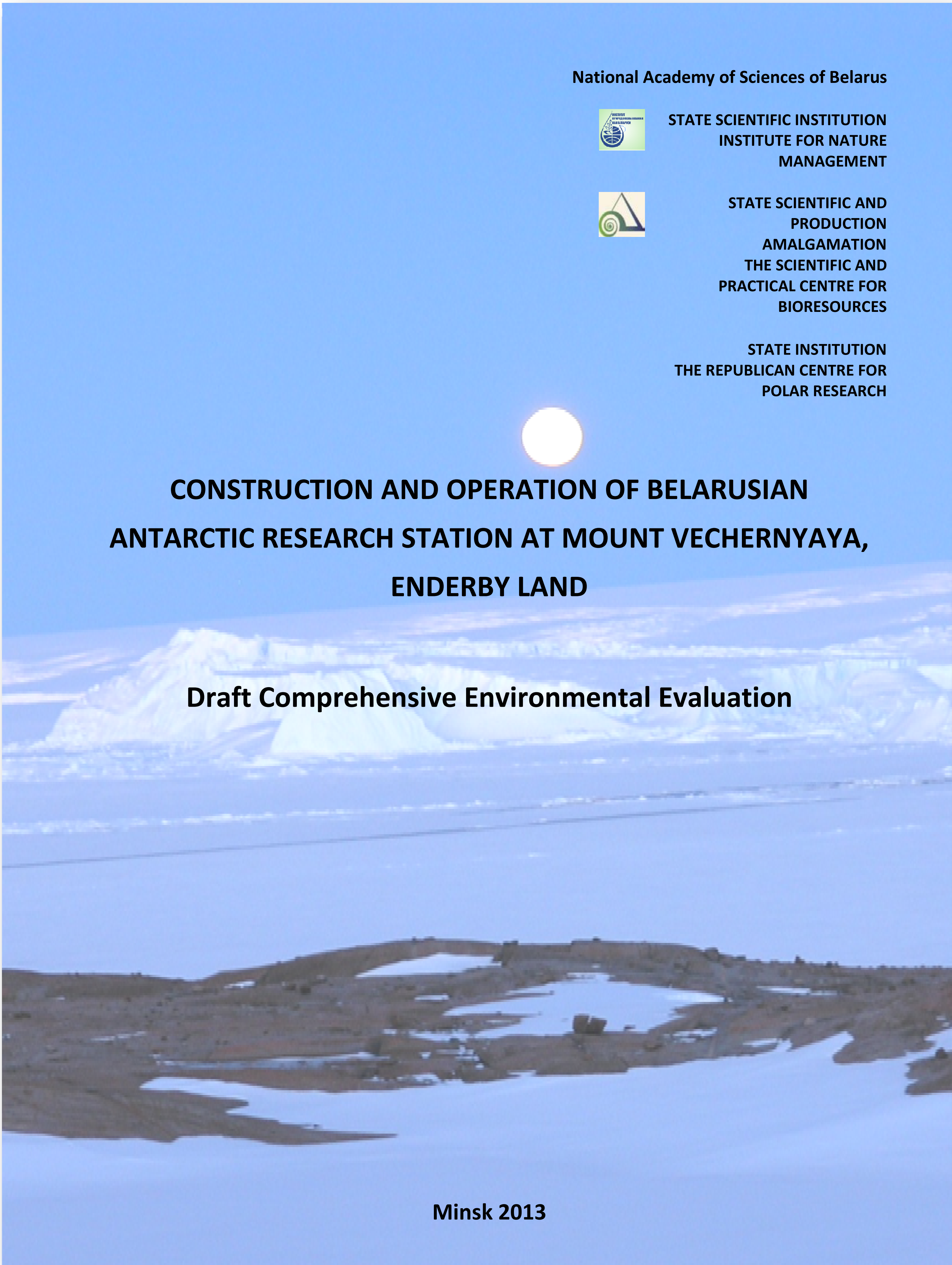

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CONSTRUCTION AND OPERATION OF BELARUSIAN ANTARCTIC RESEARCH STATION AT MOUNT VECHERNYAYA, ENDERBY LAND

Draft Comprehensive Environmental Evaluation

Minsk 2013

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Content

List of tables

List of figures

Acronyms and abbreviations

AERMOD	Atmospheric Dispersion Modeling System
AERMET	Meteorological Data Preprocessor
ASMA	Antarctic Specially Managed Area
ASPA	Antarctic Specially Protected Area
ATCM	Antarctic Treaty Consultative Meeting
BAE	Belarusian Antarctic Expedition
BAS	Belarusian Antarctic Station
BOD	Biological Oxygen Demand
CEE	Comprehensive Environmental Evaluation
CEP	Committee for Environmental Protection
CH	Hydrocarbons
CO	Carbon Oxide
COMNAP	Council of Managers of National Antarctic Program
DEM	Digital Elevation Model
EASA	European Aviation Safety Agency
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
HSM	Historic Sites and Monuments
ICAO	International Civil Aviation Organization
IEE	Initial Environmental Evaluation
MARPOL	International Convention for the Prevention of Pollution from Ship
MBM	Metal Block Module
NMSim	Noise Simulation Model
NO_2	Nitrogen dioxide
NOx	Nitrogen oxides
TSP	Total Suspended Particulate
PAH	Polycyclic Aromatic Compounds
PM10	Particulate Matter <10 µm
PM2.5	Particulate Matter <2.5 µm
PCB	Polychlorinated biphenyls
PCDF/F	Polychlorinated dibenzo(p)dioxins and dibenzofurans
RAE	Russian Antarctic Expedition
SCAR	Scientific Committee on Antarctic Research
SO_2	Sulfur dioxide
SSSI	Sites of Special Scientific Interest
UTM	Universal Transverse Mercator
US EPA	United States Environmental Protection Energy
VOC	Volatile Organic Compounds
WMP	Waste Management Plan

Non-technical summary

Introduction

This draft Comprehensive Environmental Evaluation (CEE) has been prepared by the Institute for Nature Management, the Scientific and Practical Centre for Bioresources and the Republican Centre for Polar Research of the National Academy of Sciences of Belarus within the framework of the National Program on Monitoring of the Earth's Polar Areas and Promotion of Arctic and Antarctic Expeditions for the period 2011- 2015, as approved in 2011. The CEE aims to provide the rationale for the construction of the Belarusian Antarctic research station (BAS) at Tala Hills, Enderby Land (latitude 67°39'30'' South, longitude 46°09'12'' East). The Draft CEE has been developed in conformity with Annex I to the *Protocol on Environmental Protection to the Antarctic Treaty* and *Guidelines for Environmental Impact Assessment in Antarctica* (Resolution 4, XXVIII ATCM, 2005).

Planned activity description

The first phase of the research station is designed for the work and accommodation of 5-6 polar explorers during the Antarctic summer season. Construction will take place in 2014-2018. The second phase, to be undertaken at a later stage, will be designed for 10-12 polar explorers and for year-round operation. The life cycle of the station's modules shall be a minimum of 15 years. The major elements of Belarusian scientific investigations in Antarctica are: the comprehensive terrestrial and satellite monitoring of the tropospheric aerosol, clouds and underlying surface; comprehensive ozonosphere and ultraviolet radiation investigations; hydro-meteorological support of the Belarusian Antarctic expedition and climate research; development of radio devices for monitoring snow and ice cover and atmosphere in the polar regions; geophysical and geochemical surveys of the earth's crust; assessment of prospects for renewable living resources of the Antarctic coastal ecosystems; and the environmental impact of activities related to the organisation and operation of the BAS.

Station design

Modern international experience in creating similar facilities of polar infrastructure, the practical experience of Belarusian explorers accumulated during their work in past Antarctic expeditions, and the need for the entire BAS infrastructure to comply with environmental safety requirements in order to limit adverse impacts on the Antarctic environment and ecosystems, were taken into consideration in the development of the BAS concept. During the 4th and 5th Belarusian Antarctic expeditions field investigations for the anticipated location of the BAS were undertaken and the collected information was used for the development of the BAS project and for the environmental impact assessment (EIA).

The BAS design is conceptually based on small modular structures assembled in Belarus and subsequently delivered by land, sea and air transport to Antarctica and installed on site by helicopter.

The requirements for the elements of the BAS are: all-weather performance; suitability and safety of operation in the harsh Antarctic conditions; and versatility and space-saving design for most residential and service-specific modules.

Structurally, the BAS will consist of separate modules of different functions. Each module will be built on a single stationary foundation base-plate, which will be raised above the surface with manually- operated outriggers mounted under each corner of the module. The design project for the BAS modules was developed in 2012-2013 by Midivisana Ltd. The selected station design and construction technology meet the requirements of the Protocol on Environmental Protection to the Antarctic Treaty.

The first phase of BAS construction in 2014-2018 envisages the fabrication of nine laboratory and residential, laboratory and service modules, kitchen and utility and technical blocks, boxes and pavilions to be delivered to Antarctica and installed on site.

The energy supply to the station will be based on the use of diesel generators. The supply of energy from the generators to the modules will be by aerial transmission lines.

Water from nearby lakes will be used for the water supply. Effluent will be collected in specially heated containers (400 litre capacity) located under each module. Effluent will be discharged into the sea where there are conditions for initial dilution and rapid dispersal.

All the living modules (caravans) will be equipped with electrical toilets.

Station placement and alternative options

When selecting possible sites for the location of the future BAS, geographical, topographical, geological, meteorological and hydrological factors, as well as accessibility and other important conditions (criteria) for secure living, were taken into consideration for the project development.

It was also taken into account that since 2006 Belarusian Antarctic expeditions have used the field base infrastructure of the Russian Antarctic Expedition at Mount Vechernyaya, located 20 km to the east of Molodyozhnaya Station. The Vechernyaya field base infrastructure was built in 1979. It was designed to accommodate year-round technical staff for an IL-76 aircraft landing strip. At the present time the remaining field base infrastructure is worn out, partially destroyed, and unable to support the proper operation of the station.

Four alternative sites were considered for the location of the BAS. The selected site for the station was located on the eastern slope of Mount Vechernyaya. Variants for locating the BAS in other regions of Antarctica were also analysed, taking into account scientific, environmental, logistics and other aspects. However, no alternative locations for a BAS were found which would meet all the criteria to a greater extent than the Mount Vechernyaya location.

The selected site is a relatively flat, mountain terrace, about 350 m long and 50-80 m wide, with reliable transport access for automotive and light snowmobile vehicles. The terrace is conveniently located on a wind-blown mountain coombe oriented to the prevailing wind. It is well protected from crosswinds and severe snowdrifts by the eastern spur of Mount Vechernyaya on one side and by a rocky ridge which protects the coombe from the seaward side.

The site selected for the BAS also satisfies the other requirements:

- it is located in the coastal zone of the Antarctic continent, and it is possible for a supply vessel to approach as close as possible to the proposed site for the base to carry out supply operations (according to the logistic scheme: ship - shore / barrier - station);
- it is accessible to helicopters based on the supply vessel;
- a snow and ice landing strip can be set up in the vicinity for aircraft engaged in planned intracontinental flights;
- a safe, year-round transport corridor with access to the ice dome can be engineered;
- the proximity of non-frozen water reservoirs (lakes) with fresh (potable) water;
- the availability of a selection of representative sites on the mountain terraces or adjacent areas for scientific instruments and technical equipment intended for open-air installation and deployment;
- safe walking access for station staff around the territory of the possible construction, as well as the adjacent areas;
- the presence of a year-round or seasonal station of another State Party to the Antarctic Treaty in the reasonable vicinity (20 km), whose facilities can be called on in the case of emergency or other force majeure circumstances.

Information about the choice of location has been conveyed to an Antarctic Treaty Consultative Meeting (ATCM) (*Information Paper IP056 - About the planned activities of the Republic of Belarus in Antarctica*, ATCM XXXVI, Brussels, 20-29 May 2013).

Natural surroundings and environmental conditions

The natural complex, known as Mount Vechernyaya, is located in the western part of Enderby Land, Tala Hills (eastern part), in the coastal area of the Alasheeva Gulf, Cosmonauts' Sea. It incorporates a series of rocky ridges with a dominant mountain, namely Mount Vechernyya (272.0 m), and several lower ridges, extending substantially parallel to the seashore oriented to the north-west. The north-eastern slopes of the ridges are steep and short, sometimes precipitous, and gently sloping to the south-west. The ridges are separated by terraced valleys, with glaciers and river beds of temporary water courses at their bottom. There, the Alasheeva Gulf cuts inland with the Vechernyaya, Lazurnaya, Terpeniya and Zarya Bays, which are separated by Capes Rog, Gnezdovoy and Dostupny. The Hayes outlet glacier can be considered the eastern boundary of the area. Virtually the entire territory of the Mount Vechernyaya region is composed of gneisses and plagiogneisses of the Charnockite Series.

The soil cover in the area planned for the BAS has been formed partially, only in places that are not covered by glaciers, where there are conditions for the accumulation of friable material of colluvial and fluvio-glacial origin - mainly in the hollows of slopes and water flow coombes.

