

Final Comprehensive Environmental Evaluation of the Proposed Activities:

- **Construction of the Neumayer III Station**
- **Operation of the Neumayer III Station**
- **Dismantling of the Existing Neumayer II Station**

This *Final Comprehensive Environmental Evaluation of the proposed activities "Construction of the Neumayer III Station," "Operation of the Neumayer III Station" and "Dismantling of the Existing Neumayer II Station and Removal of Materials from Antarctica"* is based in the main on the Draft Comprehensive Environmental Evaluation entitled "Rebuild and Operation of the Wintering Neumayer III Station and Retrogradation of the Present Neumayer II Station" (Version of 8 December 2004), written by Dietrich Enss, Barsbüttel, for the Alfred Wegener Institute for Polar and Marine Research (assisted by Hartwig Gernandt, Gert König-Langlo, Alfons Eckstaller, Rolf Weller, Hans Oerter, Joachim Plötz, Saad El Nagggar, Jürgen Janneck and Christoph Ruholl). All the graphic material in this document also originates from this Draft Comprehensive Environmental Evaluation.

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1. Planned activities

The Alfred Wegener Institute for Polar and Marine Research (hereafter referred to as AWI) filed a written application dated 12 October 2004 for a permit for three activities in Antarctica: for the project "Construction of the new Neumayer III Research Station," scheduled to take place in the austral summer seasons (i.e. between November and March) 2006/07 and 2007/08 (see Section 2 below), for the operation of the station, which has a proposed lifetime of approximately 25 years (see Section 3 below), and for the project "Dismantling and retro-gradation of the Neumayer III Research Station," planned to take place between 2008 and 2010 (see Section 4 below).

2. Construction of the new Neumayer III Station

2.1 Starting situation

Neumayer II, the German research station currently operating in Antarctica, was built in 1991/92 on the Ekström Ice Shelf at the Atka Iceport (70°37' S, 8°22'W) near the northeastern margin of the Weddell Sea and went into operation in February 1992. It is a steel tube building under the surface of the snow in which 9 people normally live and work all year round. During the months of the Antarctic summer up to 40 people are housed at the station – often for only a few weeks or months – most of them in tents or containers in the immediate vicinity of the station. In October 2004, the station was buried under approximately 7 metres of snow, and it will probably only be able to withstand the increasing loads on it until about 2009. For that reason, it is proposed that the station be replaced in 2007 or 2008 by a new station building to be known as "Neumayer III."

2.2 Uses of the proposed station

2.2.1 Scientific research

Like its predecessor, the proposed station is to be used primarily for scientific purposes. To that end it comprises three observatories for meteorological, geophysical and air chemistry measurements. The intention is to increase the potential of these facilities by making wider usage of the data, seeking constant technical improvements and developing their integration into global networks.

Meteorology

The meteorological observatory of Neumayer is designed as a radiation and climate monitoring station and is an integral part of many international networks, mostly associated with the World Meteorological Organization.

Air chemistry

The air-chemistry observatory at Neumayer, in close cooperation with the meteorological observatory, constitutes a significant part of the Global Atmospheric Watch (GAW) Network. Neumayer covers a wide range of GAW type measurements (aerosol, greenhouse gas, meteorology, ozone, and radionuclide). Many of these ongoing measurements were started over 20 years ago.

Geophysics

The two main research topics are seismology and geomagnetism. Some other long-term observations have been added to the observatory programme. Seismological observations were significantly improved in February 1997 with the installation of a small-aperture, short-period detection array, 44 kilometres away from the base at the Halvfar Ryggen ice rise.

2.2.2 Neumayer III Station as a logistics base

Apart from the work at the scientific observatories, the station's function as a logistics base also has high priority. Research work is now increasingly extending to the wider area around the base and requires several days' travel with tracked vehicles to the different observation posts or measuring stations.

In summer Neumayer Station serves as a stopover and re-supply base for German and international expeditions and is approached for these purposes both by ships and by small aircraft (e.g. Dornier DO228, De Havilland Twin Otter) with STOL capacity. A 1,000-metre-long and 60-metre-wide snow runway is maintained to the northwest of the station. Weather forecasting and flight weather advice for a wider area is provided by the meteorologists at the station. Neumayer is thus an important base within the Dronning Maud Land Air Network (DROM-LAN). A container workshop for the planes is operated on the snow in summer and is scheduled to be placed inside the weather-protected garage at Neumayer II Station.

Neumayer Station is often used as a control post for rescue operations in the region, which includes the polar seas north and west of Neumayer, because it has the necessary communication infrastructure. Whenever they are in the area, the two Dornier DO 228 aircraft provide AWI with an Antarctic search and rescue (SAR) capability. Equipment and personnel to limit and take remedial action against environmental damage occurring at the station or in its vicinity are on hand at Neumayer Station.

2.2.3 IS27DE infrasound observatory

The IS27DE infrasound array was installed near Neumayer Station in a cooperative venture with the Federal Institute for Geosciences and Natural Resources (BGR) in the austral summer of 2002/2003. This infrasound recording station – one of a total of four of its kind in Antarctica – is integrated into the international monitoring system (IMS) operated by the Comprehensive Test Ban Treaty Organisation (CTBTO). IS27DE station is an element in the Federal Republic of Germany's participation in the CTBTO's monitoring of adherence to the international nuclear test ban treaty. Under the provisions of this treaty, IS27DE must be kept in operation over the next few years. Recordings are transmitted via Neumayer Station's satellite link to the BGR and CTBTO, Vienna, and may also be used for scientific investigations.

2.2.4 Proposed capacity of the station

The station will be able to accommodate up to 60 people (including up to 12 people living and working there the whole year round, and during changeover another 12 people replacing them). The other up to 36 people are "summer guests" and will be accommodated in the summer part of the station. Additional people can be accommodated in cabooses and tents next to the station building.

To date, summer guests have included between 3 and 10 specialists who were engaged annually or every other year during the season in making the necessary adjustments of the buildings and outside installations to the accumulated snowfall and with major repair works or scheduled exchanges of machinery. The aim is that the new design and higher level of mechanisation at Neumayer III will reduce the complexity of this work, so that it will be possible for the wintering crew to do at least some of the work that has to be carried out each year.

Like the current station, the Neumayer III Station will have a small hospital for first-response care in cases of illness or accidents.

The "Library on Ice," currently housed in a 20-foot container, is also scheduled to be part of the new station. In 2005 (on the basis of a permit that has already been issued) it will be installed on a sledge between the balloon launching platform and the station building. Once it

has been relocated to the Neumayer III Station, the power supply cable needed for the library will be suspended on poles above ground.

Plant pool

The plant pool at Neumayer Station should continue to be extensive enough to deal with the tasks described. Besides 11 tracked transport and towing vehicles and about 30 sledges carrying up to 20 tonnes, there will also be crane-equipped vehicles, snow blowers and mobile generating plant (cf. the list of heavy plant and machinery below).

Table 1: Plant pool at Neumayer Station (2004)

No.	Make and model	Size l/w/h in metres	Weight in kg	Power in kW	Equipment	Consumption
2	Canadian Foremost Chieftain	9.7*3.0*2.7	18,500	199	Hydr. crane 12.5 tm, hydraulic winch 5 t	13-33 l/h
1	Schmidt Snow Blower	6.4*2.5*3.0	11,000	81+191	Moveable ejector chute	18-60 l/h
1	Snow blower	2.5*1.3*2.1	900	25		10 l/h
4	Kaessbohrer Pisten Bully PB 260	4.8*4.2*2.9	6,300	191	Cabin for 6-8 persons	2.5-3.2 l/km
3	Kaessbohrer Pisten Bully PB 260	4.8*4.2*3.3	7,600	191	Hydraulic crane 8.4 tm	2.5-3.2 l/km
2	Kaessbohrer Pisten Bully PB 300	4.8*4.2*2.9	7,000	240	Cabin for 6-8 persons	2.5-3.2 l/h
2	Kaessbohrer Pisten Bully PB 300	4.8*4.2*3.5	8,400	240	Hydraulic crane 8.4 tm	2.5-3.2 l/h
6	Front attachments for Pisten Bully	w = 4.6	1,100		Snow blade	
4		w = 4.4 - 5.2	1,400		12-way snow blade	
6		w = 4.2	1,200		Tipping trough	
30	20-tonne sledge (Aalener)	6.1*2.5*0.9	2,800 - 3,500		Container locks	
1	Generator	3.1*2.4*2.4	3,400	72	Mounted in 10-foot container	14-20 l/h
1	Generator		400	12	Cabin, transportable	4 -6 l/h
20	Bombardier Rotax skidoo Alpine III	3.2*1.3*1.3	288	46		Solo: 35 l/100 km With load: 55 l/100 km

2.3 Proposed site

The new building is to be sited at 70° 41' S / 8° 18' W, which in 2004 was approximately 5 kilometres south of the Neumayer II Station currently in operation.

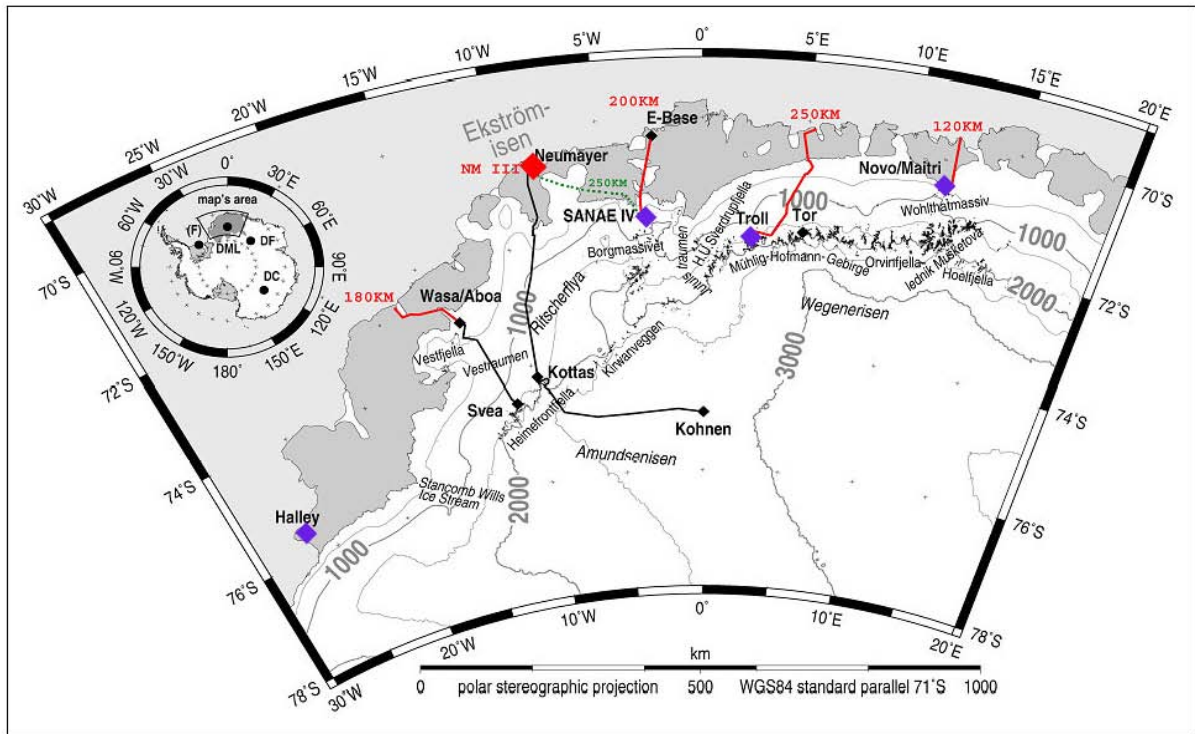


Abb. 5-2 Dronning Maud Land mit der Neumayer-Station, Nachbarstationen und zugehörigen Übereisrouten

Fig. 1: Dronning Maud Land showing Neumayer Station, neighbouring stations and the over-ice routes to them

Neumayer Station - GPS Network

Ekström Ice Shelf, Antarctica

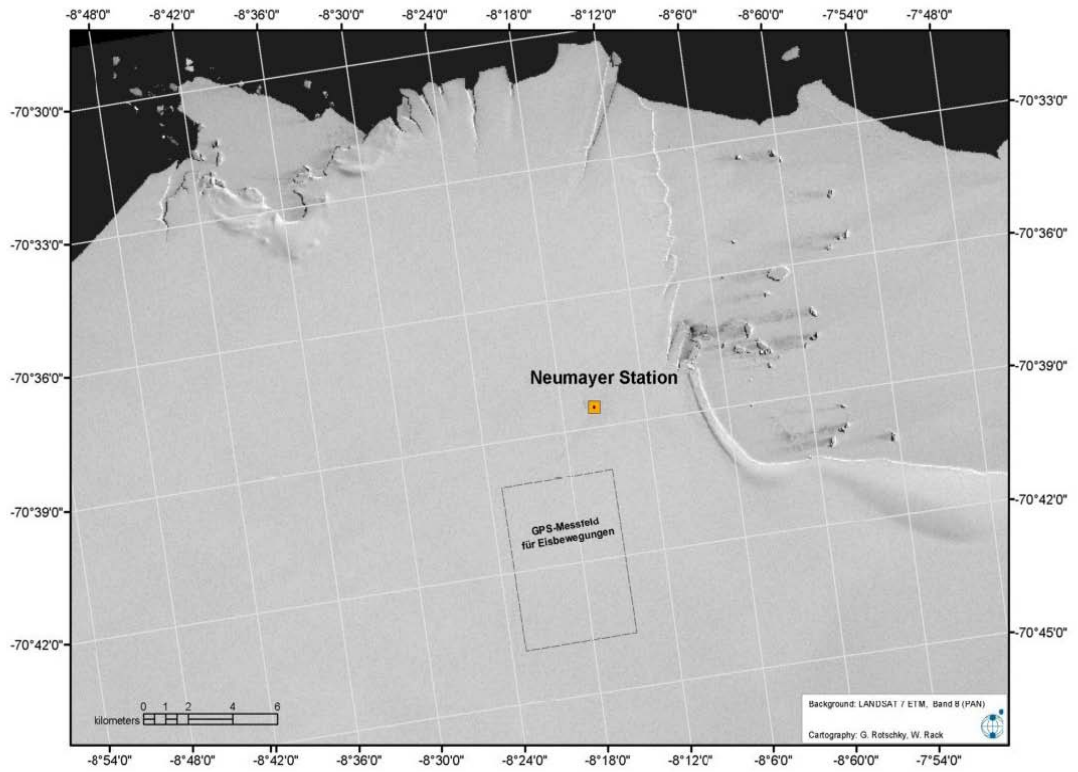


Fig. 2: Satellite image of the Neumayer Station area with fast-ice in Atka Iceport

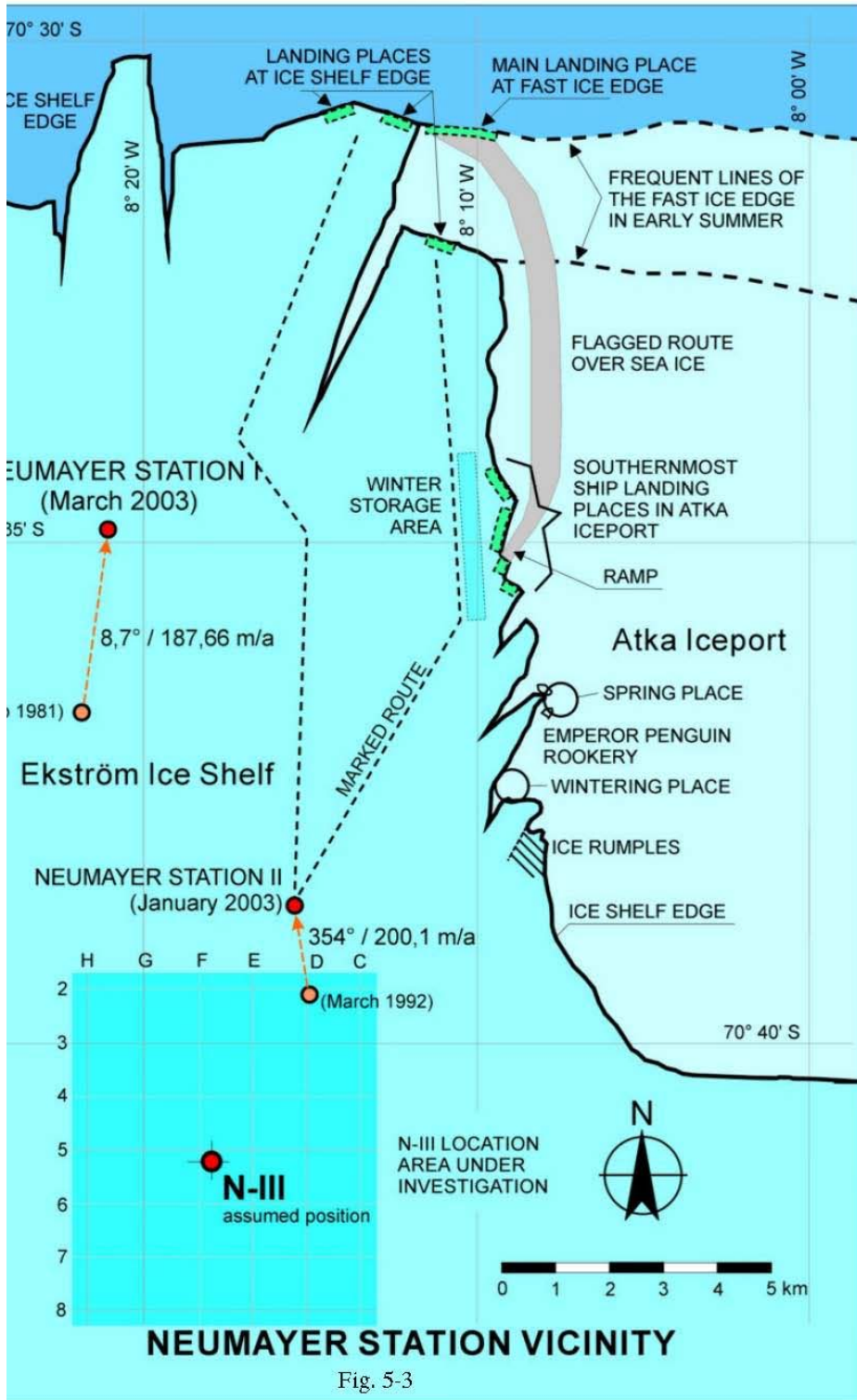


Fig. 5-3

Fig. 3: Neumayer Stations and the surrounding area

2.3.1 Criteria for selecting this site

The choice of site was based on the following considerations:

Scientific research

Scientific criteria for the location were also of great importance when selecting the site for Station Neumayer I in 1980 and the rebuild in 1991/92. The strongest reason for staying at the same location is the necessity to maintain uninterrupted measurement of various data to obtain series that are valuable for present and future research. Continuing this work at the observatories will only be possible if the station is operated at approximately the same location on the Ekström Ice Shelf.

Logistics

The location of the station has a great influence on the economy of logistics. AWI has cited the following requirements as being crucial from the point of view of logistics:

- The station must be easily reached by ship over as long a period in summer as possible;
- There must be suitable landing places near the station with distances and routes that can be covered in a few hours by tracked vehicles;
- There must be suitable flat areas adjacent to the station to allow the preparation and maintenance of an airstrip in summer;
- The station must be within reach of AWI's aircraft Polar 2 and Polar 4 when taking off from neighbouring stations, especially from Halley Station, without the need for intermediate refuelling;
- There must be suitable terrain for easy access to the hinterland by vehicle convoys;
- The distance between the ship's landing place and the station must be short enough to allow two complete round trips of a vehicle with cargo sledges, including loading and unloading times, in one extended shift of 10 hours, or 11 hours at the absolute maximum. If this condition cannot be met, the total loading or unloading time (and, when building Neumayer II Station, the construction time) will be disproportionately prolonged.¹

The envisaged location for Neumayer III next to the sites of the previous stations fulfils all these requirements. It is about 21 kilometres from the early-season landing places at the fast-ice edge (cf. map in Fig. 3).

In terms of logistics, this location has advantages over other bases in Dronning Maud Land. Most years FS Polarstern reaches the landing place by mid-December at the latest. The shelf edge, which is only 8 to 12 metres high, is ideally suited for unloading and loading. The extraordinarily stable position of the ice shelf with respect to Atka Iceport to the east of the station and also to the breaking edges in the north and west of the station has been observed for many years and is well documented. The flow velocity of the ice – not least because of the underwater obstacles – is only 160 to 200 metres per annum. For this reason, it was possible to site previous stations at comparably short distances from the ice edges. The proximity of the station to the landing places is of great advantage for the relief of the base and cuts down

¹ Assuming 35 minutes to manoeuvre sledges, decoupling and coupling at each end (twice per turnaround) and an average speed of 14 km/h empty and 9 km/h loaded, the maximum distance is 21.0 kilometres or 23.7 kilometres with 11 hour shifts.

lay days of the ships considerably. This is desirable not only for economic but also for safety reasons. There are only very few localities on the whole length of coast between Halley Station (UK) in the west and Syowa Station (Japan) in the east that can offer similar ideal conditions.

Ground conditions

To narrow down the choice of possible sites for a new station in the vicinity of the predecessor Neumayer Stations on the Ekström Ice Shelf, the long-term observations of the ice surfaces and glaciological measurements over a large area were supplemented by geodesic measurements of the flow and deformation of the ice in the 2003/04 season in an area of 8 by 10 kilometres to the south of the present Neumayer II Station, selected using satellite radar images. The analysis of the data has not yet been completed. It does, however, show that at the planned site there are comparatively complicated ice dynamics with strain vectors of strongly varying size and direction and changing flow velocities. Flow lines are not straight as would be normal in relatively small areas, but slightly and differently curved. AWI has established that the maximum horizontal strain vector allowable at the station location, or any location the station will reach on the flow line in 25 years of service life, is ± 1.5 per mill per year (in any direction). It is crucial that the orientation of the ground (defined by the curvature of the flow line the station is on) does not change by more than 5 degrees in the 25 years. This qualification has a bearing on the wind forces exerted on an above-ground building.

The station location has also been selected in such way that flow velocities along the path the station will follow in 25 years will not carry the station too near to the ice edge nor unacceptably near to the emperor rookery at Atka Iceport. After 25 years the new station will still be further away from the rookery than Neumayer II station currently is. The distance between Neumayer III and the colony will be over 5 kilometres. Even if operation of the station were to continue beyond that time, it would still not be closer than 4 kilometres to the rookery.

The environment

In terms of environmental criteria, AWI has been guided by the criterion that the station location and the re-supply route over the ice must be at a sufficient distance from the emperor penguin rookery at Atka Iceport. An appropriate distance between the mooring place of the ships at the western side of Atka Iceport and any emperors still present on the remaining fast ice in the innermost corners of the inlets has also been incorporated into the plans.

2.3.2 Alternative sites

AWI believes that the only possible location for the station - seen in the light of the scientific and logistic considerations mentioned above - is a site in the immediate vicinity of the existing station. Siting a station further away would be less suitable from a scientific point of view.

If the decision were based solely on the criteria of proximity to the old base (continuation of time series measurements) and limited distance to ships' landing places (necessary to keep transport to a minimum), other locations would also be feasible. From the observation and investigation of the underlying snow and the ice shelf at these places it is known, however, that buildings there would be subject to greater deformation than at the chosen place.

The effects on the environment of a station at a different site in the immediate vicinity would not differ from those at the previous station.

2.4 The station building

2.4.1 Description

Components

The station building will consist of two components:

- A roofed trench with snow walls and snow floor of about 2,130 square metres and 6.5 metres depth to be used as a garage and storage facility, and
- A wind-shielded, elevated platform on legs housing the two-storey working, accommodation and technical area of the station proper. It will comprise some 1,640 square metres of useable, air-conditioned space. To reduce wind forces and wind noise, this building will be enclosed in an aerodynamically designed envelope. A number of antennas and a balloon launching facility will be installed on the roof.

The platform will be supported by 20 steel columns in two rows 17 metres apart, giving the platform a clear height of about 6 metres above ground (i.e. above the flat roof of the garage/storage building positioned underneath the platform). The columns will run through the garage roof and take its loads in addition to those of the platform.

The garage will have a clear height of about 5 metres. Its snow walls and the snow floor are not clad, so that below-zero temperatures must be maintained inside the garage to keep the snow from melting. A covered snow ramp at one end of the garage will be used for access with vehicles and loads. The garage can be reached from the platform via a wind protected shaft containing a lift and ladders. There will probably also be stairs leading from the garage roof or surface level to the garage floor, in addition to the emergency exits.

The platform and the garage are separated by a 6-metre-high open space. The shaft including a lift just mentioned is the only direct link between the platform and the garage. This stairwell is protected in case of fire by compressed air aeration against intrusion of smoke. An extensive, high-performance ventilation system will be installed in the garage. It is designed to extract smoke if necessary in the event of a fire. A mobile exhaust gas extractor will also be installed for use in cases when a piece of machinery has to be operated in a stationary position, a vehicle carrying a crane to replace one of the jacks, for example.

The columns, or legs, are founded in the snow of the garage floor. Their foundations consist of so-called " pot bearings." They are made of a stiffened sole plate surrounded by vertical steel walls, without an upper plate. The foundations will go down about half a metre into the snow, but the upper rims of the pot bearings will remain above floor level. Double-acting lock-nut hydraulic cylinders will be installed at the feet of the columns so that the garage roof and the platform can be jacked up in one go to compensate for the snow accumulation. It will also be possible to lift the individual pot bearings out of the snow so that backfilling can be carried out before the column takes the loads again. Differential settlements will be detected by a building monitoring system, and the jacks can then be used to adjust the individual legs.

Alternatives

There is only a limited selection of feasible designs and building technologies for large station construction on snow that builds up permanently due to snowfall. The extreme environment poses immense technical problems to builders and maintenance crews, with blizzards and snow drift eventually burying everything. Also the number of existing stations that could serve as a model for more modern designs is very small.

Basic options for constructing station buildings

Essentially, station buildings can be placed below the surface of the snow, on the snow, or elevated on stilts above ground. Below-ground buildings are subject to the build-up of accumulated snowfall and will sooner or later be crushed by the weight of overlying snow. On-ground buildings will constantly become covered by drifting snow and require repeated relocation. And while above-ground buildings do not suffer from such disadvantages, they need facilities such as vehicle and fuel storage on or under the ground, which for weight, access or safety reasons cannot be accommodated on elevated structures.

Alternatives investigated

In the initial design stage, AWI considered and compared a total of nine different designs:

- Station in steel tube and garage,
- Station in a snow cavern,
- Station under a dome,
- Light platform and garage,
- Heavy platform and garage,
- In POLARMAR trench,
- Platform in the trench,
- Station suspended in trench.

