish the “footprint” of the station.

Sampling was performed following the guidelines from the COMNAP and SCAR “Antarctic Environmental Monitoring Handbook” and analysed for the following indicators:

- Soil: total carbon, organic and inorganic carbon; total petroleum hydrocarbons (TPH); metals (Al, Cr; K, Sb, Co, Se, As, Cu, Ag, Ba, Fe, Na, Be, Pb, Tl, Cd, Mg, V, Ca, Mn, Zn, Ni, S, Hg); polycyclic aromatic hydrocarbons

- Snow/ice: metals (Al, Cr; K, Sb, Co, Se, As, Cu, Ag, Ba, Fe, Na, Be, Pb, Tl, Cd, Mg, V, Ca, Mn, Zn, Ni, S, Hg); total petroleum hydrocarbons (TPH); particulates

- Lichens: metals (Al, Cr; K, Sb, Co, Se, As, Cu, Ag, Ba, Fe, Na, Be, Pb, Tl, Cd, Mg, V, Ca, Mn, Zn, Ni, S, Hg)

An overview of the soil and snow samples and preliminary analyses results are given in **Tables 12.4, 12.5 and 12.6**.

Sample results show that the Utsteinen site is indeed pristine, with no indication of previous human impact. These baseline analyses results can therefore be used as reference values within the environmental monitoring program that will be set-up once the station is operational. The general objectives of the monitoring program will be:

- detect, measure and monitor future environmental changes,
- verify predictions on the effect of human activities,
- detect possible unforeseen effects of human activities,
- assess the consequences of regulatory mechanisms and operating and managing facilities,
- establish the environmental status of the Antarctic environment.

4.6 Flora and Fauna

Biological research studies conducted in the Sør Rondane area are limited in number and studies at the construction site are non-existent.

4.6.1 Flora

On the Utsteinen Ridge, only a few Lichens were found, however, they are quite abundant on the Nunatak itself.

Three different species were detected, the same on both the Ridge and the Nunatak:

- *Umbilicaria aprina* Nyl.
- *Candelariella* sp. (indeterminable in absence of apothecia)
- *Caloplaca regalis* (Vain.) Zahlbr.

Fig 4.7: Lichen *Umbilicaria aprina* Nyl.

Fig 4.8 : Lichen *Candelariella* sp.

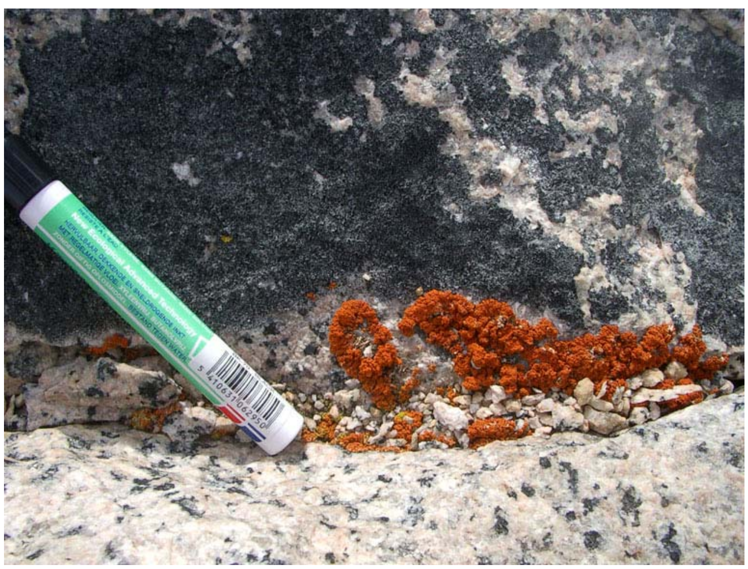

Fig 4.9: Lichen *Caloplaca regalis*

4.6.2 Vertebrate Fauna

Published data on the breeding distribution of Antarctic (sea)birds in the Sør Rondane region are very limited. The vertebrate fauna in the vicinity of the station consists of birds only: snow petrel (*Pagodroma nivea*) and Antarctic skua (*Catharacta maccormicki*).

There may be breeding colonies of Weddell seals (*Leptonychotes weddellii*) at various locations on the fast ice beside the ice front of Prinsesse Ragnhild Kyst. The offlying pack ice may support breeding populations of crabeater seal (*Lobodon carcinophaga*), Ross seal (*Ommatophoca rossii*) and leopard seal (*Hydrurga leptonyx*). During summer, coastal waters may be visited by baleen whales and toothed whales. These whale species do not breed in the region but visit the area to feed.

There are no observations of Penguin rookeries at Breid Bay, neither from all the working years of the Roi Baudouin base nor during the Belare 2005 expedition.

Snow petrel (Pagodroma nivea)

Very few data on breeding sites of snow petrels in Antarctica are available from literature. In general, colony sizes seem to range from single pairs to an estimated 20.000 pairs. Snow petrels breed amongst others on areas of exposed rock which may be as much as 300 km from the open sea during the breeding season. The colony farthest inland is in the Tottanfjella, Dronning Maud Land. The colony closest to the construction site recorded in the literature is at Pingvinane (72°00'S, 25°00'E), estimated at about 100 breeding pairs in 1959-1961 (Croxall et al, 1995).

Some snow petrel pairs are breeding on the steep slopes of Utsteinen Nunatak, at a distance of about 1 km from the new station construction site. It is extremely difficult to get an accurate census of breeding pairs. During the two site survey expeditions it was estimated that the small colony is made up of no more then 50 pairs. Most of the nests are high up the Nunatak slopes and thus difficult to access.

Snow petrels return to the nest sites in November about the time of the proposed start of station activities. One egg is laid in late November to mid-December and incubated for 41-49 days. The chick remains in the nest for an additional 7 weeks. Snow petrel chicks leave the nest in late February to mid-May, when the proposed station will have closed for the winter.

In order to complete and update the database on breeding distribution of the snow petrel for the SCAR Bird Biology Expert Group, additional relevant data from the Utsteinen Nunatak breeding site will be forwarded to the Expert Group. The breeding site will not be visited unless related to approved scientific research.

Fig 4.10: Snow petrel at Utsteinen Nunatak

Weddell seal (Leptonychotes weddellii)

During the over-land survey of the coast and access route to Utsteinen (Belare 2005), a breeding colony of Weddell seals was spotted at Breid Bay, the future unloading site for construction and yearly provisioning.

The number of individuals was estimated at about two hundred, including females and pups basking on the ice, next to openings through which they could slide into the water.

Females give birth to one pup per year in October. Mothers care for them for six weeks, after which they are weaned and on their own. Ship operations for the station at Breid Bay, including construction operations, will take place end of December to beginning of January and will thus not interfere with the breeding season of the seals. Adult and juvenile seals may haul out onto sea ice at any time of year, and will typically bask near tide cracks or the ice edge. Their usual response to noise or activity is to return to the water.

Fig 4.11: Weddell seal mother and pup at Breid Bay

4.6.3 Invertebrate Fauna

During Japanese Research Expeditions (JARE), several terrestrial invertebrate species were discovered living in the western and central part of the Sør Rondane Mountains, including one springtail and several mite species (Hiruta and Ohyama, 1995). Most of these areas supported rookeries of snow petrel, indicating a relationship between the rookeries, plant communities and soil animals.

At the construction site, no invertebrates were recorded, but may possibly be found near the small Snow Petrel breeding site at the Utsteinen Nunatak.

4.7 Tourism

There has been very limited non-governmental activity in the Sør Rondane region. One or two expeditions have visited, notably a four man expedition in 1996–1997 to climb peaks lying to the west of Byrdbreen in the eastern Sør Rondane. The expedition was serviced by a non-government organisation that also searched for alternative blue-ice runways in the Sør Rondane region. The mountains of the Sør Rondane continue to have an interest for expeditions, however, the costs associated with reaching the area tend to restrict activity.

4.8 Protected Areas and Historic Sites and Monuments

There are no Antarctic Specially Protected or Managed areas (ASPA's or ASMA's) or Historic Sites and Monuments in the region of the proposed Belgium Station. The nearest ASPA's being ASPA Nr 142 (Svarthamaren, Mühlig-Hofmannfjella (71°54'S; 05°10'E)) to the West and ASPA Nr 141 (Yukidori Valley, Langhovde, Lützow-Holmbukta (69°14'S; 33°45'E)) to the East.