The mineral part of the soils sampled at different sites in the vicinity of Mount Vechernyaya are characterised by the dominance of silicon compounds (average content of 63.4%); iron and aluminum compounds, have 14.1% and 8.0% content respectively; and calcium oxide, sodium, potassium and magnesium have 4.5%, 3.5%, 2.3% and 2% respectively. The soils have been transformed in some places under the influence of preceding activities, as evidenced by the presence of oil products, ranging from 2.5 mg/kg to 28.9 mg/kg.

In the Mount Vechernyaya region more than twenty permanent and temporary lakes were identified. Their surface area ranges from several tens to several thousands of square meters, with depths ranging from several tens of centimeters to 20 meters or deeper. The biggest lakes located near Mount Vechernyaya are Nizhnyeye Lake (Lower Lake, about 1.5 ha) and Verkhnyeye Lake (Upper Lake, 0.15 ha). These lakes are connected by a temporary watercourse. The water level of the lakes is unstable and depends on the intensity of snow-melt.

To determine the chemical composition of lake waters, water samples were taken from the Nizhnyeye, Verkhnyeye and No Name Lakes in the course of two Belarusian Antarctic Expeditions (2011-2012 and 2012-2013). The lake waters were reported to be low in mineralization, with ion contents ranging from 7.6 to 39.0 mg/l. Anions in all samples are dominated by chlorides (59-84%) and cations are mainly represented by sodium ions (68-81%). The ion balance demonstrates a significant influence of ocean water on the chemical composition of lake waters, which is explicable by their littoral location.

Research showed that the majority of trace elements in the waters varies on a scale from below the detection limit to 10 μg/l. Results included: lead – up to 1.88 μg/l; cadmium – up to 0.53 μg/l; nickel – up to 0.69 μg/l; cobalt – up to 0.29 μg/l; arsenic – up to 0.39 μg/l, copper – up to 2.17 μg/l; and chromium – up to 1.40 μg/l. The presence of oil products was detected.

The content of heavy metals in the lake sediments was significantly higher than in the soils of the Mount Vechernyaya region, e.g., the Lake Verkhnyeye sediments contained 3.5 times more copper, 2.2 times more zinc, 1.6 times more nickel, 1.5 times more lead and 1.2 times more cadmium. Higher concentrations of oil products were also recorded in the Lake Verkhnyeye sediment samples.

The elevated concentrations of oil products in the lake water, as well as the elevated concentrations of heavy metals and oil products in the lake ecosystem sediments are probably the result of past anthropogenic activities.

The peculiarities of the western Enderby Land atmospheric circulation are determined by the interaction of the pressure systems prevailing in the middle and high latitudes of the Southern Hemisphere.

According to the monitoring results from Molodyozhnaya Station, the average annual ambient temperature in the area is -11.0°C. The second half of winter (July-September) is the coldest season, and almost all the absolute minimum temperatures have been recorded in these months, getting to minus -42°C in some years.

The given region is dominated by winds from the east-north-east to south-south-easterly direction, with an annual frequency of occurrence of 85.7%. While east-north-eastern winds are associated with cyclones that prevail in the period from August to January, the south-south-eastern winds are of anticyclonic or katabatic origin, blowing in the period from February to July. Still weather is not typical. The maximum frequency of still weather is reported in July-December, while in February-April still weather is only 0.2-1.0% of the time. The highest wind speed have been recorded in March and April, and January and December are relatively less windy. The maximum average monthly wind speed has been recorded in April - 17.6 m/sec, and the minimum - in January, at 3.2 m/sec. Average wind speed is 12.6 m/sec.

Average annual precipitation is 270 mm. The main quantity of precipitation falls from March to September, with the average figure in these months fluctuating between 48 and 71 mm. The least amount of precipitation is recorded in January and December. The annual snowstorm frequency is 190 days.

According to research carried out in January 2013 the mineralisation of snow water ranges from 1.5 to 8.4 mg/l, with an average of 3.1 mg/l. Chlorides account for the anionic composition of snow water. The cationic composition of snow water is more diverse: sodium, magnesium & sodium, sodium & magnesium, calcium & magnesium. The content of sulfates in snow waters ranges from values below the detection limit to about 0.20 mg S/l (mean - 0.1 mg S/l), chlorides - 1.1 to 2.4 mg/l (mean - 1.5 mg/l), sodium ions – 0.3 to 1.1 mg/l (mean - 0.57 mg/l).

Snow water mineralisation, as sampled on the ice cap 5 km away from the BAS, was found to be on average 20% lower than the mineralisation at the station site. The content of the main ionic elements was less as well. No significant changes in the ionic composition of snow waters as a result of anthropogenic activities at Mount Vechernyaya were identified.

Living organisms in the eastern Tala Hills (in the vicinity of the proposed location of the BAS) are mainly found on the surface of rocky outcrops, in accumulations of melt water, in freshwater lakes, and in the bays of the Alasheeva Gulf and the Cosmonauts' Sea. Some species are spread around all the possible habitable places; others are found at certain locations only. In addition, a number of areas with the highest biological diversity were identified.

As of now representatives of three kingdoms of living organisms have been noted in the area. The Plants and Fungi kingdoms are represented by lower groups only, i.e.: lichens (Lychenophyta) - 28 species from 3 groups, including seven species being endemic to Antarctica; bryophytes (Bryophyta) - 3 species; seaweed (Algae) - 79 species of 8 groups. Fungi - 1 lichenophylic specie (living on lichens), Arthonia molendoi.

Almost constant low humidity, low temperatures and strong winds with their dessicating and corrosive effect on soil and plants, create very unfavorable conditions for plant organisms. Plants of one or more species settle separately in the area or form clumps ranging from several centimeters to several decimeters.

Lichens are quite widely dispersed. The substrates for lichens there are rock, friable soil, as well as other plants. After the lichens, the most common component of the plant covering in the area are mosses. They settle in areas with constant and adequate moisture and are found on the lake bottom (which does not freeze in winter).

Representatives of the animal world, trophically associated with dry land and observed here during expeditionary field work, are very small (about 1 mm). They live under rocks, in cracks and in organic material. These include several species of mites which were identified during biological sampling.

On the northern and north-eastern slopes of the Mount Vechernyaya small colonies of Adelie penguins are met. Their numbers are not significant - 500 to 600 birds. Small numbers of snow petrels and southern polar skua gulls also nest there.

Impact assessment

An assessment of impacts on the Antarctic environment was carried out at the stages of station construction and operation, taking into account all the main impact factors (pollutant emissions, noise, wastewater discharges, wastes, electromagnetic radiation) and sources of impact (power supply systems and mechanisms, motor vehicles, fuel storage and distribution systems, water supply and sewerage systems, solid waste management, auxiliary and scientific equipment), and all the main components of the natural milieu.

The assessment includes a quantitative analysis of each impact source (emissions, noise, discharges, waste generation, etc.) and the identification of impact (receptor) - levels of pollutants in ambient air were calculated, as well as noise levels, the concentration of pollutants in sewage outfalls, etc. Forecast emissions of the main and specific pollutants from fixed (diesel generators, incinerator) and mobile (helicopter, snowmobiles, etc.) sources during the construction phase, as well as for seasonal and wintering options of the station operation were also evaluated.

Modelling of the dispersion of pollutant emissions from stationary sources during the BAS operation was carried out using the AERMOD model.

The maximum and average hourly, 8-hourly and daily concentrations of pollutants, as well as daily and monthly concentrations during the reporting period were calculated. The calculation was performed for 2 scenarios of pollutant emissions. It was found that the maximal average hourly concentration of nitrogen dioxide in the region of the laboratory-residential station modules would be 67.0-77.2 $\mu g/m^3$, the daily average – 15.9-27.8 $\mu g/m^3$, which is 2.5 to 3 times lower than the single MPC value, and 1.4 to 2.5 times less than the average daily MPC value. Atmospheric pollution will be substantially lower for other pollutants.

The maximum hourly average concentration of sulfur dioxide, to which vegetation is the most sensitive, will amount to 14.8 $\mu g/m^3$ in the protected area, average daily - 3.5 $\mu g/m^3$, average monthly - 0.67 $\mu g/m^3$, well below the critical level for lichens (10 $\mu g/m^3$), as recommended by the WHO.

To assess the helicopter noise impact, the NMSim v.3.0 model was used. Calculations showed that at Cape Gnezdovoy where there is a penguin colony potentially susceptible to noise impact, the linear-weighted noise levels will not exceed 65 dB, and A-weighted will not exceed 55 dB. Maximum noise levels at the BAS could reach 95 dBA, but the time of such levels will be very short, and therefore the equivalent noise level L_{eq} and LDN levels will not exceed 50-60 dBA, which meets existing norms for residential areas.

The calculations of noise levels from diesel generators showed that the level of sound intensity in the area adjacent to the laboratory-residential modules will not exceed established norms.

The assessment of the dilution rate of sewage discharges into the sea using USEPA's Visual Plumes model showed that the concentration of pollutants will drop 91 times at a distance of 1.5-5.5 m from the discharge point.

Overall, the impact of the BAS construction and operation is identified as being a "minor or transitory impact".

It was established that, in the context of the maturation of the natural environment in the Mount Vechernyaya region, the contribution of the impact of the construction and operation of the BAS in the overall transformation of the natural components of the region where the BAS is located will be minor.

Measures, monitoring, uncertainties and gaps in knowledge

Mitigation of the environmental impact of the construction and operation of the BAS will be achieved by the following actions:

- reduction of emissions of pollutants into the air will be achieved through regular maintenance of diesel generators and motor vehicles, route optimisation, and improving fuel quality;
- reduction of emissions from waste incineration will be achieved through careful monitoring of combustible substrates, compliance control of waste feeding and burning, and dust and gas abatement performance control;
- reduction of wastewater discharge will be achieved by decreasing wastewater generation through the use of more efficient water-usage systems, as well as the introduction of systems for wastewater collection, storage and discharge;
- reduction of the impacts due to the formation and accumulation of waste will be achieved by improving the waste management system. A specific Waste Management Program will be developed;
- measures will be implemented to prevent oil spills during storage, loading and refueling. A specific Oil Spills Control Plan will be developed.

For the purposes of analysing the interrelation between the actual environmental indicators, their forecast values and actual values in the future following the construction and operation of the BAS, an Environmental Monitoring Program will be developed and implemented at the BAS.

This will allow the timely realization of measures to eliminate the negative impacts of activities. A laboratory will be equipped for research within the framework of monitoring chemical, physical and biological indicators. An Environmental Monitoring Program will be set up and implemented in accordance with the *Practical Guide for Developing Environmental Monitoring Programmes in Antarctica* (2005), as elaborated by the CEP.

In addition to monitoring the natural surrounding situation and impacts, an industrial environmental monitoring system will be established to monitor the major ecologically dangerous objects, primarily fuel storage facilities, sewage ponds, pipelines, diesel generators, etc. Detailed protocols (instructions) will be developed to specify service and maintenance procedures, minimizing the possibility of accidents and leakages. The volumes of emissions, discharges, generation, accumulation and disposal of waste, and scheduled equipment maintenance works will be properly controlled. Protocols will also regulate actions in case of emergency: leakages, spills, fires, etc. All such cases will be recorded; any measures implemented will be reported. In the case of accidents there will be kept the minimum necessary quantity of means for liquidating impacts, in particular absorptive materials and other measures for combating leakages.

Monitoring and control of the introduction of alien species will also be organised and implemented.

A number of factors introduce uncertainty into the prepared draft of the Comprehensive Environmental Evaluation. One of the factors is gaps in knowledge about a series of natural elements of the environment in connection with the insufficient study of the natural conditions of the region where the station is located, such as the dynamics of snow and ice cover, the hydrology of the Cosmonauts' Sea in the given region, the hydrology of lakes, soil processes and impacts of the functioning of the Mount Vechernyaya field base.

Information about the accumulation and migration of chemical elements in soils and bottom sediments in connection with previous activities in the region of the Mount Vechernyaya field base is limited.

There are only elementary data on the biodiversity of marine biota in the Vechernyaya, Terpeniya and Lazurnaya Bays (Alasheeva Gulf, Cosmonauts' Sea). No information about the areas of potentially greatest biological diversity – Trevozhnaya Bank (Vechernyaya Bay) and Krevetka (Shrimp) Bank (Lazurnaya Bay) – is currently available. These gaps in knowledge will be rectified in the course of further scientific research in the given region.

The prepared Draft Comprehensive Environmental Evaluation is based on existing project materials, including specifications for the equipment and tools to be used, but there is a possibility of modifications, particularly in connection with the rather long period of BAS construction. There is also the probability of deviations from the schedule due to unforeseen circumstances, "last minute" changes, etc.

A number of forecast indicators, in particular, the dispersion of pollutants, are based on simulations of variable environmental parameters (such as weather conditions).

Conclusions

The Republic of Belarus plans to establish a scientific station in the Tala Hills, Enderby Land, in order to promote its research in the region. It is proposed that construction of the first phase of the station facilities take place in 2014-2018. The construction features of the station are based on the modular principle, which will minimise construction costs, and speed up and simplify construction. It is planned that the station starts as a seasonal facility and subsequently transfer to a wintering (year-round) work variant. Limited staff numbers, efficient power, heat, water supply, sewerage and waste management systems will allow minimal impact on the environment.