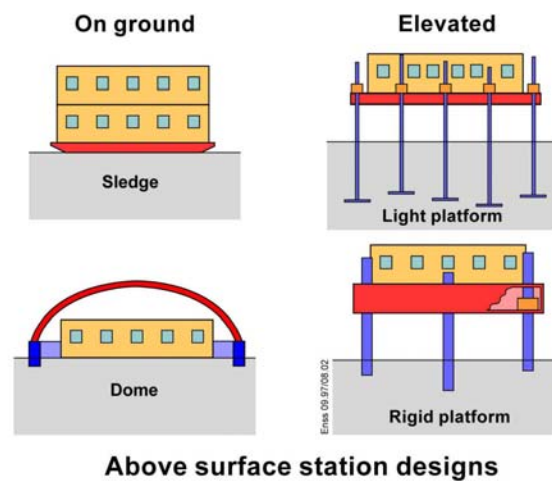
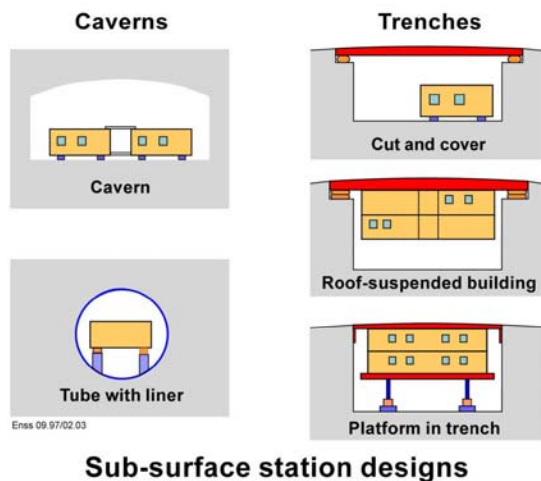


Fig. 4: Sub-surface station designs

Fig. 5: Above-surface station designs

One of these, a modular station split up and distributed on large sledges, which would have to be towed onto higher terrain once a year as the level rose, was soon abandoned when it became apparent that there was no certainty that it would be able to meet the scientific and logistic requirements at Neumayer. A similar conclusion was reported in the draft CEE for the Concordia Project base at Dome C (Gendrin G., Giuliani P. 1994).

The POLARMAR design (POLARMAR GmbH 1989) for a structure placed in a roofed trench avoids most of the disadvantages of underground and on-ground buildings. The flat roof is kept at the level of the snow surface by suitable hydraulic lifting equipment. After jacking up the roof, the floor of the trench is backfilled with snow. The garage building at Neumayer II Station is a prototype of this design. In an improved design, the roof forms part of a multi-storied building in the trench, with the building either resting on the trench floor or suspended from the roof, which is supported on the walls of the trench.

Comparison of the alternatives

The Neumayer III study covered preliminary building design, layout of the station, transport volumes, working hours for over-ice transports and construction, level of maintenance required, dismantling and retrogradation, and cost estimate. An underground-tube station building, although not considered a real alternative any longer, was included in the selection of designs to better demonstrate how the other designs differ and have been improved. The economic comparisons were based on 25 years of service life.

In this connection, AWI also compared the elements that are potentially most harmful to the environment:

- a) Fuel needed to supply the station's energy needs;
- b) Use of fuel-driven machinery and vehicles during the transport, construction, operation, maintenance and dismantling of the station at the end of its life.

Thus it became possible to make an indirect comparison of the major stresses on the environment to be expected.

Fuel needed to supply the station's energy needs

There is little difference in the energy requirements of station buildings above and under the snow surface. While snow has good insulating properties, it must be protected from melting wherever it is in contact with the structures (at Neumayer ambient temperatures can reach +5°C), and that costs energy. Also it must be considered that the heating of fresh air used in the station accounts for a sizeable portion of the energy consumption. The differences in fuel requirements between any of the feasible design alternatives are negligible.

Fuel savings can be achieved by other measures such as using wind power. It would be fundamentally possible to use wind power in most of the designs without having to make any structural changes.

Fuel consumed during the transport, construction, operation, maintenance and dismantling of the station

With regard to fuel requirements other than for power supply to the station, the overall costs of the activities using fuel are a good initial indicator that can be used in comparing the potential environmental impact. Furthermore, a look at the estimated total volume to be transported for the station building in question (and eventual retrogradation) can indirectly give an indication of the energy requirement entailed. The fuel needed for the annual maintenance work, along with the fuel needed to erect the station, were determined in the study of design alternatives and can be directly compared.²

The results of the comparison are shown in the following table.

² The number of technical staff who will have to come to Neumayer in summer to carry out the maintenance works could be used to estimate fuel for the small aircraft serving the Novolazarevskaya-Neumayer leg (assuming that these people do not come in by ship). However, averaged over several years, this number would not differ between design alternatives, whereas the differences in the level of maintenance required will be reflected in the length of time the work takes.

Table 2: Normalized comparison of the potential for environmental impact of the different station designs by selected parameters

	1	2	3	4	5
	Design option	Costs of activities that use fuel	Total transport volume	Fuel for construction of station	Fuel for annual maintenance
1	In steel tube + garage ¹⁾	127	117	109	104
2	In snow cavern	115	48	183	80
3	Under a dome	102	87	71	112
4	On light platform + garage ¹⁾	114	66	76	111
5	On heavy platform + garage ¹⁾	106	93	100	104
6	In POLARMAR trench	141	98	112	119
7	Floor based in trench	97	98	135	104
8	Roof suspended in trench	111	88	135	112
9	Design selected for Neumayer III	100	100	100	100

¹⁾ Plus garage as a separate building with a different design.

The table does not suggest that any of the designs is unequivocally superior on environmental grounds in the categories shown. A station in a snow cavern will not need a protective shell, and transport weights are correspondingly low. Annual maintenance work is lower as only very little adjustment to changing snow levels would be required. But the excavation involved in this option would be a highly energy consuming job, and other serious disadvantages – such as the large difference in outside and inside levels, the lack of daylight and the cavern's unpredictable shape stability – were key factors in deciding against this design. The dome solution is questionable with regard to drift events and snowtail formation.

AWI's overall conclusion was that two designs were best suited for Neumayer II Station. These designs also produced the best results with regard to one of AWI's main requirements, namely to keep maintenance costs to a minimum. These designs were:

- a) A station building in a roofed trench with two heated storeys and a cold storey on the trench floor for the garage/storage/workshop, and
- b) A station consisting of an elevated jack-up platform, bearing a two-storey working and accommodation building contained in an aerodynamically shaped envelope, plus an underground storage/garage/workshop hall in a roofed trench placed adjacent to the platform.

These two designs were then explored in greater depth. AWI concluded that neither of the two options was decisively better than the other. Finally the idea of combining the two designs was conceived. In this option, the covered garage/storage trench is placed directly underneath the platform, with the platform's legs running through the roof down to the trench floor. This design, which was chosen for the station, was incidentally one of the schemes that used up the smallest surface area and thus caused the least surface disturbance.

2.4.2 Station services and equipment

The hydraulic equipment for jacking up the structures will be installed in the garage part of the building. All hydraulic jacks will have setting rings (lock nuts) so that the oil pressure can be taken off when jacking is not taking place. Pumps and tanks for the hydraulic fluid are placed above the pot bearings, so that, in the event of a leakage, fluid will be collected in the pot. The jacks are hydraulically interconnected by pipes reaching outside the perimeters of the pots. These pipes are protected by collecting troughs that channel leaked fluid to the pots or other suitable containers.

Energy requirements, energy generation

The average electricity consumption is estimated at 100 to 110 kW. The increase over consumption at Neumayer II Station is mainly due to the higher requirements of the observatories, where, for instance, the air chemistry laboratory alone has a 100 % extra, permanent requirement. The station building proper at Neumayer III is also larger than the one at Neumayer II.

Electricity for the station will be generated primarily by diesel generators. The generators are located at the northern end of the platform in separate housings for safety and noise mitigation reasons. Exhaust gas treatment will be state of the art. Supplementary power will be wind generated; an output of up to 60 kW (possibly more) is envisaged in the medium term.

The size and number of the diesel motors will be chosen with the future complementary energy input by the wind generators in mind (diesel motors must run in a certain load range to work efficiently and to produce the lowest possible level of harmful emissions per unit of fuel). When determining the nominal capacity of the generators, the efficiency of the generator, the exhaust aftertreatment equipment and the quality of the fuel (in comparison to "ordinary" diesel fuel) must be considered. In effect, the nominal capacity of the engines will have to be 20 to 25 % higher than the specified electrical output. Depending on the time of day and time of year and on the power being fed in from the wind generators, either a 150-kW or a 75-kW generator will be in operation or the two together. The output data given refers to the 100-percent electrical output (nominal capacity) of the generators. In order to have enough spare capacity available during maintenance work, repairs, machine failure etc., three 150-kW and two 75-kW generators will be installed in the power station. A 150-kW generator will be installed in the emergency power station. The figures given for nominal capacities may fluctuate by plus or minus 5 per cent.

Storage of fuel and oil

There are two options for storing fuel and oil. Based on the latest designs, it will be possible to install fuel tanks on the station platform with adequate fire protection. For that reason AWI envisages no outdoor storage of fuel - neither in the immediate vicinity of the station nor in the garage and intends instead to install a fixed pumping station in the roof of the garage structure. The idea is that fuel will be brought on sledges in the existing tank containers and pumped into the storage tanks on the platform using the pumps in the pumping station. To that end, an approximately 8-metre-long hose will be installed from the tank container to a filling nozzle that will be fixed to one of the platform's columns. The lines from this nozzle to the storage tanks are fixed installations of steel. The six double-hulled storage tanks proposed are of stainless steel and will have a capacity of 9,000 litres each. This solution is subject to the building contractor being able to provide the required fire protection guarantees.

If an adequate level of fire protection cannot be guaranteed, recourse will have to be made to the alternative that envisages storing fuel to cover the station's needs for two to three months outdoors at the northern end of the station building in double-hulled container tanks. This option assumes a similar storage quantity, i.e. 60,000 litres in three of the container tanks nor-

mally used. These tanks would be installed in the garage and refilled from outside in a similar way to that envisaged in the currently proposed system. The fuel would be pumped from them to the power station on the platform through an above-ground line.

Power supply for the computer systems

To ensure a secure power supply to the computer systems, two parallel compact UPS (uninterrupted power supply) units of 20 kW/20 minutes capacity each will be installed. The battery packs are completely sealed and maintenance-free.

Heating

There are two possible options for heating the station: either a heating system that is integrated into the air-conditioning (as currently used in Neumayer II) or a system using hot water and radiators. All the energy required for heating will be generated by waste heat recovery from power generation or by using renewable energy. Cooling water and exhaust gas heat exchangers will be installed for this purpose. There will be no fuel-fired boilers.

Cooling

There will be six cooling containers at Neumayer II Station, and up to another four during changeover in summer. Other, smaller cooling units will also be used. The containers and units will use R134A and R404A as refrigerants.

Fresh water, hot water

The fresh water system will be modelled on Neumayer II Station with a snow melting tank operating on waste heat from the diesel cooling system. There will also be storage tanks providing a buffer for 3 to 5 days in winter and 2 days in summer. Hot water will be generated by waste heat from the diesel motors. The hot water storage tank will be installed on the platform in the heated part of the station, near the power station.

Fire protection and emergency precautions

If an inert gas fire extinguishing system is installed, the active fire fighting systems will be based on carbon dioxide (CO₂) and possibly nitrogen (N₂). The station will be divided into several fire compartments with barriers between them (walls, locks) able to resist a fire for a minimum of 90 minutes.

As in Neumayer II Station, the detectors and fire fighting installations there will be tested at regular intervals. The fire extinguishers are time-stamped to ensure regular checks; they will be replaced in batches and checked by the manufacturers in Germany before being exchanged for the next batch a year later. The same system will be used for the canisters containing the extinguishing agents for the automatic fire suppression system.

A survival hut for the overwintering staff will be maintained at a safe distance from the station. A small generator, emergency radio transceiver, emergency provisions and survival bags will be kept in the hut. Access to fuel will always be guaranteed since the fuel depots are dispersed.

The measures to be taken in the event of environmental damage or medical emergencies are described in detail in the Emergency Manual (AWI 2003).

Building materials

Building materials considered damaging to the environment of Antarctica will not be used in construction or furnishings and fittings. A possible exception to this would be a number of ionisation-chamber smoke detectors, on the condition that they can be securely monitored and ultimately removed from Antarctica.

All the building materials will also be selected on the grounds of fire safety. The selection criterion is that no poisonous fumes may be generated when heated or ignited.

Communications installations

Neumayer III Station's transmitting power will not be higher than Neumayer II. Transmissions via the directional satellite radio links (max. 20 W) will continue to represent the bulk of radio traffic. Transmissions on 5150 to 7775 kHz in the short-wave spectrum will not change in intensity (max. output 1,000 W) or duration (less than 30 minutes per day on average). The share of power consumption accounted for by transmissions installations at Neumayer III Station will continue to be negligible.

2.4.3 Fuels, lubricants, hydraulic fluids, technical consumables

2.4.3.1 Diesel fuel

Quality

A few years after Neumayer II Station becomes operational, the European Union's Stage IV standards for fuels, designed to regulate exhaust emissions, will take effect for stationary, non-road diesel machinery (cf. section 6.6). AWI will comply with these standards to the greatest extent possible. No distinction will be made between vehicles and stationary machines, because the same types of diesel fuel will be used at the station.

Quantities required

The annual consumption of diesel fuel for power generation will increase by approximately 54 % to 293,800 litres per year by comparison with the consumption at the present station, Neumayer II. This is due to the additional requirements of the observatories (cf. 2.4.2). These figures include the savings in fuel achieved by incorporating a 20-kW wind generator, delivering on average 35,000 kWh/a (El Naggat et al. 2000). If – as planned – more wind generators (totalling 60 kW) are used, annual diesel consumption will drop to about 267,000 litres.

The diesel fuel used for vehicles at the station varies strongly from year to year; average consumption is 21,000 l/a. No significant change for Neumayer III is envisaged here.

Storage

The storage capacity for diesel fuel at Neumayer III must therefore allow for a 551,000-litre supply if full operation is to be guaranteed over 21 months. After a season without re-supply it can be expected, however, that various measures will be taken to reduce power consumption to a level necessary for the scientific operation of the base and sufficient for the convenience of the overwintering staff. AWI therefore believes that a storage capacity of say 500,000 litres should suffice.

At present the station has 32 containerised high-grade steel tanks of 10,500- to 23,000-litre capacity at its disposal with a combined capacity of approximately 594,000 litres. One other tank of this kind is usually located on FS Polarstern. They will be used for the Neumayer III

station. They comply with the relevant standards for fuel transport containers, and have been approved by the classification company Germanischer Lloyd. A full maintenance check of all tanks will be carried out every 5 years on average. Tanks will be taken back to Germany for this purpose.

However, some of the tanks are currently used for storing kerosene, so that a number of new tanks will be needed. These new tanks will be double-walled and have all the safety equipment and acceptance test certificates required by the latest legislation.

Storage of Arctic Diesel in drums at the station will be restricted to supplying traverses. The required amounts of diesel fuel are pumped into 200-litre drums (mostly at the summer depot). A small number of drums will be stored in the summer depot at the station, all others in the winter depot near the ships' landing area at Atka Iceport.

Transport

Diesel fuel will be pumped through hoses from the ship's tanks into the station's containerised tanks. The transfer from ships, transport over the ice, handling and storage of POL is described in detail in the "Antarctica Emergency Manual" which contains an oil spill contingency plan and plans for other emergencies, along with instructions for ship loading and unloading operations, aircraft operations and traverses" (AWI 2003).

2.4.3.2 Petrol, aviation turbine fuel (kerosene)

Requirements

No change as against Neumayer II is envisaged with regard to the skidoos, whereas flight logistics are subject to rapid change and fuel requirements cannot be estimated with any degree of accuracy.

Storage

As at the Neumayer II Station, Neumayer III will also store standard lead-free petrol for the skidoos and aviation turbine fuel (kerosene JP8 and Jet-A1) for helicopters and light aircraft. Based on empirical values at Neumayer II, the storage capacity will be approximately 150,000 litres of kerosene and 18,000 litres of petrol. Large, containerised tanks will also be used where possible for these fuels. Some drums will also be required, though, for transporting fuels on small sledges and in aircraft.

2.4.3.3 Gear oils, engine oils, two-stroke oil and hydraulic fluids

Quantities required and storage

The maximum amount of gear oils, engine oils, two-stroke oil and hydraulic fluids kept at Neumayer III will come to about 8,000 litres. Of that total, about 1,600 litres of hydraulic fluid will be contained in the building's jacking system. The oils – when not directly in use in machinery – will be kept in drums, canisters and tins, and stored mainly in the station building or garage.

2.5 Construction of the station

2.5.1 Transport volumes, marine and over-ice transportation

The loads to be transported to build Neumayer III can be estimated and grouped as follows:

Table 3: Transport volumes and sledge loads required to build the new Neumayer Station

Transported goods	Tonnes	Volume in m ³	Sledge loads	Average load in kg
20-foot containers	616	4,780	112	5,500
Steel sections/structures	692	1,950	86	8,047
Foundations	25	150	5	5,000
Garage roof panels	65	360	10	6,500
Façade elements for platform	110	900	30	3,667
Crates, boxes and bundles of diverse goods	140	650	35	4,000
20-foot containers for construction camp ¹⁾	198	1,435	72	6,188
Crates and boxes for construction camp ¹⁾	30	140	14	4,286
Construction machinery that can be driven to the site and back	70	260		
Fuel, pumped to tank containers	130	bulk	8	20,000
Total	2,076	10,625	372	

¹⁾ Return transports (43 sledge loads) included in numbers of sledge loads

Marine transportation

Apart from the fuel, all cargo will be brought to Antarctica by chartered ship. The ship will be in the order of 10,000 GRT or more, having a minimum ice class corresponding to the German E3 class. AWI as the charterer will make sure that the ship is suitably equipped, including in terms of necessary standards of environmental protection. It is assumed that the ship will remain in Antarctic Treaty waters for about 38 days, split up into 7 days for the outward trip (duration dependent on the pack ice), 28 days at Neumayer, and 3 days for the journey back to the 60th parallel.

In an alternative arrangement, the construction camp and/or certain structural elements of the garage building may be shipped in one of the government expedition ships calling at Neumayer for other reasons.

The return freight will also be taken back by ship (possibly by the ship used for the retrogradation of Neumayer II). For that reason only one ship's journey will be assumed when considering the environmental impact of the building activity.

The fuel for the building activity will come in bulk with the German Research Ship FS Polarstern and be transferred to the tank containers in the usual manner.

Over-ice transportation

Over-ice transportation will be carried out with Pisten Bully vehicles and the station's Aalener sledges using the same procedure as was used when Neumayer I and Neumayer II were built. Loading the sledges from the ship will be done using the ship's gear, while Chieftain cranes will be used for unloading at the depot end of the round trip. Payloads will be limited to 25 tonnes per Pisten Bully, and the maximum number of sledges (empty or loaded) to two. There is only one person - the driver - on a train.

As shown in Table 3, the number of round trips is 169³ transports to the site, and 43 transports from site to ship. The average speed of a loaded train is 9 km/h, and empty travel is at 14 km/h. The changeover of sledges at each end of the round trip takes 35 minutes. One PB260 Pisten Bully will be needed almost full time to assist work at the site depot. As the berthing location of the ship cannot be known beforehand, the following assumptions have been made in an attempt to identify the transport requirements (cf. the map in Fig. 3):

- Maximum transportation requirements::
 - 80 % of sledge loads to be towed 8 kilometres over sea ice to the ramp,
 - 20 % of sledge loads to be towed 3 kilometres over sea ice to the ramp,
 - 40 % of sledge loads to be placed at winter depot for intermediate storage,
 - 100 % of sledge loads to be towed 13 kilometres from ramp to construction site depot,
 - 100 % of return cargo to be towed 13 kilometres from site to berthing place at ice shelf.
- Minimum transportation requirements:
 - 100 % of cargo to be towed 13 kilometres from berthing place near ramp to site and
 - 100 % of return cargo to be towed 13 kilometres to berthing place at ice shelf edge.

Based on these estimates, the upper and lower limits for the resources to be deployed for transportation can be established (see also Table 4 and Table 5 on specific consumption).

Table 4: Resources for over-ice transports

Machinery deployed	Minimum			Maximum		
	Person shifts	Plant hours	Litres of diesel	Person shifts	Plant hours	Litres of diesel
Pisten Bully 260 - loaded	75	182.0	4,950	90	269.3	7,325
Pisten Bully 260 - empty		117.0	3,276		173.1	4,848
Pisten Bully 260 at ship/depot		423.8	10,595		423.9	10,595
Pisten Bully 260 at ramp	0	0.0	0	10	84.5	2,130
Pisten Bully 260 at interim depot	0	0.0	0	3	26.2	635

³ The figure 169 has been calculated on the basis of Table 3 as follows:

No. of sledge loads (not counting return transports or trips with tank containers):	372 – 43 – 8 = 321
That gives a total number of round trips (each involving one Pisten Bully and two sledge loads) of	160.5 ≈ 161
8 tank container trips must be added to that figure, each involving one Pisten Bully and one sledge	161 + 8 = 169

Pisten Bully 300 loaded	25	92.4	3,079	31	137.0	4,563
Pisten Bully 300 empty		58.4	1,962		88.1	2,907
Pisten Bully 300 at ship/depot		74.6	1,866		74.6	1,866
Pisten Bully 300 at interim depot	0	0.0	0	2	13.3	332
Chieftains (mobile cranes)	32	278.9	6,415	43	378.6	8,707
Machinery that can be driven to the site (2 cranes)	2	13.0	234	2	17.0	306
Total	134	1,240	32,377	181	1,686	44,214
Of that: camp to ship transportation	17	143	3,687	17	143	3,687

Person shifts are used instead of person days because round-the-clock working may be necessary to put the plant to the best use and to keep charter times as short as possible. Downtimes due to bad weather, ice conditions or machine failures will be considered when the workforce and the total times are calculated. Downtimes have almost no influence on fuel consumption.

Table 5: Fuel and oil consumption of the Pisten Bullies

Parameter	Dimension	PB 260	PB 300
Fuel consumption at idle	Litres/hour	2.0	2.1
Empty (on average 14/15 km/h)	Litres/hour	28.0	33.0
Empty (on average 14/15 km/h)	Litres/km	2.0	2.2
Sledge pulling 20-30 tonnes (av. 8/9 km/h)	Litres/hour	27.2	33.3
Sledge pulling 20-30 tonnes (av. 8/9 km/h)	Litres/km	3.4	3.7
Pre-heating (Webasto) ¹⁾		Negligible	
Engine oil consumption	Litres /100 km	1.0	1.0
Complete oil change	Litres /year	Approx. 20	Approx. 20
Complete change of hydraulic oil ²⁾	Interval in years	2	2
Excluding crane	Litres	70-75	70-75
Including crane	Litres	Approx. 110	Approx. 110

¹⁾ The Pisten Bullies are fitted with Webasto pre-heating, used for starting at temperatures below -10°C. Fuel consumption is very low and included in the overall figures.

²⁾ There is no "consumption" of hydraulic fluid unless there is a leak.

Alternatives

There are no feasible alternatives to transporting the bulk of the goods required for building Neumayer II Station by ship.

2.5.2 Building site logistics

Although the rebuild of Neumayer will be supported in many ways by the present Neumayer II Station, especially during the preparatory phase, the operation of the building site will be strictly separated from the station, where it is vital that all the scientific programmes continue without interference from the building activities.

The building site comprises areas for the construction of the station building itself, for the construction camp, for vehicle and sledge parking, for vehicle and plant refuelling, for a site office, a workshop and for materials/parts storage. Transportation of goods between these facilities will be necessary and will include driving on changing tracks as the snow surface allows. At some places where drifting snow can cause trouble, snow may be piled up to create berms and shallow ramps.

The different areas mentioned need to be positioned in a way that mutual interference by drifting snow is minimized and that building operations are not unduly hampered. The exact layout of the site is the concern of the contractor, but the following restrictions will be imposed by AWI:

- A north-south line running 200 metres east of the station building (perimeter) must not be transgressed.
- A west-east line running 300 metres south of the station building (perimeter) must not be transgressed (except for setting up outstations/observatories).
- A distance of at least 2000 metres to the southernmost observatory installations of Neumayer II Station must be maintained.
- Unless permitted by the station commander, no traffic is allowed to pass by on the eastern side of Neumayer II Station and its outstations.

The area on the snow surface used for the site proper and for temporary site facilities may not be more than one square kilometre in total.

2.5.2.1 Construction camp

At the very beginning of the building activities a small advance group from the construction team will use the facilities of Neumayer II Station while setting up a construction camp some 200 metres north of the building site proper. Some of the camp equipment may be brought to the Antarctic in the 2005/06 season before the main construction works begin.

The construction camp is basically temporary accommodation for a maximum of 48 construction personnel. It will only operate for two to three months in the 2006/07 season and possibly again in 2007/08 for the same length of time (an average of 75 days each season). The maximum area covered by camp buildings or tents will be 750 m², the maximum area occupied by the camp in its entirety will be 1,500 m².

The camp will comprise many of the technical services of an Antarctic base, such as its own power station (60- to 80-kW generator; estimated average diesel fuel consumption 320 litres/day), water production plant, HVAC, sanitary installations, food stores, kitchen and mess room. The existing Neumayer II Station will provide medical facilities and support.

Virtually all the camp facilities will be placed on the snow surface, possibly on top of a snow berm not higher than 1.5 metres to reduce piling-up of blown snow. Any foundations, anchorings, cables or pipes that are installed below the surface will be at a depth not exceeding 1 metre, and will be removed again in their entirety when the camp is struck after completion of the station construction.

Water will be generated from snow using waste heat from the diesel generator. AWI estimates the maximum demand will be 100 litres per person per day (i.e. a total of 4,800 litres/day), but average demand will be nearer to half this figure if flushing toilets are not used.

Grey wastewater from the kitchen, laundry and washrooms, which has a relatively low bacterial load, will undergo simple treatment before it is discharged to a pit in the snow. The treatment comprises the separation of solids, fat and grease from the liquid, then screening and disinfection by UV light. After treatment, the grey water is no longer biologically active. As in Neumayer II Station only biodegradable detergents will be allowed at the camp. The amount of grey water that will be returned to the snow corresponds approximately to the fresh water produced (maximum of 4,800 litres/day).

AWI's plans for disposal of black wastewater (human waste) have not yet been finalised. It is highly likely that the system chosen will involve in-situ evaporation (diesel-oil or electrically operated incinerating toilets) with the residues being collected and removed from Antarctica. The alternative would be to remove black wastewater by ship in weld-sealed plastic bags or in suitable tanks. The waste would then be treated on board the ship (e.g. incinerated) or taken to a land facility for proper disposal. Another option examined was to transport faeces for treatment in the plant at the Neumayer II Station. However, since this option would probably disrupt the summer operation of the Neumayer II Station, it was not given any further consideration.