The DROMLAN link has been used for access to the Sør Rondane region for preliminary studies. The link may be used for some of the building crew during the construction phase or scientists and station staff during the operational phase. The following Historic Site and Monument is situated near to the Novolazarevskaya airfield used by the DROMLAN link:

Historic Site and Monument No. 44: A plaque erected at the temporary Indian station, Dakshin Gangotri, 70°45'S 11°38'E, marks the First Indian Antarctic Expedition.

4.9 Prediction of the future environmental reference state in the absence of the proposed activity

The site of the new station is on the north ridge of Utsteinen Nunatak. There has been previous human activity in the area resulting from survey and research programmes run at Asuka (Japan) and Roi Baudouin (Belgium) stations. There have also been two recent visits to the area undertaken by Belspo/IPF in order to identify likely sites and to collect baseline data.

Although there are some records of previous operations at the proposed station area, no signs of such human activities were recorded during the 2004 and 2005 visits.

In the absence of the proposed activity, the near pristine state of the regions will be maintained and the aesthetic and wilderness values will be unaffected. It is likely that periglacial processes will continue at the site shaping the geomorphology of the region and breeding bird species will continue to occupy suitable nest sites.

The ice shelves of Prinsesse Ragnhild Kyst, where unloading of construction materials will take place, are an active ice front that continually refreshes itself.

5. LIKELY IMPACTS, ASSESSMENT, MINIMISATION AND MITIGATION OF THE PROPOSED ACTIVITIES

The following section identifies the direct effects on the environment of the proposed station construction, operation and logistic support activities described in **Section 2**. The Source–Pathway–Receptor process has been used to assess origins and outputs of activities and their likely environmental effects. Minimisation and mitigation measures to reduce these impacts are then described. The assumption is made that the minimisation and mitigation measures described will be applied. Finally, a summary of the impacts and mitigating measures is given in the impact matrix **Table 5.4** in **Section 5.13**.

The main sources of direct impacts are:

- construction activities
- emissions and fuel spills
- grey water
- noise
- impacts resulting from visitor disturbance

Indirect impacts are described in **Section 6**.

5.1 Methodologies

Likely Impacts are assessed qualitatively in **Sections 5.3-5.12** using the criteria outlined below. These criteria are used in the impact matrix in **Section 5.13**.

Nature
The nature of the impact caused by the activity on potential receptors.

Scope
The geographical area affected by the impact in local, regional or continental terms.

Persistence
The duration of the impact and whether it is likely to be short-term (minutes–hours), medium-term (days–weeks), long-term (months–years), permanent or unknown. There may be a lag time between when the output occurs and the time of the impacts.

Intensity
The overall severity of the impact is assessed in relative terms (low, medium or high).

Probability
The likelihood of the impact occurring. This is assessed as low (<25% probability), medium (25–75% probability), high (>75% probability).

Importance
The overall importance of the impact is assessed in relative terms (low, medium or high).

Description of effect.
This categorises qualitatively the direct, indirect and cumulative effects of the specific impact. Three types of impact categories are specified in Article 3 of Annex I of the Environmental Protocol and the CEP (2005) definition of each category is adopted for this CEE.

(1) Direct Effects: Any first order effect, impact or consequence that may be associated with an activity. For example, acute toxicity effects (mortality) in marine birds, or in intertidal limpets, or in pelagic krill caused by exposure to toxic constituents of petroleum products spilt at sea.

(2) *Indirect and Second Order Effects*: Any second order effect, impact or consequence that may be causally associated with an activity. For example, particulate emissions from combustion leading to melting of ice or snow that subsequently causes loss of ice or snow algae habitat.

(3) *Cumulative Impacts*: Effects, impact, or consequences that may come from similar or varied sources, but that are additive, antagonistic or synergistic in their effect, impact or consequence. For example, disturbance to nesting skuas caused by existing scientific use and by a proposed use.

5.2 Source, Pathways and Receptors

The Source-Pathway-Receptor principle has been used for the identification and likely result of impacts resulting from activities. This is in accord with the Environmental Protocol, which recognises that impacts may be greater, for example, where waste products are carried to areas of high ablation (Environmental Protocol Annex III, Art 4(2)).

The proposed location of the station is in an area of limited rock outcrops, where there is the possibility of waste produced or emissions generated in one area, flowing along a pathway to another. The Protocol recognises ice as a pathway but here are also transient pathways such as seasonal melt water that may carry pollutants between sources and receptors.

5.3 Atmospheric Emissions

The station has been designed for minimum energy requirement and maximum use of renewable resources. The fossil fuel requirement for operation of the station will, therefore, be kept as low as possible. There may be greater fossil fuel requirements during the construction phase until the station becomes operational.

Fuels used will include:

- Aviation kerosene, Jet A1 (air transport, tractors, heating)
- Unleaded gasoline (snowmobiles, generators)
- White gas (small stoves)
- Propane(larger stoves)
- Lubricants and hydraulic oils (mechanical equipment and vehicles)

Atmospheric emissions during the construction of the station will come primarily from the combustion of fossil fuels during the transport of materials and the construction of the station. A minor amount of fugitive emissions will occur during fuelling activities. During the operational phase transport and fuel spills will be the main source of emissions.

The geographical area affected will include the route of the ship, the unloading site at Breid Bay, the traverse route, aircraft flight routes and the station area. Areas visited during scientific fieldwork will also be affected.

Estimate of fuel usage

The major use of fuel during the construction phase will be for transport. Fuel will be used for ship transport to the ice edge, by the tractors to transport materials to the station, and, locally, at the station by vehicles and generators. Fuel will also be used for flights for the input of personnel.

The operational phase will require fuel for the annual re-supply of the station by ship, local transport from the ship to the station (by helicopter and/or tractors) and for local and scientific field transport. It is envisaged that the fuel requirements for station operation (excluding transport) will be minimal and the ultimate aim is to operate the station using only renewable energy sources.

There are limited data available to estimate fuel use for the above activities. Figures from other station construction activities by other national operators have been used to estimate fuel consumption:

Fuel type and use	Construction (litres)	Operation (litres) per year
Jet A1 (Flight within Antarctica)	8,000	4,000
Jet A1 (Land transport)	17,000	5,000
Jet A1 (Power Generation)	8,000	100-2,500
Unleaded Gasoline (Land Transport)	2,000	2,000
White gas / propane (Cooking and heating)	Not known	Not known

Table 5.1: Estimates of fuel use for construction and operation of the station (litres)

Fuel amounts are relatively low compared to other Antarctic operations because of the small scale of the proposed station and the philosophy to minimise fuel requirements.

Fuel consumption for shipping has not been included as it is not yet known which ship will be used for construction or operational phases, and to what extent that ship might be deviating from its usual operational activities. However, it is acknowledged that shipping accounts for significant air emissions due to the high amount of fuel burnt.

Fuel use during intercontinental flight has also not been included. Fuel consumption during these flights will be reported by the DROMLAN operator to the relevant authority.

Air and ship transport to Antarctica

Ship and air transport used in the construction and operation of the Belgian research station will be negotiated on a year by year basis, using the facilities of existing operators in the area. For shipping, the environmental impacts will therefore be based on the additional amount of cargo carried and the deviation from the ship's normal itinerary. The impact of air transport (DROMLAN and local) depends on the amount of people and cargo transported, but the use of existing facilities has environmental benefits.

Emissions during passage to Antarctica by ship and aircraft will be rapidly dispersed and are unlikely to have any significant impact on wildlife, marine or air quality.

Coast

The time the supply ship will spend berthed at the coast during unloading operations will depend on a variety of factors including sea ice and weather conditions, and the speed at which construction materials can be moved to the station location. Emission calculations have been based on an estimated period of 10 days during which there will be ship and vehicle activity at the coastline.

In the operational phase, re-supply of the station by ship should take around 1–2 days only.

Emissions at the coastline will be rapidly dispersed and are unlikely to have any significant impact on wildlife, marine systems or air quality.

Traverse route

Fuel will be used by vehicles in transporting construction materials, stores and personnel between the ship and the station location. There will be emissions to air along the route to the station that will be repeated each year but at a reduced level once the station is operational. Emissions to air will be rapidly dispersed although there may be local areas of increased concentration where tractors stop, fuel or are allowed to idle for long periods.