Analysis of the proposed research activities makes it possible to conclude that the knowledge gained and the associated socio-economic benefits resulting from research to be carried out at the Belarusian Station (Enderby Land, East Antarctica) under the National Scientific Programme will significantly outweigh the minimal losses that may be caused to the natural Antarctic environment during the construction and operation of the station.

Additional information

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1. Introduction

1.1. Regulatory framework for activities in Antarctica and history of the Belarusian scientific research in Antarctica

The Antarctic Treaty done in 1959 aims at providing the continent's non-military use, freedom of scientific investigations in Antarctica and cooperation with these purposes. According to this Treaty, governments, organisations and nationals of all the countries are allowed to carry out scientific work in Antarctica on equal basis, provided the compliance with its provisions. The Treaty defines the determining conditions necessary for unhindered implementation of the principle of the freedom of scientific research.

The Republic of Belarus acceded to the Antarctic Treaty in virtue of the Belarusian Law No. 157-3 on accession of the Republic of Belarus to the Antarctic Treaty of July 19, 2006 (Belarusian National Register for Legal Acts, 2006, No. 122, 2/1254). This Treaty entry into force for Belarus since December 27, 2006.

Given the crucial importance of Antarctica as a natural untouched territory, the Protocol on Environmental Protection to the Antarctic Treaty was signed in 1991. In 2008, the President of the Republic of Belarus signed the Decree on accession of the Republic of Belarus to the Protocol on Environmental Protection to the Antarctic Treaty (Presidential Decree No. 200 of April 10, 2008) (entry into force for Belarus since August 15, 2008).

It should be noted that the Belarusian polar explorations in Antarctica began actively in 1957 and have been pursued for many years as part of the Soviet Antarctic Expeditions (SAE). All in all, for the entire period of Antarctic explorations about 70 specialists from Belarus visited Antarctica as members of different expeditions, thus gaining considerable experience in research, logistics and other activities. Belarusian polar explorers contributed a lot in scientific studies of various domains. As an example, in 1983 SAE explorers of the National Hydrometeorology Centre reported the planet's lowest temperature at Vostok Station (-89.2°C) and in 1989 - strongest wind blow (78 m/s) in Antarctica at Leningradskaya station.

The new phase of Antarctic research for the Republic of Belarus started in 2006, when the National Program on Monitoring of the Earth's polar areas and promotion of the Arctic and Antarctic expeditions in 2007-2010 and for the period up to 2015 was adopted and implemented (as approved by Ordinance No. 1104 of the Council of Ministers of August 31, 2006). It was succeeded by the National Program on Monitoring of the Earth's polar areas and promotion of the Arctic and Antarctic expeditions for the period 2011- 2015, launched in 2011 (as approved by Ordinance No. 587 of the Council of Ministers on May 10, 2011).

In 2007, the National Centre for Polar Investigations, a governance authority, was organised for the practical implementation of the objectives set by the National Program. For the period since the National Program adoption, a considerable scope of work in Antarctica has been performed by scientists and specialists of the National Centre for Polar Investigations, research organisations of the National Academy of Sciences and other institutions involved in the

Antarctic program. Antarctic expeditions were organised in 2006-2007, 2007-2008, 2008-2009, 2010-2011, 2011-2012 and 2012-2013 (*Summary ... , 2007; Brief Report ..., 2011*).

As agreed upon with the Russian Antarctic Expedition (RAE), the Belarusian seasonal field camp was organised in the area of Molodyozhnaya Russian Federation station (East Antarctica) at Mount Vechernyaya field base. To provide the vital activities of Belarusian polar explorers, a number of premises at Mount Vechernyaya field base were reactivated, top priority repair work was performed, scientific equipment was installed and meteorological, geophysical, ozonometric, geological, geochemical and biological experiments and observations as well as new scientific equipment elaborated by Belarusian scientists testing have been conducted.

1.2. Objectives of the Belarusian explorations in Antarctica

The major object of the National Programs serves the deployment of research investigations and monitoring of the natural environment at the Earth's Polar Regions, aimed at obtaining the equal participant status of the Republic of Belarus in the global process, and, in future, the Consultative Party status in explorations and use of the planet's high latitude regions. It will promote its long-term political, economic and scientific interests in the Polar Regions, fulfillment of the international obligations under the Antarctic Treaty and the Protocol on Environmental Protection to the Antarctic Treaty.

The main objectives of the National Program for the period 2011-2015, taking into account the outcome of the first stage of the 2007-2010 National Program, are as follows:

- comprehensive scientific investigations and technological development for the study and monitoring of the Antarctic environment, development of a modern system of integrated environmental monitoring in the area of the Belarusian Antarctic expedition using remote sensing technologies;
- organisation of scientific expeditions and construction of the Belarusian Antarctic base infrastructure, equipped with up-to-date technological equipment, practical implementation of the new techniques, technologies and devices, as designed under the National Program, by testing their performance in polar expeditions;
- development of international cooperation in studying the Earth's polar regions, integration of the sensing systems in the international network of environmental monitoring, implementation of measures aimed at Belarus' obtaining of the Antarctic Treaty Consultative Party status.

Resulting from the National Program implementation, it is expected:

- to create pre-conditions for Belarus' obtaining of the Consultative Party status in accordance with the provisions of the Antarctic Treaty (deployment of a scientific station or scientific expeditions organisation);
- to strengthen the role of the Republic of Belarus in the Antarctic Treaty system;
- to promote the effective implementation of the Belarus' international obligations under the Antarctic Treaty and the Protocol on Environmental Protection to the Antarctic Treaty;

- to participate actively in bilateral relations, including cooperation with the Russian Federation, as well as in multilateral international programs within the framework of international cooperation in Antarctica;

- to develop the Belarusian Antarctic station infrastructure;

- to create of new components and upgrade the existing elements of the integrated environmental monitoring system in the area of the Belarusian Antarctic expedition performance, with prevailing use of remote fixed and satellite sensing systems;

- to obtain practical experience in procurement and logistics of polar expeditions and to involve young scientists for Antarctic explorations.

In May 2012 by the order of the Council of Ministers of the Republic of Belarus and pursuant to the objects and objectives of the National Program, a plan of BAS construction was worked out, presupposing its phase-to-phase implementation, starting from 2014.

The western sector of Enderby Land, Mount Vechernyaya Russian field base, located 20 km east of Molodyozhnaya Russian station has been selected as the principal site for BAS deployment (see Figure 1.1).

1.3. Necessity of drafting of CEE of the Belarusian Antarctic station construction

Pursuant to the 1991 Protocol on Environmental Protection to the Antarctic Treaty (Art. 8), "Each Party shall ensure that the assessment procedures set out in Annex I are applied in the planning processes leading to decisions about any activities undertaken in the Antarctic Treaty area pursuant to scientific research programs, tourism and all other governmental and non-governmental activities in the Antarctic Treaty area for which advance notice is required under Article VII (5) of the Antarctic Treaty, including associated logistic support activities". Reference to this requirement, the Initial Environmental Evaluation for the BAS construction and operation was prepared in accordance with the requirements of the Protocol on Environmental Protection to the Antarctic Treaty, based on the architectural design of the station and extrapolating the impact of the existing sources of Mount Vechernyaya field base, taking into consideration the scheduled increase of personnel in 2012. The impact assessment demonstrated that the BAS construction and further operation near Mount Vechernyaya RAE field base will be accompanied by emissions to the atmosphere, domestic water discharges, wastes accumulation, mechanical impacts on soil and ice, as well as heat, noise, electromagnetic exposure and possible introduction of microorganisms. Thus, the impact will be caused to all the major environmental elements within the station area.

Generally, the BAS construction and operation was mainly identified as having "a minor or transitory impact". However, for more accurate and complete estimation of consequences of the BAS construction and operation for the Antarctic environment and taking into account the ATCM Recommendation XV-17, it was decided to prepare a Comprehensive Environmental Evaluation in connection with the Belarusian Antarctic station construction.

The Draft Comprehensive Environmental Evaluation (CEE) of the Belarusian Antarctic station construction and operation has been elaborated pursuant to the Belarusian Antarctic Station Deployment Plan according to the EIA procedures set out in Annex 1 to the Protocol on Environmental Protection to the Antarctic Treaty, national statutory instruments and specification related to EIA, with adaptations to the BAS specific operation.

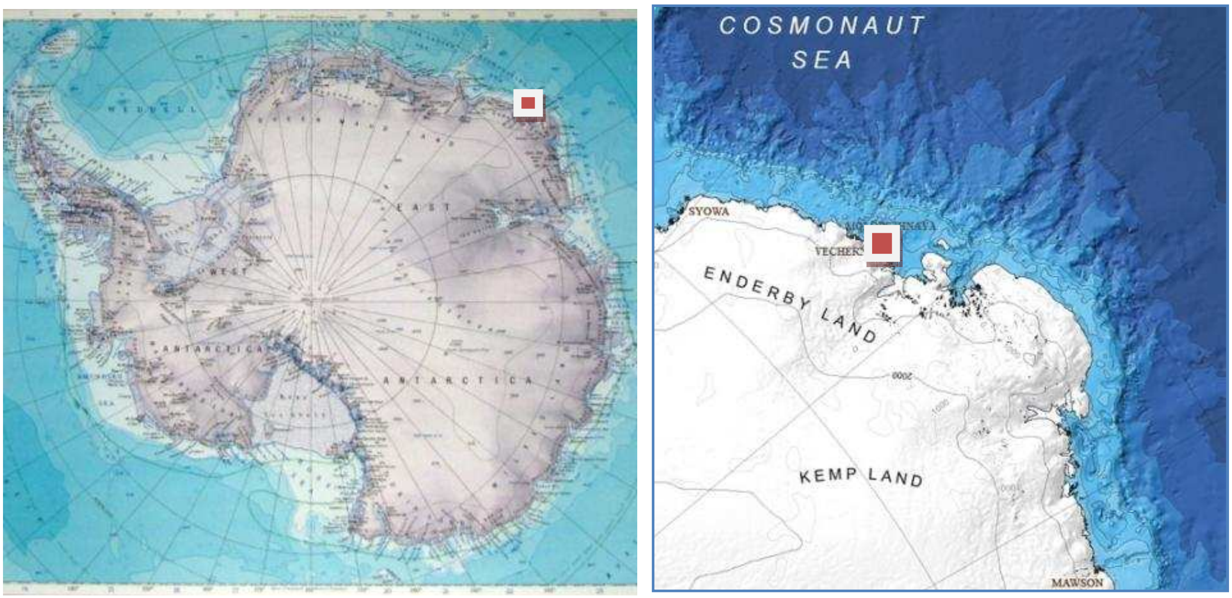


Figure 1.1 – Planed location of the Belarusian Antarctic station

2. Description of planned activity

2.1. Major scientific activities the Republic of Belarus in Antarctica

Pursuant to the Belarusian Act on accession of the Republic of Belarus to the Antarctic Treaty of July 19, 2006, the Republic of Belarus has been engaged in international scientific and logistic activities at the Earth's South Polar Region since 2007.

Starting from 2007, the National Program on Monitoring of the Earth's polar areas and promotion of the Arctic and Antarctic expeditions has been implemented by the Republic of Belarus.

The scientific and practical activities under the National Program is carried out by the National Academy of Sciences of Belarus and Ministry for Natural Resources and Environmental Protection, which organise the research and logistic support of the Belarusian Antarctic expeditions, as well as preparing the necessary legal and technological support in the field of polar investigations.

The major elements of the Belarusian scientific investigations in Antarctica under the National Program are:

1. The comprehensive terrestrial and satellite monitoring of tropospheric aerosol, clouds and underlying surface in Antarctica; development of extra channels for sensing tropospheric ozone and stratospheric polar clouds and creating instrumentation, methodology and software for calibration of satellite optical instruments at the Antarctic ground surroundings;
2. The comprehensive ozonosphere and ultraviolet radiation investigations; hydrometeorological support of the Belarusian Antarctic expedition and climate research;
3. Development of radio devices for monitoring snow & ice cover and atmosphere in the Polar Regions;
4. Geophysical and geochemical surveys of the earth's crust in Antarctica at the Belarusian Antarctic expedition areas;
5. Assessment of prospects for renewable living resources of the Antarctic coastal ecosystems and environmental impact of activities related to the organisation and functioning of the Belarusian Antarctic station.

2.2. Belarusian Antarctic station construction site selection criteria

When selecting the possible sites for construction of the future Belarusian Antarctic station (*Comparative analysis of criteria.., 2007*), the geographical, topographical, geological, meteorological, hydrological factors, as well as accessibility and other important conditions (criteria) for secure living were taken into consideration, i.e.:

- location at the coastal area of the Antarctic continent and possibility of supply vessels to approach as close as possible to the intended place of major structures and facilities deployment, as well as to storage tanks for the main and emergency supply of fuel and lubricants, and easier supply operations (according to the logistic scheme: ship - shore / barrier - station);

- presence of significant flat outcrops of rocks or alluvial deposits at the site;

- accessibility for ship-based helicopters;

- feasibility to arrange a snow & ice landing strip for aircraft engaged on scheduled inland flights;

- friendly topography and windproof properties of natural obstacles;

- site's optimal orientation, as refers to the prevailing wind direction;

- feasibility of engineering a safe, year-round transport corridor with access to the ice canopy and Molodyozhnaya – Mount Vechernyaya field base route;

- proximity of non-frozen water reservoirs (lakes) with fresh (potable) water;

- availability of representative sites to be opted at the mountain terraces or nearby areas for scientific instruments and process equipment intended for open-air installation and deployment;

- availability of safe walking of the station staff around the territory of the possible development, as well as at the adjacent areas;

- presence of year-round or seasonal station of another State Party to the Antarctic Treaty in the reasonable vicinity (20 km), in order to use its facilities (fuel, diesel generators, foodstuff, buildings and structures) in case of emergency or other force majeure circumstances;

- favorable ecological environment at the selected site.