2.5.2.2 Plant and equipment for the building site

The plant and equipment used for transports to and from the ship is dealt with in section 2.5.1 above. The same equipment will be used for transports on site and between the site depot(s) and the site. Mobile cranes will be used at the site depots and at the site as required for loading. During the peak times of transports to or from the ship, mobile cranes will be stationed more or less full time at the relevant storage locations or on-site.

Almost all the plant available at Neumayer II Station (cf. Table 1), with the exception of the skidoos, will be employed for transportation purposes. When the transportation work has been completed, the site will return two or three Pisten Bullies to the Neumayer II Station.

A filling station will be set up temporarily at the building site, consisting of a 15,000-litre tank container fitted with an electric filling pump, hose and fuelling nozzle with hold-open latch and trigger. Refilling of the tank container will be done by pulling a full tank container to the filling station and pumping fuel across using the same pump. Motor oil, lubricants and hydraulic fluids may be filled up wherever a machine is employed, but complete changes will always be carried out either at the workshop of Neumayer II Station or at a workshop the contractor has set up at the site. If losses of technical fluids are due to leaks, the leak must be contained (drip pan etc.) and the machine brought to the workshop for repair. If snow has been contaminated, the provisions in the Emergency Manual (AWI 2003) for oil pollution contingencies apply.

AWI does not intend to use skidoos on the building site (with the probably rare exception that the station hires one out). Thus there will be no skidoo refuelling at or near the site. The facilities at the existing station will be used for refuelling skidoos.

2.5.2.3 Site depots

The building materials and components will probably be brought to Neumayer in two batches in the season before building works start and in the season when the station is being built. The vast majority will be stored in one or more depots until they are needed on site. Only very few building components will be brought directly to the site for immediate assembly.

A large, provisional depot for these components and materials will be set up in the northwest quadrant of the building site. A second depot may be required near the ice edge, especially if materials are brought in the first season, if over-ice transport capacities are limited at that time, or if the preparation of the site depot proper has not been finished by then. The depot area at the ice edge designated winter storage area (cf. Fig. 3) may be used for this, and if necessary be extended to the north. The winter storage area is not so badly affected by drifts because of the higher wind speeds at the ice shelf edge.

The depots will be positioned on the flat snow surface perpendicular to the prevailing wind. Small berms may be made for storing small or delicate items. The depot areas will be marked and subdivided by aluminium or wooden marker poles.

As soon as they are no longer needed, depots will be completely cleared and cleaned up sector by sector finishing at the latest in the season after building works are completed. Some parts collected at this point from the storage depots may be kept at the station for spares, but the bulk of them will be removed from the Antarctic Treaty area.

2.5.2.4 Resources for site installations (construction camp, office, workshop, filling station)

The table below comprises two seasons of construction camp operation and mob/demob activities.

Table 6: Resources required to set up and run the building site

Resources	Person-days	Plant hours ¹⁾	Diesel in litres
Construction crew: setting up the construction camp	12		
Setting up office, workshop, filling station	4		
Dismantling site installations, clean up	10		
Running construction camp (2 seasons)	280		
Pisten Bully PB 260		20	550
Pisten Bully PB 300		10	330
Chieftain (included in transports)			
Generator 60 to 80 kW, 2*70 d at 60 %		141,120 kWh el.	47,000
Total	306		47,880

¹⁾ Plant drivers' working hours are included in the person-days column.

2.5.3 Construction and fit-out works

In order to keep the construction works in Antarctica to a minimum for reasons of cost, there will be a very high degree of prefabrication. Although a number of design details and the exact degree of prefabrication are not yet known, AWI assumes that the building elements will be prefabricated taking permissible transport weights and volumes into account and that the building proper will be put together quickly from large units which will already be fitted out with installations, interior decoration and fixtures.

The works in the Antarctic will begin with the excavation of the garage trench. The trench will not be cut to the nominal depth.⁴ The foundations, columns, jacking installations, and roof structure will then be assembled in the trench. The trench will then be completed by using the snow blower to throw snow against the apron around the roof, which will act as formwork.

Cranes will be needed to assemble the platform structure. They will have to be brought to the building site. Work on the station's building services will begin as soon as possible and run in parallel with the assembly works for the platform structure and with the completion of the protective envelope. Power will be provided by diesel generators on the building site. From March onwards lighting will be needed at night.

The following estimate of resources required for the construction and fit-out (Table 7) is based on a two-season schedule and includes on-site transports.

Table 7: Resources for construction and fit-out works

Resource	Person-days	Plant hours	Diesel in litres
Construction crew: trench, snow blocking	68		
Build garage, install jacking system	484		
Assemble platform and envelope	576		
Build inner, insulated building	132		
Install services/equipment	568		
Mobile crane		566	10,189
Pisten Bully		535	16,035
Chieftain		425	8,490
Schmidt snowblower		14	700
2 30 kW generators (40% 140 days)		80,640 kWh el.	26,760
Station generator tests/commissioning		3,000 kWh mot	806
Total	1,828		62,980

¹⁾ Plant drivers' working hours are included in the person-days column.

⁴ New Zealand's Opinion considers the word "not" to be an editorial error and proposes deleting it. However, in the description of the works that follows, it emerges that the necessary depth for the trench is created only partially by removing snow and ice. The remaining depth is achieved by piling up layers of snow on the surface.

2.5.4 Relocation of antennas, wind generator and outstations

There are altogether 24 antennas to be relocated from Neumayer II to Neumayer III Station. 16 of these antennas are currently fixed to the station building, the remainder are placed on masts in the snow. At the new station, 19 antennas will be mounted on the roof of the platform building, and probably only 5 antennas will be placed at some distance away from the station building on masts founded in the snow. All the antenna cables will run above ground on poles.

The wind generator will have to be dismantled for transport to the new location, where a new foundation will be buried at a depth of about 2 metres. Again, the cables will remain above ground. The containerised outstations on elevated platforms will be taken off and put on sledges for transport.

The containers on the platforms of the outstations (balloon launching station, magnetics/ seismics observatory) will be taken down and transported on sledges to the new locations. The steel platforms will be dismantled for re-use, together with the above-ground leg sections.

The magnetics observatory container and a number of measuring instruments will have to be taken out of a deep cavern in the snow. The snow removal will be the main part of the works. The observatory will be placed in a covered snow pit, which will develop into a cavern when snow accumulates on the cover.

Relocating the infrasound array with its hut and instruments and the long cables will take a comparatively long time because of the size of the array and the caution required.

A 1000-volt shielded power cable, almost 1700 metres long, will be used to supply power to the scientific observatories. The intention is to transform the current to high voltage in order to make the cable cross-sections smaller and to reduce the number of individual cables from three (at Neumayer II) to one. However, high-voltage cables are both dangerous to personnel and also at risk themselves when run above ground (which means they would have to be raised repeatedly), so that on safety grounds alone it is not possible to run this power cable above ground.

All relocation operations at the outstations must be carried out as quickly as possible in order to minimise disruption of the measurement programmes. Some of the scientific installations and equipment in the observatories need to be disassembled or very carefully secured before transport, which makes up a substantial part of the works. The positioning of the observatory facilities with respect to the Neumayer III station building will remain the same or very similar to the situation at Neumayer II (cf. site plan 7-10 in the Draft CEE).

The "Library on Ice" will also be relocated. Apart from transportation by sledge, this also entails (as mentioned above) laying the power cable above ground.

The parts of the structures and foundations scheduled to be left in the snow at Neumayer II are described in section 4.2.4 below.

It is estimated that the relocation of antennas, wind generator and outstations will require the following resources:

Table 8: Resources needed to relocate antennas, wind generator and outstations

Resource	Person days	Plant hours ¹⁾	Diesel in litres
Building crew: antennas	51		
Outstations	185		
Wind generator	23		
Pisten Bully PB 260		200	5,500

Pisten Bully PB 300		66	2,184
Chieftain		26	546
Schmidt snowblower		12	480
Small snowblower		118	1.180
30 kW generator		26	220
Total	259	548	10,110

¹⁾ Plant drivers' working hours are included in the person-days column.

2.5.5 Schedules with extra time built in to allow for possible delays, estimated total number of person-days and diesel fuel consumption

AWI intends to appoint a building contractor to deliver and construct the station. Detailed time schedules therefore depend on future agreements with the contractor. The contract will probably include a premium for turn-key completion in one season, in the summer 2006/2007.⁵ This would enable commissioning early enough for the start of operations at the end of that season. Early completion would be easier to achieve if some of the transports – or even preparatory works and possibly initial on-site assembly - were started in the season before. Current plans envisage the first transports to Antarctica starting at the beginning of the 2006/2007. AWI is essentially working to the following schedule:

Table 9: Proposed schedule

Year	2005	2006		2007			2008		2009		2010		2011		
Activity Season	W	S	W	S	W	S	W	S	W	S	W	S	W	S	
Neumayer II operation															
Neumayer III transports															
Neumayer III construction															
Neumayer III operation															
Neumayer II dismantling															
Neumayer II return transports															
Neumayer III retrogradation	>2033														

Shading		Most likely schedule, without delays
		Earliest start date/latest completion date

⁵ Neumayer I and Neumayer II Stations were each built and commissioned in one season.

The available plant for over-ice transports and construction support is limited and may be a decisive factor for planning a two-season construction period. Under normal weather conditions this period is considered long enough to finish the transport and building works. Operations at Neumayer III Station would then begin in March 2008.

Alternative

The possibility of compensating for delays to a certain extent by flying more workforce to Neumayer via the Novolazarevskaya connection could be considered as an alternative. However, even then, severe delays - mainly due to weather and sea ice conditions - could still occur and have to be taken into account during any works in Antarctica. AWI has therefore included the 2008/09 season in the schedule as a back-up construction period. It would still be possible to operate Neumayer II Station until then.

In total, about 2,860 work shifts will be required, which corresponds to an average workforce of 38 people over a 75-day period. 38 persons cannot be effectively employed at certain times within this period (e.g. during transports), so that a variable workforce with up to 45 persons may be needed. Up to three persons must be added to this total to carry out the site supervision.

The total diesel fuel consumption of 213 m³ for the construction of Neumayer III Station (including the transportation involved) is slightly less than the annual consumption at Neumayer II Station (220 m³ including vehicles).

Table 10: Total number of work shifts required (including downtimes) and diesel fuel consumption

Type of work	No. of shifts	Downtimes (to be added)		Total no. of shifts	Diesel consumption in litres
		Percentage			
Transports	181	20	36	217	44,214
Set up and operate building site	306	15	46	352	95,880
Garage: snow works	68	35	24	92	62,980
Garage: assembly work	484	15	73	557	
Assembly of platforms	576	10	58	634	
Assembly of inner building	132	5	7	139	
Installation of services/equipment	568	5	28	596	10,110
Outstations, wind generator ...	259	10	26	285	
Total	2,574	(11.6)	297	2,872	213,184

3. Operation of the station

The envisaged capacity of the station and the infrastructure necessary for its operation are described in sections 2.2.4 and 2.4.

3.1 Staff

3.1.1 Overwinterers

The number and composition of winterover personnel will in general remain the same as in Neumayer II Station: four to six scientists and five service staff including the base doctor. It should be possible for the wintering crew to be increased without difficulty if special programmes require extra personnel. The number of winterover personnel doubles during the overlap in summer.

All winterover personnel must complete a comprehensive training programme (cf. 8.1.1 below) before they come to the station. All participants in summer activities travelling under AWI permission to Neumayer Station also receive instruction as needed. In addition, everyone who travels to the Neumayer Station must complete a seminar on environmental protection, which includes the pertinent laws and regulations.

3.1.2 Summer personnel (summer guests) and visitors

The station is to provide accommodation for up to 36 summer guests in a separate section called "summer base."⁶ If necessary, a limited additional number of summer guests can be housed in cabooses and tents on the snow. Summer guests stay at the station for variable times ranging from a few hours to the full summer season. They can be divided into two groups according to their tasks:

Group A:

- Scientific/technical support for station observatories and installations; ordinary, regular technical maintenance of station buildings and services
- Special technical support on station buildings (major overhauls/repairs)
- VIPs, executive personnel, inspectors
- Day visitors/crew from ships (not staying overnight)

Group B:

- Scientists and support staff using Neumayer III as a base or interim base for their research activities and not otherwise connected to the station (expedition personnel)
- Adventure tourists have very seldom visited the Neumayer Station due to its remoteness and difficult access. Tourists and Antarctic tour operators are not encouraged to visit Neumayer Station⁷. AWI does not intend to change this in the future.

For the assessment of environmental impacts, the average residence figures at Neumayer III can be assumed to be those shown in the table below.

⁶ Anyone who is not a member of the winterover teams is referred to as a summer guest.

⁷ Advance requests for visits are required in all cases, but AWI will allow visits only in very well justified cases. It considers the number of station personnel to be too small to deal with tourists.

Peak occupancy may reach 60 (24 winterover personnel + 36 guests) for a few days. The station could even support more people accommodated in tents/cabooses next to the base, if required, under conditions that are not foreseeable at present.

Table 11: Average number of persons by period and length of stay at Neumayer III Station

Group	Average number of people by period					Total/year Person-days
	16.03 - 30.11	01.12 - 15.12	16.12 - 31.12.	01.01. - 28.02.	01.03. - 15.03.	
Number of days	260	15	16	59	15	
Winterover crews	10	11	12	20	11	4,302
Scientific/technical support		0.3	3	3	0.3	234
Building/technical support		0.3	2	3		213
Special building maintenance work			0.5	1.5		97
VIPs, executive personnel, inspectors			1	1.2		87
Day visitors from ships			1.5 ¹⁾	1 ¹⁾		42
Expedition personnel		2	5	6	1	479
Total	2,600	204	388	2,076	185	5,454

¹⁾ Only during the day, counted 50% in the total.

3.2 Provisioning logistics and annual relief

Neumayer Station will be relieved once a year by ship. Provisions are transported to the station in 20-foot containers on sledges. Containers will not be exchanged, with the exception of the refuse containers and – in rare cases – when containers need repairs that can only be carried out in Germany.

Emergency food supplies are provided for a 15- to 18-month period at Neumayer. A two-year supply of all provisions previously had to be available at the end of a summer season. This was a safety measure to ensure survival in case the ship was unable to get through to the station. The flight connection via Novolazarevskaya now has the capability of bringing in provisions and exchanging crews in emergencies, so more extensive storage of provisions is unnecessary.

3.3 Power requirement, power generation, and energy management

As mentioned above, AWI anticipates an average electricity requirement of 100 to 110 kW (cf. section 2.4.2 above). Electricity for the station will be produced primarily by diesel generators, as well as wind generators.

Plans do not include oil-powered heating of the air needed for turbo-charging at cold starts. Instead, an electronic control will limit the capacity of the diesel engines during cold start in order to minimize the risk of damage. Taking into account the efficiency factor of the generator, the exhaust gas treatment system, and the fuel quality (compared with "ordinary" diesel fuel), the nominal capacity of the engines will have to be 20 to 25% higher than the specified electrical output. An analysis of rated exhaust gas constituents (mostly given as g/kWh) must

be based on the output of the diesel engine rather than that of the generator.

Consumption of electric power and heat at Neumayer III Station will be controlled by a comprehensive energy management system. The system will allocate power according to predefined priorities, ensure optimal input of wind power, switch a second diesel generator on or off as demand requires, and issue warnings in case of conflicts or if specific limits are exceeded. The energy management system will be supplemented by a number of rules to be observed by station staff, mainly aimed at saving energy. Preferable times during the day for certain activities requiring electricity will be specified or selected.

The use of fuel cells was also considered, but based on details provided by the manufacturer this turned out to be unsuitable for the Neumayer station. Another alternative –generating energy through solar cells - is similarly not technologically mature enough for it to be feasible at present at the station.

Station diesel exhaust gas treatment

The emission of gaseous and particulate pollutants from internal combustion engines is highly dependent on fuel quality, so all diesel fuel used at Neumayer III Station will be low-sulphur. The diesel engines of the generating plant will be equipped with exhaust gas treatment equipment that will guarantee compliance with the relevant European standards (Directive 97/68/EC and various supplements, as well as Directive 2002/88/EC). These require the current maximum sulphur content of 2,000 ppm (mg/kg) to be reduced to 1,000 ppm in 2008, then to 50 ppm and from about 2014 on to 10 ppm. In addition, particulate limits will be 0.025 g/kWh beginning in 2011. It is anticipated that engines will have to be equipped with particulate filters to comply with those limits. The NO_x limit of 0.4 g/kWh that will then also be necessary will require treatment to reduce NO_x.

3.4 Heating and ventilation (air conditioning)

As mentioned above, there are two options for heating the station: either heating integrated into the ventilation system (as in the current Neumayer II Station) or the use of hot water and radiators. All space heating at the current Neumayer II Station uses warmed air in combination with ventilation of the station. The energy is taken from the waste heat produced by the diesel generators. The system has advantages (for example, no heating pipes or radiators are required), as well as disadvantages, for instance when regulating the temperature in individual rooms. The best possible heating system for the Neumayer III Station will therefore not be chosen until the detailed planning phase.

Regardless of the heating system that is ultimately used, no fuel will be directly burnt for heating. As a matter of principle, all of the necessary heat must be obtained by recovering heat during power generation or through the use of renewable energy sources (wind). Cooling water and exhaust gas heat exchangers will be installed for heat recovery. There will be no fuel-powered boilers. Under certain conditions (low consumption of electricity accompanied by high wind energy output), it is possible that sufficient waste heat will not be available. Supplementary electric heating may be necessary in such rare cases, for which renewable energy sources will be used depending on the system.

3.5 Fuels and lubricants

Annual consumption

The estimated average annual consumption of fuels and lubricants at the Neumayer III Station is shown in Table 12.

Table 12: Predicted average annual consumption of fuel and lubricants at Neumayer III

Fuel/lubricating oil	Consumer	Average consumption (litres/year)
Diesel with additives for use down to -40°C	Station diesel gensets	294,000
	Tracked vehicles and mobile diesel generators	21,000
JP-8 / Jet-A1 kerosene	Aircraft and helicopters	50,000
Standard petrol, lead-free	Skidoos, mobile generators	2,000
10W40 motor oil	Miscellaneous motors	2,400
Two-stroke oil ¹⁾	Skidoos	50
EP 75W/90 gear oil	Vehicles	approx. 5
AVIA Syntofluid PB 32 hydraulic oil (also known as AVIA Syntofluid 32; Biofluid AVILUB PB 32)	PB vehicles, PB cranes	20
SHELL Donax TM hydraulic oil	Vehicles, cranes, snowblowers, station lifting jacks	40

¹⁾ The two-stroke mixture is not produced before filling the vehicle. The skidoos have separate tanks for petrol and oil, and the vehicle produces the mixture.

Polar Diesel and Arctic Diesel have the following specifications (there may be additional changes to the fuel specifications before 2006-07 due to technical developments):

Table 13: Fuel specification for Polar Diesel (Super Eco Diesel, Petro SA) (synthetic)

Viscosity, at 40°C typical	1.4 cSt	
Density, at 20°C typical	0.8 kg/l	(max. 0.81)
Flash Point (TAG)	62°C min	(typical: 93)
Kinematic viscosity at 40°C, typical	2.7 cSt	
Water content	< 0.01% v/v	
Carbon, residue, Ramsbottom (on 10% residue)	0.15% m/m	
Ash content	< 0.01% m/m	
Calorific value, gross typical	46300 kJ/kg	
Cetane min no.	45	(typical 54)
Cold filter plugging point (CFPP), typical	< - 45°C (- 30°C max)	
Distillation, typical:		
IBP (distillation begins)	220°C	

50% EVAP	250°C	
90% EVAP	320°C	
FBP (distillation ends)	340°C	
Total sulphur max.	0.001% m/m.	(typical: 0.0004)

Table 14: Fuel specification for Arctic Diesel (Haltermann)

Arctic Diesel (Haltermann, Germany):

Gravity at 60°F	44 API
Density at 15°C	0.8 (0.789-0.805) kg/l
Flash point	55° C
Pour point	-53°C
Cloud point	-48°C
Sulphur	0.3%
Ash	0.02%
Water	nil (mg/kg)
Cetane Index	44

Table 15: Fuel specification of Arctic Diesel, Polar Diesel, petrol, JP-8 kerosene, and Jet-A1 kerosene

Parameter	Dim.	Arctic Diesel	Polar Diesel	Petrol	Kerosene JP-8	Kerosene Jet-A1 1)
Brand name		Arctic Diesel (Haltermann)	Diesel 13200 S.A. supplier	Standard petrol, leadfree (91 Octane)	Aviation turbine fuel (Shell, BP, others)	Aviation turbine fuel (Shell, BP, others)
Appearance, colour		Colourless		Colourless, yellowish	Clear, light, pale yellow	Clear, glossy
Odour		Characteristic	Characteristic	Characteristic	Characteristic petroleum distillate odour	Characteristic petroleum distillate odour
Danger of explosion at volume %		Small; at 1.1 to 6.5	Small; at 1.1 to 6.5	Great; at 0.6 to 8.0	Small; at 0.6 to 4.7	Small; at 0.6 to 4.7

Danger of static charge					Yes	Yes
Toxicity		Little		Poisonous, carcinogenic	See Material Data Sheets	
Density at 15°C	kg/m ³	789 - 805	◆800	725 -780	775-840	775 -840
Calorific value	kJ/kg		46,300			42,800
Viscosity at x°C	mm ² /s (cSt)	20°: 1	40°C: 1.4		-20°C: 8.0 20°C: 1.75	-20°: 8.0
Ignition temp.	°C	240		Approx. 220	Approx. 220	
Flash point	°C	55	43	<21	38	38
Pour point	°C	-53			-50	
Cloud point (freezing point)	°C	-48	-48		-47 -65 4)	-47 -56 5)
CFPP	°C		-40			
Cetane Index	No	44	45			
Sulphur content	Weight %	0.3	0.1		0.3	0.3
Lead content	mg/l			max. 13		
Ash	%	0.02				
Additives					2)	3)
UN-Number		1202	1202	1203	1223	1223
IMDG/GGVSee		None	None	3.1	3.3	3.3
Dangerous Goods Code		None	None	T, F+	N, Xn, Xi	N, Xn, Xi
Danger classification for water		WGK 1, weak	WGK 1, weak	WGK 3, weak	WGK 2, weak	WGK 2, weak

¹⁾ Jet A-1 product information: aviation turbine fuels (jet fuels) are manufactured predominantly from straight-run kerosenes, which normally require further treatment to meet the specification requirements. At some refineries there is an increasing tendency to incorporate proportions of product produced by hydrocracking processes. The Check List for Jet A-1, a kerosene fuel having a maximum freezing point of -47°C, forms the basis of international supply of virtually all commercial aviation world-wide. Most military organisations now use kerosene type fuels, which are virtually identical to Jet A-1 in basic properties, differing mainly in the types of additives required. In areas where the same basic grade is used by both military and commercial industries, only one grade need be manufactured, stored and distributed as the additives required can be injected as the fuel is supplied to the military. BP Jet A-1 is a petroleum distillate blended from kerosene fractions having a

freezing point below -40°C and a flash point above 38°C . It does not usually contain a static dissipator additive.

- 2) Corrosion inhibitor/lubricity enhancer (9-24 g/m³), icing inhibitor (0.1-0.15 vol%), static dissipator additive (3-5 ppm)
- 3) Kerosenes, if they have been hydroprocessed or if they contain any hydroprocessed components, must contain the antioxidants laid down in the DEF STAN 91-91/4 standard, in the specified margins. If they are not hydroprocessed, they may contain these same antioxidants up to a maximum of 24 mg/l. When they have to comply with the electric conductivity specification, they must incorporate the authorised SDA (Stadis 450), up to a maximum of 3.0 mg/l in the first additives added, and 5.0 mg/l in the accumulated total for any possible further additives added. They may also contain the metal deactivator authorised (MDA) under the DEF STAN 91-91/4 standard up to a maximum of 5.7 mg/l. The use of an anti-icing inhibitor is not allowed (FSII). Nor are corrosion inhibitors/lubricity improvers allowed, except in operational circumstances which require them to be used, and with the knowledge and agreement of the parties.
- 4) With the relevant additives JP-8 is usable to -65°C
- 5) With the relevant additives Jet-A1 is usable to -56°C

Hydraulic fluid

AWI currently uses two different types of hydraulic fluid:

- Shell DONAX TM is the standard hydraulic oil for general applications; it is made of a blend of highly refined mineral oils and additives. Although major constituents are expected to be inherently biodegradable, the product contains components that may persist in the environment.
- The synthetic hydraulic fluid AVIA SYNTOFLUID N 32 is also used. It does not come under the dangerous goods code. It has been awarded the “Blue Angel” environmental label under registration RAL-UZ 79 by RAL, the German quality assurance and labelling organisation. However, it does cause problems in the Antarctic when Pisten Bully snow mobiles are used at higher altitudes and at very cold temperatures, such as during the Kohnen traverses. Complete replacement of all hydraulic lines and a number of other hydraulic components has been necessary in the past, and the vehicles had to be taken to Germany for completion of the work.

Transport

The required fuel will be pumped from the aforementioned storage in double-hull container tanks through an above-ground line to the power plant on the platform. The tanks are also used as a filling station for station vehicles. Refilling will be done by pulling tank containers from one of the open-air storage areas to the filling station and pumping in the fuel.

Fuel and lubricants (as well as other technical fluids) that are not stored in the containerised tanks will be supplied in 200-litre drums or smaller commercial containers and transported by sledge to storage locations at the station.

3.6 Other technical consumables

The number and quantities of technical consumables other than fuel and lubricants will be very limited. Some of them (such as welding and cutting gases and battery acid) are classified as dangerous goods.

3.7 Fresh water generation and supply

The average daily fresh water consumption is currently 117 litres per person at Neumayer II, including air humidification. Neumayer III Station may have a lower consumption if vacuum toilets are installed.

Fresh water will be generated in a snow melter located in the garage. Snow will be taken from the surface to the east of the station and pushed through a chute into the melting vessel. A drift snow collector is being developed and tested and may prove helpful in reducing the effort for snow transport. The melter will be designed in line with requirements and will have the capacity to serve a summer population of up to 58 (at a slightly reduced rate).

The nominal capacity of the melter will be in the range of 25 kW. The melter will be driven by waste heat from the diesel generators. The waste heat will also be used to heat water. There will be no backup or emergency heating because emergency supplies are already provided for the motors. It is possible, however, that a secondary heating system similar to the one used for space heating will be required during the rare times when diesel power demand (and therefore heat production) is very low while wind power generation is at its maximum (target 60 kW). The secondary heating will be electric to ensure that no extra fuel is required and emissions are kept low.

3.8 Waste disposal

The volumes and composition of waste are expected to be similar to those at the Neumayer II Station because numbers of personnel, both during winter and summer operations, will differ only slightly, or not at all, from those at Neumayer II. These volumes include the waste brought back from field camps or traverses.

Waste disposal – particularly the waste treatment facilities – will also correspond to what is provided at the Neumayer II Station. All solid waste, including food waste, is to be collected separately outdoors or in containers in the station's waste transport containers. The largest waste fraction is packaging material. Waste incineration in or at the Neumayer III Station is not planned. Paper, cardboard, and plastics will be compressed in special compactors, and glass and tins will be shredded. All waste will be safely stored in clearly-labelled containers, with dangerous and non-dangerous waste to be separated.