Ship unloading during the operational phase may be assisted by helicopter depending on the facilities available on the ship.

Station

Emissions to air at the station location will be greatest during the construction phase due to increased vehicle activity and the use of fossil fuels by the construction camp. Once operational, emissions to air will reduce significantly, although there will continue to be limited vehicle and flight activity at the station in support of scientific work and to re-supply the station. Very low quantities of CO_2 will be produced by the waste water treatment system.

Fall out from combustion products generated at the station locality may result in impacting the flora and breeding bird colonies on Utsteinen Nunatak and the surrounding snow and ice. There is the possibility of cumulative impacts to these systems during the lifetime of the station. The Sør Rondane are noted for frequent and persistent winds. At Utsteinen Nunatak they are from an E to SSE direction (see **Section 4.4** Climate) so emissions to air will normally be dispersed away from the Nunatak and the Sør Rondane generally.

Heavy particulates, such as carbon soot, may deposit a short distance down-wind from the station and may have an impact on future ice-related research. Studies at other stations have shown that downwind contamination of snow and ice rapidly reduces to background levels within 10 km of the origin (Suttie and Wolff, 1993).

Predicted atmospheric emissions

Based on the estimates of fuel use given above and in **Table 5.1**, atmospheric emissions have been calculated and are shown in **Table 5.2**:

Emission	**Construction (tonnes)**			**Totals (tonnes)**
	Air transport	**Land transport**	**Generators**	
CO_2	20.317	49.841	17.46	87.618
CO	0.033	0.421	0.005	0.459
NO_x	0.013	0.592	0.02	0.625
N_2O	0.0014	0.0034	0.0014	0.0062
SO_x	0.038	0.082	0.038	0.158
CH_4	0.0006	0.0035	0.0004	0.0045
VOC	0.005	0.084	0.004	0.093

Total calculated atmospheric emissions for the construction phase

Emission	Operation (tonnes per year)			Totals (tonnes per year)
	Air transport	Land transport	Generators	
CO_2	10.159	17.404	5.456	33.019
CO	0.017	0.147	0.002	0.166
NO_x	0.04	0.207	0.006	0.253
N_2O	0.0007	0.0012	0.0004	0.0023
SO_x	0.019	0.024	0.012	0.055
CH_4	0.0003	0.0013	0.0001	0.0017
VOC	0.003	0.029	0.001	0.033

Calculated annual atmospheric emissions for the operation of the station

Table 5.2: Calculated atmospheric emissions
Notes: Weight fraction of Sulphur in fuel used for SOx calculation = 0.3% by weight for Jet-A1 and 0.02% by weight for unleaded gasoline ; Density of Jet-A1 = 0.795 kg l-1; Density of unleaded gasoline = 0.735 kg l-1 (Emission factors from Shah and Pope, 1994)

There is a high level of uncertainty in the estimation of emissions from the above activities and emissions will vary depending on temperature and specific fuel and engine characteristics.

Impact of emissions

Use of fossil fuels will generate combustion products including CO_2, SO_2, NO_x and particulate matter. The impacts from these emissions will depend on the location at which they are generated. As most of the emissions will be from transport, they will be rapidly dispersed.

Impacts will only occur during the summer months, and are of a relatively low intensity. The predicted impacts are contamination of snow, ice and rock surfaces which may affect biota. This may result in a loss in scientific value of the affected areas. Particulate matter may remain in the snow/ice for thousands of years and could affect a down-stream environment on release to the ocean. Measurements at the proposed site indicate that there is relatively little ice movement (see **Section 4.3**).

Atmospheric emissions are cumulative and certain gases emitted may contribute to regional and global atmospheric pollution.

Minimisation and Mitigation

When negotiating the use of shipping and aircraft, environmental considerations will be taken into account. For example, a supply vessel which uses Marine Gas Oil (not heavy fuel oils) and which complies with MARPOL Annex VI on air emissions would be preferred. The overall environmental impact of ‘sharing’ shipping and aircraft facilities is very much reduced compared to having dedicated facilities.

During the unloading and construction phase the quantity and quality of emissions to air will be minimised by the use of energy conservation practices, including minimal use of vehicles and aircraft, not leaving vehicles and aircraft idling for long periods, and use of clean fuels where ever practicable (such as low sulphur fuels).

During the construction phase it is planned to use twelve sledges and six vehicles - of which 3 tractors - to transport materials from the ship to the construction site, so that the tractors can run almost continuously during the operation. Sledges will be pre-loaded at the coast ready for pick-up and a loaded sledge can then be exchanged for an empty sledge at the construction site without any delay. This will also give plenty of time for the loading and unloading of sledges, thus reducing the probability of accidents and mistakes. In addition, it will reduce idling time and will reduce the potential for increased concentrations of emissions at loading and unloading points.

Vehicles will be chosen based on their fuel efficiency and environmental performance where possible. They will be maintained to high standards and serviced regularly. Where practical, catalytic converters will be fitted to reduce output of contaminants. Only two heavy vehicles will be used during the operational phase.

The station has been designed with a low energy requirement with a focus on using solar or wind generation wherever possible to minimise the use of fossil fuels during operation. There will be a continuous process during the operation of the station to reduce its energy requirement by the use of energy conservation measures and investigation of alternative energy solutions to further reduce the use of fossil fuels.

The station site is also being designed to minimise the requirement for mechanised transport for station operations.

5.4 Fuel and Oil Spills

A variety of fuels and lubricating and hydraulic oils will be used during the transport, construction and operation of the station. The type of fuels and oils include aviation kerosene (Jet A1), unleaded gasoline, white gas, propane and minor quantities of oils.

Most fuels will be transported in bulk in 12m^3 sledge-based bunded bulk fuel tanks. Some fuel and oils will also be transported in UN classified 205 litre tight-head drums. Small cans (20 litres) will be used at the station and during field work for storage and transportation of smaller quantities of fuel.

Fuel and oil spills may occur during maintenance and fuelling of aircraft, vehicles, generators, stoves and heaters, and by leakage from bulk fuel tanks, depoted drums or small cans. Fuelling of vehicles and leakage from damaged drums are the most likely sources of fuel spills.

Most spills are likely to be less than 5 litres and the maximum risk is the loss of a bulk fuel tank. Damage to the supply vessel at the coast could lead to a large fuel spill.

Fuel is relatively volatile and spills will rapidly evaporate but a waxy residue may remain. There will be some fugitive emissions dependent on the scale of the spill. Fuel spills on snow will migrate downwards to an ice layer where the fuel will be encapsulated and remain in the ice until point of release. Released contaminants could, therefore, affect a downstream environment, most likely marine, in the future. Once released in the ocean, the fuel would rapidly disperse.

Spills on rock exposures may have a biological effect on cryptogamic flora. Fuel spills may also lead to contamination of any soil layer. Spills during the transport and construction phases may have an indirect effect on the scientific value of the area during the operational phase. Over time, fuel spills will contribute to the cumulative effects of the station.

Minimisation and Mitigation

Standard procedures will be developed for the transport, handling, transfer and use of fuels (see also **Section 2.4.17**: documentation). The underlying structure of these procedures will be the prevention of fuel spills by use of the correct equipment, minimising handling and transfer of fuels, secondary containment and staff training.

Fuel tanks will be sited where they are least likely to be damaged and fuel drum depots will be clearly marked to avoid loss of fuel or collision with drums.

Minimisation of spills during fuelling activities, the most likely time for minor spills, will be managed by identifying fuelling points that have suitable absorbent mats, spill containment and clean-up equipment. Proprietary secondary containment drum stands will be used for fuel transfers, for example when fuelling snowmobiles and stoves.

An Oil Spill Contingency Plan will be prepared for the transport and construction phases, and a separate plan prepared for operation of the station. Staff involved in refuelling operations will be trained appropriately and spill response exercises will be held. Fuel handling and spill response procedures will be regularly audited. All spills will be reported to the Project Manager (construction) or Station Manager (operation) and will be recorded for monitoring purposes.

5.5 Domestic Waste Water ('Grey' water)

Domestic waste water (grey water) will result from washing, food preparation and ablution activities. It does not include any solid waste from human, food, or garbage wastes.