As mentioned above, since 2006 the Belarusian Antarctic expeditions used the infrastructure of Mount Vechernyaya field base of Russian Antarctic expedition, located 20 km east of Molodyozhnaya Russian station. In this regard, the Mount Vechernyaya field base site was considered the top priority for the BAS placement. The field base location and BAS intended deployment area in coordination with Molodyozhnaya station location is given at Figure 2.1.

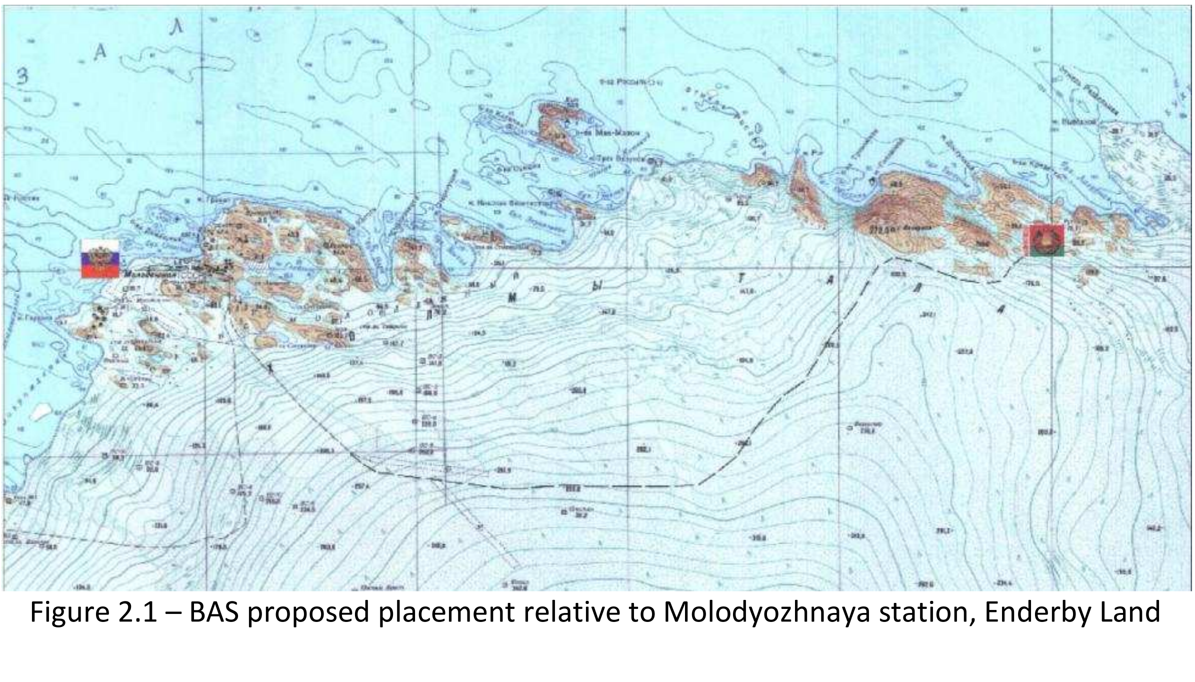


Figure 2.1 – BAS proposed placement relative to Molodyozhnaya station, Enderby Land

Three alternative sites were considered for the Belarusian Antarctic station possible placement (see Figure 2.2).

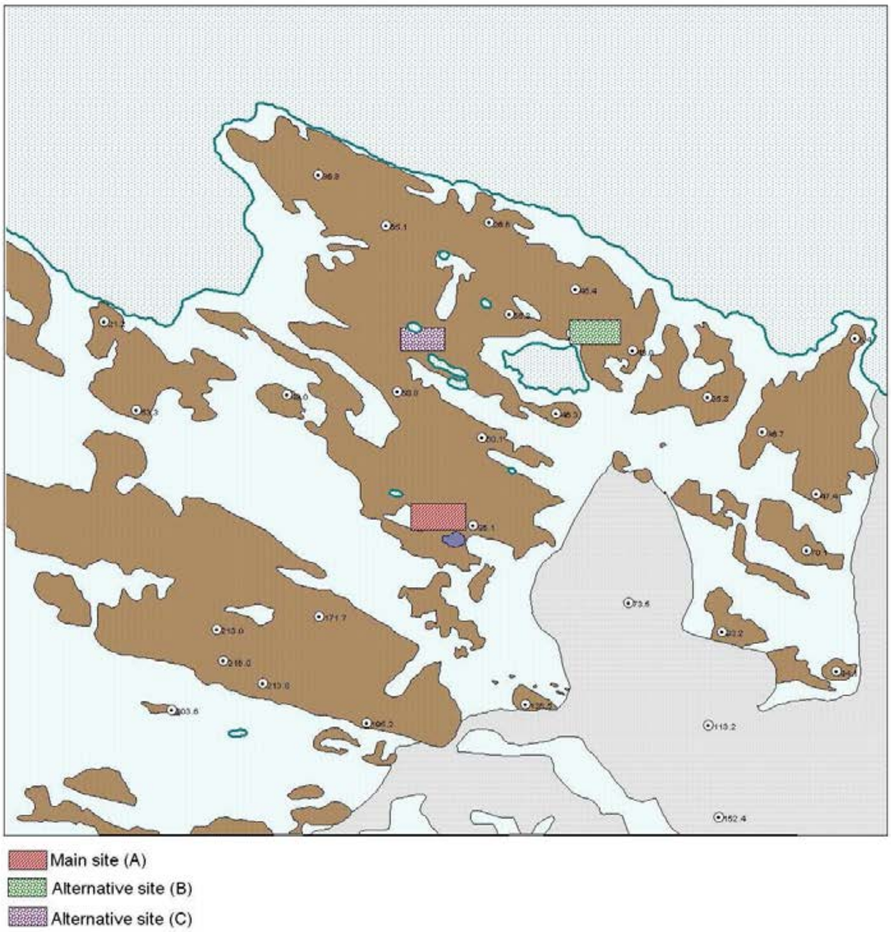


Figure 2.2 – Alternative sites for BAS construction at Mount Vechernyaya

Site A. Located on the eastern slope of Mount Vechernyaya. The selected site is a relatively flat, mountain terrace, sized about 350 m long and 50-80 m wide, having a reliable transport access for automotive and light snowmobile vehicles. The terrace is conveniently located towards the prevailing wind in a blown mountain ravine. It is well protected from katabatic winds and severe snowdrifts by the Mount Vechernyaya eastern spur from the one side and by a rocky ridge to cover up this hollow from the seaside.

Site A is located at approx. 120 m distance from Mount Vechernyaya RAE field base residential premises and 12 - 15 m higher. It stands at about 250 m distance from the RAE Mount Vechernyaya field base main complex of buildings and structures and Nizhneye lakeside.

The Site A convenient location on the eastern slope of Mount Vechernyaya makes it feasible to engineer a year-round, reliable transport access, including that available for tracked vehicles.

At the site area (approx. 0.5 km^2 around) no faulty equipment and/or waste deposits from past production activities are reported. This deems to be rather favorable for the Belarusian explorers.

The only minor problem, currently evident and associated with Site A location, may arise with independent supply of fresh water at winter seasons. The distance between the site and the Nizhneye Lake and 50-60 m vertical drop can substantially complicate the water supply process. The problem of domestic and potable water supply can be resolved by electric snow-melting heater to be placed in the immediate vicinity of the buildings and facilities. At the same time, the abundant glacial, seasonally melt waters of small lakes at the terrace, being accumulated during the November-March period, can serve the evidence of no such potable water problem to exist for at least half-year period. If needed in other seasons (April to October), the potable water can be periodically delivered by a specially designed tank trailer from the nearest non-frozen pond – the Nizhneye Lake.

The comparative analysis of the initially selected sites showed that Site A combines the best characteristics for BAS location and should be considered as the top priority option. The characteristics of the alternative sites are provided in Section 2.4 below.

2.3. Possibilities to use the RAE Mount Vechernyaya field base infrastructure

The all-steel modular residential complex and other facilities of Mount Vechernyaya RAE field base are situated at 100-200 m distance northeast of the selected site. The Vechernyaya field base infrastructure was built in 1979. It was designed to accommodate year-round technical staff for IL-76 aircraft landing strip. Originally, Vechernyaya field base residential and production premises consisted of 13 individual and semi-detached buildings. For 10 years, until the end of IL-76 flights from the Soviet Union, Vechernyaya field base operated year-round independently. Since 2006 the field base has been accommodated by 2-6 BAE staff scientists in summers. Nowadays, Mount Vechernyaya field base residential and production premises compose of 7 individual and semi-detached buildings; the rest facilities were dismantled by the Russian Antarctic Expedition with participation of Belarusian specialists during the period 2006-2009.

At the present time the remaining field base infrastructure is worn out, partially destroyed, and unable to support the proper operation of the station and accomplishment of the objectives set by the National Program on Monitoring of the Earth's polar areas.

2.4. Station design concept and major parameters

2.4.1. Station design concept

The requirements for the national infrastructure creation in Antarctica are all-weather performance, versatility and space-saving design of most residential and service-specific modules.

Modern international experience in creating similar facilities of polar infrastructure, the practical experience of Belarusian explorers accumulated during their work in earlier Antarctic expeditions, and the need for the entire BAS infrastructure to comply with environmental safety requirements in order to limit adverse impacts on the Antarctic environment and ecosystems, were taken into consideration in the development of the BAS concept.

The BAS design is conceptually based on small modular structures, being assembled in Belarus, with their subsequent delivery by land, sea and air transport to Antarctica and installation on site by helicopter. Reference to the Belarusian Antarctic station creation plan, during the period 2014-2018 the following residential & production modules and service-specific blocks, pavilions and boxes will be deployed stage-by-stage, i.e.:

- laboratory & residential module, single-storey;
- service & residential module, single-storey;
- laboratory & residential module, two-storey;
- two production & residential modules, two-storey;
- sanitary & hygiene block;
- heated and unheated warehouse pavilions;
- garage & conservation box.

During the period 2014-2018, nine service & residential, kitchen & utility and production modules, specifically designed for operation in the harsh Antarctic environment, are expected to be delivered to Antarctica and installed on site.

At later periods (2019-2020 and further on), the following facilities will be deployed:

- non-magnetic pavilion;
- fuel & lubricant tanks (2 tanks of 50 m^3 each, 1 tank of 25 m^3, 2 tanks of 3-5 m^3 each);
- 2 diesel power stations of 100 kW capacity each;
- incinerator (waste disposal burner);
- press for empty fuel barrels disposal;
- jet dump device with sewage collector for water waste disposal to the coastal marine area;
- water supply system (to buildings);
- 2 refuel pumps (diesel/petrol) for motor vehicles.

Electric power will be mainly supplied by diesel generators and solar panels; in future, wind power generators are also planned to be used.

2.4.2. Structural features and major parameters of modules

Design features

Structurally, the Belarusian Antarctic station (BAS) will consist of separate modules of different functions. Each module will be built on a single fixed-site basement, elevated above the surface with manually operated outriggers, mounted under each corner of the module. The design project for the Belarusian Antarctic station modules was developed in 2012-2013 by Midivisana Ltd. BAS modules will be mounted to the basement on-site and fixed with special clamps.

The module is based on 20-ft container core with welded steel frame, made of shaped tube with 120 mm beam flange height.

The steel basement will be encased by panels. The panel encasement will be made of precast polyurethane sandwich panels with integrated special inserts for internal hardware to be installed. The module panels are fixed rigidly on metal rivets with sealing agent applied. The panel thickness, depending on its location in the module, varies from 75 to 120 mm. The internal insulating layer is made of rigid polyurethane foam with density of at least 70 kg/m^2.

Each panel will be composed of:

- siding: galvanised steel with white-coloured polymer coating;
- inner lining: galvanised steel with polyester coating;
- exterior finish elements of the wagon (hardware) - stainless steel;
- floor: wear-resistant linoleum;
- furniture and interior of the modules: water-resistant plastic-laminated plywood.

Windows: three-chamber double-glass PVC panes with swing-open mechanism, curtains.

Doors: inward open, fixed window at the front door. Metal profile water drains above each window. The access to the modules is provided from platforms, made of metal plates with punching. The ladder to the platform is non-folding, bolted. When in transport position, it is secured to the outer side of the module. When transporting, the entry ladder is removed.

The modules are equipped with lobbies. The internal walls and partitions are made of MDF with laminated coating. For most efficient keeping of indoor operating temperature, an automatic climate system is designed, with a backup device - electric heater.