Hazardous liquid waste (used oil, used hydraulic fluid, contaminated liquids from the station hospital, photo-chemical liquids, and chemical liquids from laboratories) will be collected in separate (marked) containers and stored in a designated transport container until removal from Antarctica.

The waste will be hauled away by ship once a year for recycling or dumping in accordance with regulations.

3.9 Wastewater

The amount of wastewater at the station primarily depends on the number of people living there at any given time. AWI anticipates an average of 117 litres per person per day. That means up to 4,250 litres of wastewater per day during the six months of summer (with 36 people) and up to 1,300 litres during the six months of winter (11 people). More than 7,000 litres is expected during peak periods (60 people). The actual volume will be slightly less than this because grey water will be used to flush the toilets (cf. below under trace heating).

Pollution of wastewater by detergents and cleaners will be minimized by using limited quantities of specific biodegradable detergents and cleaning agents.

A containerised combined wastewater treatment plant for grey and black water will remove harmful micro-organisms from wastewater at the station. All residue from the process that cannot be further treated will be stored in the plant, sealed in polypropylene containers, and loaded onto the supply ship once a year for incineration there or on land outside of the Antarctic. The purified wastewater will be disinfected – most likely using ultraviolet light – and discharged through an above-ground pipe that is approximately 50 mm wide and 80 metres long onto the snow, west of the station.

Lower volumes of wastewater increase the risk of the temperature of the sewage pipe dropping to an unacceptable level, or of its average temperature dropping. Since a frozen sewage pipe must be avoided at all costs, trace heating is planned for Neumayer III Station. This heating system is temperature-activated. It switches on and uses energy only when required, a situation that under normal operational conditions almost never occurs.

3.10 Flight activities

Operational activities also include flights with fixed-wing aircraft and helicopters. Flight paths for fixed-wing aircraft at Neumayer are east-west because of the layout of the skiway (108°/288°). Takeoffs are generally east-southeast due to the prevailing east wind.

All refuelling of aircraft at Neumayer uses the pressure refuelling method, in which the fuel is pumped into the tanks through a tightly connected hose with locking valves at the ends. There is no gravity flow, which is difficult to control, and no residual fuel can leak from the filling hose. Gaseous emissions are also limited to a great extent, but evaporation is low anyway because of the prevailing temperatures.

Since ambient temperatures at Neumayer are not very low during the flying season, there is no need for “hot refuelling” of the planes. All aircraft refuelling is therefore done with engines switched off, which is also safer. The power needed for pumping is provided by the ground unit.

3.11 Planned service life of the station building and preview of the eventual dismantling

The lifetime of the Neumayer III Station building will no longer be dependent on snow accumulation or on deposition of drifting snow as the buildings of the preceding bases were, because the building will be adapted to the level of the terrain and because the above-surface parts of the building are elevated and will thus prevent the formation of snow drifts for the most part. AWI expects that the service life of the building will therefore mainly be determined by use and the resulting wear. It has also been taken into account that the building might become obsolete because it can no longer meet new needs. The planned service life has consequently been set at a minimum of 25 years.

The station location is sufficiently distant from the breaking edge of the ice shelf to ensure that the building cannot get near it during the envisaged service life. It is of decisive importance that the building can be dismantled completely without a major impact on the environment and that most of it can be removed from Antarctica Treaty territory. This removal of the building will be carried out in any case regardless of the lifetime that is ultimately reached.

Therefore, the simplest and most economical method of disassembly is a condition for the design of the station. For example, welded connections will be avoided as far as possible.

The work involved in dismantling and transporting the disassembled parts to a ship at the ice edge more or less corresponds to the work involved in construction in terms of time, effort, and equipment. Therefore, the impact on the environment can be assumed to be of an equal order of magnitude as assembly of the station.

These are conservative assumptions because some of the disassembly work can be done faster than construction work. Table 16 contains an estimate of this (cf. Table 10 on construction).

Table 16: Savings in time and use of equipment when dismantling the Neumayer III Station as compared with construction

Components of work to dismantle Neumayer III	Time	Equipment
Construction camp (smaller than for assembly)	40%	40%
Garage building: pit in the snow ¹⁾	90%	90%
Disassembly of all installations inside hull and garage	10%	5%
Dismantling of platform	5%	0%
Garage: disassembly of roof, supports, and jacking equipment ²⁾	10%	0%
Packaging ³⁾	30%	40%
Non-retrievable installations/parts ⁴⁾	90%	90%
Transport from site to ship, loading/unloading of sledges ⁵⁾	15%	15%
Shutdown (compared with start-up of operation) ⁶⁾	80%	0%

1) No excavation is required, and the pit of the garage does not need to be backfilled because it will be filled with drifting snow in a short time.

2) No sealing work, no tests of hydraulics.

3) Many parts will not be used again and do not need to be protected.

4) It is assumed that the steel frame foundations of the wind generators and outstations, as well as some cables buried in the snow, can remain in Antarctica because the removal work would have more impact on the environment than leaving these parts in the ice shelf. Details can be found in section 4.2.4, where the issue is discussed with regard to the dismantling of Neumayer II Station.

5) The savings are due to the shorter distance between the station and the ship's mooring place. The Station will have moved about 4.75 kilometres (25*0.19) nearer to the ice edges in the 25 or more years until Neumayer III operations end. With an average transport distance of 21 kilometres at the time of construction, this amounts to a 22.6% reduction in the distance.

6) No time is required for the time-consuming adjustments of the legs, breaking in various machines, and all approvals with the tests and drills they entail. On the other hand, pipes and vessels have to be drained with special care in order to avoid any spills.

Total savings of about 800 person-days and 48,000 litres of diesel fuel will be achieved. The total consumption of diesel fuel for dismantling Neumayer III Station and for over-ice transport will be around 165,000 litres, some 23% less than needed for the erection of the base.

4. Dismantling and retrograding of the Neumayer II Station

4.1 Buildings and equipment at the Neumayer II Station

4.1.1 General description

The Neumayer II Station comprises an underground complex with accessways leading to the snow surface and some on-ground installations in the immediate vicinity. There are also a few scientific outposts up to about 4 kilometres away from the main building which are self-sufficient in terms of power supply, using batteries should power be required. If, in the course of the relocation to Neumayer III, anything at the outposts is renewed the replaced parts will be removed from Antarctica. The question of dismantling any foundations in the snow at these outposts – in cases where they exist – is dealt with later in this chapter.

4.1.2 Protective tube building and accessways

The station building proper is housed in tubes of 8.38 metres diameter, made of 7-mm curved plates of corrugated steel, connected by 20-mm bolts. The tubes are kept cold. Plates in the bottom section are plain steel; plates in the remaining circumference are zinc-galvanised.

There are two parallel tubes, 90 metres and 83 metres long respectively, and one interconnecting tube, 95 metres in length, running crosswise. A smaller tube, 4.10 metres in diameter and 16 metres long, connects the parallel tubes about halfway along their length. The tube ends are closed off with strong steel bulkheads. The bulkhead at the east end of the Cross Tube has a large two-leaf entrance gate opening onto a ramp structure wide enough to allow access for the largest vehicles at the base. The bulkheads at the southern ends of the parallel tubes form part of the staircases leading to the main entrances at the top. The western part of the Cross Tube is sealed off by a firewall and contains six 22,000-litre fuel tanks fitted inside 20-foot container frames. The tank containers are placed in pairs in steel drip trays that serve as secondary containment. In the event of fire, two more barriers shut off the tubes to prevent smoke spreading. A short tube section attached to the Cross Tube near the ramp entrance leads to a 60 metres long passable snow tunnel, which connects the garage building with the station tubes.

A total of five shafts lead from the tubes to the snow surface. From time to time they have to be extended. The smallest is made of flanged 813-mm steel tube sections and serves as a snow chute to the melter tank. The other shafts are also tubular, but are made of corrugated steel sheets connected by bolts. Two of them are 1.57 metres in diameter and house the insulated exhaust gas pipes; the other two are ventilation shafts for the air conditioning system.

The ramp has a snow floor and snow walls and is covered with a stepped roof that follows the gradient of the ramp. The loadbearing roof structure consists of steel joists in the lower sections, while wooden trusses are used in the upper sections where the snow loads are not as great. The roof covering is made of timber and plywood. At the top end of the ramp the covering consists of small timber/plywood elements that can be lifted by two men. The ramp is extended by a new step whenever the snow accumulation makes adjustments necessary.

The stair "towers" at the southern ends of the parallel tubes are in a steel framework construction with plywood cladding on shallow timber foundations. The staircases are made of steel segments. There is a 100-kg SWL electric goods hoist installed in one of the towers. The uppermost sections of the towers, with exit doors and several antennas mounted on top, are kept above snow level by inserting a new tower/stair section whenever required.

The stair towers are connected by a snow tunnel at tube floor level. The tunnel continues southwards from the west stairtower for 150 metres to a blind end. This 2.4-metre wide and in

2004 only 1.7-metre-high tunnel serves as a duct for fresh air which is drawn in by a ventilator from outside through the permeable snow, which – at least on warmer days – cools it down. For this reason it is called the “air tunnel.” The method helps to keep drifting snow out of the station and provides temperate air throughout the year. The tunnel roof initially had a plywood covering, but this was removed a long time ago.

An emergency exit shaft, which is made of strong timber frames and plywood and contains a steel ladder, is situated at the western end of the Cross Tube. A fuel pipe, used for refilling the tank containers in the POL store, runs down this shaft.

The connecting snow tunnel to the garage originally had a wooden roof structure, which - after much deformation - was taken out in the 2003/04 season. This opportunity was used to re-profile the tunnel. There is now a steep ramp at the northern end where the tunnel connects to the garage, which is raised as the snow accumulates.

The Cross Tube has no substructure to support a floor but is filled with snow to a level where at least 6 metres floor width is reached. The floor is plain snow. Vehicles can manoeuvre in the eastern section of the Cross Tube and enter the East Tube and the large workshop situated there.

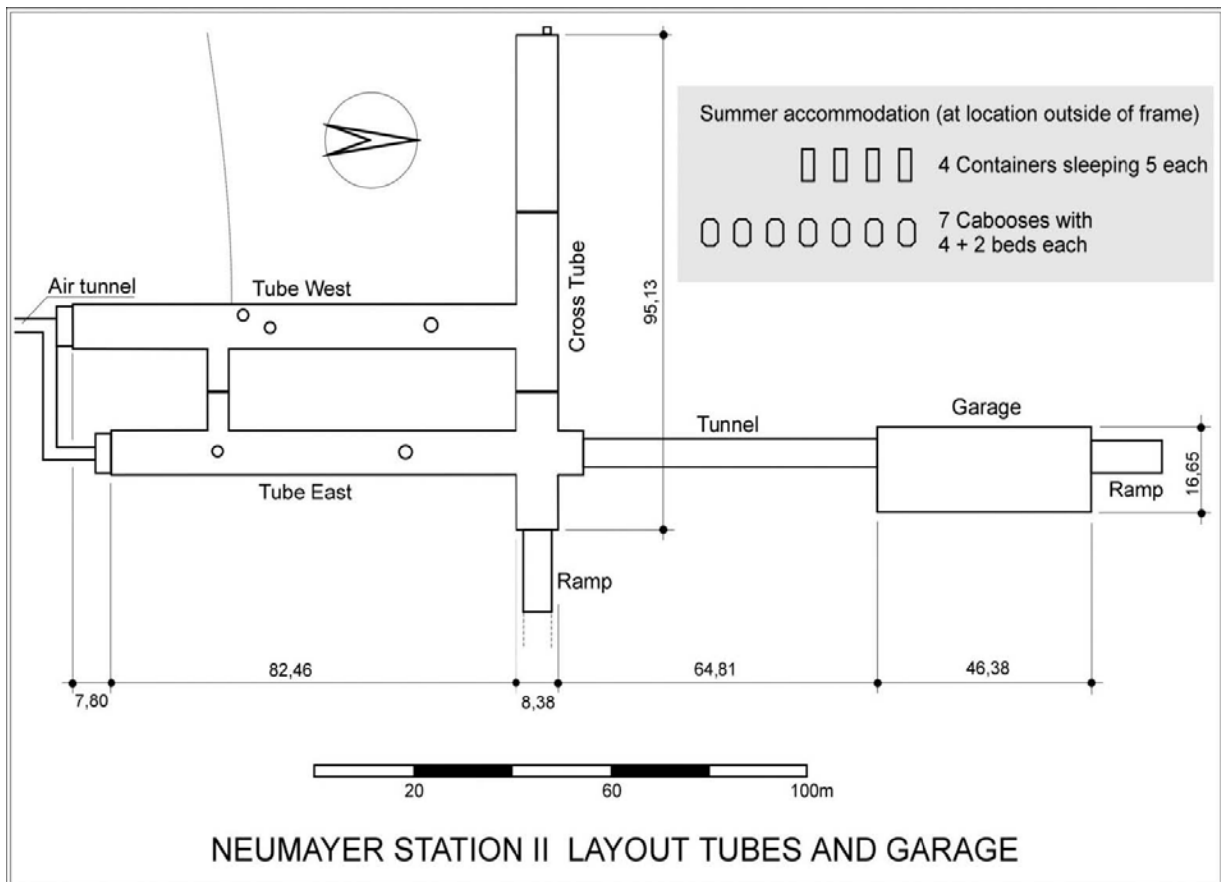


Fig. 6: Neumayer II Station, including garage

4.1.3 Structures housed in the tubes

All heated or air conditioned spaces are located in the two parallel tubes. With the exception of the workshop building, they are all containerised on the basis of ordinary 20-foot transport containers. The overall height of the containers is 2.90 metres (9' 5"). There is an adjustable steel sub-structure to transfer and distribute the building loads to the tube. Areas not housed inside containers are covered with timber flooring. Small gangways run along both sides of the rows of containers, serving as escape routes. Normal circulation is inside the rows of containers, along a corridor extending from end to end.

The containers have steel frames and are equipped with corner fittings. Walls and roofs have steel sheet on the outside and mineral-based (fireproof) facing slabs on the inside, with mineral wool insulation in between. The floor has plywood, instead of the mineral facing slabs, and carpet or rubber flooring.

The workshop and the attached store (l/w/h = 19.0/6.5/5.0 metres) are made of steel framework and 150-mm plywood sandwich panels. The insulation is 120 mm rockwool throughout. Fire protective cladding (slabs) on a mineral basis is fixed to the inside of the walls and roof.

4.1.4 Garage building

The garage building is a comparatively light structure placed in a snow trench and consisting of a 46.4-metre by 16.7-metre roof supported by three rows of seven tubular steel columns. The height of the columns is adjustable from 4.3 to 4.8 metres; they rest on shallow timber/steel foundations directly on the snow floor of the trench. The flat roof consists of steel girders and plywood sandwich panels. There are several joints between the roof panels sealed with silicone rubber strips. The snow walls have no cladding. A 1.5-metre-high plywood apron mounted on steel supports runs along the roof edges to provide horizontal stability and sealing against snow ingress.

The roof is tied down by around 40 steel wire ropes of 12 mm diameter, extending about 8 metres down into the snow (2004) where they are fixed to snow anchors. These wire ropes are lengthened when the roof is raised.

There is a snow ramp on the narrow side of the garage in the north with a steel-plywood composite hinged ramp cover that can be operated with pulleys attached to a steel portal.

4.1.5 Building services

Most of the services (power and water generation, HVAC, wastewater treatment) are located inside the building containers. Most of the cables and ducts are laid on the container roofs, while water pipes run underneath the containers. A steel fuel line connects the tanks in the Cross Tube with the day tanks on the roofs of the three power stations.

All the underground spaces are lit and electric fans are located at the air tunnel and at various air outlets. There are no cables or pipes under the snow floor in the Cross Tube.

A 96.5-metre-long pressure sewage pipe runs horizontally from the West Tube towards the pit in the snow. The pipe is laid directly into the snow at the foundation level of the tube building. It consists of 6-metre prefabricated sections of 60.3 x 5 mm steel pipe with CFC-free polyurethane foam insulation and protective PE sheathing. The sections were joined by press fittings when the pipe was laid. A 10 W/m trace heating tape is fixed to the steel pipe along its entire length. The sewage pipe is bolted to a spigot that is welded onto the outside of the West Tube.

4.1.6 Antennas and wind generator

A total of 24 different antennas have been installed at Neumayer II Station. The masts erected on the two stair towers carry 13 small antennas. Two dome-protected antennas are mounted on the ventilation shafts mentioned above. Two broadband dipoles are placed in the antenna field southwest of the station building, and four smaller ones are mounted to masts near the entrance ramp at the Cross Tube. A 2-metre diameter dome with a satellite antenna (PRARE) is mounted on the balloon filling station. The heaviest (dish) antenna serving the continuous satellite data link was installed in 1999 under a 4-metre dome fitted on a bolted steel framework tower erected about 35 metres northwest of the western end of the Cross Tube. The height of the antenna is raised from time to time by inserting a new 2.8-metre-high tower section. The 6-metre by 5-metre shallow foundation is made of timber and steel sections and was initially 2 metres deep. In the 2008 season the foundation will be buried 8 to 9 metres deep in the snow.

The wind generator, rated at 20 kW, is mounted on a tubular shaft and placed on a steel framework foundation, which projects in places only slightly above the snow surface. It has a three-legged shape on plan to provide support for the three raking struts of the generator shaft and extends to 7.0 metres from the centre to the end of a leg. The generator is raised in a very similar way to the antenna by adding new sections to the foundation. Because of the vibrations generated by the machine, especially when running in heavy winds, the foundation sections are connected by preloading bolts. Cables from the generator to the station run above ground on poles.

4.1.7 Outstations and other facilities

The outstations and observatories connected by cable to the station are listed and their locations are shown on the site plan (Fig. 7). The survival hut is a plastic caboose on skids, which is moved once a year so that it stays above ground. The old, emptied 20-foot seismic container is in a snow cavern 12 metres below ground and accessed by a ladder in a snow shaft lined with plywood. The three operational observatory container buildings for magnetics/seismics, trace compounds (air chemistry) and the balloon launching station are placed on elevated, jackable steel platforms. The four steel legs on each of these platforms extend far down into the snow where they rest on timber spread footings.

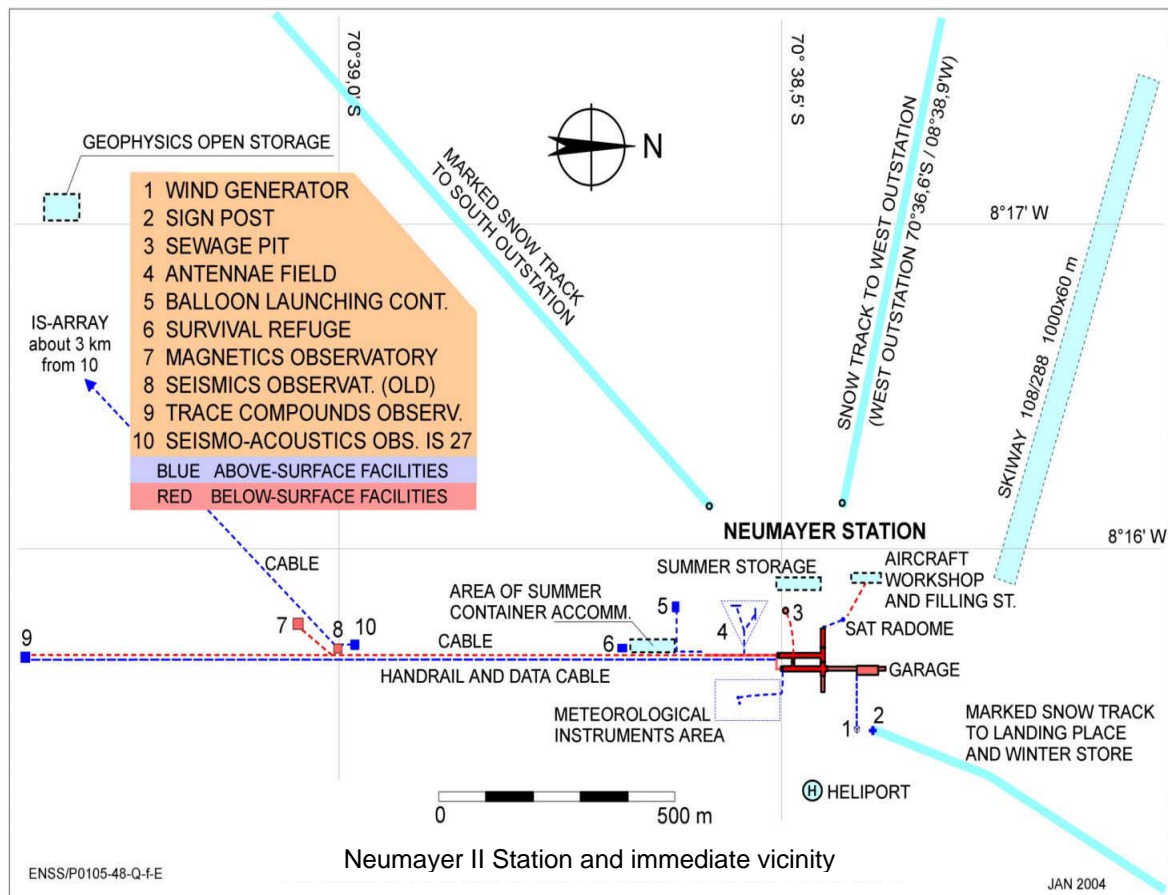


Fig. 7: Neumayer II Station and installations in the immediate vicinity

The infrasound array is a subsurface arrangement of tubes and cables with a number of data logger boxes covering an area of about 3 km². The array has to be dug out from time to time for maintenance, and is then installed again at a higher level because of the accumulated snow.

Electric cables to the different facilities are above-ground, with the exception of a 1,650-metre-long, 20-kW triple power line connecting the station with the old seismic container and with the trace compounds observatory. The cables run initially through the air tunnel and for the remaining 1,500 metres are buried in the snow at a depth of 8 metres (2004). The below-ground cable between the Radome antenna and the filling station (cf. Fig. 7) is a summer-only facility and is taken out during the winter.

The snow routes, the open storage areas, the landing strip for aircraft and the helicopter landing place are marked by poles and a small number of empty drums. All markers are regularly set higher to overcome snow accumulation. The storage areas are used for short-term (intermediate) storage only.

4.2 The dismantling and retrograding process and its time frame

4.2.1 General description

Neumayer II Station will be replaced in February or March 2008 by the new Neumayer III Station, which will have been built by then. There is a possibility, though only small, that Neumayer III might be finished and commissioned at the end of the 2006/2007 season, or equally that works might be hampered by unusual conditions or incidents that delay commissioning until the 2008/2009 season. Moving from Neumayer II to Neumayer III cannot take place over any extended time because the scientific programmes and measurements have to continue with as little interruption and disturbance as possible. For this reason, it is not intended to move building components, or any self-contained units, or fitted furnishings and equipment from the old base to the new base.⁸ In any case, the linear arrangement of the facilities in the steel tubes at Neumayer II does not allow the dismantling and moving of parts in a sequence compatible with installation schedules at Neumayer III.

The plan is to decommission Neumayer II Station immediately after the new station has started operation. Decommissioning includes the drainage and removal of all possibly harmful substances, especially oil-based and chemical liquids. These substances will be brought to Neumayer III and be dealt with in accordance with the waste management plan. The station will be completely idle after decommissioning and thus have no operational impact on the environment.

Dismantling works will commence in the season after Neumayer III goes into operation and may require two or more seasons depending on the logistic capacities available. The intention is to finish all dismantling and removal works by the 2009/10 season at the latest. Parts dismantled will be stored at the winter depot near the ice edge at Atka Iceport until they can be loaded onto a ship. AWI would like to achieve swift disassembly and loading and brief storage periods, but cannot rule out the possibility that storage time for certain bulky or heavy items may exceed a year.

The garage building may be used for some time after decommissioning of Neumayer II Station. It is not subject to heavy snow loads as its roof is kept at surface level by raising the garage structure at yearly or two-yearly intervals. Dismantling of this building might be delayed for this reason, but it will be completely removed from Antarctica when no longer in use and definitely before it has moved with the ice to a position that is no longer safe. All relevant works connected with the removal are described later in this document.

The dismantling of services that are in a narrow tube deeply buried in the snow requires skilled personnel. All relevant working and safety rules must be adhered to. When applied to certain dismantling works, such as taking out the steel tubes themselves, these rules will, under the circumstances we are dealing with here, entail an extremely complex procedure technically and logistically, which itself will cause more unwanted impact on the environment than leaving these parts behind in the snow. The intention, therefore, is to dismantle Neumayer II Station only as far as is environmentally sound, and to remove all dismantled parts from Antarctica by ship.

⁸ By contrast, movable equipment, spare parts, furnishing etc. that can be used in Station Neumayer III, will be moved there (see below).

4.2.2 Dismantling Neumayer II Station

Building site logistics

AWI needs a small team of a maximum of 12 people to carry out the dismantling works. The team will be accommodated in the summer section of Neumayer III and will travel the short distance between the site and Neumayer III by Pisten Bully. At the site a workshop container and one or two heated containers or cabooses will be placed near the snow ramp for weather protection during breaks. Environment-friendly toilet facilities will be provided, e.g. similar to those at the construction camp for the construction of Neumayer III. A mobile generator in the range of 40 kW will run during working hours to provide power for heating the cabooses, lighting and ventilation in the tubes at Neumayer II, and for electric tools. A 15,000-litre tank container with an electric pump will be brought to Neumayer II and serve as a refuelling station, mainly for the transport vehicles, but also for the generator. A VHF radio link between Neumayer II and Neumayer III will be installed for safety reasons.

Dismantling works and packing

The 50 containers inserted into the station as insulated units are equipped with corner fittings and will be used as 20-foot transport containers in the same way as when they were brought to Antarctica in 1991. Some of them will have to be fitted with temporary walls for that purpose. About another eight ordinary 20-foot containers are required to remove any items that do not fit into the 50 station containers or that would increase their weights above acceptable levels. The additional containers will help to reduce the packing work and use of packing materials, and one or two of them will be used to collect any garbage produced during the dismantling works.

When the station is decommissioned, all movable equipment, spares, furniture etc. that can be used in the new station will be taken out first. Then the pipes and tanks will be drained. The six tank containers will be emptied during the last months of station operation and drained when operation ends. They will then be disconnected and pulled out through the Cross Tube and over the snow ramp. These tank containers will remain at Neumayer III for further use.

Drained liquids, with the exception of the glycol-based antifreeze-liquid ("Tyfocor L") from the secondary cooling circuits, will be taken to Neumayer III and stored there awaiting removal from Antarctica in accordance with the waste management plan. The Tyfocor will be pumped into 200-litre steel drums for transport along with the components of Neumayer II.