There are limited data for grey water output at stations. Mäkitalo (1992) and Markland (1990) recorded average waste water output of 60 litres per day per person at Wasa Station, Basen Nunatak, a seasonally occupied permanent facility with sauna, showers and low-water consumption dishwashers and washing machines. Neumayer II station (Germany), Ekström Ice Shelf, estimated an average of 117 litres per day per person (Enss, 2004). Neumayer II is a year-round station with a winter population of 10–12, rising to 25–30 in summer. The year round US Amundsen–Scott South Pole station estimates 95 litres per day per person (summer population of 230–235; NSF, 2004).

The proposed station will be designed to minimise generation of grey water with a further objective of no grey water output. It is accepted, however, that during construction and initial operation there may be some grey water discharge.

Grey water will be discharged to a designated area on the lee-side of Utsteinen Ridge where there is a naturally formed fissure between the rock outcrop and permanent ice (randkluft). Discharge sites will be marked and the locations recorded. Care will be taken that no grey water discharges are made in the vicinity of wildlife or onto ice-free surfaces.

All grey water will be filtered at the station before disposal to remove solid material. Residues from filtration will be collected and removed from Antarctica. Due to the use of the ‘randkluft’, there will be no surface discharge of grey water either to the snow surface or to exposed rock outcrops. Discharging grey water into the ‘randkluft’ will contain it in a restricted area where it will freeze. **Section 4.3** shows that there is limited ice movement and discharged grey water is unlikely to be transported to other areas. An overview of the expected effluent quality of the grey water is given in **Section 12**, **Table 12.3.**

The direct effect of grey water disposal will be contamination of the underlying snow and ice. Grey water will have a local scope and low intensity but a long-term persistence and is therefore assessed to be of low–medium importance. Contaminated ice may eventually flow to the coast over a period of tens of thousands of years, where it will be diluted and dispersed as it enters the marine environment. The indirect and cumulative effect will be the spread of the contaminated area and a reduction in scientific value of the contaminated ice.

Minimisation and Mitigation

The station design will specify no grey water output. This will be achieved by two processes. The first is to reduce the water requirement of the station by only using consumer units that have low to extremely low water needs. Second, all grey water output will be collected, treated and, as far as practicable, recycled. The recycled water will be used for non-potable applications.

It is recognised that technologies for zero grey water output are still relatively unproven. During construction and the initial period of operation, all grey water will be collected, filtered and treated as far as practicable but there will be a limited grey water discharge. The construction camp will be organised so that grey water is collected at designated locations for filtering and treatment before disposal.

5.6 Solid Waste

Construction phase

Substantial quantities of non-hazardous solid waste will be generated during the construction of the station. The largest part of this will be packaging and construction materials, including metals, plastics, glass and wood.

Construction will also generate limited quantities of hazardous waste, such as adhesives, batteries, solvents, oily wastes and paints. Solid sewage and food garbage will also be generated. Estimates for the amounts of wastes that may be generated will not be possible until details of the design and construction methods have been finalised.

If not securely contained, waste materials may be blown away by strong winds, buried by snow fall or scavenged by skuas. If not properly managed, solid waste may have a direct effect as litter or have a biological effect on fauna. Solid waste may also have an indirect effect on the future scientific value of the area.

Minimisation and Mitigation

Minimisation will be achieved by

- Prefabrication of structures before shipping to Antarctica.
- Reduction of packaging where practicable.
- No prohibited products (listed in Annex III of the Environmental Protocol) brought to Antarctica.
- Sorting and labelling of all waste and putting into a designated shipping container ready for removal and to prevent wind dispersal or scavenging.
- Removal from Antarctica and reused, recycled or correctly disposed by licensed contractors.
- Weekly inspections will be made to retrieve any litter around the construction area or blown downwind.
- Solid sewage waste and food waste will be stored securely and removed from Antarctica.

A Waste Management Plan will be prepared for construction activities.

Operational phase

Solid wastes will be generated during the operational phase and will fall into the following categories as defined in Annex III (Art. 8) of the Environmental Protocol:

- Sewage (Group 1)
- Garbage (Groups 3 and 4: metals, plastic, paper, wood, glass, etc.)
- Fuel drums (Group 4)
- Food waste (Group 3 or 4)
- Hazardous or special waste (Group 2: oils, oily rags, etc.; Group 4: batteries.)
- Scientific waste

Data from year round stations indicate an annual solid waste output of 2–3 m^3 per person (Enss, 2004; NSF, 2004; BAS, 2005). The likely output from the proposed summer only station will be less than 1 m^3 per person.

If not correctly managed, some waste may be scattered by winds or buried by snowfall. Wastes could be scavenged by the local avian population or contaminate exposed rock surfaces and flora if not contained.

Activities at remote scientific sites will generate human waste that may, occasionally, be disposed of locally.

Minimisation and Mitigation

A Waste Management Plan (WMP) will be prepared to document the procedures for the collection, storage, reduction, recycling and disposal of wastes (see **Section 2.7**). A principle measure in the WMP will be minimisation of packaging brought to Antarctica as this has been shown to be a primary source of solid wastes (Enss, 2004; BAS, 2005). Waste items will be re-used and recycled as much as possible. The WMP will also deal with the disposal of wastes outside Antarctica, which is likely to be through a licensed waste contractor in Cape Town.

The amount of hazardous materials brought to the station will be kept to an absolute minimum.

The proximity of breeding bird species requires that food wastes are managed particularly carefully. Only certified poultry food products will be brought into Antarctica and all food wastes will be stored in secure containers prior to removal.

Solid sewage waste will initially be shipped out of Antarctica. However, it is planned that a treatment system, which is integrated with the water recycling system, will be used in the future. Wherever practical, human waste generated at remote scientific camps will be returned to the station for correct disposal.

All waste will be sorted and stored in a shipping container at the station. A member of each summer team will be designated as Waste Management Officer, responsible for implementing correct waste procedures. All station personnel will be briefed on waste management procedures and there will be regular inspections to collect any litter around the station and identify any potential sources of litter.

5.7 Noise

Noise will be generated by:

- Ship and cargo activity at the ice shelf
- Station operation
- Scientific activity

- Aircraft operation
- Land transport
- Wind turbines

Breeding bird species that nest in the Sør Rondane nunataks and seals breeding on the fast ice adjacent to the ice shelf may be disturbed by noise. The coastal lead may be used by feeding birds, seals and whales. Disturbance may result in a temporary increase in metabolic rate and consequent energy expenditure.

Breeding birds in the Sør Rondane nunataks are at the extreme edge of their range. Noise (or physical) disturbance resulting from the station, wind turbines, transport or scientific activity may result in loss of eggs or chicks through abandonment of nests, raiding by skuas and general disturbance. In severe cases noise can lead to the mortality of entire breeding communities. The nearest breeding birds are on Utsteinen Nunatak, around 1 km away from the station.

General activity and, in particular, vehicle use may generate noise in the station area. Scientific activities that require generators or other mechanical equipment may also generate noise. A wind farm at 350 metres has a noise level around 35–45 dBA. This is slightly more than a quiet bedroom at 20 dBA and slightly less than a busy general office at 60 dBA (WWF, 2000). It is unlikely that there will be significant disturbance to the birds from activities at the station.

Minimisation and Mitigation

Disturbance by ship and cargo activity at the shelf front is unavoidable. Selection of the unloading site should take account of known seal haul-out locations, especially if these are breeding sites, and the seasonality of breeding activity. Vehicle and helicopter movements at the ice edge should be kept to a minimum.

Aircraft noise will be minimised by using aircraft only when required and by keeping to minimum height and spatial separations unless weather, mechanical or operational changes during a flight require descent to lower altitudes for safety.

Resolution XXVII-2 provides recommended spatial and height distances for over flight of wildlife and guidance for crossing coastlines. Flight approach plans will be prepared for the station to avoid over flight of any of the nunataks which have known breeding bird sites. Flight plans will be abandoned and modified for future use if there is any indication of disturbance caused by flight activity

By avoiding over flight and maintaining minimum height and spatial separations when in the vicinity of wildlife, there is a low probability of disturbance to wildlife caused by aircraft noise.

The station will be designed to operate from renewable resources, and generator use will be minimal. Other activities will be conducted in such a way as to minimise noise. Vehicles will be routinely serviced to minimise noise output. Noise from the workshop and garage will be attenuated as these facilities will be sited underground.

The larger wind turbines will be collapsed during the winter and there will just be one small turbine close to the station while it is unoccupied.