Power supply system: The wiring will be made open through cable ducts. The power system will be equipped with switchboard / junction box, which integrates automatic circuit breakers and residual current circuit breakers. Metal parts of power installations, electrical housing and drives will be made in compliance with the regulatory documents and specifications. 380V separate socket and 220V outlet block will be mounted in each sleeping room and 3 blocks in the main room (under the table, at the stand for electrical devices and between the sink and refrigerator). External power source (380V) with earthing and a cable of 40 m long. The lights, both internal and external, have dustproof and waterproof design. Individual lights are installed near each bed and above the basin mirror.

Alternative power supply: solar panels with total capacity 1-1.5 kW at each module.

Emergency power supply: indoor-located high-capacity batteries.

Ventilation: forced plenum and extract ventilation, through open windows and doors. Backup device -side air vent with sealed cap.

Water supply: water heater, made of stainless steel with fittings and piping for user-friendly consumption.

Sanitary equipment:

For heating: electric boiler with automatic shutoff in case of water deficiency.

For water supply to consumers: water pumping system without a water tower installed.

Drainage system: downstream the drain siphon, a degreasing station is installed, providing waste water purification from fat and impurities with further water forwarding to the sewerage system.

Excreta disposal system: electric toilet (Incinolet) with recovery system will be installed in the residential modules. The processed residues (ash) will be disposed as household wastes.

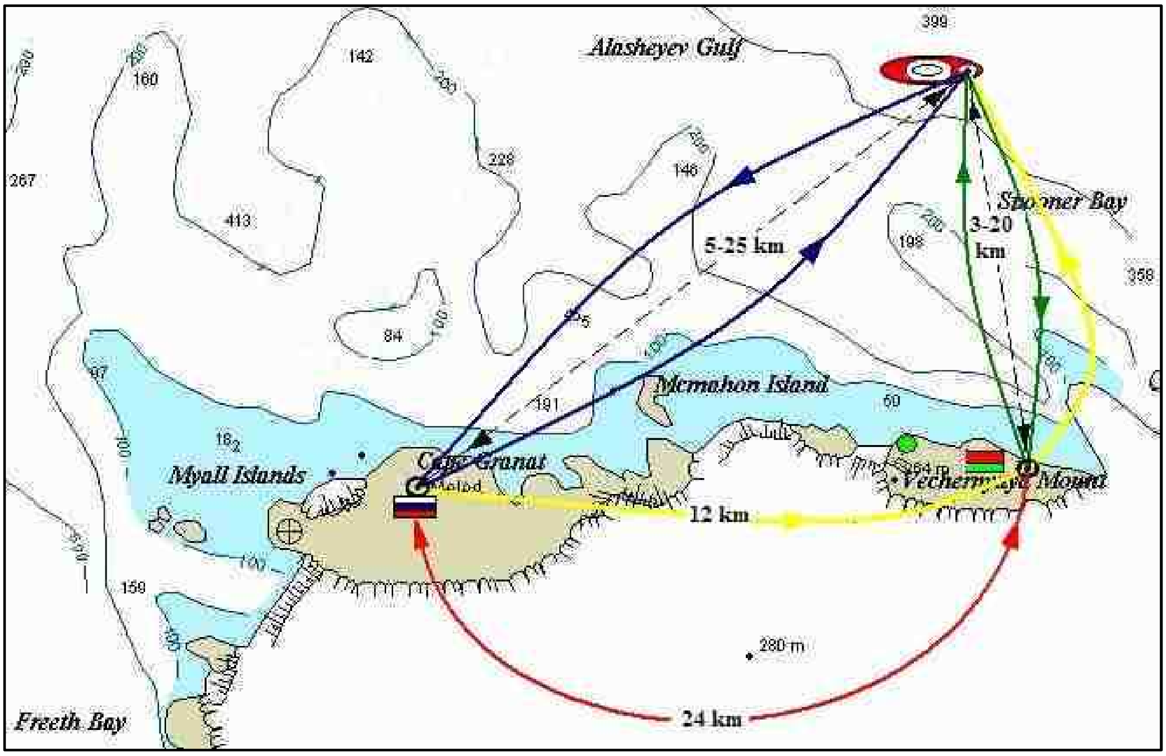
Drainage: drainage system with a set of heated pipes and fittings, with optional connection to the central collector or wastewater storage tank of heated double-layer wall design.

Communication devices: cable gland for connecting automatic exchange open lines and socket connections.

The general view of the planned Belarusian Antarctic station (modules deployment option) is shown at Figure 2.3 below.

Figure 2.3 – General view of several BAS modules (architectural design)

The modules will be pre-assembled and transported to the operation site in Antarctica by sea (on RAE ships) and air (Ka-32 helicopter) (Figure 2.4).



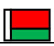
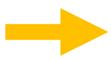
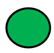
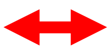
Symbols	Description
	Russian Antarctic Molodyozhnaya station
	Mount Vechernyaya field base of the Belarusian Antarctic expedition
	Research supply ship with helicopter landing spot
	Helicopter flight route for Molodyozhnaya RAE logistics & procurement
	Helicopter flight route for BAS modules delivery
	Possible helicopter transit route through Molodyozhnaya RAE to Mount Vechernyaya field camp for BAS instrumentation and equipment deliveries
	Adelie penguin colony at Gnezdovoy Bay 3.5 km along the coast to the west from BAS Mount Vechernyaya field camp
	Land route for transport vehicles shuttling between RAE Molodyozhnaya field base and BAS Mount Vechernyaya field base

Figure 2.4 – Plan of the modules delivery from ships to the construction site

Parameters of modules

The modules are designed to operate at the following conditions:

- ambient outdoor air – from -60 to +40°C;
- atmospheric pressure – from 60 to 107 kPa (450 to 800 mm Hg);
- relative humidity ranging 30 to 98%;
- resistant to snow, rain, frost and wind (blasts up to 70 m/sec).

Modules feature different sizes and accessories. The major parameters of modules are given in Table 2.1 below.

Table 2.1 – Types and major parameters of BAS modules

Module type	Dimensions, mm			Overall weight, kg
	Length	Width	Height	
Laboratory & residential, single-storey	6058	7314	2438	8900
Service & residential, single-storey	6 058	7314	2 438	10250
Laboratory & residential, two-storey	6 058	2 438	4 876	6300
Production & residential, two-storey	6 058	6 058	4 876	9 300

<u>The laboratory & residential single-storey module</u> (Figure 2.5) composes of:

- 2-section prefabricated platform-basement;
- one lab & household butterfly-type wagon section (single-sided);
- one container-type service & residential wagon section.

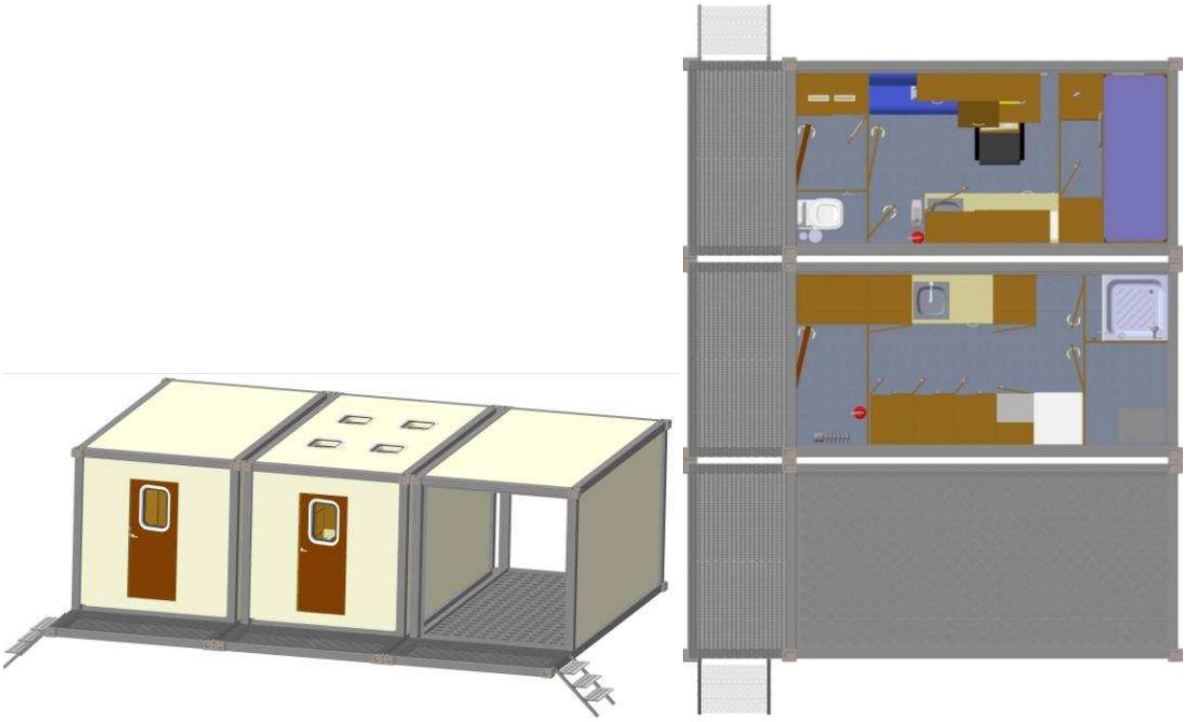


Figure 2.5 – General view (A) and layout (B) of the laboratory & residential single-storey module

<u>The service & residential single-storey module</u> (Figure 2.6) composes of:

- 3-section prefabricated platform-basement;
- two container-type service & residential wagon sections;
- one container-type household wagon section.

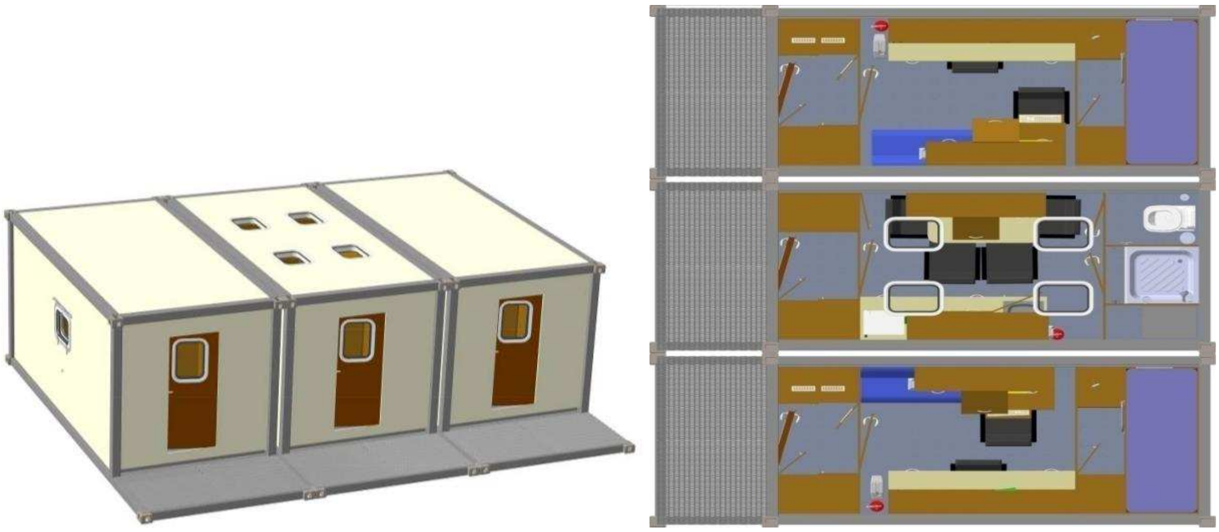


Figure 2.6 – General view (A) and layout (B) of the service & residential single-storey module

<u>The laboratory & residential two-storey block module</u> (Figure 2.7) composes of:

- one container-type service & residential wagon section;
- one block (wagon section) for communications, navigation and routine weather monitoring.