Dismantling proper will proceed in reverse order of the installation. Cables, channels, lighting fixtures and pipes running on the outside of the container buildings or along the tube walls will be disassembled first and secured inside the containers for transport. The containers will be pulled one by one into the Cross Tube and put on flat skids. If the weather is bad, they will be loaded up with disassembled parts and closed off with temporary plywood walls here. Otherwise, the containers can be got ready for transport after they have been pulled out into the open over the snow ramp.

The workshop building may be useful for preparing containers in front of it for transport. However, it must be dismantled before the containers of the East Tube are taken out. Once all the containers and the workshop have been removed, the heavy timber floor planking will be taken up and bundled for transport. All timber floors in the stair towers will be removed in the same way.

The substructures (on which the container buildings and the floors had rested) are mostly bolt connected, which means that they are easy to disassemble. The packing units will be crates and bundles, and boxes for small items. The three large 30,000-litre steel trays, each of which had two tank containers in them, are not re-usable and will be cut into manageable sizes for transport.

Torch-cutting these trays is the largest of the very few disassembly works where acetylene gas will be needed. Very little welding was undertaken when the station was built, one of the reasons being the risk of zinc poisoning. The drip trays are not zinc galvanised. Cutting, if at all required, will be done mechanically, as it was for the electric cables, for example.

The steel tubes - after being emptied - will be left in the snow along with the steel bulkheads and the steel parts of the staircases.

All steel and timber parts that project above the snow surface or can be reached from there will be dismantled and removed. This includes stair towers, ventilation shafts, the emergency exit and ramp cover. The lower part of the emergency (ladder) exit shaft at the western end of the Cross Tube is firmly embedded in the snow and cannot be dismantled without endangering personnel. The steel fuel pipe running down the shaft will, however, be dismantled.

The 96.5-metre-long underground sewage pipe will also remain in place, as will the 1,500-metre-long buried part of the triple power cable from the end of the air tunnel to the trace compounds observatory. However, the section of triple power cable that runs through the air tunnel (about 150 metres) will be cut off for removal. In the same way, all the other cables in the air tunnel will be taken out and packed for shipping.

The dismantling of the garage building will be comparatively easy as all the parts are accessible from the surface or from the garage floor. In addition, the 46.4 metre by 16.6 metre roof has many flexible, silicon-rubber sealed joints so that it can be taken off in 12 panels, measuring 42 to 83 m². These panels are plywood sandwiches filled with non-toxic PU foam. They consist of smaller 2.44*3.64 metre sections, which are tongue and grooved together and have 6*50mm/200 mm screws for fixing.

All electric cables and installations will be disassembled at the outset. The steel roof structure and the supports are all bolted and are therefore easy to disassemble. The steel-timber composite foundations have been lifted many times to raise the garage and will be shipped without any further dismantling. The steel anchoring wires will be cut off at the level of the garage snow floor.

The following elements will be dismantled and – unless they are to be used in the new station – transported out of Antarctica⁹:

Table 17: Components of Neumayer II Station scheduled for dismantling and their weights

Description of component	Materials	Weight in tonnes
"Tyfocor L" antifreeze heating agent, 2000 litres	Glycol-water mixture, 200-litre steel drums	2.3
Oil spill trays for tank containers	Sheet steel, sectional steel, untreated	9.6
Fuel tanks (day tanks), pipes, pumps	Steel, aluminium, plastics	4.1
Exhaust gas piping system	Steel, rockwool	3.6
Water pipes with insulation, partly trace heated	Steel, PU foam, Armaflex elastomeric rubber, PVC, copper	6.1

⁹ The building materials and equipment used for Neumayer II Station are very well documented in specifications and in the box lists prepared for the initial transport of the station. The parts scheduled for dismantling and retrogradation or for leaving in the snow can therefore be precisely detailed.

Air ducts with insulation	Sheet steel PVC-coated/ galvanised, PU foam, rockwool mats	9.0
Tubes and mountings for the steel tube ventilation	Steel, aluminium	7.7
Electric cables (mostly ship's cable MGCG)	Copper, tinned copper wire braid, EPR/PCP insulation/sheath	6.3
Power cable H07RN-F3*70 from air tunnel, approx. 3*150 m, d = 41 mm	Copper, rubber, PCP (Neoprene)	1.7
Cable guides with fittings	Steel, aluminium, plastic	1.5
Containers (50 Nos 20', 1 No 10') with the following installations and equipment:	Steel, rockwool insulation, wood, plastic	248.4
Equipment, furniture	Steel, wood, plastic	15.5
Diesel generators and accessories	Steel, copper, plastic	8.2
Electrical installations, switchboards	Copper, steel, rubber, silicone	10.1
Lighting	Metal, glass, plastic	1.6
Sanitary installations	Steel, ceramics	2.4
Cold/warm water installations	Steel, PVC, plastic	12.8
Air conditioning installations	Steel, plastic	22.3
Fire protection installations	Plastic, copper, PVC	1.4
Shorings, container supports	Timber, hardwood	3.3
Steel framing, protective floor covers in workshop	Steel section galvanised, sheet steel untreated	18.8
Wall/roof panels with fire protective lining, workshop	Plywood, rockwool, embedded mineral fibres	10.5
Floorboards	Timber, impregnated against fire	64.0
Steel structures in tubes, gratings	Steel, galvanised steel	54.6
Head section of emergency exit	Timber, plywood, steel fittings	0.6
Wall/roof slabs for staircase towers	Plywood, phenolic-resin-coated	2.6
Flooring of stairs and landings in staircase towers	Wood	4.1
Steel structure staircase towers	Steel sections, primered/ galvanised	2.7
Exhaust air hoods	Sheet steel, galvanised	3.9
Ramp construction, main east entrance	Galvanised steel, timber	37.0
Roof panels, garage building	Timber, painted plywood, CFC-free PU foam	52.7
Sealing strips (garage roof)	Silicone rubber	0.3
Panels (roof edges & aprons, garage)	Plywood	3.9
Steel structure of garage (columns, beams)	Steel, primered	94.6
Ramp cover of garage (in one piece)	Steel, timber, painted plywood	4.6
Dangerous goods: batteries	Plastic, lead, acid	0.6
Dangerous goods: halon fire extinguishing system	Steel, halon, plastics	1.2

Dangerous goods: fire extinguishers	Steel, extinguishing powder, CO ₂	0.9
Dangerous goods: ionisation-smoke detectors	Plastic, radioactive element	--
Sum of items earmarked for dismantling and retrogradation		735.5

A list of all containers and packages with exact descriptions of the contents will be prepared during dismantling and packing

The dismantling works are independent of other activities at the station and not greatly influenced by bad weather.

4.2.3 Relocation of the outstations and antennas

The relocation of the outstations and antennas is part of the construction of the Neumayer III Station and has been dealt with in section 2.5.4 above.

4.2.4 Foundations that will remain in-situ

Deeply buried foundations consisting of steel sections and timber and also other parts of the station will not be dug out. For some components, the reasons AWI gives for this decision is that dismantling them would be very complex, energy-intensive, difficult, and in some cases, even dangerous. Secondly, AWI says that no damage to the environment is to be expected.

The components in question, identified using the construction drawings, are listed below (Table 18).

Table 18: Components of Neumayer II Station that will be left behind in the snow

Description of component	Materials	Tonnes	Reasons given by AWI ¹⁾
Steel tubes (corrugated sheets), shaft sockets	Steel (approx. 75% galvanised)	578.5	0, 1, 3, 4
Fasteners, connecting elements (tubes, shafts)	Galvanised steel	23.1	
Shafts (on tubes, deeply buried sections)	Galvanised steel	7.1	0, 1, 2
Bulkheads	Sectional and sheet steel, galvanised or primered	46.2	0, 3
Structural steelwork of stair towers (lower sections only)	Sectional steel, primered/galvanised	33.0	0, 4
Container bearings (bedding)	Volcanic slag	32.0	0
Emergency exit (Cross Tube)	Timber, plywood	2.5	0, 1, 2, 4
Snow anchors, steel wires in garage	Steel, galvanised steel	1.7	0, 2
Power cable H07RN-F3*70, l = 3*1,500 m, d = 41 mm	Copper, rubber, steel wire, neoprene sleeve	16.6	0, 1, 2
Sewage pipe	Steel, CFC-free PU foam, PE sleeve	1.5	0, 1, 2, 4
Satcom antenna tower, steel structure, depth 2008: -9 m to -0.4 m	Sectional steel, 35% galvanised	4.1	0, 2
Foundation pads	Timber 10/20 cm, 5.0 m	1.8	

Dipole antennas, triangular steel form-work sections, steel section foundation beam, depth 2008 -10 to -1m	Steel tubes (galvanised) and sectional steel (primered)	1.0	
Guy wires	Steel wire 10 mm, galvan.	0.1	
Foundation pads, dead men	Timber various sizes	0.9	
Wind generator foundation, steel structure, depth 2008: -10 m to -0.5 m	Sectional steel, sheet steel 35% galvanised	5.9	0, 2
Balloon launching platform, steel structure depth 2008: -6 m to -0.5 m (bottom section)	Sectional steel, primered	2.4	
Foundation pads	Timber 10/20 cm, 1.6 m	0.6	
Air chemistry platform, steel structure depth 2008: -9.5 to -0.4 m	Sectional steel, 35% galvanised	3.6	
Foundation pads	Timber 10/20 cm, 1.0 m	0.4	
Seismo-acoustic platform, steel structure, depth 2008: -6 m to -0.5 m	Sectional steel, primered	2.2	
Foundation pads	Timber 10/20 cm, 1.0 m	0.4	
Sum of all components that will be left in the snow		733.6	

¹⁾ AWI's justification:

- 0 = No environmental harm to be expected
- 1 = Disassembly very energy consuming
- 2 = Access too difficult because of depth in snow
- 3 = Disassembly requires a great deal of torch-cutting
- 4 = Disassembly dangerous (accident risk)

4.2.5 Retrogradation of the dismantled items

AWI plans to remove from the Antarctic Treaty Area all dismantled items that will not be used in Neumayer III and reuse, recycle or dispose of them in an environmentally sound manner. The items, materials and quantities will be meticulously listed and include details of the points of delivery for final disposal.

Over-ice transports

Use of station vehicles (including vehicles with cranes) and sledges is planned for the transportation of dismantled items to the ice edge or the ship's landing place. Station personnel may help as drivers with the transports. The distances can be estimated as 8 kilometres from Neumayer II to the storage area and 8 kilometres again from there to the landing place at the sea ice edge of Atka Iceport (see map in Fig. 3). The over-ice transportation depends on vehicles, plant and sledges the station may urgently need for other jobs.

About 60 round trips will have to be made to transport the dismantled containers and items, weighing a total of about 750 tonnes, on sledges to the intermediate storage place, and about 86 round trips for transportation from the storage place to the ship. For the latter, "mobilisation" tours from Neumayer III Station of about 25 kilometres (there and back) must be added. Altogether this amounts to 1,200 kilometres of trips with sledge loads and 1,600 kilometres

empty. Including the generator, the crane vehicles and secondary transports (e.g. fuel, workshop, personnel), the diesel fuel consumption will be 16,600 litres.

The dismantling works and the transportation to the storage place will be carried out in parallel. About 430 person-days are estimated for dismantling and transportation to the ship. Bad weather and longer routes over the sea ice could lead to longer transport times and higher fuel consumption, while a ship berthing at the storage place would make the second stage of the over-ice transports unnecessary. The calculated total diesel fuel requirement must therefore be adjusted by a plus/minus margin of roughly the amount needed for the second part of the transports as described above, namely $\pm 6,100$ litres (see Table 19).

Transportation by ship

It is not yet known what ships AWI will employ for transporting the Neumayer II components. The timely provision of shipping space is subject to the logistic constraints typical for the area.

4.2.6 Total requirements, work schedules, possibility and consequences of delays

The total resources needed for dismantling and transports are detailed below. Auxiliary work and downtimes have also been taken into account:

Table 19: Overview of time required for the work, including downtimes, and total diesel fuel consumption

Work	Person days	Downtimes (to be added)		Total person days	Diesel consumption in litres
		Percentage			
Site mobilisation – demobilisation	4	5	0	4	300
Dismantling/packing	321	5	16	337	6,120
Transportation to storage	29	20	6	35	3,795
Transportation from storage to ship	41	20	8	49	6,103
Transport variations	± 41	20	± 8	± 49	$\pm 6,100$
Clean-up and sealing	4	20	1	5	282
Total	399 \pm 41		31 \pm 8	430 \pm 49	16,600 \pm 6,100

AWI intends to employ (through a contractor) enough personnel to complete each work phase, or possibly the entire work, under normal conditions in a period of time significantly shorter than a season, so that delays do not lead to additional trips to Antarctica. Delays would have predominantly economic consequences; they would not be expected to have an environmental impact.

4.2.7 Alternatives to dismantling and transportation ***Leaving the station in Antarctica***

Essentially the Protocol on Environmental Protection to the Antarctic Treaty and Article 27 of the German Act Implementing the Environmental Protection Protocol require that research stations that are no longer operational be dismantled. For that reason, leaving the station in its entirety in Antarctica is not an option. Using the station for other purposes is also not possible. Feasible alternatives can thus only be concerned with the dismantling method and proposals to leave certain components in the snow.

Dismantling method

The dismantling method proposed for Neumayer II Station was tested on Station Neumayer I and proved successful. No other comparably effective method is known.

Removing the remaining components of the station

There is an alternative to the proposal to leave the above-mentioned components of the station in the snow – namely to dismantle them and remove them from Antarctica. The work involved in dismantling the station tubes or digging out the sewage pipes, the power cables (triple cable) and steel foundations would entail the extensive use of machinery, which would produce large quantities of harmful exhaust gases.

It is difficult to calculate exactly the required effort and employment of machines involved in removing the station tubes. The 8.4-metre-diameter tubes consist of corrugated steel plates weighing 415 kg each or more, with numerous bolted connections at the radial and longitudinal lap joints. There are two rows of bolts at all longitudinal (i.e. parallel to the tube axis) plate joints. In order to get sufficient access to the plates, their removal would have to strictly follow the reverse sequence of the assembly. Disconnecting the plates by simply removing the nuts from the bolts will not be possible, however, because the bolts cannot be tightened/untightened on the outside of the tube, and because they are held in place by the snow. Furthermore, special washers have been used to stop the nuts from working loose. The bolts would therefore have to be cut and driven out into the snow to free the plates. Even then the plates would remain stuck behind the overlaps and the snow. To pull them down by force would involve dangerous work, including fixing wire ropes and cutting provisional fixings. Accident prevention regulations would make the venture a very laborious exercise, which would therefore put a strain on resources.

If we use the calculations made for the disassembly of the Neumayer I Station tubes and modify them to account for sizes, weights and specific bolting patterns, the removal of the Neumayer II tubes would take 355 person-days of work and 23,500 litres of Arctic Diesel fuel. Ship transportation, personnel travel and back-up services (e.g. accommodation) are not included in these figures.

AWI examined two other options for disassembling the tubes:

- a) Cutting the plates into easy-to-handle sections. With 7.25-millimetre-thick plates this would require enormous amounts of cutting gas. Melted snow would make cutting difficult. But a more severe hindrance is the unavoidable production of poisonous zinc fumes (most of the plates are zinc galvanised).
- b) Digging down from the snow surface to reach the tubes on the outside. The statements about excavations made above apply. In addition - with the large and deep pits required - there would be the danger of drift snow ingress. And freeing the tubes proper from snow and ice would have to be done by hand, as mechanical excavation and removal would have to stop at a safe distance from the steel components.

With regard to the sewage pipe: it could be retrieved either from the snow surface by cutting a 15-metre-deep and 100-metre-long trench or by driving a horizontal tunnel 1.2 metres wide and 2.2 metres high above the pipe, starting from the tube. The trench would have to be about 5.5 metres wide in order to allow Pisten Bullies with blades to pass along it. The first part of the cutting proper would have to be carried out with a snow cutter/blower, a machine that has a high fuel consumption (cf. plant list in Table 1), and later in firmer snow layers using pneumatic or electric chisels. The tunnel could only be driven manually using tools such as chain saws and electric or pneumatic chisels. Fresh air would have to be brought to the progressing front end of the tunnel through ventilation tubes. AWI calculated that 15,390 litres of Arctic Diesel fuel would be needed to remove it (plus the fuel needed to transport that fuel).

Since the power cables are buried at an identical depth, but are over 15 times the length of the sewage pipe, the fuel consumption involved in retrieving the cables amounts to at least 200 m.³

Transportation

No feasible alternatives for the transportation have been identified.

5. The environment at the planned site

5.1 Description of the existing environment

The area around Neumayer Station on the Ekström Ice Shelf is characterised by the coast-like feature of an ice shelf edge in the South Polar Sea, which is typical for extensive areas of the Antarctic coastline at latitudes between 65 and 75° S. The station is located near the north-eastern and northern end of the ice shelf, which is delimited by a more-or-less permanent indentation in the ice front, only a few kilometres to the east, called the Atka Iceport, which is about 16 kilometres deep and 16 kilometres wide. It narrows to the north, forming a distinct "neck of ice" between the bay and the Weddell Sea, which extends to the west and southwest.

There are no Specially Protected Areas pursuant to the Antarctic Treaty in the vicinity of the station. The nearest is the Svarthamaren (Mühlig-Hofmannfjella, ASPA No. 142), an ice-free area 496 kilometres to the east-southeast. The nearest ice-free rock is the 220-metre-high Boreas Nunatak, over 117 kilometres to the south-southeast. There are no ice-free mountain ranges closer than 250 kilometres away.

5.1.1 The physical environment

Ekström Ice Shelf, which is 8,700 km² in size, is small by comparison with the major ice shelves Ross and Filchner/Ronne further to the south. At the Neumayer Station the ice shelf protrudes noticeably to the north in the direction of the general flow with a geographically-stable breaking edge. This particular feature is due to rises on the sea floor that extend higher than the underside of the ice shelf which, when floating free, is immersed down to 210 metres. The ice flow is pushed over these underwater obstacles, forming ice rises or ice rumples with heavily crevassed surfaces. Ice or even icebergs cannot break off from the ice shelf before passing over the obstacles, but the ice breaks off even faster afterwards because of the numerous fissures in the ice.

Another characteristic feature of the ice shelf near Neumayer is the deep, narrow inlets in the ice front to the east of the station on the western side of the Atka Iceport. They are believed to be generated when the northward flowing ice is forced to round the western end of the rises on the southern edge of the Bay, with large shearing forces causing the characteristic fractures. The fractured ice edge is then pushed further north by the general ice shelf movement.

Some of the inlets at the ice edge north of the station are formed by similar processes, and some are formed by ice spreading out when it is no longer constrained on both sides.

The area around the station is almost entirely flat, with the typical sastrugi surface structure caused by wind. The elevation above mean sea level at the station is around 25 metres, and the thickness of the ice shelf is 230 metres. The ice there flows northward at a rate of 150 to 200 metres per year.

Atka Iceport and the adjacent continental shelf waters are under the influence of a strong coastal current which, as a branch of the East Wind Drift, enters the Weddell Sea from the east and flows southward. The bay is flanked by floating or grounded ice shelf with cliff-like edges up to 20 metres high. The continental flat water zone is only about 5 kilometres wide, with water depths ranging from 100 to 500 metres and increasing rapidly to 1,000 metres beyond that. Submarine contours in the inner part of the bay are characterised by a steep canyon that is 275 metres deep. The sea bottom is covered with glacial mud and extends to unknown distances under the floating ice shelf. There is no coastal area in the strict sense – with shallow water zones, sandy gravel beaches, or rocky cliffs – in Atka Iceport or elsewhere along the east coast.

The Weddell Sea to the west extends south to 78° S. The continental shelf along the eastern coast is narrow, extending no more than 90 kilometres. Typical water depths are 200 to 500 metres. Shallower areas are mostly covered by the continental ice sheet with high ice cliffs forming the coastline of the eastern and southern part of the Weddell Sea. The shelf edge is located in an area where the water is 500 to 800 metres deep. As part of the Weddell Gyre, a strong current flows southward along the eastern coast. Between March and December of each year the sea at the foot of the ice cliffs freezes and fast ice extends westward to the pack ice region of the central Weddell Sea.

Due to its sheltered situation, the sea ice in Atka Iceport forms a bit earlier (late February) and breaks up a bit later (December) than the ice in the adjacent waters, so the bay is covered for most of the year with fast ice reaching a thickness of 2 metres or more by late winter. Icebergs quite often run aground in the bay, and some of them remain there for years before breaking up and moving on. Drifting snow forms natural steep ramps from sea ice to ice shelf surfaces at many places when it is deposited in the protected zones of the ice edge.

A polynya (area of open sea surrounded by ice) forms at the outlet of Atka Iceport and the ice shelf north of Neumayer at irregular intervals of a few days under the action of intermittent catabatic winds that are accelerated at the ice cliffs and blow forcefully down from there. Weddell Polynya, which has a different size (oval shaped and about 300 nautical miles across) and cause (upwelling water), appears more-or-less regularly in the sea or pack ice about 500 nautical miles northeast of Atka Iceport, allowing easier navigation than in comparable surrounding areas. There is a distinct semi-diurnal tide on the ice coast with an average range of 1.2 metres. The ice shelf follows the tide where it does not rest on sea-bottom rises. Tidal currents accordingly extend far beneath the ice shelf and have been directly measured at Neumayer through holes in the ice. Mean surface temperatures of the sea are close to freezing point throughout the year.

The weather around Neumayer Station is strongly influenced by cyclone activities (König 1985). Most of the cyclones move eastward north of the station, which is the main cause of frequent blizzards from easterly directions. Winds from the north are rare, while winds from the south are quite common. Without exception they are weak and occur only under stable weather conditions. They are derived from local downslope currents of cold air near the ground.

Weather conditions at Neumayer Station:

Air temperature (Gube-Lehnhard 1987 and various later sources):

Annual mean	-16.1°C
August (coldest month)	average -24.9°C
January (warmest month)	average -4.1°C
Minimum	-47.3°C
Maximum	+ 4.5°C
Summer (season)	-23.0°C to +1.2°C (average min. to max. 15.12 to 10.03)

Wind velocities and snow drift (König 1985 and various later sources):

Annual mean	9.1 m/s
Maximum (max. 10 minutes mean, FF10)	36.5 m/s
Maximum (max. 1 minutes mean)	39.9 m/s
Maximum gust	50.0 m/s
Days of snow drift	60%

The main results of wind spectra measured at Neumayer can be seen in the Draft CEE (Figure 4-8). The vast majority of winds and storms are easterly. Drifting snow appears as blowing snow at wind velocities around 5 metres per second and becomes intense at 10 metres per second, which meteorologists call "grade 4 drift."

The snow accumulation rate varies strongly over shorter periods and totals 70 to 80 cm of snow or 320 kg/metre per year at undisturbed areas near Neumayer Station (Oerter 2003, Schlosser, et al. 1999). Separation into precipitation, evaporation and drift snow contributions is difficult and has not been investigated so far. The disturbances from tracks in the snow and obstacles in the vicinity of the station cause slightly higher accumulation rates there. Snow accumulation has been measured at Neumayer since 1982, and the records show varying multi-year trends, which may overlap with other trends from even longer periods which have not yet been clearly determined.

5.1.2 Biota

Due to the difficult ice conditions and the fact that the size of fish and krill stocks is not yet known, the Weddell Sea shelves are not exploited by man, and thus represent a virgin ecosystem of the high Antarctic. Germany has carried out regular seagoing operations since the austral summer of 1979-80 to study the present status and the seasonal and year-to-year variations of the Weddell Sea coastal system and its interactions with the oceanic gyre.

The shelf system of the eastern Weddell Sea shows a diverse and abundant benthic community which is particularly rich in echinoderms and detritophage sponges. More than 50 species of demersal fish have been reported. In terms of biomass, the principal species on the eastern shelf are the channichthyids *Chionodraco myersi* and *Chionodraco hamatus* and the nototheniids *Trematomus eulepidotus* and *Trematomus lepidorhinus* (Ekau 1990). The herring-like midwater fish *Pleuragramma antarcticum* is the central species in the pelagic system of these areas, apparently more abundant here than elsewhere in the Southern Ocean (Hubold 1984).

Large numbers of marine mammals and birds migrate into the shelf waters of the eastern Weddell Sea during the break-up of sea ice in early summer. When fast sea ice forms again they leave the vicinity of the coast to winter in oceanic pack ice regions. Winter aggregations of crabeater seals (*Lobodon carcinophagus*) and Adélie penguins (*Pygoscelis adeliae*) have been found in the northeastern Weddell Sea pack ice, about 700 kilometres north of the continental margin (Plötz, et al. 1991). The obvious differences in the seasonal abundance and distribution patterns of these top predators may be related to the annual cycle of their principal food, the shrimp-like krill *Euphausia superba*. Krill swarms, which form an unlimited food reserve in the seasonal pack ice zone of the East Wind Drift, appear only temporarily in the coastal shelf waters of the eastern Weddell Sea, where they feed on patches of phytoplankton blooms during the short period of ice break-up in summer. In winter the bulk of the krill population moves into the oceanic pack ice habitat, where it is associated with the ice algae community (Smetacek et al. 1991). Therefore, specialised krill-feeding mammals and birds are scarce on the east coast during winter, while the opportunistically feeding Weddell seal (*Leptonychotes weddellii*) and emperor penguin (*Aptenodytes forsteri*) show strong affinities to the coastal shelf waters throughout the year.

Marine biota of the Atka Iceport have not been studied in detail but are expected to be similar, on a small scale, to important features of the eastern Weddell Sea shelf areas which are all under the influence of the East Wind Drift.

The wind-sheltered fast sea ice at the foot of the ice cliffs provides ideal breeding sites for emperor penguins and Weddell seals. Even under conditions of maximum ice cover during winter the animals have easy access to the open sea at the wide mouth of Atka Iceport because of the presence of the pronounced polynya along the ice coast described above. The resting sites of seals and penguins are destroyed, and the animals are compelled to move elsewhere in December each year when the sea ice in the bay breaks off close to the ice cliffs where it is weakened by tide cracks.

Seals are common at Atka Iceport. In spring they return to traditional pupping sites in fast-ice areas close to the ice cliffs, where the aforementioned perennial cracks provide access to the water. According to observations made by the overwintering crews of Neumayer Station, the whelping season lasts from late September to early November, and the pups are weaned at the age of six weeks. Emperor penguins are the most abundant birds in Atka Iceport. Adults assemble at the traditional breeding sites for courtship and pairing in April and May. Single eggs are laid in late May and early June, and the males incubate alone for about nine weeks throughout the winter months June and July. Chicks are hatched in late July and early August, and after a five-month rearing period they are ready to leave the colony site with the break-up of the fast sea ice at the end of the year.

There is an emperor penguin rookery near the southwest corner of Atka Iceport (cf. Fig. 3 above) which is sheltered by the high ice cliffs of an inlet and quite often by some grounded icebergs. The colony was roughly counted from the air in the 1980s (the count has been classed as a guesstimate, accurate only to the nearest order of magnitude) and indicated 8,000 pairs (Woehler 1993). In 1991 the overwintering crew of Neumayer Station reported that the size of the colony was on the order of 5,000 breeding pairs. Station staff have had an opportunity to observe the colony over longer periods, but only on random occasions and not under an observation scheme; they report that the season-to-season variation in breeding success varies considerably with the ice conditions. The colony is situated about 5 kilometres northeast of Neumayer II Station and about 9 kilometres to the north-northeast of the proposed site for Neumayer III Station.