5.8 Light Pollution

The construction and operation of the station in a previously unoccupied area will generate light. For most of the operating season, the station will be in 24 hour daylight and there will be no impact. If the station is open during periods of dark there is the possibility of disturbing breeding bird species or affecting light-sensitive scientific programmes.

Minimisation and Mitigation

External lighting will be designed to minimise stray light emission, particularly above the horizontal. Station windows will have blinds fitted if the base operates during dark periods to prevent disorientating returning snow petrels.

5.9 Flora and Fauna

There are very few lichen growths on the rock exposure where the proposed station will be sited, but they are more abundant on the main Nunatak (Belare, 2004). The few growths on the station site are likely to be affected by construction, but this and the subsequent operation activities will not affect the flora on the Nunatak itself, except for possible uptake of emissions to air.

Activity at the shelf ice edge from ship and cargo operations may have a minor impact on seals. At the likely ship arrival time in January, the Weddell seal breeding season will have finished. However, there may be seals hauled out on the ice that may be disturbed by noise and general activity.

The colony of breeding snow petrels on Utsteinen Nunatak may be impacted by the construction of the station but this will be transitory. Activity will be less during operation of the station and breeding petrels are less likely to be disturbed. Birds have been known to fly into the blades of wind turbines, but it has been shown that strikes are highly unlikely to occur in good visibility conditions and in poor visibility birds are less likely to be in the vicinity of turbines. Most birds fly over or around turbines (WWF, 2000). During the field visit in 2005, birds were observed to fly on either side of the rock ridge where the turbines will be sited, rather than above it (personal observation).

Minimisation and Mitigation

Noise and physical activity at the station during the most sensitive petrel breeding periods will be kept to a minimum. Aircraft will not over fly the station and the skiway will be sited at least 1 km from the Nunatak.

Visits to the Nunatak by station staff will be restricted during breeding periods and all staff will be given guidance on minimising disturbance to the petrel colony, any skua nest sites and lichen growth.

Ship, cargo handlers and construction staff will be instructed in minimising disturbance to seals, birds or penguins that are hauled out or feeding at the ice edge.

The wind turbines will be monitored to see if they have any effect on birds, and if they do then bird deterrent devices may be used.

5.10 Physical Disturbance, Aesthetic Values

The construction of a station on the ridge at Utsteinen Nunatak, an area of outstanding wilderness, will have a minor visual impact in the locality but only within line of sight.

There will be some disturbance to the rock ridge as the station legs and wind turbines will be anchored to the rock. Also there may be some local disturbance to loose rocks which may be used for heat storage. These will be left unaltered at the site after the station is decommissioned.

Station construction and operation will require an amount of snow management. The garage building will be located below the snow surface and this will necessitate significant snow moving during the construction phase. Introducing a new above surface structure to the ridge at Utsteinen Nunatak may cause minor local changes to snow deposition and wind effects but these will be temporary for the duration of the station.

The use of vehicles will leave tracks and a skiway will be maintained during the summer months. Water will be from melting snow and this may require some stockpiling of clean snow during some periods. The likely effect of the presence of the station on the snow/ice environment is likely to be minor and transitory.

Minimisation and Mitigation

The station is being designed to have a minimal visual impact. Extensive wind tunnel testing has been conducted to find the optimal situation for the station with respect to snow management. The layout of fuel tanks and other equipment at the station site will be designed to keep visual impact and effect on snow accumulation to a minimum. Marked vehicle routes will be used to minimise the amount of tracks made.

5.11 Introduction of alien species and translocation of diseases

Construction and operation of the station, linked to support by rapid inter-continental air transport, presents a moderate risk of the introduction of alien species or translocation of diseases into Antarctica. Introduction may occur through imported food or contaminated packaging and equipment entering the environment.

Scavenging of unsecured food wastes by skuas is a simple pathway for alien species or diseases to enter the system. Soil and seeds may be introduced by unclean footwear or equipment, resulting in the accidental transfer of non-native organisms to the Antarctic.

Antarctic bird populations are susceptible to infection by disease. Highly contagious viral diseases, such as morbillivirus, Newcastle disease and influenza, immunosuppressant diseases, such as infectious bursal disease, morbillivirus and retrovirus, and agricultural and zoonotic diseases, such as brucellosis, tuberculosis and leptospirosis are considered to be the greatest potential risk to the health of Antarctic wildlife.

Minimisation & mitigation

Strict observation of Environmental Protocol Annex II Art. 4(5)-(6) and Appendices will ensure the prevention of introduction and translocation of species and disease. The following practices will be implemented to minimise the introduction of alien species and diseases:

- poultry products must be certified clear of Newcastle's and other contagious diseases;
- proper food handling and secure storage procedures at the station and in field camps;
- poultry waste separated and contained in secure storage for disposal at an appropriate reception facility outside the Antarctic Treaty Area;
- as far as practicable, all clothing (particularly foot wear), scientific instruments, mechanical and field equipment to be cleaned before importing into Antarctica.
- tracked and wheeled vehicles in particular to be steam cleaned before importation.

The probability of introducing alien species will therefore be extremely low.

5.12 Adjacent and Associated Ecosystems

Two features of the proposed activities are likely to impact associated ecosystems:

- Emissions to air (see **Section 5.3**): contribution to regional and global air pollution burdens.
- Removal of waste to South Africa (see **Section 5.6**): increased landfill in Cape Town; indirect effect of contamination of soil and groundwater; and disease transfer during sewage handling.

5.13 Impact Matrix

An impact matrix (**Table 5.4**) has been prepared to summarise the environmental impacts of the construction and operation of the proposed station at Utsteinen Nunatak. Activities which will have an impact are identified and the duration and output of the activity are stated. The scope, persistence, intensity, probability and importance are ranked according to the criteria described in **Section 5.1**. These criteria are summarised in **Table 5.3** below.

Heading	*Content*	*Detail*
Activity		
Nature	Type of activity	
Duration	Time period of activity	Listed in days, weeks, months etc.
Output		
	Description of potential results of activity that may cause impact	
Impact		
Scope	Geographical area affected	Local, regional, continental (L, R, C)
Persistence	Duration of impact	Short (minutes–hours), medium (days–weeks), long (months–years), permanent, unknown (S, M, L, P, U)
Intensity	Severity of impact	Low, medium, high (L, M, H)
Probability	Likelihood of impact occurring	Low (<25%), medium (25–75%), high (>75%) (L, M, H)
Importance	Importance of impact	Low, medium, high (L, M, H)
Effects		
Direct	Qualitative description of what is directly, indirectly and cumulatively impacted by the Activity/Output.	
Indirect		
Cumulative		

Table 5.3: criteria for ranking scope, persistence, intensity, probability and importance of the activity

The final two columns in the impact matrix describe the predicted impacts and indicate the measures that will be put in place to mitigate or prevent them from occurring.

Table 5.4: Impact matrix, showing preventative or mitigating measures

Nature	*Duration*	*Output*	*Scope*	*Persist.*	*Intens.*	*Prob.*	*Imp.*	*Predicted Impacts*	*Mitigation*
Shipping									
Shipping and cargo handling	10 days for construction; 1–2 days per year during operation	Atmospheric emissions	L	M–L	L	H	M–H	Cumulative contribution to regional and global air pollution; contamination of snow / ice and biota	Minimise ship movements; use ship which uses MGO; maintain engines to high standard; shared use of ship
		Noise / physical disturbance of wildlife	L	S	M	L	L–M	Disturbance of wildlife decrease in colony size; loss of biodiversity	Staff briefed on minimising disturbance of fauna
		Grey water, food, solid waste, human waste	L	S–L	L	H	L	Contamination of local marine environment; potential introduction of alien species and diseases	Prepare Waste Management Plan; poultry products retained on-board; wastes stored or discharged according to MARPOL
Aircraft									
Aircraft flight and landing	Repeated during season (Nov-Feb)	Atmospheric emissions	L	M–L	L	H	M–H	Cumulative contribution to regional and global air pollution; contamination of snow / ice and biota	Minimise flight operations; minimal ground running.
Fuelling	Repeated during season (Nov-Feb)	Fuel spill: <200 litre. Oil: <5 litre	L	M–L	H	M–H	M–H	Cumulative contamination of snow and ice; reduction in scientific value	Care and attention during fuelling Use of spill mats; Oil Spill Contingency plan prepared
Over flight of bird or seal breeding colonies	<1 hr per flight	Noise	L	S	M	L	L–M	Cumulative if repeated. Disturbance of wildlife decrease in colony size; loss of biodiversity	Aircrews to follow Resolution XXVII-2 Aircrews to follow local wildlife avoidance guidelines
Vehicles									
Running snow vehicles / generator / stoves	Repeatedly throughout season	Atmospheric emissions	L	M–L	L	H	L–M	Cumulative contribution to regional contamination of local ecosystems (lichens) & snow	Maintain equipment to high standard; minimal use; do not leave vehicles idling