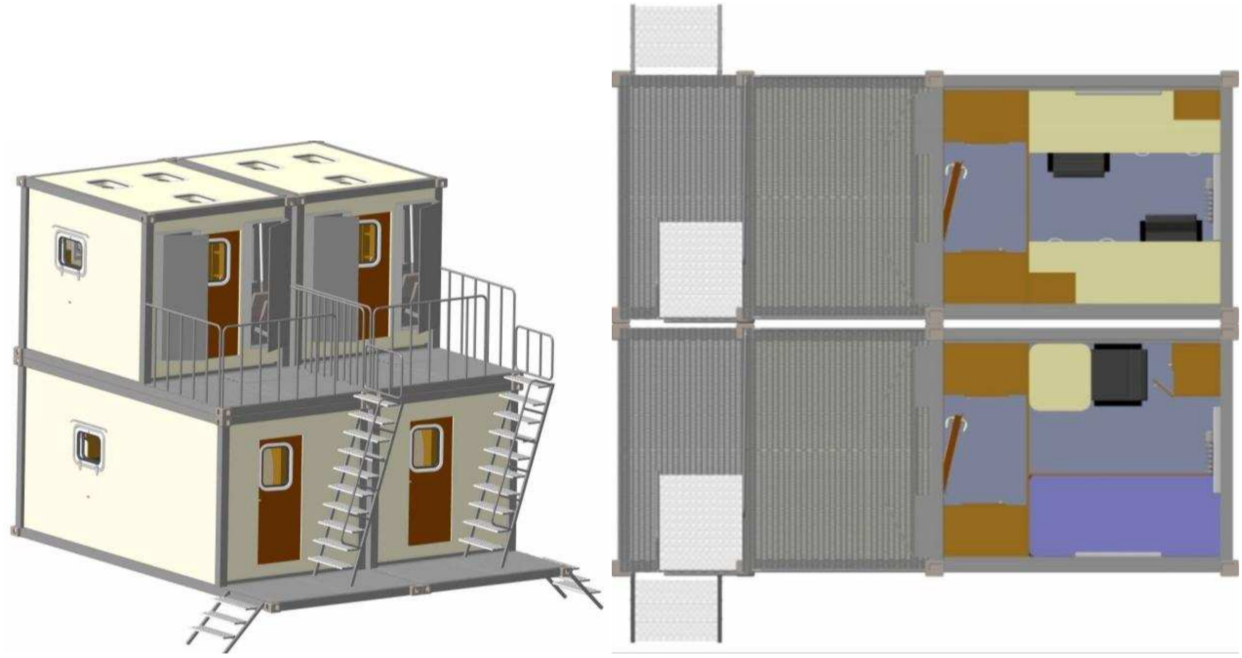
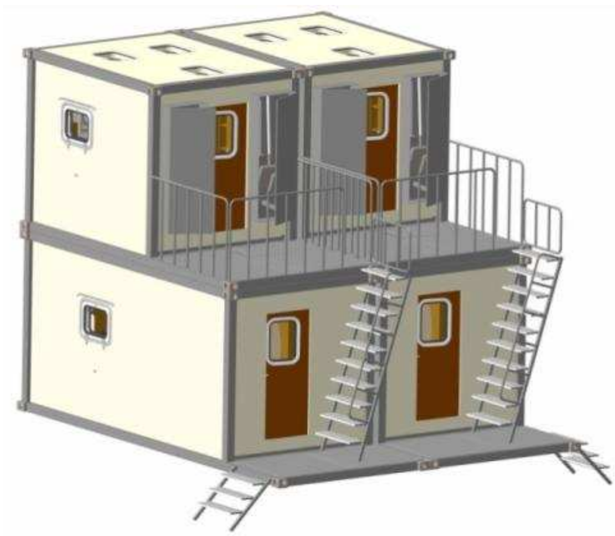


Figure 2.7 – General view (A) and layout (B) of the laboratory & residential two-storey module

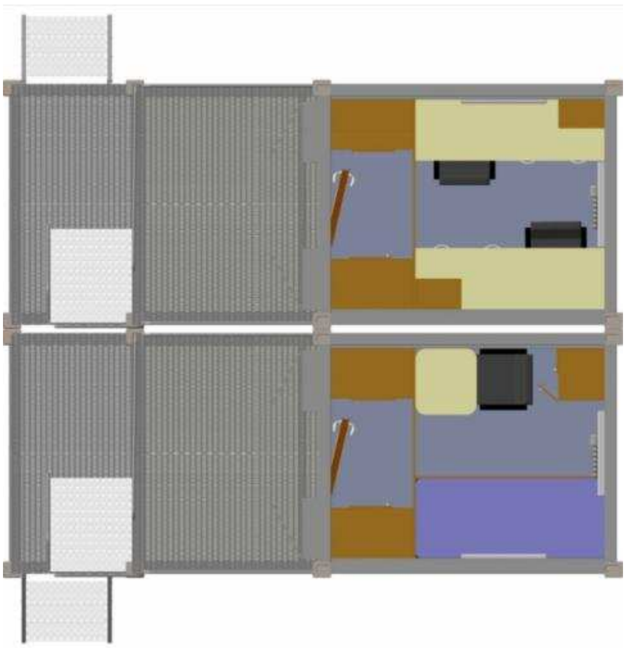
<u>The production & residential two-storey module</u> (Figure 2.8) composes of:

- simplex prefabricated platform-basement;
- container-type residential wagon section (lower block);
- container-type production wagon section (upper block)

A)



Б) В)



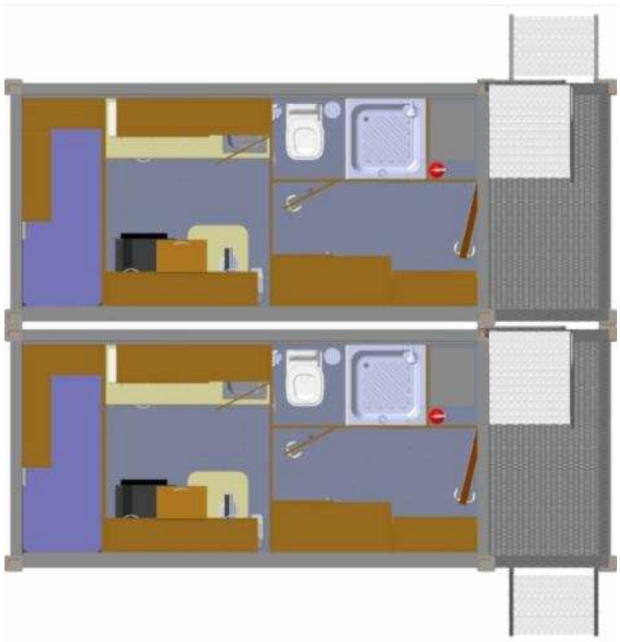


Figure 2.8 – General view (A) and layout (B) of the production & residential two-storey module

The modules will be mounted on platform-basements and fixed with outrigger jacks and extra telescopic adjustable legs. To install the container-type wagon section onto the basements, easy-removable ladders and enclosures will be used.

Some special-purpose wagon sections will be equipped with self-contained power supply systems.

In general, the complex of multi-purpose modular structures for the Belarusian Antarctic station is designed to provide all life-sustaining conditions during the seasonal (up to 6 months) and wintering (up to 18 months) Belarusian Antarctic expeditions in the extreme climatic environment of Antarctica.

The design lifetime of the modules – min. 15 years.

The detailed BAS modules specifications are given in the Annex 1.

The on-site disposition of the BAS facilities is given at Figure 2.9 below.

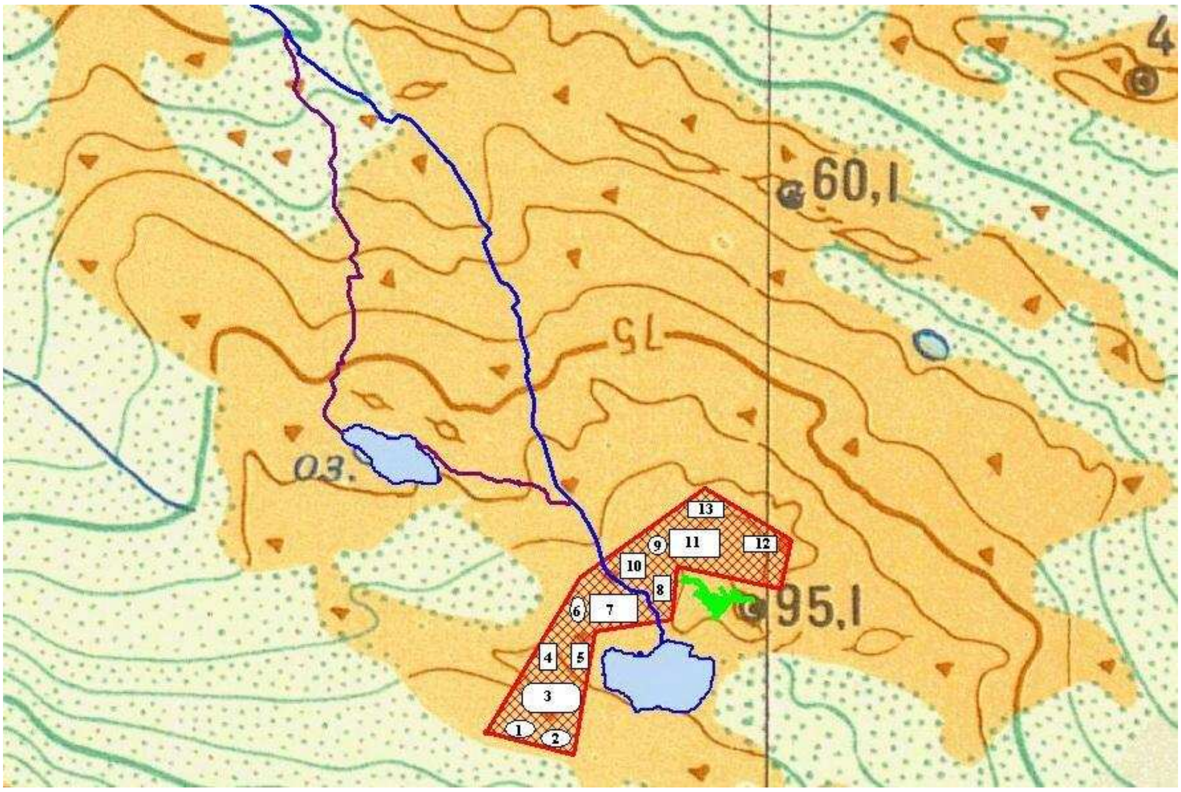


Figure 2.9 – BAS facilities allocation at construction site: 1 and 2 - 50 m^3 fuel & lubricant tanks; 3 - Semi-detached containers with diesel power station of 20, 60 and 100 kVA capacity; 4 - incinerator (waste burner); 5 – sanitary unit; 6 - 25 m^3 fuel & lubricant tank; 7 – garage & storage facility box; 8 - production & residential two-storey module; 9 - jet dump device with sewage collector for water waste disposal; 10 - two semi-detached warehouse pavilion (heated and unheated); 11 – laboratory & residential container module; 12 and 14 - semi-detached laboratory & residential and industrial & residential block modules; 13 – service & residential container module.

2.4.3. Power supply system

The station's power supply system will be based on diesel generators and also solar power installations. The first phase of BAS construction is expected to operate the existing diesel generators of DG-20 AD16-T400-2RP, DG-60 AD60-T48C-2RP and GEKO 6401 type, currently located at Mount Vechernyaya field base; specific fuel consumption ranging 1.43 to 15.5 l/h, diesel fuel (Table 2.1), as well as generators with petrol engines (3 pcs.) as standby facilities, and diesel-operated blow heaters (Table 2.2).

Table 2.2 – Parameters of diesel generators to be used at the BAS

Generator type	Fuel consumption, depending on output, ref. to the manufacturer's specifications		Type of fuel	Actual fuel consumption in Antarctic conditions
	% output/kW	l/h		
DG-20 AD16-T400-2RP	100/16	5.4	diesel	5.94
	75/12	4.6	diesel	5.06
	50/8	2.7	diesel	2.97
	idle run	1.5	diesel	1.65
DG-60 AD60-T48C-2RP	100/48	14.1	diesel	15.50
	75/36	10.8	diesel	11.88
	50/24	7.4	diesel	8.14
	idle run	3.0	diesel	3.30
GEKO 6401	100	1.8	diesel	1.98
	50	1.3	diesel	1.43

Table 2.3 – Parameters of blow heaters and petrol engines to be used at BAS

Unit type	Fuel consumption, depending on output, ref. to the manufacturer's specifications		Type of fuel	Actual fuel consumption in Antarctic conditions
	% output/kW	l/h		
Blow heater, 20 kW	100/20	3.3	diesel	3.30
Blow heater, 44 kW	100/44	4.0	diesel	4.00
MAKITA power generator, 4.2 kW	100/3.5 50/1.75	2.5 1.3	petroleum	2.75 1.45
GEKO 7401ED-AA power generator	100/6.4 50/3.7	3.3 1.8	petroleum	3.63 1.98
GEKO 1001E-S/UHBA power generator	100/0.7 50/0.35	0.64 0.32	petroleum	6.5 0.35

As part of the laboratory & residential two-storey module, 2.5-3.5 kW (service & residential) and 1.0-1.5 kW (communication unit) emergency power generator are planned to be integrated.

All laboratory & service modules will accommodate rotary metal frames with adjustable inclination for solar panel installation.

The power from the generators to the station modules will supplied on overhead lines.

2.4.4. Water supply and drainage

The amount of fresh water, as required for BAS seasonal operation (5-6 persons), is expected to count (min.) 5.0-6.0 m^3 per month, the rated water consumption for 10-12 people in winter is (min.) 9.0-10.0 m^3 monthly. For four months' period (November-February), potable water will be taken from the nearby seasonal lakes. The water will be pumped to metal water tanks placed directly in the BAS kitchen & utility modules. In the other periods, the water will be transported from the Nizhneye Lake in special tanks mounted on a sled.

During the BAS first-phase construction and operation (2014-2018 years), each kitchen & utility module (wagon section) will be equipped with a system for collecting wastewater / storage tank (400 l capacity with internal heating). The storage tank will be transported separately and mounted underneath the wagon section following the platform-basement deployment. Upon wastewater accumulation it will be pumped from time to time into a special container on a sled for further domestic wastewater discharge to the seacoast locations, which are reported to be fit for initial dilution and rapid dispersal.

At the second phase (2019-2020 and later), a jet dump device is expected to be built for waste water disposal through central sewage collector to the coastal marine area. For domestic wastewater discharge to the central collector, a powerful hydraulic pump will be used. The wastewater is planned to be discharged through the central collector directly into the sea in areas, which are reported to be fit for waste waters initial dilution and rapid dispersal.