The position of the rookery was checked and found unchanged by the Neumayer overwintering team in late May 2004. As observed in previous years, the rearing of emperor chicks in Atka Iceport is almost entirely completed prior to break-out of the sea ice in December. At this

time, large parts of the bay become ice-free within a few days, and most of the adult and juvenile penguins have left, except for several hundred adults associated with groups of still moulting chicks that have hatched outside the optimal period. These animals gather on the remaining fast ice in the innermost parts of the southwest inlets, where they are well protected from all station activity.

In the summer months, Adélie penguins and crabeater and Weddell seals are often seen in the Atka Iceport whenever ice floes are present. Smaller numbers of southern giant petrels (*Macronectes giganteus*), skuas (*Catharacta* spp.), Antarctic petrels (*Thalassoica antarctica*), and snow petrels (*Pagodroma nivea*) can also be observed. A few emperor and Adélie penguins and skuas have occasionally visited Neumayer I and II Stations. The penguins make use of the natural snow ramps to climb up to the ice shelf. They sometimes stay there to complete their moult.

No terrestrial life exists in the Atka Iceport area or elsewhere on the Ekström Ice Shelf. Although it is known that colonies of bacteria are able to survive the long winters of extreme cold thanks to a form of hibernation, it seems highly unlikely that any microbial life that exists on the snow surface near Neumayer (in spite of the instability caused by the enormous wind-borne snow transport) could be harmed by station activities.

Virtually no information is available on the biological environment below the ice shelf at Neumayer Station (personal communication by Plötz, Nixdorf). It may be assumed, however, that marine life is no different from life beneath other ice shelves, where a few invertebrates and fishes have been recorded by remotely-operated cameras.

5.1.3 Past and present uses of the area

Ekström Ice Shelf was not often visited prior to the Neumayer Station activities. In 1939 the German Schwabenland Expedition surveyed Dronning Maud Land by aerophotogrammetry. The International Norwegian-British-Swedish Antarctic Expedition explored the coast by ship from 1949 to 1952 from Cape Norvegia (12° W) to about the longitude where SANAE Station is now located (3° W), and also explored a wider area by air, including the mountain ranges 450 kilometres inland. A wintering base known as Maudheim was set up 60 kilometres north-east of Cape Norvegia on Quarisen, and extensive exploration tours over the ice were made from there. The Russians later had a summer base on Quarisen for some years. The geographical position and the contours of Atka Iceport were the same then as today.

Ekströmisén is named after an expedition member who was tragically lost on the expedition. The ice shelf was known as the Eastern Ice Shelf before the expedition. Atka Iceport was named by personnel of the USS ATKA which moored there in 1955 while looking for possible base sites for International Geophysical Year operations.

The German Neumayer Stations (I followed by II) have been operating without interruption on Ekström Ice Shelf near Atka Iceport (often referred to as Atka Bay or "the bay") since 1981. The winter complement is nine on average, and up to about 40 people are housed at the station during the summer season. The station activities are reduced geographically to a very small range of about 80 kilometres and include the sea ice of the bay in winter, but not the sea or the pack ice. There are no boats at the station.

Neumayer Station is relieved by ship in summer. Ships moor at the edges of the ice shelf or the fast ice in Atka Iceport. Transport between the ship and the station uses tracked vehicles and sledges. Neumayer Station increasingly serves as a logistical base or intermediate point of support for various expedition activities in summer and can be reached by fixed-wing aircraft from Novorazalevskaya and Halley V stations. Helicopters have at several times visited from SANAE. An over-ice route between Neumayer and SANAE IV was traversed by the South Africans for the first time during the 2003-04 season.

The first Neumayer Station was abandoned in 1992, and all parts that could be removed from the station tubes were taken out of Antarctica. The area is currently used only for operation of the Neumayer II Station and the research programmes run from there.

5.2 Prediction of the future environment in the absence of the proposed activities

Within just a few days after the station is dismantled and removed the environment of Neumayer Station would on first impression appear no different from the environment of more distant undisturbed areas. The reason is to be found in the drifting snow, which covers and conceals all traces of activity on the snow surface within a very short time.

Deposits on the snow on the ice shelf from the exhaust gases due to operation of the Neumayer I and II Stations during the 27 years from 1981 until 2007 are distributed over a depth of 15 metres because of snow accumulation. With regard to horizontal extension, it can safely be assumed that evidence of the station's exhaust gas emissions are found in westerly directions only up to the ice edge at a maximum distance of 35 kilometres, and in all other directions up to maximum distances of 10 kilometres. Current technology would probably not be able to trace exhaust gases from the station at distances over 5 kilometres (cf. Rankin 2003). Discharges into the sea or onto the sea ice to the west of Neumayer have in all probability been dispersed widely by the sea currents and ice drift and most likely cannot be distinguished from background levels due to the extremely low concentrations.

The two ice lenses formed in the snow by the wastewater from the stations can reach a depth of about 60 metres maximum where the snow is transformed to ice. Measurements at Neumayer I have shown depths of only about 28 metres, which can be explained by the small volumes of wastewater and the corresponding faster cooling when horizontally permeating the denser layers of the snow. Moreover, several thin ice layers from a few millimetres to some centimetres thick are embedded in the snow at Neumayer; they were generated by re-freezing of snow that melted on the surface on sunny days in summer. These ice layers slow the vertical penetration of the snow by wastewater. When the lenses eventually reach the ocean, it can be expected that melting will take enough time to allow for sufficient dilution by sea water so that the water quality is not adversely affected.

The tubes made of corrugated steel plates at Neumayer I and II Stations, which are to be left in Antarctica according to AWI's plan, will have a snow overburden of about 16 metres and 7 metres respectively when Neumayer II Station is abandoned. These actual overburdens will increase more than the corresponding snow accumulation in the area because the tubes will be compressed. The bottoms of the tubes will remain in the snow layers, where they were laid during construction.

It can be assumed that the three hot-water boreholes drilled through the ice shelf near Neumayer in 1993 have left almost no traces and have had no impact on the environment. Drilled holes close quickly under the horizontal ice pressure when not kept open. No casing was installed, and no chemicals have been used in the holes (Nixdorf, et al. 1994). Two electric cables about 250 metres in length and another cable that is 440 metres long and extends to the sea floor (each about 2 cm in diameter) had to be left in the boreholes after conclusion of most of the experiments because of freezing. An ultrasonic echo-sounder that is 30 cm in length by 10 cm in diameter, which is fixed to a 2-metre-long steel rod, has been left at the lower end of one of the boreholes. In addition, a cable carrying 11 temperature gauges (thermistors) located near the lower end of the cable is frozen in one of the other boreholes and was still operational in 2004.

Taking these impacts into account, the snow volume physically disturbed by station operation until 2007 will have about the following dimensions after the Neumayer II Station is abandoned:

North-south direction: 7 km N-I/N-II + 2*5 km = 17 km

East-west direction: 4 km N-I/N-II + 2*5 km = 14 km

Depth: 7 to 60 metres; at 1 kilometre south of Neumayer II locally down to the lower edge of the ice shelf.

This affected body of snow will increasingly be farther away from the surface and at the same time move in a generally northern direction with the ice flow toward the breaking edge (see map in Fig. 3). The snow body will probably reach the breaking edge of the ice shelf from around 2045 to 2060, and in the course of about 85 more years it will break off in several pieces and drift away. The solid parts and emission substances held in the snow will be freed by melting and will either sink or rise to the surface and will then be dispersed over an area of the sea which is difficult to assess but certainly large.

Adverse effects on the marine environment, including the sea floor, are not expected. The most massive parts are the steel tubes of the protective structures of the two Stations. The steel tubes could cause some damage to the benthos when striking the sea floor, but it will be very limited.

Environmental impacts on the Atka Iceport to the east or on the sea to the west of the station locations and their paths with the moving ice shelf will not differ from those to be expected when the activities take place.

Considering only visible signs of Neumayer activities, the initial environmental reference state would be regained after about three years. After that, it is likely that even the flat snow hill that forms over the station due to the rougher surface characteristics would no longer be recognizable. Taking into account the components and substances left in the snow on the ice shelf (Neumayer I and II), the initial environmental reference state will be regained after about 120 years if left undisturbed, and after about 150 years taking into account the planned life span of Neumayer III Station.

6. Data and methods used to predict impacts of the proposed activities

6.1 Basis

The description of the planned activities is based on AWI's experience from more than 20 years operating the station at Neumayer, a total of four station buildings in the Antarctic¹⁰ and the comprehensive data on activities at an Antarctic station. The data basis for the assessment of environmental impacts is comparatively small, on the other hand, because a systematic and documented approach to environmental protection did not begin until shortly before the introduction of the Environmental Protocol.

Previous comprehensive environmental evaluations have therefore been a valuable source of information on the scope and analysis of impacts and on assessment methods. Particularly useful were the CEE on Development and Implementation of Surface Traverse Capabilities in Antarctica (NSF 2004) and the Concordia Project Dome C CEE (Gendrin, Giuliani 1994). The EPICA/Dronning Maud Land CEE (AWI 2000) covers AWI's resources, some of which are identical to those used for the activities described here.

Data on the fuel consumption of motors that will be used in the future was obtained from suppliers, while the data collected over many years at the station could be used for Dornier aircraft and for all vehicles and plant at the Neumayer Station. Antarctica Logistics Centre International (PTY) Ltd., operator of the flights between Cape Town and Novolazarevskaya Station,

¹⁰ Neumayer I and II, Filchner and Kohlen.

supplied data on the fuel consumption of the Ilyushin aircraft. Fuel consumption of a chartered transport vessel has been estimated on the basis of comparable ships' data.

Emission data for the station diesel generators (taking into account exhaust gas treatment) and generally for the fuels used at Neumayer Station was compiled by Professor R. Behrens of Bremerhaven University of Applied Sciences.

Calculations of the distribution of exhaust gas from the station and ships' diesel engines and calculations of the actual distribution of pollution on the snow using different methods often yield widely differing results. The results vary strongly depending on the initial data, which is often based on various applicable parameters with considerable ranges. The physical form parameters of the station structure are still unknown (and the elevated structure is not covered in the basic catalogue of forms), as is the relevant data on engines and exhaust. The difficulties in determining valid building downwash factors are mirrored by the strong variations in air turbulence observed during the wind tunnel tests when applying different building shapes or when changing locations of secondary structures on the roof of the station building.

Concentrations of pollutants vary considerably, even when applying a straightforward single-source Gaussian distribution model and using the 1996 version of the SCREEN3 program,¹¹ which is a conservative screening technique designed to estimate the worst-case impact based on the meteorological matrix, (cf. Annex 8 of the EIA). These calculations have therefore not been done to give an exact picture but rather to back up estimates of extreme conditions and assessments made elsewhere (cf. the paper by Rankin on the effect of generators on local snow and aerosol chemistry at a coastal Antarctic research station, circa. 2003).

6.2 Criteria for the assessment of potential impacts

Table 20 below shows the criteria for assessing potential environmental impacts. The classification criteria are assigned in accordance with recommendations by Wesnigk (1999) and other CEEs that have been published recently.

Table 20: Criteria for the assessment of potential impacts

Parameter of impact	Affected environment	Classification of impact			
		L (Low)	M (Medium)	H (High)	VH (Very High)
Dimension, extent	Air	Local, confined	Part of area affected, small scale but more than local	Major part of area or whole area affected	Large scale, no limit to spread
	Sea ice				
	Ice shelf				
	Sea				
	Fauna	No disturbance or impairment	Disturbance or impairment possible	Major impairment of individuals, reduced breeding success	Impairment at population level
Length, recovery	Air	Short term, up to one	Medium term, several sea-	Long term, decades, but still	Permanent, irreversible or
	Sea ice				

¹¹ The SCREEN3 model is a PC-compatible companion to the revised screening procedures document, "Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised," EPA-450/R-92-019. SCREEN3 uses a Gaussian plume model that incorporates source-related factors and meteorological factors to estimate pollutant concentration from continuous sources. The SCREEN3 model utilizes a matrix of meteorological conditions covering a range of wind speed and stability categories. It is assumed that the pollutant does not undergo any chemical reactions, and that no other removal processes, such as wet or dry deposition, act on the plume during its transport from the source. Details can be found at the U.S. EPA Technology Transfer Network website, Support Center for Regulatory Air Models, www.epa.gov/scram001/tt22.htm.

	Ice shelf	season	sons or years, but reversible	reversible	chronic changes
	Sea				
	Fauna	Short compared to season or breeding season	Recovery likely within growth period or season (weeks/months)	Recovery in one growth period or season not certain	Recovery unlikely in one year, permanent changes
Intensity	Air	Minimal, natural functions or processes not affected	Medium, natural functions or processes influenced for short period	High, natural functions or processes influenced or changed over years	Extensive, permanent disruption of natural functions or processes
	Sea ice				
	Ice shelf				
	Sea				
	Fauna	Natural functions or processes not affected	Natural functions or processes influenced over a short time	Natural functions or processes temporarily influenced or changed	Natural functions or processes are permanently disrupted

7. Analysis of direct environmental impacts by the planned activities

The potential impacts caused by the activities described in this document have been compiled pursuant to Article 3 (4) of the implementing legislation and Article 3 (2b) of the Protocol of Environmental Protection to the Antarctic Treaty and in accordance with the Guidelines for Environmental Impact Assessment in Antarctica (COMNAP 1999, CEP 2002; 2005 supplement).

7.1 Compilation of emission data and other data relevant to impact

There are two major environmental indicators for activities in Antarctica: consumption of mineral fuel and the number of active people. The effects they can cause are listed in Table 21. A rough estimate of probability and environmental relevance – in each case under the conditions at Neumayer Station – has been added. The overwhelming environmental importance of fuel combustion becomes clearly apparent.

Table 21: Strong environmental indicators at Neumayer

Indicator	Action	Trigger factor	Affected assets	Probability	Relevance
Fuel	Spill	Pollution	Snow, sea	-	++
	Evaporation	Pollution	Air	+	-
	Combustion	Pollution	Air, snow, sea	+++	+++
People	Travel	Tracks	Snow surface	+++	+
		Noise, movement	Animals	++	-
	Presence	Water generation	Snow	+++	-
		Wastewater (treated)	Snow, sea	+++	+
		Solid waste	None directly	+++	-

7.1.1 Emissions from the fuel combustion

Internal combustion engines convert the chemical energy contained in the fuel into mechanical power. The exhaust gases that are discharged from the engines contain several constituents that are harmful to human health and to the environment. The specific amounts of harmful or even toxic materials in exhaust depend on various parameters determined by the types of engines, the operating mode (load and load changes), the exhaust gas treatment, and – to a considerable extent – the quality of the fuel. The most effective (and often only technically feasible) measures to achieve such reductions are "cleaner" fuels and exhaust gas purification.

Transporting materials to the Antarctic is projected to begin in late 2005, and the construction work will start at the earliest in late 2006. AWI intends to use the cleanest fuels that are available and can be used in the existing engines. Only unleaded petrol is used at the present time. As soon as the industry will, in conformity with stricter legal requirements, provide low-sulphur diesel fuel this will be used for both stationary equipment and heavy vehicles.

While the production of the greenhouse gas CO₂ as a result of combustion is more or less solely dependent on the carbon content of the fuel (which does not vary much with different fuels and may be assumed to be 84 to 87% of the fuel mass), the other constituents of the exhaust gas are much more variable, and their specific amounts are therefore normally calculated using emission factors published by institutions like the EPA, EEA or industrial associations. These factors are not very consistent, a reflection of the many uncertainties resulting from fuel variations, machine configurations and operating conditions. Thus differing factors can also be found in the most recently published CEEs on activities in Antarctica or derived from them.

The emission factors used in this document are listed in Table 22 along with fuel consumption and the corresponding emissions.

Table 22: Emission factors (g/kg of fuel)

Engine type/fuel	Source	CO ₂	NO _x	CO	HC	VOC	PM	SO _x
Ships: medium speed engines/MDO	IMO IMO	3200	57	7.4	1.80	2.4	4.3	30 ¹⁾
		3200	40 ²⁾	7.4	1.80	2.4	0.6	1.0 ²⁾
FS Polarstern/MDO 0.9% S	AWI/GL	3100	26.2	4.6	1.80	nda	0.55	18
FS Polarstern/MDO 0.05% S	AWI	3100	26.2	4.6	1.80	nda	0.55	1.0
Ships: auxil. engines/MDO 0.05% S	Var.	3200	63	6.8	1.82	nda	1.36	1.0
Generators/Polar Diesel	EU/IV	3124	1.82	15.9	0.86	nda	0.114	0.03
Snow vehicles/Polar Diesel	EU/II	3111	27.3	15.9	1.80	nda	0.909	0.03
International aircraft cruising average/ kerosene	IPCC	3150	17.0	5.0	1.80	2.7	2.2	1.0
Dornier Do 228 /kerosene	³⁾	3180	40.4	16.9	1.80	nda	2.2	1.0
Skidoos/petrol	Var.	1763	18.3	548	134	nda	nda	nda
International aircraft, kg per LTO/kerosene	IPPC	7900	41	50	nda	15	(22)	2.5

Entries in *italics* represent assumed values or less reliable information

nda = no data available

- 1) Based on limit for MDO with maximum 1.5% sulphur content, probably allowed until 2007.
 2) The nitrogen oxide emission factor will apply when water injection (i.e., emulsified fuel) and/or exhaust gas recirculation are used. The SO emission factor will apply when sulphur content is < 500 ppm in MDO.
 3) Values of the CEE on Concordia (JP-8) have been used for lack of other data.

Table 23: Fuel consumption and exhaust emissions all activities

	Activity	Fuel	1)		Duration	S	CO ₂	NOx	CO	HC	VOC	PM	SOx
		1)	litres	kg									
1	A N-III intercontinental flights	K	40387	33310	1	L	104926	566	167	60	90	73	33
2	Flights Novo-Neum.-Novo	K	9687	7750	4	L	24645	313	131	14	46	17	8
3	Chartered ship 1 trip	M	179882	152000	8	L	486400	8664	1125	274	365	654	4560
4	28 days at ice edge ³⁾	M	143148	120960	28	P	387072	6895	895	218	290	520	3629
5	Erection and construction camp	D	168970	135176	75	P	420533	3690	2149	243		123	4
6	Transport over ice	D	44214	33371	28	L	103817	911	531	60		30	1
7	A N-III transport and assembly		586288	482567	approx. 80		1527393	21039	4998	869		1417	8235
8	A N-III dismantling	D	131000	104800	60	P	327395	191	1666	90		12	3
9	Transport over ice	D	34000	27200	22	L	84973	50	432	23		3	1
10	Chartered ship 1 trip	M	179882	152000	8	L	486400	6080	1125	274	365	91	152
11	14 days at ice edge ⁴⁾	M	71574	60480	14	P	193536	3810	411	110		82	60
12	A N-III retrogradation		416456	344480	approx. 65		1092304	10131	3634	497		188	216
13	A N-III build + retrogradation		1002744	827047	approx. 145		2619697	31170	8632	1366		1605	8451
14	B N-III operation generators	D	294000	235200	365	P	734765	428	3740	202		27	7
15	Snow vehicles	D	21000	16800	120	L	52483	31	267	14		4	1
16	Snow vehicles	P	2000	1520	120	L	2680	28	833	204		0	0
17	Aircraft/helicopters	K	50000	40000	90	L	127200	1616	676	72	239	88	40
18	FS Polarstern 1 trip ⁶⁾	M	244615	206700	5	L	640770	5416	951	372		114	207
19	2 days at ice edge ⁷⁾	M	47337	40000	2	P	124000	1048	184	72		22	40
20	B N-III operation total p.a.		658952	540220	p.a.		1681898	8567	6651	936		255	295
21	C N-II dismantling	D	6702	5362	29	P	16681	146	85	10		5	0
22	Removal transports	D	9898	7918	14	L	24633	216	126	14		7	0
23	Chartered ship 1 trip	M	151479	128000	8	L	409600	5120	947	230	307	77	128
24	10 days at ice edge ⁵⁾	M	38343	32400	10	P	103680	2041	220	59		44	32
25	C N-II retrogradation total		206422	173680	approx.35		554594	7523	1378	313		133	160

- 1) Fuel (abbreviation) and specific weights g/litre:
 D = Polar Diesel 800
 K = JP-8/Jet-A1 800 kerosene P = Petrol 760
 M = MDO (marine diesel oil) 845
- 2) Emission source designations: P = point source, L = line source
- 3) Assuming 800 kW average output by auxiliary diesel engines (generators); 0.225 kg/kWh, 28 days, then consumption = $0.225 \text{ kg/kWh} \times 28 \times 24 \text{ h} \times 800 \text{ kW} = 120,960 \text{ kg} = 143,148 \text{ litres MDO}$
- 4) Assuming 800 kW average output by auxiliary diesel engines (generators), as above but 14 days
- 5) Assuming 600 kW average output by auxiliary diesel engines (generators), as above but 10 days
- 6) Distance from Cape Town 60°S to Neumayer 650 N.M. one way, total one trip 1300 N.M. Average speed 10.5 knots (some ice considered), thus total travelling time $1300/10.5 = 124 \text{ h}$. MDO consumption while travelling 40 tonnes/24h, here $40 \times 124/24 = 206.7 \text{ tonnes} = 206,700 \text{ kg}$.
- 7) Polarstern uses main engines at ice edge (thrusters, air conditioning, lighting, cranes, etc.) at 50% on average = 20 tonnes/day. A re-supply stay at the ice edge usually lasts 2 days, takes 40 tonnes MDO.

The three emission factors considered here are presented separately to show the corresponding emissions. Emissions are broken down further by point and line sources in view of the effects that are considered later. Finally, the times are listed as well to demonstrate the temporal distribution of the emissions. The results of the emission calculations and estimates are shown in Table 24.

Table 24: Emissions by the activities as a result of fuel consumption

Group	Activity	Neumayer III				Neumayer III		Neumayer II	
		Construction		Retrogradation		Operation/year		Retrogradation	
Point sources	Total duration*)	Minimum 76 days		Minimum 60 days		More than 25 years		Minimum 34 days	
	Fuel/Emission	kg	d	kg	d	kg	d	kg	d
	Polar Diesel	135,176	76	104,800	60	235,200	365	5,362	34
	Marine DO	120,960	28	60,480	14	40,000	2	32,400	10
	Total fuels	256,136	76	165,280	60	275,200	365	37,762	34
	CO ₂	807,605		520,931		858,765		120,361	
	CO	3,044		2,077		3,924		305	
	HC	461		200		274		69	
	NO _x	10,585		4,001		1,476		2,187	
	SO _x	3,633		63		47		32	
	PM	643		94		49		49	
	Line sources	Polar Diesel	33,371	28	27,200		16,800	120	7,918
Kerosene		41,060	5	0		40,000	120	0	

	Petrol	0		0		1,520	120	0	
	Marine DO	152,000	8	152,000	8	206,700	5	128,000	8
	Total fuels	226,431	28	179,200	22	265,020	120	135,918	14
	CO ₂	917,788		571,373		823,133		434,233	
	CO	1,954		1,557		2,727		1,073	
	HC	408		297		662		244	
	NO _x	10,454		6,130		7,091		5,336	
	SO _x	4,602		153		248		128	
	PM	774		94		206		84	
Total quantities	Fuels	482,567	76	344,480	60	540,220	365	173,680	
	CO ₂	1,527,393		1,092,304		1,681,898		554,594	
	CO	4,998		3,634		6,651		1,378	
	HC	869		497		936		313	
	NO _x	21,039		10,131		8,567		7,523	
	SO _x	8,235		216		295		160	
	PM	1,417		188		255		133	

*) The shortest time periods in each case, but without reducing consumption, which leads to the highest emission rates.

The calculations show that the emissions from ships are remarkably high during all three activities. The relatively powerful ships' engines require a great deal of fuel, which is also of lower quality than fuels used on land.

The percentages of emissions from ships' engines measured against the total emissions of an activity are shown in Table 25. Due to the high standard of exhaust gas treatment and the use of superior fuel qualities, some of the emissions by station engines are very low when compared with ships' emissions.

Table 25: Percentage of fuel consumption by ships and emissions from ships during the individual activities

Activity	Diesel	CO ₂	NO _x	CO	HC	PM*)	SO _x
A Building Neumayer III Station	55	57	57	40	57	83	99
A Retrogradation Neumayer III Station	60	62	97	42	77	92	98
B Operation of Neumayer III Station	44	45	75	17	47	53	84
C Retrogradation Neumayer II Station	92	93	95	85	92	91	100

*) PM = Particulate matter

7.1.2 Other combustion by-products in exhaust gases

The other by-products in exhaust gas, especially metallic components, depend mainly on the fuel quality. A small portion of the motor oils that are used will be burnt along with the fuel. The amounts in the exhaust gas can be regarded as insignificant with respect to possible harm to the environment at Neumayer.

7.1.3 Emissions from the storage and handling of fuels

Oil spills could be a major cause of emissions of oil onto snow and ice. Spills must be carefully registered under the environmental rules and as specified in the Oil Spill Contingency Plan for Neumayer (AWI 2003). Spills have been avoided so far, and a number of mitigation measures are in place to avoid such incidents (cf. section 8.2). Since the fuels have been widely distributed for storage, possible spills are limited to the maximum tank storage capacity of about 23,000 litres.

Evaporative emissions occur during tank filling (working losses) and in the form of diurnal losses from tanks (venting, standing losses). While under moderate climate conditions working losses for diesel fuel are estimated to reach 1.5 ppm per transfer, and standing losses are estimated to be an equal amount per year, the release of hydrocarbon vapours will be considerably reduced under Antarctic conditions. If half of the rate mentioned for a moderate climate and two transfers is considered to be a realistic assessment, then the 292,000 kg of diesel and kerosene consumed annually at Neumayer III Station will lose $0.5 \cdot 3 \cdot 292,000 \cdot 1.5 \cdot 10^{-6} = 0.7$ kg through evaporation. This is a negligible amount. The station construction and dismantling activities will each require less fuel than the annual operation of Neumayer and do not change this evaluation.

7.1.4 Emissions from fire fighting equipment and the cooling plant

Halon or any other extinguishing gases containing CFCs will not be used at Neumayer III Station. A final decision on the extinguishing agents to be used has not yet been made, but CO₂- or N₂-based gases will probably be chosen. The central extinguishing agent will be water mist which will probably be atomised using nitrogen or alternatively helium. Losses from the containers will be extremely low, and emissions of these gases will not have a noticeable impact on the environment even if they are used during a fire.

No major environmental effects are to be expected from refrigerants R134A and R404A. The ozone depletion potential (ODP) of R134A and R404A is zero, and the global warming potential (GWP) is 1300 for R134A, and similar for R404A¹². Environmental effects by possible losses of refrigerants from cooling plant at Neumayer III Station must therefore be considered negligible.