Nature	*Duration*	*Output*	*Scope*	*Persist.*	*Intens.*	*Prob.*	*Imp.*	*Predicted Impacts*	*Mitigation*
		Noise	L	S	M	L	L–M	Cumulative if repeated. Disturbance of wildlife decrease in colony size; loss of biodiversity	Minimise vehicle activity in vicinity of wildlife; maintain minimal distances so that wildlife not disturbed
Fuelling	Repeated during season (Nov-Feb)	Fuel spill: <200 litre. Oil: <5 litre	L	M–L	H	M–H	M–H	Cumulative contamination of snow and ice ; reduction in scientific value	Care and attention during fuelling Use of spill mats ; Oil Spill Contingency plan prepared
Station									
Snow clearing	<100 hr per season	Physical disturbance	L	S–M	L	H	M	Aesthetic; cause of ablation; loss of scientific value	
Waste generation	Throughout season	Grey water and sewage	L	S–L	L	H	L	Contamination of snow and ice; loss of scientific value	Primary treatment and filtration before disposal; record disposal site
		Hazardous and non-Hazardous waste	L	M–L	L–M	H	M–H	Indirect effect of waste disposal outside Antarctica; contamination of snow if not stored securely	Prepare Waste Management Plan; remove waste from Antarctica; minimise packaging; recycle / reuse where possible.
		Introduction of alien species	L–R	P	H	L	H	Spread of alien diseases; loss of biodiversity	Clean equipment and clothing prior to departure; use certified poultry products; poultry waste stored securely.
Wind turbines	Throughout season; small turbine in winter	Noise	L	S–M	M	L	L–M	Disturb birds; decrease in colony size	
		Bird strikes	L	L	H	L	H	Damage or death of birds	Use bird deterrents
Light	Periods of darkness (minimal)	Disturbance of birds	L	L	L	M	L	Disturbance and disorientation of birds; decrease in colony size	Use blinds; minimal use of outside lights; lights to be angled below the horizontal
Science									
Site visits	Throughout season	Litter/waste	L–R	M–P	L	L	L–M	Spread of waste; expansion of 'footprint; loss of scientific value	Staff briefed on minimising impacts
		Trampling (rock)	L	M–P	L	L	M	Damage to lichens; disturbance of breeding birds	Staff to follow Recommendation XVIII-1

6. INDIRECT & CUMULATIVE IMPACTS

The station will be designed to have a low environmental footprint with low energy consumption and minimal waste output. It is therefore unlikely to have any significant indirect impacts.

All impacts if repeated, however, have the potential to become cumulative. The only significant cumulative impacts that may result from the construction and operation of the station are emissions to air (**Section 5.3**), fuel spills (**Section 5.4**) and local discharge of grey water (**Section 5.5**).

These cumulative impacts may affect the biota in the region and reduce the scientific value of the area. Outputs that lead to cumulative impacts, such as emissions to air or discharge of grey water, can be measured but it may only be possible to gauge their cumulative impact by measuring deviation from baseline data over time.

7. MONITORING AND VERIFICATION

Baseline data was collected during the Belare 2004 and 2005 site survey expeditions, in order to obtain reliable information about the initial clean state of the environment and to establish the "footprint" of the station (see **Section 4.5**).

Monitoring is one of the key components of the planned science at the new station (see **Section 1.3, iii**). A monitoring program will be developed to integrate with other work undertaken by national operators and using the Practical Guidelines for Developing and Designing Monitoring Programmes in Antarctica (COMNAP, 2005b). Monitoring activities may include the following:

- Collection of air, water, soil, lichen, snow and ice samples in the immediate vicinity of the station for analysis
- Investigation of bacteria of human origin in Utsteinen Nunatak
- Changes in breeding population of spp (snow petrel or Antarctic skua)
- Changes in snow deposition characteristics
- Effect on breeding seal population due to ship activity (Weddell seal)
- Introduction of non-native biota, diseases or toxic substances

Monitoring will be designed to investigate the potential impacts of the activity, so that adverse effects will be discovered in good time, allowing for modification of the activity to remove or reduce the impact. This work will also increase knowledge about human interaction with the Antarctic environment.

Information on the operation of the station will also be recorded for monitoring purposes. This includes fuel consumption data, fuel spills, station population, waste generation, waste disposal routes etc. This information will be used to validate the CEE and establish if the impacts are as predicted. Recommended mitigation measures will be reviewed as information about the extent and intensity of impacts becomes available.

8. GAPS IN KNOWLEDGE AND UNCERTAINTIES

The following major gaps and uncertainties in the assessment of the environmental impacts of the construction and operation of the Belgian research station are:

- Unpredictability of sea ice extent at Breid Bay and local weather conditions during construction of the station. May lead to delay in completion of construction.
- Exact conditions at unloading site.
- Incomplete details of final station design.

- Incomplete details of logistic operations for the construction of the station, i.e. which ship and aircraft will be used.
- Location of breeding species in a 200 km range – birds, penguins, seals.
- Changes in future scientific and logistic activities.

9. ENVIRONMENTAL MANAGEMENT PLAN

An Environmental Management Plan (EMP) will be prepared prior to the start of construction that will contain the following elements:

- Statement of Intent to follow Belspo environmental policies and procedures.
- Definitions of roles and responsibilities of parties involved in carrying out the proposed transport and construction activities and for specified project personnel.
- Description of general environmental management activities which will provide the framework for implementation of the recommended mitigation measures.
- Plan for implementation of recommended mitigation measures for specific environmental impacts.

Statement of Intent

Standard policies and procedures will be developed for the various activities including waste management, fuelling operations, field operations and operation of equipment (see also **Section 2.4.17**). The underlying structure of these procedures will be to ensure safety and the prevention of environmental impacts by correct use of equipment, proper maintenance and safe operation.

Roles and responsibilities

Protection of the environment is a management responsibility that starts with senior personnel in Belspo/IPY and is implemented by personnel in the field.

Senior managers at Belspo/IPF will be identified as responsible for overall environmental performance during the transport and construction phases. Senior management control may change for the operational phase. A member of the Antarctic field team will be identified as having overall responsibility to monitor implementation of environmental requirements in the field.

General Environmental Management Activities

This section outlines recommended environmental management activities before and during the transport and construction phases. Belspo will be in charge of environmental management during the operational phase.

Before the project commences

- Belspo will obtain all relevant clearances and necessary approvals from authorities prior to commencing the operation.
- IPF will brief all contractors and crew on sensitive aspects of the environment and expected environmental conduct.
- IPF will brief all contractors and crew on the requirements of the EMP.
- IPF will be responsible for the training of all personnel involved in the activities on emergency procedures and implementation of the EMP.

During transport and construction

- IPF will report environmental incidents or accidents to Belspo.
- The IPF Project Manager will ensure that the Environmental Management Plan is implemented by the Antarctic field team.

After transport and construction phases have been completed

- IPF will complete a report summarising environment, health and safety issues, incidents/accidents and observations.

- IPF shall ensure that any contractual requirements, including any reporting or follow up activities required, are completed to Belspo's satisfaction.

Plan for Implementation of Mitigation Measures
The IPF Project Manager will be responsible for implementing the mitigation measures identified in **Sections 5.3–5.12** and in the impact matrix in **Section 5.13** during the construction of the research station. During station operation the Belspo Station Manager will be responsible for the implementation of mitigation measures.

Implementation is not a static process and the Managers will be responsible for reviewing and updating minimization and mitigation measures during the construction and operational phases as conditions change.

10. CONCLUSION

Belgium considers its decision to reconstruct a new research station in Antarctica in line with its position as one of the original signatories of the Antarctic Treaty. The "Do not go" alternative is considered as opposed to the philosophy of growing importance of Antarctica's key role in Global Change and increased concern of the state of its environment.