All BAS kitchen & utility modules (wagon sections) will be equipped with electric toilets (Incinolet) and showers. The service & residential modules may alternatively be equipped with portable bio-toilets.

2.4.5. Waste management

The station operation will be inevitably accompanied by solid waste generation. Improper waste management might cause environmental problems due to waste accumulation.

According to estimates (see chapter 4.1.2.6) in case of 5-6 people engaged in the BAS field season operation, the following wastes will be generated per season: 700-1000 kg of household wastes, including 180-290 kg of food wastes and 240-300 kg of combustible wastes as allowed for incineration under the Protocol on Environmental Protection. At year-round operation number of wastes will be approximately 6 times higher.

During vehicles and equipment operation and maintenance, a significant amount of industrial wastes, including barrels from fuel, lubricants, antifreeze, defective engine parts and equipment, etc. will be generated. In particular, the amount of annual accumulation of empty fuel & lubricant barrels during the first phase station operation will be 15-20 pieces.

The service and maintenance of diesel generators and vehicles will produce oil sludge (waste oils) and antifreeze. The total amount of oil sludge to be generated is estimated at 100 liters per month, the waste antifreeze – no more than 50 liters per month.

A separate waste collection, including combustible, non-combustible, food, oil sludge, fuel & lubricant containers, etc. will be organised. Any combustible wastes can be accumulated and further incinerated at RAE Molodyozhnaya station incinerator in accordance with the Protocol on Environmental Protection (until the incinerator is installed at BAS); non-combustible wastes, including hazardous substances, are planned to be stored on-site in containers and barrels, until removed to the continent. Food wastes will be dumped into the sea in accordance with the requirements of the Protocol on Environmental Protection.

Oil sludge and waste antifreeze will also be accumulated and further transported to the continent.

The incinerator parameters and projected emissions are given in Section 4.1 below.

2.4.6. Logistics

According the existing agreements, the delivery of the station modules and cargo, as may be required for the BAS construction and operation and further research activities will be carried out by Academician Fedorov and Academician Treshnikov RAE ships generally engaged to supply RAE research stations, including Molodyozhnaya field base. The modules and cargo will be transferred from the ships to the station construction site by Ka-32 helicopters. The parameters of the vessels and helicopters are given in Section 4.1.

2.5. BAS construction alternative sites at Mount Vechernyaya locations and zero alternative

2.5.1. Alternative sites at Mount Vechernyaya

Site B. This site is located on the Nizhneye lakeside, opposite to Mount Vechernyaya field base at approx. 350 m distance from the base' residential premises and ~20 m above the Nizhneye lake surface.

The site features a slightly rugged plot of rocky outcrops, sized 150x50 m. It borders on the Nizhneye lake basin from the south-western side and on a small rocky ridge from the north-east, sloping steeply to the coastal ice barrier.

Site C. Located at the same line with the core group of buildings and structures of Mount Vechernyaya field base, at 250 m distance from the outermost field base building (diesel generator).

It features a slightly rugged plot of rocky outcrops, sized approx. 100x100 m. In the vicinity, there are two small, freezing in winter, fresh water reservoirs.

These sites, as well as the principal site (Site A), are situated at 2 km vicinity from each other at similar locations. Site D was also subject to alternative consideration, which is located at Granat Cape ~ 1.2 km north-east from the residential centre of Molodyozhnaya field base. It is a slightly billowy plot at Molodyozhny oasis territory, sized ~ 250x250 m.

The alternative options, as examined, presuppose the station to be built outside oasis boundaries (no nesting birds and/or places with high biodiversity, etc.), and therefore will not be significant differences in the environmental impacts when choosing any site option. Reference to the comparative analysis of the selected sites, Site A possesses the best characteristics for BAS deployment.

2.5.2. Alternative construction sites in other Antarctic areas

Other BAS placement options in other Antarctic regions were further analised, taking into consideration scientific, environmental, logistic and other aspects. However, no alternative site for BAS placement was reported to meet all the criteria to a greater extent than that at Mount Vechernyaya location selected.

2.5.3. Zero alternative (no construction)

As a zero alternative option, renovation and continuation of use of the Mount Vechernyaya field base infrastructure was subject to analysis. However, continued use of the residential premises and other RAE field base infrastructure turns out to become increasingly problematic due to their deterioration and incompliance to the Antarctic environmental protection requirements.

Therefore, the zero alternative option seems to be only a temporary postponement of own station construction.

Unavailability of existing facilities hampers substantially the development of scientific research, increasing the number of staff involved in BAE, making the field season longer and thus jeopardising the proper implementation of the National Program in its entirety.

The up-to-date station construction would benefit to friendlier environment for living and working of polar explorers and contribute to reduced impact on the environment.

3. Initial Environmental Evaluation

3.1. General geographic description and relief

The natural complex known as Mount Vechernyaya is located at the western part of Enderby Land, Tala Hills (eastern part), at the coastal area of the Alasheeva Gulf, Cosmonaut Sea. It incorporates a series of rocky ridges with a dominant mountain, the Mount Vecherniaya (272.0 m), and several lower ridges, breaking through the Antarctic ice sheet on the Cosmonauts Sea shore. The Alasheeva Gulf cuts inland with the Vechernyaya, Lazurnaya, Terpeniya and Zarya Bays, which are separated by the Rog, Gnezdovoy and Dostupny Capes (Figures 3.1-3.2). The Hayes outlet glacier, flowing into the sea on the ice-covered valley, can be treated the eastern boundary of the area.

The area stretched about 8 km along the seacoast; its utmost width is about 2 km. Geographically, the area can be treated as a western extension of adjacent Molodyozhnaya station oasis. Topography, the area belongs to the exarational low rocky hills near Mount Vechernyaya, consisting of several ridges extending substantially parallel to the seashore of Terpeniya Bay with focus to the north-west. The ridges are max. 1 km long and about 150 meters wide. The north-eastern slopes of the ridges are steep and short, sometimes precipitous, while being flat at the south-west (Figure 3.3). The ridges are separated by terraced valleys, with glaciers and river beds of temporary streams at the bottoms. In particular, to the east of Mount Vechernyaya, there is a flat mountain terrace of about 350 m long and 50-80 m wide, turning into an elongated southeast slide, which houses freshwater lakes (Verkhneye and Nizhneye) connected with a temporary watercourse. The elevation drop between the terrace and Nizhneye Lake is 50-60 m. The availability of lakes makes the Mount Vechernyaya area similar to the other Antarctic oases.

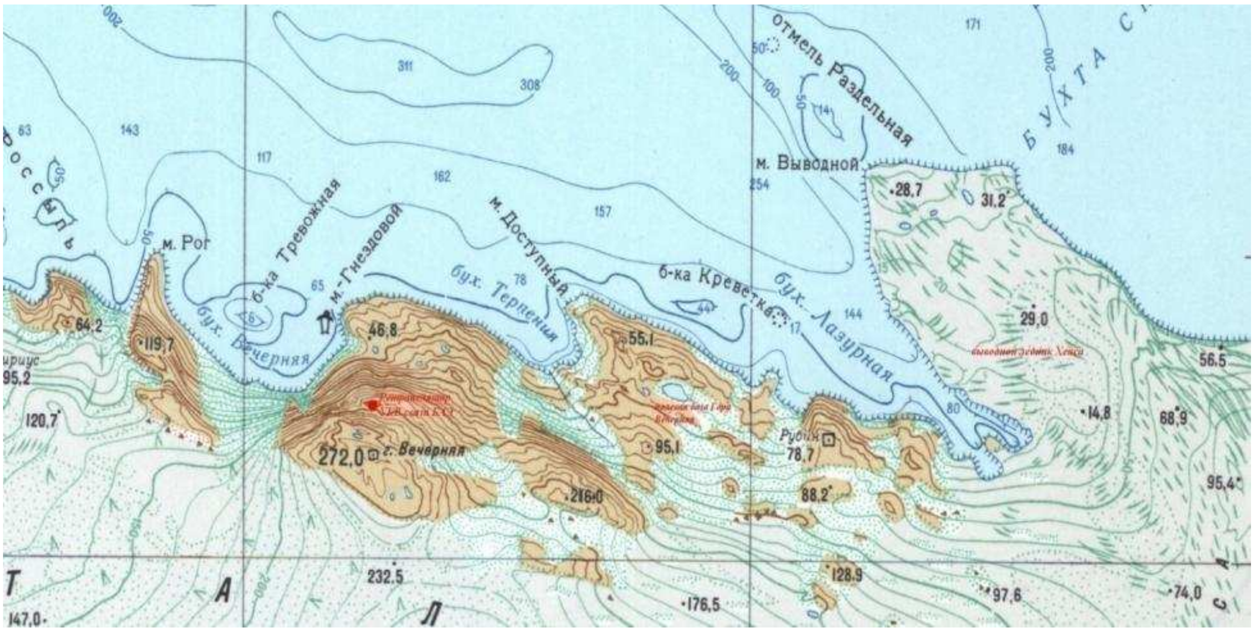


Figure 3.1 – Topographic map of Mount Vechernyaya area

To the south of Mount Vechernyaya, a gradually rising slope of the Antarctic ice sheet is located. It gains 350 m height at 3 km distance from Mount Vechernyaya and 1000 m height at 70 km distance.

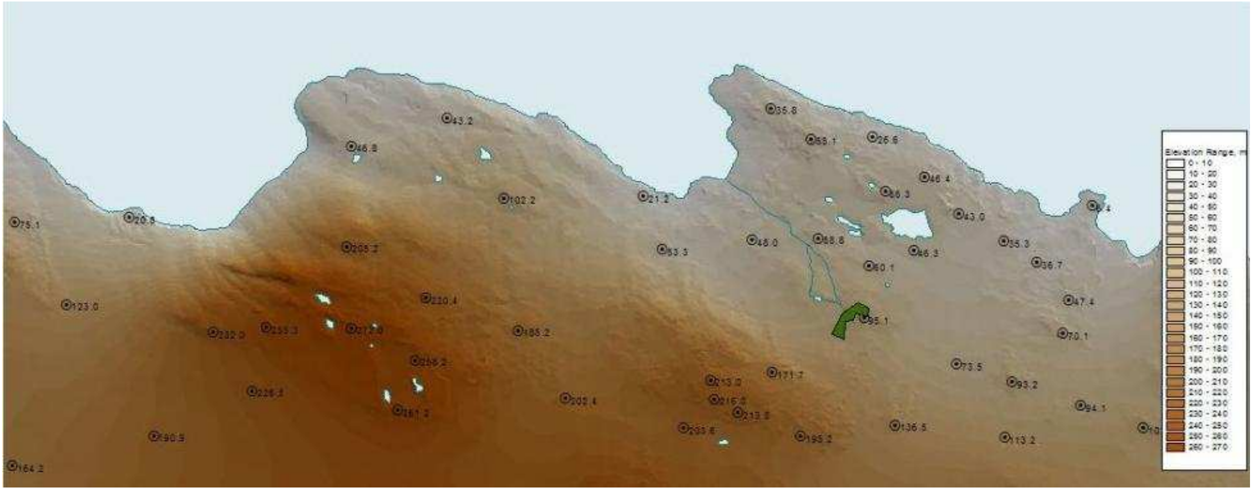


Figure 3.2 – Hypsometric map of Mount Vechernyaya

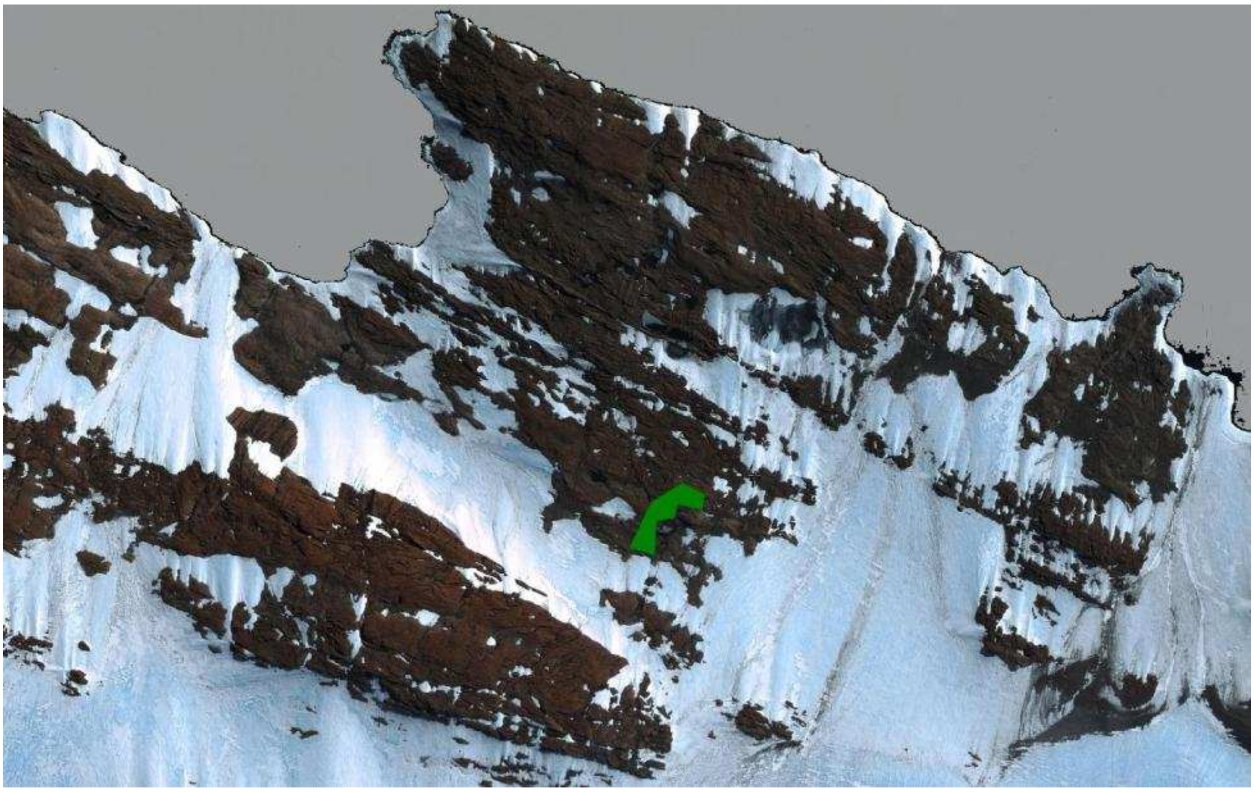


Figure 3.3 – Google map of Mount Vechernyaya area (site of planned BAS location is shown)

3.2. Sea and sea ice

The Cosmonauts Sea description is given under the Electronic directory on the Antarctic environment (http://www.aari.aq/gis/web/kosm/opisanie.html). The Cosmonauts Sea area is about 435,000 km^2. The Cosmonauts Sea coast stretches over 1,200 km and looks almost everywhere as a ridge of ice cliffs of 10 to 30 m high and more (Figure 3.4). Being rather tortuous, the coast line forms large peninsulas with bays in-between, including the Alasheeva Gulf. In the bays there are small ice-free islands, detached or in clusters.