7.1.5 Use of snow

With the number of people at Neumayer shown in Table 11 and an unchanged average water consumption of 117 litres per person and day, 638,118 kg (5,454*117) of snow will be taken from the surface for water production every year. This figure is an upper limit, since water for

¹² The Ozone Depletion Potential is the potential for a single molecule of the refrigerant to destroy the ozone layer. The refrigerant R11 serves as a datum reference and thus R11 has an ODP of 1.0. The smaller the value of the ODP the less the refrigerant affects the ozone layer and therefore the environment. The Global Warming Potential is a measurement of how much effect the given refrigerant will have on Global Warming in relation to carbon dioxide, where CO₂ has a GWP of 1 and the reference coolant R11 has a GWP of 4000. This is usually measured over a 100-year period. Again: the lower the value of GWP the better the refrigerant is for the environment.

flushing toilets will probably be much less than at Neumayer II and summer personnel (21% of total annual occupation) normally use less than 117 litres per day.

About 8,500 m³ of snow will be cut out for the trench and deposited nearby when building the garage for Neumayer III Station. A good part of that snow (up to 5,000 m³) will be used shortly thereafter for backfilling the upper parts of the garage walls behind formwork. Later about 1,700 m³ of snow will be taken from the surface for backfilling on the garage floor each year to compensate for snow accumulation. This 1,700 m³/year is almost equal to the 638 tonnes of snow needed annually for water production.

An unknown amount of snow from windtails may need to be removed at regular intervals on the lee side of the Neumayer III Station building. Experience with platforms (in Greenland and Antarctica) shows that such windtails cannot be entirely avoided and that their growth must be limited. The design of the above-ground structure is therefore intended to reduce disturbances on the lee side which cause such windtails. Snow scraped from windtails will be deposited nearby.

The snow surface areas immediately around the station and snow surfaces of the tracks leading to the ice edge and to the outstations will be disturbed by vehicle traffic.

7.1.6 Disposal of wastewater

The wastewater will be treated (see section 3.9), and only treated and disinfected wastewater will be discharged to the pit in the snow. The amount is equal to the mass of snow taken for water production.

7.2 Environmental effects of the planned activities

The activities described in this document do not lead to any environmental impacts that are not already present at Neumayer II Station.

Tables 26 to 29 contain an evaluation of the impacts caused by the three activities, which is based on the data described in the previous sections. The size of the area affected, the duration, the intensity of the environmental effect, the potential for recovery of the environmental asset and the probability that the effect will occur are the aspects under consideration.

The activities primarily affect the ambient air and the snow environment. The sea is much less affected, and flora and fauna are not to be found anywhere near the station, with the exception of the temporary presence of penguins and seals.

Table 26: Construction of Neumayer III Station: Summary of Environmental Effects

Action	Duration (days) ¹⁾	Start (M.Y) ²⁾	Trigger factors	Environmental assets affected	Environmental effects classification ⁸⁾				
					Extent	Duration	Intensity	Recovery	Probability
Flight operations (travel)	2 days inter-continental, 4 days supply flights	12.06	Exhaust emissions	Air	M	L	L	M	VH
				Snow, ice	L	L	L	LM	H
			Noise	Fauna	L	L	L	L	M
			Spills	Snow	L	L	L	M	L
Transport by ship (passage)	8	12.06	Exhaust emissions	Air	M	L	L	L	VH
				Sea, Sea ice	M	L	L	VH	
Ship transport (berthing at ice edge)	28	01.07 ³⁾	Exhaust emissions	Air	M	L	L	L	VH
				Snow, ice, Sea	M	L	L	M	H
			Spills	Snow, Sea	L	L	L	L	L
Transport over ice shelf and sea ice	28	01.07 ³⁾	Exhaust emissions	Air	L	L	L	L	VH
				Snow, ice	L	L	L	L	VH
			Surface damage	Snow, ice	L	L	L	L	H
			Noise	Fauna	L	L	L	L	L
			Spills	Snow	L	H	H	M	L
Assembly work	75	12.06	Exhaust emissions	Air	L	L	L	L	VH
				Excavation, fill	Snow	L	L	L	L
			Noise	Fauna	L	L	L	L	L
			Oil, lost parts	Snow	L	L	L	M	L
Operation of construction camp	75	12.06	Supply by ship (Polarstern), here:	Air	L	L	L	L	VH
				Snow	L	L	L	M	VH
			Wastewater discharge	Snow, Sea	L	H	M	M	VH
Part and material management	75	12.06	Pollution	Snow	L	L	L	L	L

Table 27: Operation of Neumayer III Station: Summary of Environmental Impacts

Action	Duration (days)	Start (M.Y) ⁴⁾	Trigger factors	Environmental assets affected	Environmental effects classification ⁸⁾				
					Extent	Duration	Intensity	Recovery	Probability
Power generation and usage	On-going > 25 years	03.07	Exhaust emissions gas	Air	M	L	L	L	VH
				Snow, ice	M	M	L	M	H
			Spills	Snow	L	L	L	M	L
			EM radiation	Fauna	L	L	L	L	L
Re-supply by ship (Polarstern), passage	5 days per year	12.07	Exhaust emissions gas	Air	M	L	L	L	VH
				Sea, sea ice	M	L	L	L	H
Re-supply by ship (Polarstern), berthing time	2 days per year	12.07	Exhaust emissions gas	Air	M	L	L	L	VH
				Snow, ice, sea	M	L	L	M	H
			Spills	Snow, sea	L	L	L	L	L
Traffic/transport by snow vehicles	120 days per year	Dec. of every year ⁵⁾	Exhaust emissions gas	Air	L	L	L	L	VH
				Snow, ice	L	M	L	M	VH
			Surface damage	Snow, ice	L	L	L	L	H
			Noise	Fauna	L	L	L	M	L
			Spills	Snow	L	H	H	M	L
Flight operations	100 days per year	12.07	Exhaust emissions gas	Air, snow	M	L	L	L	VH
				Noise	Fauna	L	L	L	L
			Spills	Snow	L	L	L	M	L
Removal of snow (drifts), snow work for garage floor	12 days/season	01.08	Surface change	Snow	L	H	H	L	VH
			Surface damage	Snow	L	L	L	L	VH
Water generation	on-going	03.07	Snow removal	Snow	G	M	G	G	SH
			Wastewater discharge	Snow	G	H	M	M	SH
Waste management	on-going	03.07	Pollution	Snow	G	H	G	G	G

Table 28: Retrogradation of Neumayer II Station

Action	Duration (days)	Start (M.Y) ⁶⁾	Trigger factors	Environmental assets affected	Environmental impact classification ⁸⁾				
					Extent	Duration	Intensity	Recovery	Probability
Transport by ship, passage	8 days	01.09	Exhaust emissions	Air	M	L	L	L	VH
				Sea, sea ice	M	L	L	L	H
Transport by ship, berthing at ice edge	10 days	01.09	Exhaust emissions	Air	M	L	L	L	VH
				Snow, ice, sea	M	L	L	M	H
Transport over shelf and sea ice	14 ⁷⁾	01.09	Exhaust emissions	Air	L	L	L	L	VH
				Snow, ice	L	L	L	L	VH
			Surface disturbance	Snow, ice	L	L	L	L	H
			Noise	Fauna	L	L	L	L	L
Dismantling work	29	01.09	Exhaust emissions	Air, Snow	L	L	L	L	VH
				Parts left in snow	Snow, sea	M	H	M	H
Parts and material management	29	01.09	Pollution	Snow	L	H	L	L	L

Table 29: Retrogradation of Neumayer III Station

Action	Duration (days)	Start (M.Y)	Trigger factors	Environmental assets affected	Environmental impact classification ⁸⁾				
					Extent	Duration	Intensity	Recovery	Probability
Ship transport, passage	8	Dec., not before 2032	Exhaust emissions	Air	M	L	L	L	VH
				Sea, sea ice	M	L	L	L	H
Ship transport, berthing at ice edge	14		Exhaust emissions	Air	M	L	L	L	VH
				Snow, ice, sea	M	L	L	M	H
Transport over shelf and sea ice	22 ⁷⁾		Exhaust emissions	Air	L	L	L	L	VH
				snow, ice	L	L	L	L	VH
			Surface disturbance	snow, ice	L	L	L	L	H
			Noise	Fauna	L	L	L	L	L
Dismantling work	60		Spills	Snow	L	H	H	M	L
				Exhaust emissions	Air, snow	L	L	L	L
Parts and material management	60	Parts left in snow	Snow, sea	L	H	M	M	H	
			Pollution	Snow	L	H	L	L	L

Footnotes, Tables 9-6 to 9-9

- 1) Shortest feasible durations when building is finished in one season.
- 2) Earliest start.
- 3) Very early start in late December possible, but not very likely.
- 4) Earliest start. Delay of operations by one year possible.
- 5) Very little vehicle use outside the season, negligible.
- 6) Most likely time for starting. Start could be one year earlier or one year later.
- 7) Transport may be carried out over two seasons, with shorter terms per season
- 8) Like Table 20: L = low, M = medium, H = high, VH = very high

7.2.1 Effects on air quality

All emissions from the combustion of fuels in connection with the described activities at Neumayer affect air quality. The overall impacts are low, however, because the emissions are distributed over longer time spans and, where mobile sources are concerned, over large areas. Due to the prevailing winds at Neumayer, the emitted substances are dispersed quickly to very low concentrations.

A simple calculation (Annex 8, Table A8-1 in the Draft CEE) using the SCREEN3 Gaussian vane distribution model (see footnote 10) yields the highest concentrations of exhaust gas components from the diesel engines at the station and the ship berthed at the ice edge at distances less than one kilometre from the respective source. Distances and densities of the highest concentrations are very much dependent on wind velocities and on the occurrence and strength of downwash effects downwind of the structures. Chimneys or stacks extending above building or ship structures reduce exhaust gas concentrations near the ground. The maximum concentrations are further away when wind velocities are greater, but concentrations are lower.

In any case, the highest exhaust gas concentrations will be found at very low wind velocities and assuming there is downwash (Draft CEE, Annex 8, Table A8-1, runs A4 and B1). Calculations indicate that they can reach peak concentrations of:

- 55,890 microgrammes/m³ on the ice shelf surface at a distance of 37 metres from the station building
- 71,920 microgrammes/m³ at sea level or on the sea ice at a distance of 270 metres from the ship.

If a distribution of the exhaust gas components shown in Table 23 (activity “Neumayer III: operation,” point sources) is calculated according to percent by weight, peak concentrations will be reached on the order of magnitude shown in Table 30.

Table 30: Highest concentrations of pollutants from exhaust gas from Neumayer III Station and from exhaust gas from a ship berthing at the ice edge in µg/m³

Components	Percent by weight	Pollutant (µg/m ³)		Limit value (µg/m ³)	1)
		Station	Ship		
CO	0.454	254	327	10,000	2)
NO _x	0.171	96	123	200	3)
SO _x	0.00543	3.0	3.9	125	4)
PM	0.00567	3.2	4.1	20	5)

1) The limit values for NO_x, SO_x, and PM are specified in Directive 1999/30/EC.

2) Limit values from Directive 2000/69/EC; targets: health protection, 8-hour exposure, date of validity 1 January 2005.

3) The limit value of 200 µg NO₂/m³ air on hourly average was specified to protect human health. It must be fulfilled by 1 January 2010 and after that time should not be exceeded more than 18 times in one calendar year. A limit value of 30 µg NO_x/m³ air on annual average has been specified since 2001 to protect vegetation. However, the conditions underlying the calculated limit values occur only rarely and for short times during the course of a year.

4) The limit value relates to SO₂ and health protection (average for 24-hour exposure) starting in January 2005. As a comparison: the average annual limit value to protect vegetation is 20 µg SO₂/m³ according to Directive 1999/30/EC.

5) The limit value is an annual average to protect human safety with a tolerance margin of 50% starting in 2005. That margin must be reduced to 0% by 2010, making the limit value 20 µg from that time.

The composition of exhaust gas emissions from ships berthing at the ice edge will differ somewhat when compared with emissions from the station diesel engines as long as marine fuels are of poorer quality. Thus the amount of SO_x in the ship's exhaust gas will be somewhat higher than that shown in Table 25 because higher sulphur content is still allowed in marine diesel fuels, and the SO_x from the station will be slightly less than what is indicated in Table 25. The duration of the impact of the ship's emissions is very limited (a few days), however, compared with continuous operation of the diesel engines at the station.

CO, an ozone precursor like NO_x, survives in the atmosphere for approximately one month, but is eventually oxidised to carbon dioxide (CO₂). Carbon dioxide, on the other hand, is in any case by far the most abundant product of combustion. Carbon dioxide does not directly impair human health. However, since it is a greenhouse gas that traps the earth's heat and contributes to the potential for global warming, it is a problem in terms of environmental protection.

The details above also apply to additional atmospheric emissions that would occur during dismantling of the Neumayer II Station, if it were to be dismantled and removed from Antarctica in its entirety. Since these emissions would be significantly diluted, the pollution they would be expected to cause in the vicinity of Neumayer II Station would be less serious.

7.2.2 Effects on snow and ice

Lifting, removing and backfilling snow is of no environmental relevance. Snow is the only ground for many kilometres around and is more than 200 metres deep, so the amount of snow affected by activities is completely negligible.

The snow accumulation of 70 to 80 cm per year, combined with the horizontal transportation of large quantities of snow by the wind, effectively conceals all traces of human activity on the snow surface.

The treated and disinfected wastewater from Neumayer III Station will collect in the form of a frozen, isolated ice lens in the snow. The method of disposal poses no threat to human health and does not cause any harmful impact on the snow or the environment. Current operations at the existing station use this method.

Parts of the station buildings and installations left in the snow after dismantling will have no effect on the snow, and they in turn will not be affected by the snow.

Exhaust gases produced by all activities will reach a large area of the snow, predominantly to the west of the station. Pollution levels will be low due to dilution by the prevailing strong winds, and deposits will not accumulate on a fixed surface level and instead will be distributed over the snow layers that build up constantly over time. When looking at the low pollutant concentrations calculated for operation of Neumayer III Station, it may safely be assumed that it will not be possible to detect any traces of the gas components over a wide stretch of the ice shelf before reaching the edge west of Neumayer (cf. Suttie and Wolff 1993, Rankin 2003). This means that no environmentally harmful concentrations are to be anticipated in the Weddell Sea or the sea ice.

The parts of the Neumayer II Station that are to remain in Antarctica according to the above description will be enclosed in the ice shelf for many years but will eventually enter the marine environment. They are not expected to cause any harm to the environment while they remain in the ice shelf.

7.2.3 Effects on the marine environment

Effects on the marine environment are to be expected primarily from the exhaust gases occurring as a result of the transportation by ship, both during the voyage and when it is berthed at the ice edge. These effects will occur during all the activities, but will be greater during the activities "Construction of the Neumayer III Station" and "Dismantling of the Neumayer II Station" than during operation of the Neumayer III Station.

In addition, as described above, the ice shelf area will reach the sea in about 50-100 years and then take many years to break off from the edge in smaller pieces. Taking into account the ice shelf areas affected by operations at the Neumayer I and II Stations, the first parts and materials left in the snow will reach the sea around 2050 (cf. section 5.2). They would be, on the one hand, sewage that had been locked within the ice and on the other hand the components of Neumayer II Station that had been left behind after dismantling. Since this process will occur over a long period of time and because the ice that is broken off will drift away from the calving place and will then melt or disintegrate slowly, it can be assumed that these components and substances will be dispersed in the sea over a large area.

AWI does not see that any harm will be caused to the environment as a result of this, although it does point out that the steel parts may cause destruction of flora and fauna over a specific area when they sink to the sea floor. However, that area is very small (especially when compared to iceberg scouring). Metals and wood will disintegrate over longer periods. Since 1990 AWI has taken care to use only untreated timber for foundations. The synthetic materials are nearly inert; they are CFC-free and will not dissolve in sea water. It can be expected that the sewage pipe's foam insulation will have disintegrated by the time the pipe reaches the ice shelf edge due to ice pressure and later to shear movement in the ice when passing the ice rises. AWI therefore believes the environmental impact from leaving the parts in Antarctica to be negligible.

7.2.4 Effects on areas of biological significance, on flora and fauna

There is no flora at Neumayer, and the nearest marine life can be found at Atka Ice Port about 5 kilometres away from Neumayer II Station and more than 7 kilometres from Neumayer III Station.

7.2.4.1 Flights

Impacts on the emperor penguin colony at Atka Iceport are expected primarily from the noise of aircraft approaching and leaving the station. Little is known about the effects of noise on penguins, but the disturbances caused by noise from aircraft can be unexpected and high (Culik, et al. 1990).

To avoid such disturbances, pilots approaching Neumayer Station are informed about the presence and location of the emperor penguin rookery at Atka Iceport, either during the planning phase of the flight or at the latest when contacting Neumayer before landing. The interim guidelines as laid out in ATCM XXV/WP-026 (United Kingdom 2002) have applied to all scientific flights since 2002. AWI intends to ensure that supplementary information regarding Neumayer based on these guidelines (and on those set forth in XXVII ATCM WP 010, Guidelines for the Operation of Aircraft near Concentrations of Birds in Antarctica) is included in the Antarctic Flight Information Manual (AFIM) of COMNAP as soon as possible and in any case before construction activity for the new station begins.

According to AWI, helicopter pilots working at Neumayer Station are not allowed to fly over the west side of the Atka Iceport unless all penguins have left the colony site. Pilots are advised to keep at least 1.5 kilometres west of the western rim of Atka Iceport when flying between ship mooring places at the ice edge and Neumayer Station. Helicopter landings anywhere near the

colony (for example to visit the colony) are not allowed. However, AWI has no influence on visits by third parties.

When flying a straight course of 108° after take-off, the flight path passes to the south of the rookery (cf. map of the vicinity in Fig. 3). The horizontal distance between this flight path and the breeding site of the emperor colony is being reduced by about 200 metres each year as the position of the station changes along the flow line of the ice. The minimum separation distance of the flight path will be reached when Neumayer II Station is closed and will be just over 2 kilometres. Neumayer III Station will be located at least 5 kilometres further south, reaching its northernmost position, which will still be south of the current position of Neumayer II, after 25 years. The 2 kilometre horizontal distance of the flight path can thus be regarded as the overall (and short-term) minimum. This minimum distance is considerably larger than distances recommended in the applicable guidelines, especially the guidelines mentioned above, which are widely accepted and used in various management plans for protected areas in Antarctica.

Flights over the emperor penguin colony are not allowed and are therefore not envisaged. Nevertheless, the vertical distance of aeroplanes over the ice edge of Atka Iceport is of interest. This distance is at least 493 metres as deduced from the following calculation: the east-west distance between lift-off point and the ice edge at Atka Iceport is greater than 4 kilometres. The maximum climbing rate of a loaded Do 228 aircraft is 1,500 feet/min at a relative speed¹³ of 120 knots, so the aircraft will be at an altitude of 493 metres ($1500 \cdot 0.3048 \cdot 1.08$) when it reaches the ice edge after 1.08 minutes ($4000/1852/(120/60)$). In order to avoid any disturbance to the penguin colony, changes of flight direction are also possible; here they would have to turn right (i.e. southwards) once an altitude of 1,000 feet is reached, which will be the case well before arriving at the ice edge.

Night flights do not take place at Neumayer Station in spite of 24 hours of daylight in summer; this will continue to be the case in the future. This is an additional mitigation measure when considering that penguins have been observed to reduce their activities during night hours, bringing less food into the colonies (personal communication by J. Plötz).

AWI's flight restrictions can be lifted by the Station Commander when no further bird concentrations (moulting penguins) are observed at Atka Iceport, which is usually the case starting around mid-January.

7.2.4.2 Visits to the penguin colony

Certain disruptions to the emperor penguin colony may be expected from relatives of station personnel or the construction team who visit the colony during their time off. However, this can be avoided by following behavioural rules (maintaining a distance of at least 30 metres from the birds).

7.2.5 Effects on weather and climate

No direct effects on climate or weather are to be expected by the proposed activities. Any contribution to global CO₂ will have very little effect on climate change due to atmospheric circulation and the comparatively small amounts of fuels used, so it can be considered negligible.

Another possible impact is soot deposition on the snow surface from the exhaust gases resulting from fuel combustion, which could cause or accelerate melting. As shown above, however, concentrations are much too low to do this, and the snow surface changes too fast for such effects to cause noticeable changes.

¹³ Relative speed is measured in relation to the surrounding air. The absolute speed (or speed over ground) is lower than the relative speed when a head wind is encountered. When taking off against the prevailing east wind at Neumayer, the flight level reached at the ice edge would thus be greater than the calculation above.

7.2.6 Other effects

Aesthetic and wilderness values are not affected.

7.3 Indirect and second order impacts of the planned activities

The planned activities have been comprehensively considered, including ship and air transport within the limits of the Antarctic Treaty Area. The only effects not covered are those which could possibly be caused by personnel when using the DROMLAN airfield facilities near Novolazarevskaya Station while waiting for connecting flights. It is not anticipated that an environmental impact of any significance will be caused by this.

Activities not directly connected to the planned activities (construction and operation of the new Neumayer III Station, retrogradation of the Neumayer II Station), such as excursions to Atka Iceport during time off, are not planned and will not be supported by AWI. The rules at the station require the approval of the Station Commander or of the person in charge of operations for all excursions outside the planned range, and concern for the environment will be the main factor in deciding whether to allow such excursions.

The assembly crew working on construction of the Neumayer III Station and retrogradation of the Neumayer II Station will be instructed not to disrupt scientific work at the active station and during transport not to drive through areas reserved for scientific work or their vicinity. It is therefore very unlikely that there will be impacts of this type.

It is possible, however, that the logistical support given by the active station to the construction activity and later to the dismantling activity will have to be extended beyond the planned level, and that the observatory work will be adversely affected. The scientific work has priority, though, and the probability of second-order impacts of that kind is low here as well.

Finally, impacts on the environment will occur in the event of catastrophes like a major oil spill or a large fire. Very stringent measures are being taken to avoid such events, and AWI has drawn up emergency plans for quick and effective response in order to minimise the damage (AWI 2003).

7.4 Cumulative effects

All activities discussed in this document are required to allow continuation of research work at the Neumayer Station location and its function as a logistical base. Combined effects are limited to the comparatively short times when activities overlap with or are conducted simultaneously with operation of the station (cf. schedule under section 2.5.5).

So far no other logistical or scientific activity is being conducted or planned which could possibly have an adverse effect on the environmental status at Neumayer Station or its surrounding area. There will probably be increased summer activities in future using Neumayer III Station as a temporary support base. Impacts will be cumulative with the impacts generated by station operation, and Neumayer Station impacts will increase due to accommodation of a greater number of personnel than usual.

8. Mitigation measures

8.1 Mitigation measures in place

8.1.1 Training, safety and environmental protection regulations

Environmental impacts as a result of human activities can most easily be avoided or minimised when people are aware of the impacts they can have and know about the damage or danger of

such impacts. Training is therefore a very effective mitigation measure. The laws regarding environmental protection in Antarctica and the special regulations to be observed at the station are communicated and explained during training, and copies are handed out to station crews and participants in expeditions. They can also be viewed at the station at any time. Participation in courses on environmental protection is compulsory. Finally, the duties of reporting on a regular basis about environmentally relevant activities and events certainly help to promote environmental consciousness.

The training and preparation of the overwintering personnel comprises 42 different courses and takes a total of more than 500 person-days (based on a crew of nine people). A complete list is provided in Annex 4 of the Draft CEE. The courses can be grouped by the themes environment, safety, technical operation, and community life. Courses on safety and technical operation also deal with various aspects of environmental protection. The standards set forth in the training and reporting checklists of TRAINET¹⁴ are being followed, and training programmes for all staff going to Antarctica will also in future be well matched with TRAINET provisions.

The most comprehensive environment-related course for all expedition personnel is a compulsory full-day seminar on environmental protection in Antarctica. Biologists and experts from AWI, and sometimes external experts, give lectures, discuss the issues with participants, and offer advice on the improvement of environmental awareness in Antarctica. Experts from the German Federal Environmental Agency (UBA) have regularly contributed to the seminar.

The agenda of the seminar includes the following topics:

- Introduction to the Antarctic environment: Southern Ocean, ice-covered and ice-free landscapes
- Introduction to Antarctic flora and fauna and their distinctive characteristics
- Wildlife-watching guidelines; practices to be observed when working near animals
- Introduction to environmentally-friendly technologies at Neumayer Station
- Monitoring of emissions at the station
- Rules to follow during emergencies, especially oil spills; Emergency Manual
- Waste management plan
- Reporting requirements
- Introduction to international laws, rules and regulations for environmental protection of the Antarctic
- The application for permits and permit award by UBA for activities in Antarctica

When they arrive at Neumayer Station, AWI's personnel and expeditioners are again briefed by the Station Commander about the most important environmental and safety regulations, as well as rules to be followed at the station. This briefing is also compulsory. All instructions given during the briefing are permanently displayed on the notice board in the station. The Station Commander will provide similar information on rules and regulations to visitors to the station who are not part of AWI's expeditions.

The Station Rules (*Stationsordnung*) concentrate on preventive and safety measures to be taken by crews and visitors at Neumayer Station. Failure to follow safety rules in Antarctica can quickly lead to emergencies which can in turn cause severe harm to the environment, either directly or indirectly when rescue operations must be undertaken. Strict observance of safety rules

¹⁴ Training Network in connection with the Antarctic Environmental Officers Network AEON, cf. ATCM XXVII/IP013.

therefore contributes to environmental protection and must be regarded as a preventive measure.

8.1.2 Measures to save energy/fuel and reduce emissions

An energy management system will be used at Neumayer Station to achieve a maximum effect with minimum consumption of energy and fuel.

All required heating at the station will be provided by using waste heat from the diesel engines or renewable energy sources. The engines will be expertly maintained to avoid extra fuel consumption and preventable emissions.

Continued and increased use of wind energy is planned (cf. section 2.4.2 above). Solar cells may help reduce fuel demand in the future.

A state-of-the-art exhaust gas purification system will be installed in the power plant of the Neumayer III Station. Quality (e.g. low-sulphur or sulphur-free) fuels will be employed on the ice.

Details of the measures are described above.

8.2 Special measures with respect to station operation, vehicle use, transport and construction work

8.2.1 Emergency planning

AWI has many years of experience in emergency planning. Reference should be made in that regard to the safety methods used in the station buildings and technical systems, on which safe living at the station depends.

AWI revised and supplemented its emergency planning for Antarctic activities in 1998-99 in accordance with the recommendations of COMNAP/SCALOP. The recommendations are intended to ensure maximum compliance with the standards developed by COMNAP by all emergency plans in place at the various facilities of the countries in Antarctica. In addition, the plans must be complete in themselves and not involve reference or other supporting documents which could result in delays to obtain them. AWI followed these standards when it introduced its comprehensive Antarctica Emergency Manual in 1998 (AWI 2003). The Manual is available in both English and German versions.