The station will be situated at the foot of the Sør Rondane Mountains, Dronning Maud Land, having access to all geographical regions (polynia, coast, ice shelf, ice sheet, marginal mountain area and dry valleys, inland plateau) within a radius of 200 km.

The station concept is unique in several ways. Situated on a small exposed rock surface completely surrounded by snow, the station will have a hybrid design exploiting maximally this 'island' effect. The main building will be anchored on the snow-free granitic ridge, while the garage/storage building will be constructed under the adjacent snow surface.

The design of the station is based on sustainable technology and high energy efficiency, using renewable energy as the primary energy source, thereby limiting the use of fossil fuels to transport and field work.

The main building has a concentric architecture laid out around a "hot technical core" for temperature-sensitive installations and equipment. Second and third concentric layers will contain respectively the active and passive living spaces. When closed down for winter each individual layer will be "sealed" thereby creating a number of temperature-controlled buffer zones against the cold exterior environment.

The CEE has identified and evaluated potential impacts that may be generated during construction and operation of the station. Due to its 'Island' position and the remarkable constant wind direction, fall out from emission products at the station will be dispersed away from the nunatak and mountain areas. This and the sustainability concept of the station assure a low environmental footprint with minimal waste output.

Belgium therefore concludes that the global scientific importance and value to be gained by the construction and operation of the new Belgian station in the 1072 km empty sector between the Japanese Syowa station and the Russian Novolazarevskaya station outweighs the more than minor and transitory impacts the station construction and operation will have on the Antarctic environment and fully justifies the launch of this project.

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12. APPENDICES, TABLES ETC.

ATCM	Antarctic Treaty Consultative Meeting
AWS	Automatic Weather Station
Belspo	Belgian Federal Science Policy Office
Belare	Belgian Antarctic Research Expedition
CEE	Comprehensive Environmental Evaluation
CEP	Committee for Environmental Protection
COMNAP	Council of Managers of National Antarctic Programs
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EOMR	End of Mission report
FMEA	Failure Mode Effect Analysis
GDRP	Geodetic Reference Point
HVAC	Heating, Ventilation, Air Conditioning
IPF	International Polar Foundation
MEUR	Million Euro
SCAR	Scientific Committee on Antarctic Research
UPS	Uninterrupted Power Supply
VHF	Very High Frequency
VOC	Volatile Organic Carbon
WMP	Waste Management Plan

Table 12.1: Acronyms used in the Draft CEE

Site	*Latitude*	*Longitude*
Basen Nunatak	73º05'S	014º30'W
Belgica Mountains	72°35′S	031°15′E
Breid Bay	70º15'S	024º15'E
Byrdbreen	71°45′S	26°00′E
Derwael ice rise	70°15′S	026°30′E
Ekström Ice Shelf	70º37'S	008º22'W
Enderby Land	60°30′S	53°00′E
Gunnestadbreen	72°03′S	23°50′E
Jenningsbreen	71°57′S	24°22′E
Leopold III Bay	70°20′S	024°13′E
Nansenisen	72°40′S	024°00′E
Novolazarevskaya Station (Russian Federation)	71º46'S	011º50'E
Pingvinane	72°00′S	25°00′E
Polarhav Bay	70°18′S	024°40′E
Prinsesse Ragnhild Kyst	70º30'S	027º00'E
Queen Fabiola Mountains	71°30′S	35°40′E
Roi Baudouin Research Station (Belgium)	70º26'S	024º18'E
Romnaesfjellet	71°28′S	023°56′E
Sør Rondane	72º00'S	025º00'E
Seal or Selungen Nunatak	71°32′S	024°04′E
Syowa Station (Japan)	69º00'S	039º35'E
Utsteinen Nunatak	71°57'S	023°20'E
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Table 12.2: Site Coordinates

Parameter		
CODt	g/l	45
EC	mS/cm	2,5
pH	-	8,3
TOC	g/L	0
Sulphate	mg/L	80
Phosphate	mg/L	24
Ammonium	g/L	0
Fluoride	mg/L	0.5
Chloride	mg/L	96
Nitrates	mg/L	78
Mg	mg/L	4
K	mg/L	125
Ca	mg/L	11
Na	mg/L	95
Turbidity	-	5,0
Total coliform		<100
E.Coli		0
Enterococci		<10

Table 12. 3: expected effluent quality of the bio membrane reactor after final ozone, peroxide and chlorine treatment

Sample ID	Date sampling	Latitude (S)	Longitude (E)	Altitude (m)
1	28/11/2004	71°57.027′	023°20.478′	1373
2	28/11/2004	71°57.013′	023°20.492′	1382
3	28/11/2004	71°56.586′	023°20.508′	1385
4	28/11/2004	71°56.561′	023°20.513′	1372
5	28/11/2004	71°56.529′	023°20.505′	1365
6	28/11/2004	71°56.533′	023°20.509′	1363
7	28/11/2004	71°56.491′	023°20.486′	1367
8	28/11/2004	71°56.481′	023°20.469′	1372
9	28/11/2004	71°56.468′	023°20.447′	1377
10	28/11/2004	71°56.449′	023°20.423′	1369
1	22/11/2005	71°57.033′	023°20.802′	-
2	22/11/2005	71°57.023′	023°20.821′	-
3	22/11/2005	71°57.016′	023°20.822′	-
4	22/11/2005	71°57.006′	023°20.828′	-
5	22/11/2005	71°57.005′	023°20.847′	-
6	22/11/2005	71°57.002′	023°20.843′	-
7	22/11/2005	71°57.000′	023°20.845′	-
8	22/11/2005	71°56.997′	023°20.852′	-
9	22/11/2005	71°56.994′	023°20.847′	-
10	22/11/2005	71°56.981′	023°20.844′	-
11	22/11/2005	71°56.972′	023°20.842′	-

Table 12.4: Overview soil samples

Sample ID	Date sampling	Latitude (S)	Longitude (E)	Altitude (m)
1	28/11/2004	71°56.705′	023°20.838′	1365
2	28/11/2004	71°56.789′	023°20.930′	1366
3	28/11/2004	71°56.852′	023°20.978′	1363
4	28/11/2004	71°56.984′	023°21.181′	1374
5	28/11/2004	71°57.100′	023°20.845′	1381
6	28/11/2004	71°57.015′	023°20.569′	1381
7	28/11/2004	71°56.854′	023°20.743′	1372
8	28/11/2004	71°56.773′	023°20.651′	1382
9	28/11/2004	71°56.699′	023°20.536′	1380
10	28/11/2004	71°56.817′	023°19.150′	1359

Table 12.5: Overview snow samples

Table 12.6: Preliminary analyses results baseline monitoring

Snow													
Dissolved fraction (filtration after storage, filtered on 0.45µm))													
	Be	**Mo**	**Ag**	**Cd**	**Sn**	**Sb**	**Hg**	**Tl**	**Pb**	**Al**	**V**	**Cr**	**Mn**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
snow 1	0,002	0,014	0,072	0,011	0,028	0,010	0,007	<0.001	0,070	1,330	0,008	0,033	0,252
snow 2	0,001	0,011	0,009	0,006	0,030	0,005	0,004	<0.001	0,015	1,370	0,006	0,029	0,095
snow 3	0,004	0,014	0,012	0,018	0,041	0,008	0,002	<0.001	0,028	1,217	0,006	0,037	0,115
snow 4	0,002	0,037	0,016	0,013	0,021	0,005	0,008	<0.001	0,032	1,680	0,006	0,043	0,205
snow 5	0,001	0,035	0,015	0,038	0,024	0,011	0,007	<0.001	0,037	1,299	0,007	0,109	0,097
snow 6	0,001	0,014	0,020	0,025	0,018	0,008	0,005	<0.001	0,040	0,970	0,008	0,048	0,420
snow 7	0,002	0,013	0,018	0,015	0,015	0,007	0,007	<0.001	0,069	0,740	0,004	0,022	0,435
snow 8	0,001	0,011	0,013	0,012	0,023	0,003	0,005	<0.001	0,052	1,000	0,005	0,022	0,131
snow 9	0,001	0,006	0,013	0,015	0,013	0,004	0,004	<0.001	0,037	0,470	0,007	0,010	0,093
snow 10	0,004	0,007	0,013	0,009	0,019	0,004	0,004	<0.001	0,030	1,981	0,008	0,027	0,453
	Fe	**Co**	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Ba**	**Ca**	**K**	**Mg**	**Na**	**S**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
snow 1	0,543	0,009	0,089	0,234	2,832	0,006	0,020	0,0001	0,0689	0,0435	0,0276	0,1788	0,1204
snow 2	0,646	0,006	0,038	0,035	1,066	0,004	0,020	0,0001	0,0348	0,0100	0,0197	0,0990	0,0459
snow 3	0,350	0,005	0,056	0,147	2,325	0,004	0,010	0,0001	0,0461	0,0395	0,0128	0,0940	0,0412
snow 4	0,350	0,006	0,064	0,118	1,299	0,004	0,020	0,0004	0,0655	0,0100	0,0267	0,1931	0,0429
snow 5	0,520	0,006	0,100	0,261	3,012	0,013	0,024	0,0005	0,1242	0,0624	0,0228	0,1322	0,0450
snow 6	0,410	0,007	0,080	0,216	3,193	0,013	0,026	0,0002	0,0883	0,0035	0,0284	0,1854	0,0514
snow 7	0,340	0,015	0,137	0,107	2,280	0,014	0,010	0,0002	0,0780	0,0100	0,0203	0,1508	0,0271
snow 8	0,360	0,005	0,082	0,125	1,750	0,001	0,022	0,0002	0,0487	0,0397	0,0197	0,1307	0,0555
snow 9	0,210	0,005	0,056	0,093	2,880	0,009	0,025	0,0001	0,0250	0,0038	0,0129	0,0744	0,0334
snow 10	0,396	0,014	0,074	0,101	1,441	0,002	0,010	0,0001	0,0679	0,0564	0,0173	0,0837	0,0353
Acid leachable fraction (unfiltered, acidified 0.5% HNO3)													
	Be	**Mo**	**Ag**	**Cd**	**Sn**	**Sb**	**Hg**	**Tl**	**Pb**	**Al**	**V**	**Cr**	**Mn**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
snow 1	0,002	0,014	0,071	0,023	0,165	0,011	0,011	<0.001	0,203	8,62	0,022	0,033	0,442
snow 2	0,001	0,011	0,009	0,006	0,039	0,006	0,004	<0.001	0,038	5,49	0,009	0,030	0,136
snow 3	0,040	0,011	0,013	0,023	0,060	0,008	0,002	<0.001	0,074	4,55	0,014	0,060	0,205
snow 4	0,004	0,023	0,020	0,013	0,038	0,005	0,017	<0.001	0,036	4,79	0,020	0,048	0,380
snow 5	0,002	0,050	0,015	0,041	0,042	0,011	0,010	<0.001	0,093	5,30	0,014	0,137	0,142
snow 6	0,002	0,045	0,020	0,026	0,031	0,011	0,005	<0.001	0,068	3,37	0,011	0,065	0,577
snow 7	0,003	0,047	0,018	0,017	0,017	0,007	0,01	<0.001	0,095	3,88	0,010	0,022	0,526
snow 8	0,003	0,017	0,013	0,013	0,023	0,003	0,005	<0.001	0,074	7,83	0,016	0,026	0,222
snow 9	0,004	0,019	0,015	0,016	0,018	0,004	0,004	<0.001	0,064	3,03	0,013	0,063	0,121
snow 10	0,004	0,031	0,015	0,009	0,020	0,004	0,002	<0.001	0,035	9,16	0,025	0,042	0,605

	Fe	Co	Ni	Cu	Zn	As	Se	Ba	Ca	K	Mg	Na	S	Particulates
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
snow 1	6,200	0,013	0,092	0,281	3,290	0,014	0,020	0,0002	0,0728	0,0442	0,0251	0,1788	0,1204	6
snow 2	1,590	0,006	0,054	0,036	1,086	0,004	0,025	0,0001	0,0333	0,010	0,0177	0,0990	0,0459	4
snow 3	2,670	0,008	0,056	0,154	2,325	0,005	0,010	0,0005	0,0433	0,0313	0,0121	0,0940	0,0412	5
snow 4	3,190	0,010	0,086	0,121	1,322	0,006	0,024	0,0007	0,0678	0,0658	0,0268	0,1931	0,0429	3
snow 5	5,190	0,010	0,133	0,261	3,074	0,015	0,024	0,0004	0,1209	0,0735	0,0234	0,1322	0,0450	3
snow 6	2,650	0,014	0,095	0,220	4,743	0,017	0,047	0,0004	0,0878	0,0174	0,0246	0,1854	0,0514	6
snow 7	3,860	0,020	0,171	0,129	2,300	0,016	0,010	0,0002	0,0730	0,0157	0,0185	0,1508	0,0271	9
snow 8	4,440	0,008	0,097	0,128	1,799	0,003	0,022	0,0002	0,0491	0,0612	0,0212	0,1307	0,0555	4
snow 9	3,170	0,013	0,098	0,119	3,010	0,010	0,024	0,0001	0,0255	0,0181	0,0126	0,0744	0,0334	3
snow 10	9,205	0,020	0,064	0,117	1,478	0,003	0,010	0,0003	0,0613	0,0573	0,0174	0,0837	0,0353	7

Soil															
samples	**Be**	**Mo**	**Cd**	**Sn**	**Sb**	**Hg**	**Tl**	**Pb**	**V**	**Cr**	**Co**	**Ni**	**Cu**		
	µg/g	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**		
soil1	0,43	14,59	0,17	1,96	0,010	0,035	0,64	10,1	80,8	39,7	12,7	20,8	38,1		
soil7	0,32	3,15	0,27	1,55	0,014	0,054	0,41	10,7	67,2	31,4	10,6	17,3	29,2		
samples	**Zn**	**As**	**Se**	**Al**	**Ba**	**Ca**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**P**	**S**	**Sr**	**POC**	**PIC**
	µg/g	**µg/g**	**µg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**%**	**%**
soil1	73,0	1,40	0,38	26,0	0,2	10,3	51,9	12,4	15,4	0,616	1,505	3,07	2,00	0,092	1,19	0,003
soil7	44,1	1,96	0,43	19,0	0,1	11,6	35,6	7,0	11,9	0,412	0,922	3,88	1,88	0,107	3,89	0,030

Lichens																
samples	**Be**	**Mo**	**Cd**	**Sn**	**Sb**	**Hg**	**Tl**	**Pb**	**V**	**Cr**	**Co**	**Ni**	**Cu**			
	µg/g	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**	**µg/g**			
lichens1	0,01	4,67	0,06	0,06	0,004	0,340	0,02	0,39	0,85	0,63	0,20	0,72	5,55			
lichens2	0,17	1,49	0,13	0,41	0,014	0,116	0,14	3,33	10,99	7,24	2,45	4,67	4,79			
lichens3	0,04	0,32	1,01	0,17	0,008	0,008	0,04	1,46	2,64	1,18	0,38	0,78	7,61			
lichens4	0,04	2,14	0,07	0,02	0,002	0,234	0,06	1,31	2,50	1,85	0,45	0,96	5,57			
lichens5	0,00	0,35	1,19	0,02	0,008	0,017	0,01	0,05	0,16	0,07	0,05	0,30	12,32			
samples	**Zn**	**As**	**Se**	**Al**	**Ba**	**Ca**	**Fe**	**K**	**Mg**	**Mn**	**Na**	**P**	**S**	**Sr**		
	µg/g	**µg/g**	**µg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**	**mg/g**		
lichens1	21,4	0,68	0,98	0,252	0,003	1,06	0,48	4,56	0,48	0,017	0,140	2,46	2,26	0,010		
lichens2	21,1	0,57	0,23	4,852	0,029	3,43	10,66	2,00	2,57	0,158	0,145	1,05	0,88	0,024		
lichens3	19,4	0,50	1,02	1,121	0,007	8,86	2,84	1,09	0,59	0,038	0,331	2,95	0,81	0,064		
lichens4	18,4	0,95	1,15	1,220	0,006	0,94	2,99	5,58	0,83	0,050	0,078	2,84	2,84	0,006		
lichens5	11,6	2,49	3,85	0,018	0,002	4,91	0,06	5,53	1,36	0,004	3,874	8,78	5,37	0,089		