Other legal requirements for emergency planning are also being met. Ships in Antarctic waters south of the 60th parallel must adhere to the stringent safety and environmental protection directives of various IMO regulations. They have to carry an approved Shipboard Oil Pollution Emergency Plan (SOPEP) and follow special environmental protection laws in Antarctica which are laid down in the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Signatories to the Treaty are also required to take measures to protect against environmental damage in Antarctica pursuant to the Protocol on Environmental Protection to the Antarctic Treaty and the associated German implementing legislation.

8.2.2 Oil Spill Contingency Plan

An Oil Spill Contingency Plan for Neumayer Station and all of AWI's activities in the Antarctic – except for shipping operations at sea – is contained in a separate part of the Antarctica Emergency Manual (AWI 2003). The plan is based on guidelines for oil spill planning developed by COMNAP and SCALOP whose scope extends from small, local oil spills (Facility Plan) to large, catastrophic spills that require a joint response by several (international) operators in Antarctica (Multi-Operator Plan).

8.2.3 Emergency measures

A number of preventive measures are described in the Antarctica Emergency Manual (AWI 2003), which also contains detailed instructions for actions to be taken in case of an emergency. Emergencies – even if no personal injury or environmental damage has occurred – must be documented and reported to AWI. The associated German implementing legislation also requires emergencies to be reported to the German Federal Environmental Agency.

8.2.4 Contamination by substances other than fuel and oil

AWI's safety measures treat spills of hydraulic fluids like oil spills, even if completely biodegradable fluids are used. The hydraulic jacking system at Neumayer III Station will be equipped with automatic devices to limit spills, and secondary containments will be employed throughout.

To prevent sawdust from being blown away by the wind when timber and plywood are sawn outdoors, all sawing work (except work to be done directly at the place of installation) will be done at a wind-protected workshop facility (e.g. with a circular saw) where dust can be collected. Metal dust from grinding will be negligible since little or no welding will be done at the building sites.

The refuse bins and containers at the Neumayer II and III construction sites will be protected against wind by either doors or chutes with flaps so that no refuse can be picked up by the wind and blown away. AWI plans to strictly prohibit throwing away cigarette butts, but points out that such a prohibition is difficult to monitor and enforce.

8.2.5 Regular maintenance of vehicles

All vehicles are to be regularly maintained so that, inter alia, environmental damage will be avoided. The vehicles at Neumayer are under the supervision of an engineer. At least one vehicle specialist will be present during major operations such as construction of the station. Vehicles are shipped back to Germany for thorough inspection at regular intervals (e.g. Pisten Bullies after six or seven years) or before large operations and are returned to the station during the following season.

Skidoos now use Bombardier Rotax two-stroke engines. Fuel losses through the exhaust pipe can be almost completely ruled out. These engines use as much as 25% less fuel and have emission levels that are up to 50% lower while offering the same power as a conventional carburetted engine (information from manufacturer and EPA 2002).

8.2.6 Distance to the emperor penguin colony and bird concentrations

8.2.6.1 Vehicles, people on foot

Antarctic bird life is sensitive to noise. A safe distance must therefore be maintained between the emperor penguin colony at Atka Iceport and all motorised Station activity. AWI has already introduced the rules to be followed in this respect. People who visit the colony during their time off must also remain at a sufficient distance – at least 30 metres – from the birds.

8.2.6.2 Fixed-wing aircraft and helicopters

Measures to avoid or reduce damage to the emperor penguin colony are described in section 7.2.4.

9. Unavoidable environmental impacts of the proposed activities

All activities described in this document will affect the Antarctic environment. Most impacts will be local, and some of them will be of short duration only. No impacts are to be expected on the living environment if the mitigation measures described above (section 7.2.4) are taken.

9.1 Snow

The activities will cause repeated, short-term physical disturbance of the snow surface as long as they last. The impacts are due to surface travel with tracked vehicles and removal of snow for water production. The impacts are negligible because the snow surface regenerates quickly on the ice shelf, and disturbance of snow surfaces on fast ice (blue sea ice is practically never encountered in the Atka Iceport) will not change the seasonal breakage and melting of the sea ice in any way. Although the impacts are low, there is no known method to avoid them.

Emissions of pollutants into snow as a result of operating internal combustion engines are also unavoidable.

9.2 Ice shelf, water

The release of treated, disinfected wastewater to the ice shelf and thus later to the sea is a minor and transient impact due to the low contaminating effects and the dilution to be expected by the anticipated slow melting process in the sea. This impact would only be avoidable if a closed-loop recycling system were used. The energy requirements of such a system with the respective impacts from transporting fuel and from emissions would be counter-productive, however, unless comparable amounts of fuel are needed for melting of the snow. That is the case at the French-Italian Concordia Station, where the snow is considerably colder than at Neumayer, and where wastewater recycling will be tried for the first time in Antarctica (personal communication by P. Godon, Institut Polaire Paul Emile Victor).

9.3 Air

Air pollution by the exhaust gas from internal combustion engines is also considered unavoidable, but various efforts are made to keep it as low as possible (see measures described in section 8.1.2).

The decision to leave parts of the station(s) in the snow is based on a comparison of the associated impacts on the environment with those that would be unavoidable when digging the items out for removal.

No practicable methods or alternatives have been found to avoid these impacts at this time. But the planned mitigation measures will help to minimise adverse impacts.

10. Monitoring

10.1 Supervision of activities

Because the observation of environmental impacts and the monitoring of pollution levels is extremely difficult, the monitoring programme at Neumayer II Station (see Table 31 below) concentrates on complete recording of all activities and on regular formal reporting about parameters with environmental significance.

The monitoring programme is being constantly improved and will probably be enhanced during the service life of Neumayer III Station. However, AWI does not intend to monitor pollution levels because it cannot be expected that quantifiable results will be obtained. Deposits on the snow from exhaust gases can be detected in the immediate vicinity of the station, but no usable find-

ings or information about changes would be obtained due to the great inconsistency of such surface measurements.

Table 31: Monitoring parameters and frequencies

Parameter	Timing/Frequency	Relevance	Remarks
POL transfer/transport	All events	Snow	POL Logbook
POL consumption	Weekly	Atmosphere, snow, sea	Technical report ¹⁾
POL storage	All changes	Snow	Fuel/oil logbook
Spills	When occurring	Snow	Emergency Manual /Oil Spill Contingency Plan ²⁾
Diesel generators, exhaust gas components (Station)	On average once a month, each motor ³⁾	Atmosphere, snow, sea	Separate report
Wastewater treatment	Daily inspection	Snow (sea)	Wastewater treatment logbook
Continuous			
Weekly			
Intermittent ⁴⁾			
Sludge production/ removal	Daily/annually	(Returned)	Reports on waste (waste management plan)
Solid waste	End of activity/ annually	(Returned)	
Liquid wastes (classified)	End of activity/ annually	(Returned)	
Water production from snow	Weekly	Snow	Technical report
Snow surface (such as marking, new trails)	When carried out	Snow	Technical report
Air: aerosols, trace compounds ⁵⁾	Continuous	Atmosphere, background levels	Observatory programme

1) The technical reports are registered and evaluated by the station monitoring team in AWI's Logistics Department.

2) The handling of spills is detailed in the Antarctica Emergency Manual. The urgency of reporting on spills depends on the severity of the incident. The absence of spills must also be confirmed in the Technical Report.

3) Each monitoring session consists of a series of 30 measurements per generator, preferably carried out before and after maintenance overhauls. Timing thus depends largely on these events. Measurements are taken at the engine's MCR (maximum continuous rating).

4) Measurements were initially taken to verify proper functioning of the plant. It turned out that this check could be done more simply and directly by visual and olfactory inspection.

- 5) The observatory is at a distance of 1,500 metres. No pollution caused by operation of the station can be detected. The measurements are therefore suitable to establish background levels. Meticulous records are also kept on all technical consumables other than fuel and lubricants, and the data is stored in appropriate inventory records.

10.2 Reports to the German Environmental Agency (UBA)

AWI will provide the following information to the UBA after conclusion of the relevant activity:

- (1) a register of the parts actually left in the snow after dismantling Neumayer II Station, including information on materials, weights and volumes, and the exact locations with a corresponding sketch-map,
- (2) a list of parts removed from the Antarctic during dismantling of Neumayer II Station, with information on materials, weights, and volumes, and provision for reuse, recycling, or environmentally-sound disposal.
- (3) a compilation of the actual fuel consumption with allocation to the activities "construction of Neumayer III Station" and "retrogradation of Neumayer II Station," as well as information on consumers and consumption times.

11. Effects on scientific research and other uses

Since research is the main purpose of Neumayer Station, the activities described in this document will be conducted in such a way that impacts on research work are minimised and confined to what is unavoidable. If logistic capacities of AWI and the station are used to assist the activities "Construction of Neumayer III Station" and "Dismantling of Neumayer II Station," some adjustments in terms of logistic support for research work might be necessary. However, no disturbance to the research programmes of other countries are foreseeable.

Therefore AWI does not expect the planned activities overall to have any serious effects on scientific research. The undisruptive nature of the activities, at least for the research fields that are currently envisaged, is shown by the fact that they are closely connected to the research logistics and that research work will continue in the immediate vicinity of the places where they are carried out.

To the best of AWI's knowledge, the areas affected by the planned activities are a maximum of 100 kilometres to the west and 10 kilometres in all other directions from Neumayer Station. These areas essentially comprise ice shelf, ice edges and sea or sea-ice areas. They do not exhibit any unusual characteristics. The location of the Neumayer Station and its natural surroundings are thus not unique in a way that would mean that no other equally suitable place could be found nearby where research and other activities could be carried out in virgin conditions. On the contrary, many equivalent morphological structures in pristine condition can be found both closer and further away.

The reference value of the Antarctic as clean space (ground and air) will not be adversely affected to any noticeable degree by the planned activities. The substances from the station operation and related activities that are discharged to the surrounding snow body will be transported to the ocean along with the flowing ice in the foreseeable future and will most likely be widely distributed by currents. The compounds emitted into the air will primarily be dispersed by the prevailing winds over the Weddell Sea. Northerly winds that could carry station air emissions to the interior part of the continent are negligible.

Other uses, including those that are implicitly dependent on the area where the stations are located, are not currently foreseeable.

12. Gaps in knowledge and uncertainties

While the physical environment in the area of the activities is relatively well known and understood due to many years of observations and station operation, the living environment around Neumayer has not been thoroughly studied or monitored, particularly with regard to any possible impact by the station. The nearest place where biological research (on seals and emperor penguins) is being conducted is Drescher Inlet, about 300 kilometres away from the station.

Uncertainties caused by weather or sea-ice conditions have been considered in this CEE to an extent regarded as appropriate, based on past experience. Some uncertainties still remain, however, as natural conditions are sometimes subject to extreme changes.

The existing technical and operational uncertainties result from the wide scope of the activities and the length of time during which operation is planned, which extends 25 years into the future. Over such a long time, technological progress may lead to changes in the installations and operations that cannot be covered in this document. Such changes will be subject to additional or supplementary environmental evaluations. Some lesser uncertainties must be attributed to the fact that the planning phase has not yet been concluded.

Uncertainties in the environmental impact assessments are dependent both on the accuracy of technical and logistic predictions and on a correct evaluation of the effects.

The uncertainties mentioned in this document are listed in Table 32. The rating in the “effects” column indicates whether factors other than those used above as a basis for the environmental impacts that have been described will cause high, medium, or low discrepancies or whether none are expected.

Table 32: Uncertainties associated with this CEE

Reference	Uncertainty	Effect
Fuel consumption	Distribution between wind and diesel power generation may vary considerably depending on installation of wind generators.	Medium (pollution caused by exhaust gas)
Time schedule	Number of seasons required to build Neumayer III (planned 2, extremes 1 or 3)	Medium (diesel consumption)
Time schedule	Number of seasons required for retrogradation of Neumayer II Station	Low (diesel consumption)
Feeder flights	Aircraft other than the envisaged Dornier Do 228-101 may be used to fly personnel on the Novolazarevskaya-Neumayer air link.	Low (kerosene consumption will not change much)
Personnel	The number of people taking part in the activities may differ slightly from figures envisaged in this CEE.	Low (fuel for travel, wastewater)
Station design	The exact dimensions, layout, and shape of the station buildings may differ slightly from those during the planning stage.	None
Station location	The exact location of the station could be up to 4 kilometres away from the position specified in the CEE ¹⁾ .	Medium (fuel for transport)
Station services	The type of HVAC at Neumayer III has not yet been determined: hot water radiators or forced heated air.	None (diesel waste heat only)
Toilet facilities at the construction camps	The method for disposing of human waste at the construction camps (construction of Neumayer III Station and retrogradation of Neumayer II Station) has not yet been finally determined: incineration versus enclosure/removal versus treatment in plant at Station	Low (emissions into the air from incineration)
Quantities transported	The total amount and volumes of the packages to be transported for construction of the Neumayer III Station may deviate slightly from the specified figures	Low (fuel consumption from over-ice transport)
Marine transport	The number, size, and timing of ships used for transport may vary slightly	Medium (exhaust gas emissions)

¹⁾ The geodesic surveys in the area chosen for the station are still continuing and may yield results that disagree with earlier findings. The probability of such disagreement and subsequent new positioning of the site is very low, however.

13. Non-technical summary

13.1 Planned activities

This Comprehensive Environmental Evaluation summarizes the environmental impacts of the following activities proposed by the Alfred Wegener Institute for Polar and Marine Research:

1. Construction of Neumayer III Station on Ekström Ice Shelf in the Atka Iceport in Antarctica,
2. Year-round operation of Neumayer III Station for at least 25 years,
3. Dismantling and retrogradation of the existing Neumayer II Station at the same location.

Planning of these activities is for the most part complete, but it has not yet been finalised.

The reason for submitting the application for the above activities is first the foreseeable end of the operational service life of the present Neumayer II Station and second AWI's intention to continue observations and research work at the site of the existing Station and to further develop its logistical capacities (DROMLAN network).

13.2 Construction of Neumayer III Station

13.2.1 Purpose

Research priorities at Neumayer Station are in the fields of meteorology, geophysics, and air chemistry. Programmes have been carried out in the respective observatories continuously since March 1981. A fourth observatory comprising an infrasound array was installed at Neumayer Station in 2003 as part of the international monitoring system of the Comprehensive Nuclear Test Ban Treaty Organisation. All observatory programmes at Neumayer Station are integrated into a series of international monitoring networks. Very valuable, and in some cases unique, time series have been obtained at the station's observatories over the past two decades. Continuation of the observatory programmes at the same location is therefore of great importance.

Over the years Neumayer Station has developed into a logistical centre serving scientific expeditions and flight operations in the area of Dronning Maud Land and beyond during the summer. The population at the station therefore varies, with 9 to 11 people overwintering and often more than 40 people at a time staying in the station in summer. A considerable fleet of tracked vehicles, mobile cranes and heavy sledges is stored and maintained at Neumayer.

The first station at Atka Iceport was built during the 1980-81 season and started operation in March 1981. It was an underground structure consisting of containerised building modules placed in protective tubes assembled from corrugated steel plates. This design has certain advantages in the rough environment of an Antarctic ice shelf, but is also subject to ever-increasing loads from snow accumulation which will inevitably lead to its destruction. The station lasted 11 years and was replaced in 1992 by the present Neumayer II Station with basically the same design but located about 7 kilometres further south. This station is now buried under about 7 metres of snow and will not withstand further loads beyond about 2009.

13.2.2 Location and design

A new station building, Neumayer III Station, is therefore to take its place in 2007 or 2008. It will be built further to the south to allow for movement with the ice shelf over a period of at least 25 years, the planned lifetime of the new station, without getting too near to the ice shelf edge.

The design of Neumayer III Station will be different from that of its predecessors. The Station proper, containing two stories of living and working space, will be placed above ground on an elevated platform measuring about 82 by 20 metres. An aerodynamic shell will protect the building from wind and reduce snow accumulation or erosion around the base. A 26-metre-wide trench in the snow under the platform, which will be accessible via a ramp, will serve as garage and cold storage room. The trench is covered by a flat, rigid roof that is level with the snow surface. The legs or columns supporting the platform extend through the roof and support its load. They end at the trench or garage floor, where they transfer their load over shallow foundations into the snow of the trench floor.

The whole structure will be kept at a predetermined height in relation to the changing level of the snow surface using hydraulic jacks. The trench floor must be raised and the foundations back-filled with snow from time to time to adjust to these changes in level. The annual adjustments are to be done once a year, and the necessary work on the building will take fewer person-days than at previous stations.

Building services will be state-of-the-art and appropriate for conditions in a remote, self-sufficient base. Energy conservation has positive effects on the environment and is also an important economic issue. Fuel consumption and the resulting exhaust gas emissions will be minimised by sophisticated energy management with full use of waste heat from the diesel generators and by greater use of wind power. The station wastewater will be treated and disinfected before being discharged to a pit in the ice shelf.

13.2.3 Construction work

The construction work is to be done over two seasons, with an option for early finishing within one season if ice and weather conditions are favourable; poor conditions would prolong construction by another season. The work requires temporary installation of a construction camp for about 40 people. Parts and construction equipment will be brought to the Antarctic by ship, while most of the construction personnel will travel by air.

The move from Neumayer II to the new Neumayer III Station cannot take place until the new station is fully operational, in order to keep disruptions and interruptions of the scientific work to a minimum. Therefore, dismantling of Neumayer II Station can begin only after Neumayer III Station has been commissioned.

13.3 Operation of Neumayer III Station; retrogradation at the end of a service life lasting about 25 years

13.3.1 Number of people

On average between 9 and 11 overwinterers and up to 36 summer guests and visitors will stay at the station. On a small number of peak days a total of 60 people may be expected. The station will be relieved once a year by ship.

13.3.2 Power requirements, fuel consumption

The station's power requirement is between 100 and 110 kW. Electricity will be produced primarily by diesel generators; wind generators will also be used. Consumption of electric power and heat at the station will be optimised using a comprehensive energy management system. estimated average annual consumption of fuels is:

- Diesel fuel: 315,000 litres,
- JP-8/Jet-A1 kerosene: 50,000 litres,
- Standard petrol, lead-free: 2,000 litres,

- SAE 10W40 motor oil: 2,400 litres, and
- Smaller quantities of other fuels.

13.3.3 Heating

The station's heating will either be integrated into the ventilation system or hot water and radiators will be used. A decision about this has not yet been taken. Regardless of the heating system that is ultimately used, no fuel will be directly burnt for heating. On the contrary, AWI plans to obtain all the necessary heat by recovering heat during power generation or through the use of renewable energy sources (wind).

13.3.3 Fresh water

Approximately 117 litres of fresh water per person are needed each day. This water will be produced by melting snow. The snow melter will also be operated on waste heat from the diesel generators.

13.3.4 Waste disposal

The volumes and composition of waste are expected to be similar to those at the Neumayer II Station currently in operation. Waste disposal – particularly the waste treatment facilities – will also correspond to what is provided at the Neumayer II Station. All solid waste, including food waste, is to be collected separately outdoors or in containers in the station's waste transport containers. Paper, cardboard, and plastics will be compressed in special compactors, and glass and tins will be shredded. Hazardous liquid waste will be collected in separate containers (labelled with details of contents) and stored in a transport container until removal from Antarctica. Waste incineration in or at the Neumayer III Station is not planned.

The waste will be hauled away by ship once a year for recycling or dumping outside Antarctica in accordance with regulations.

13.3.5 Wastewater disposal

Based on 117 litres of wastewater per person per day, up to 4,250 litres of wastewater will be produced per day during the six months of summer and up to 1,300 litres during the six months of winter. At peak occupancy up to 7,000 litres can be expected.

Pollution of wastewater by detergents and cleaners will be minimized by using limited quantities of specific biodegradable detergents and cleaning agents.

A containerised combined wastewater treatment plant for grey and black water will remove harmful micro-organisms from wastewater at the station. All residue from the process that cannot be further treated will be dried in the plant, sealed in polypropylene containers, and loaded onto the supply ship once a year for incineration there or on land outside of the Antarctic. The purified wastewater will be disinfected – most likely using ultraviolet light – and discharged through an above-ground pipe that is approximately 50 mm wide and 80 metres long onto the snow west of the station.

13.3.6 Service life and subsequent dismantling of the station

The new station is to be in operation for 25 years. At the end of its service life, AWI intends to dismantle it and remove the majority of the components from Antarctica. For that reason, great importance has been attached to ensuring that the Neumayer III Station is designed in a way that will permit it to be retrograded as completely as possible. The removal of Neumayer III Station from Antarctica at the end of its operational lifetime and the possible impact on the environ-

ment associated with that are also considered in the study. AWI expects the work involved in dismantling the station to be significantly less than that involved in building it.

13.4 Dismantling and retrograding of the Neumayer II Station

Once the new Neumayer III Station is operational, the current Neumayer II Station will be abandoned and dismantled. It comprises an underground complex with accessways leading to the snow surface and some on-ground installations in the immediate vicinity. The station building proper is housed in tubes of 8.38 metres diameter. A garage building is situated nearby. All heated or air conditioned spaces are located in two parallel tubes. With the exception of the workshop building, they are all containerised on the basis of ordinary 20-foot transport containers. The station's main services (power and water generation, HVAC, sewage treatment) are also located inside the building containers.

The dismantling and retrogradation activities are likely to take two or more seasons. AWI has estimated that approximately 430 person-days will be required for the dismantling work and over-ice transportation. Works are scheduled to begin in the season after Neumayer III is commissioned (most likely in the 2008/2009 season) and be completed in the 2009/2010 season at the latest. Parts dismantled will be stored at the winter depot near the ice edge at Atka Iceport until they can be loaded onto a ship.

13.4.1 Building site logistics

The dismantling works will be carried out by a maximum of 12 people, who will be accommodated in the Neumayer III Station and will travel the short distance between the site and Neumayer III by Piston Bully. A workshop container and one or two heated cabooses will be erected at the site for weather protection. Environment-friendly toilet facilities will be provided. A mobile generator (approx. 40 kW) will provide power for heating the cabooses, lighting and ventilation in the tubes of Neumayer II, and for electric tools. A 15,000-litre tank container with a pump will be brought to Neumayer II and serve as a refuelling station, mainly for the transport vehicles, but also for the generator.

13.4.2 Dismantling works and packing

The 50 containers built as insulated rooms into the station will be used as transport containers. AWI needs about another eight 20-foot containers are required to transport additional items.

A vast range of different kinds of work will be involved in dismantling the station. They are described in detail in sections 4.2.2 and 4.2.3 above. The plan is to transport the majority of the building's components out of Antarctica. In particular, all steel and timber parts that project above the snow surface or can be reached from there will be dismantled and removed.

By contrast, the steel tubes will remain in the snow once they have been completely cleared out, as will the steel bulkheads, the steel parts of the staircases and part of the emergency (ladder) exit shaft at the western end of the Cross Tube. The 96.5-metre-long underground sewage pipe will also remain in place, as will the 1,500-metre-long triple power cable between the end of the air tunnel and the trace compounds observatory. For some components, the reasons AWI gives for this is that dismantling them would be very complex, energy-intensive, difficult, and in some cases, even dangerous. Secondly, AWI says that no damage to the environment is to be expected. The material in question totals approximately 733.6 tonnes. The parts of the building left behind will most likely flow into the sea with the ice shelf.

13.4.3 Transport

Use of station vehicles and sledges is planned for the transportation of dismantled items to the storage area (8 kilometres) and from there to the ice edge or the ship's landing place (also 8 kilometres). 16,600 litres of diesel fuel will be needed for this. It is not yet known what ships will be used for the marine transports.

13.5 The environment at the planned site

Ekström Ice Shelf is situated at the northeastern edge of the Weddell Sea in Dronning Maud Land at about 71° southern latitude. The station location is near the northeastern end of the ice shelf with the bay in the ice front called Atka Iceport only a few kilometres away to the east. The ice shelf at Neumayer Station is 230 metres thick and moves at a rate of about 170 metres per year towards the breaking edge some 16 kilometres to the north. The ice coast is geographically stable because of risings of the sea floor extending to the floating ice. The ice shelf has to pass these obstacles before calving (breaking off from the edge) can occur.

Temperatures range between -10° C summer mean and -26° C winter mean, with extremes at +4° C and -45° C. There is snow drift on 60 percent of all days, a main characteristic of the location. Annual snow accumulation at the station totals 80 cm. The winds are predominantly from the east, with a second maximum of considerable lower velocities and frequencies for winds from the west.

No terrestrial life exists in the area. The ice shelf around the station does not support any plant or animal life, and stray penguins or birds are very rarely observed near the station. There is an emperor penguin colony at Atka Iceport during the winter, and Adélie penguins visit the bay in early summer when the sea ice is breaking. Weddell and crabeater seals can be seen in Atka Iceport when ice floes are present.

13.6 Environmental impacts of the activities

The environmental effects of all three activities – including potential cumulative impacts – have been determined separately, but how they overlap has been evaluated depending on the individual circumstances. Transport of material and ship and plane travel by personnel are included in the assessments when they occur in the Antarctic Treaty Territory.

The environmental effects are detailed individually in Tables 26 to 29 above. These Tables also contain an evaluation of the impacts classified by their duration, intensity, the size of the area affected, and the probability that the effect will occur. It becomes clear that a major impact on the environment – in all three activities – will be air pollution from exhaust gases. Pollution of the snow/ice in particular by wastewater (albeit pre-treated) should also be stressed. Similarly, contamination by possible oil spills should not be ignored. Although it is not very likely that spills of that kind will occur, the impact they would have makes precautionary measures indispensable. Furthermore, noise, disturbance of the surface of the snow/ice, and pollution of the snow/ice are also to be expected. Finally, in connection with the dismantling of Neumayer II Station, the fact that the building components mentioned above - a total of 733.6 tonnes – will remain in the snow is significant. These components will later reach the sea and sink to the sea bed.

In view of their character, all these impacts are considered to be unavoidable. However, there extent can to a certain degree be reduced.

13.7 Measures to prevent and mitigate impacts on the environment and monitoring

To prevent or mitigate impacts on the environment, AWI proposes to implement many different measures that are already in place at Neumayer II Station:

- Training, safety and environmental protection regulations,
- Energy- and fuel-saving measures, reducing emissions,
- Emergency planning,
- Preventing pollution by substances other than fuel and lubricants,
- Regular maintenance of vehicles,
- Distances to be maintained by vehicles, pedestrians and aeroplanes and helicopters from the emperor penguin colony and bird concentrations.

AWI's proposed monitoring activities are listed in Table 31 above. Because it is extremely difficult to monitor actual environmental impacts, the work will concentrate on complete recording of all activities and the causes they set for for environmental harm, and on regular formal reporting about parameters with environmental significance.

13.8 Gaps in knowledge and uncertainties

Gaps in knowledge and uncertainties in assessing the environmental impacts of the activities are due mainly to the fact that the planning process has not yet been completed. They are listed separately above. An assessment of their potential effect has shown that no changes of plans are expected to have impacts on the environment different from those described above.

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