Figure 3.4 – Coast line at Mount Vechernyaya

The shelf width in the Cosmonauts Sea varies from 80 km average in the west to 40 km of Enderby Land north ridge in the east. The Gulf's coastal bottom topography turns out to be similar to the structure of the inland coast: characteristic ridges and valley-typical slides, trending northwest. Except for some basins with thick silt deposits, the shelf is almost completely covered with sand and siltstone sediments.

Drifting ice

The stable autumn ice formation begins at the Cosmonauts Sea coastal area only in the second half of March, while in other Antarctic basins - in late February - early March (http://www.aari.aq/gis/web/kosm/opisanie.html). However, a significant expansion of the ice belt is inhibited until April. The rocketed increase in ice cover occurs only in May-July, when the ice moves rapidly to the north from average latitude 67° S to 62° S. In August, it usually extends to latitude 60° S, where it stabilises until the spring thaw in late October, shifting slightly to the north to 59° S. Unlike most Antarctic areas, the Cosmonauts Sea ice belt grows to its maximum size by mid-October, i.e. a month later. The ice cover pool in this area reaches an average of about 0.9 mln. km^2, and its edge extends to latitude 59° S.

The ice cover is reported to step away basically in two summer months - from December to January. The drifting ice belt width is reduced in this period by 400-500 miles, with the pool edge retreating in January to latitude 67° S. The following reduction of the sea ice cover in February and March mainly depends on the intensity of the local fast ice breaking.

Fast ice

The Cosmonauts Sea refers to the relatively small number of marginal seas of the Southern Ocean with well-developed fast ice (http://www.aari.aq/gis/web/kosm/opisanie.html).

The stable formation of fast ice in the Cosmonauts Sea starts generally in the first half of May, and after about a month it covers the entire shelf zone of the basin, laying there until spring break in October. The fast ice usually keeps on growing until early November, reaching the thickness of about 1.5 m.

The fast ice in the Cosmonauts Sea starts to break in October and goes on through April. The destruction of the fast ice is finalised, as a rule, with beginning of the new autumn ice formation in the Alasheeva Gulf at the second half of March. Therefore, in most cases, it is not actually removed in its entirety. However, on-going removal of the fast ice hacks actually benefits to annual 'washing' of the old bay ice.

Currents

The main elements of the large-scale circulation in the area are the east-directed stream in the northern part of the sea and the Antarctic slope stream, which transports waters in general westerly direction along the Antarctic continental slope. The northern part of the sea is characterised by large-scale anti-cyclonic meander east of longitude 35° E, with its southern peripheral water turning to the west at longitude 50° E.

3.3. Geology and soils

Geologically the Enderby Land belong to East Antarctic Platform or Antarctic Precambrian Crystalline Shield. The area's structural formation can be traced back to the paleoproterozoic age. According to the research performed by RAE and BAE the territory of the Mount Vechernyaya area is composed of mainly enderbite and charnokite gneisses and plagiogneisses. Reference to the investigations made, the Mount Vechernyaya plot area developed under linear granite-gneiss dome-type pattern.

Soils

The soils in the area of planned BAS construction are forming only in places that are not covered by glaciers, where there are conditions for the accumulation of friable material of colluvial and fluvio-glacial origin – mainly in depressions and water flows hollows (Figure 3.5). The area occupied by soils within the BAS site takes no more than 5-10% of the ice-free surface (similar to the other Antarctic oases). The rest territory is represented by solid rocks.

A) B)

Figure 3.5 – Examples of soil formation at the BAS deployment area: a) at the lower part of slope; b) in a hollow

Parent rocks are products of bedrock weathering, exposed to gravitational movement – colluviums, as well as fluvioglacial deposits. The soils are poorly developed, the upper layers are formed by detritus & gravel and sand & gravel materials, coloured gray-brown and brown. Such differences in soils can be explained by terrain features and moisture effects due to snow melting at summers and further distribution of melt waters. These kinds of soils can be classified (*Abakumov, Krylenkov, 2011*) as nano-litozem (or petrozem), generally characteristic for the Antarctic coastal area. The soil depth basically does not exceed 20 cm.

The beds (bottom) of temporary (seasonal) streams accumulates a fine fraction of weathering products; due to movement of waters, in some cases, similar-to-alluvial deposits are formed, predominantly represented by coarse sand (Figure 3.6).

Figure 3.6 – Fluvioglacial deposits at temporary stream beds

According to the investigations made (*Lupachev et al, 2012; Abakumov, Lupachev, 2011-2012*), the intact Antarctic oases soils contain from 5-10 to 30% of silt (fractions under 1 mm diameter). The ratio of physical sand and physical clay turns to be almost equal for different types of soil, amounting to 85-95/5-15%. The soils in elevated areas, devoid of vegetation, demonstrate mainly low-alkalinity reaction; the soils are characterized with low C_{org} content (0.2-1%). At the areas of lichen vegetation, the soils are slightly acidic or acidic, C_{org} reaches 8-10%.

The soils are mostly uncovered by vegetation, although algae (in rare cases – crustose lichens) quickly develop in rock crevices and melkozem substrate in their short growing season, thus playing an important role in weathering and soil formation.

At penguin habitats to the north-east of the intended BAS deployment, specific organic soils (or mineral organic soil-similar substrates) are generated under guano layers. In general, the organic substances of animal origin (guano, feathers, tissue and bones of birds and other animals), enriching the soils and ground with nitrogen and phosphor, play an important role in soil formation in Antarctica.

Chemical analysis of soil samples performed showed that the loss on ignition ranges 0.4 to 1.54%, averaging 0.9%, indicating low content of organic material in the soil. The deposits of temporary stream beds are mainly represented by minerals, having the loss on ignition factor of less than 0.01%.

The mineral part of the soils sampled at different sites in the vicinity of Mount Vechernyaya is characterised by the dominance of silicon compounds (average content – 63.4%); content of iron and aluminum compounds – 14.1% and 8.0% respectively; content of calcium oxide, sodium, potassium and magnesium – 4.5%, 3.5%, 2.3% and 2% respectively.

The structure of temporary stream deposits is also dominated with silicates, although their content is somewhat lower than in the soils (Table 3.1). At the same time, as compared to soils, increased iron oxide (13.3%) and calcium oxide (6.0%) content is reported.

Table 3.1 – Macroelement content in soil samples taken at Mount Vechernyaya sites, %

Year	Sample No	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	Loss on ignition
2012	1	60.17	0.93	14.49	10.1	0.10	3.11	4.47	1.96	3.25	0.29	0.13	1.15
2013	1	57.07	2.13	12.77	13.28	-	6.00	3.23	2.00	2.50	0.51	<0.10	<0.01
	13	64.86	0.99	13.77	8.12	-	4.87	1.89	1.8	3.56	0.18	<0.10	0.46
	25	63.4	0.71	14.18	8.02	-	4.87	1.89	2.04	3.63	0.18	<0.10	0.52
	27	64.82	0.72	14.14	7.29	-	4.50	1.35	2.30	3.63	0.24	<0.10	0.86
	29	63.72	0.68	13.95	7.26	-	4.87	2.43	1.80	3.63	0.26	<0.10	1.54
	31	63.09	1.01	13.89	8.92	-	4.50	2.16	1.90	3.30	0.21	<0.10	0.4
	34	63.92	0.77	14.14	6.94	-	4.50	1.89	2.20	3.50	0.21	<0.10	1.19

3.4. Glaciers and inland waters

Glaciers

Glaciers cover about 70% of the Mount Vechernyaya territory. They mainly belong to the icecap - part of the East Antarctica ice sheet. The ice sheet slope is 3.5º average. It has is reported 10-20 m thickness at the coastal area, while reaching 500 m thickness at 10 km distance from the seashore.

The coastal areas are characterised by strong differentiation of the ice cover profile. The areas with relatively even subglacial topography are covered with hilly glaciers, with ravines and terraces on the surface, specific micro-relief due to wind performance and accumulation of snow. Areas with steep slopes of subglacial relief generate ice-broken platforms with numerous cracks (*Kotlyakov, 2000*). The cracks in the ice sheet are observed within 20-30 km strip along the seacoast. Cracks are also characteristic for the Hayes outlet glacier.

The icecap flows down to the Cosmonauts Sea with 10-30 m high ledges. Apart from the main ice sheet, the leeward slopes of the Tala Hills ridges are covered with isolated wind-blown glaciers and perennial snowfields.

The speed of undifferentiated ice sheet edge in this area is assessed to be average for Antarctica at about 100 m / year, according to V. M. Kotlyakov (*2000*).

Trough depressions of subglacial relief accommodate outlet glaciers, moving inside the ice sheet at relatively high speeds. The Hayes outlet glacier borders on the area in the east. The absolute heights of the Hayes glacier at the Lazurnaya Bay area do not exceed 30 m, with glacier speed ranging 900 to 1400 m / year, according to different estimates.

The accumulation of ice cover at the Enderby Land coastal area is estimated at 20-40 g/cm^2. The firn snow thickness ranges from zero to 80 m, depending on snow accumulation (*Kotlyakov, 2000*), the firn snow age averages to 60-70 years.

Figure 3.7 – View of the excurrent Heys Glacier from field camp Mount Vechernyaya

Figure 3.8 – Crevasse at Heys Glacier

Lakes

In the Mount Vechernyaya region more than twenty permanent and temporary lakes were identified. Their surface area ranges from several tens to several thousands of square meters, with depths ranging from several tens of centimeters to 20 meters or deeper.

А) Б)

Figure 3.9 – Permanent and seasonal fresh water lakes at feld camp Mount Vechernyaya

The largest lakes are located near the Mount Vechernyaya – Nizhneye Lake (about 1.5 ha) and Verkhneye Lake (0.15 ha). These lakes are connected by a temporary watercourse. The water level of the lakes is unstable and depends on the melting snow intensity. Periodically, the inland water is discharged into the sea, thus resulting in significant shallowing of the lakes.

The Nizhneye Lake is covered with ice all-the-year-round, only a narrow discontinuous rim free of ice is opened by late summer. According to the bathymetric survey of 2008, the maximum depth of the lake is 3-3.5 m.

The Verkhneye Lake is completely free of ice by mid-summer. Freezing occurs no earlier than by mid-February. The lake is deep, with max. 20 m depth. The thickness of ice cover in winter reaches 2-2.5 m and more.

Reference to BAE studies performed, the lakes' bottom sediments are reported to be represented mainly by sand fractions with inclusions of gravel, uniform in colour (gray-brown, gray-black, green). The organic part of the sediments is formed by algae residues, with the loss on ignition factor ranging 11.4 to 23.8%. The macroelement content in the lake sediments is similar to that of inland soils (Table 3.2), which serve the source of mineral particles brought with melting water. It should be noted that, in some cases, the loss on ignition factor of the Verkhneye Lake sediments reached 66.4%, proving the heterogeneity of the emerging deposits.

Table 3.2 – Macroelement content in bottom lake sediments at Mount Vechernyaya area, %

Sampling site	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	Loss on ignition
Nizhneye Lake	54.56	1.22	12.46	7.74	0.21	0.38	4.59	3.6	2.2	0.43	0.21	12.34
Verkhneye Lake	47.36	0.92	11.48	5.47	0.1	0.38	4.59	2.35	2.35	0.47	0.47	23.84
No Name Lake	56.00	0.77	13.95	5.46	0.15	3.11	3.35	2.30	3.00	0.25	0.26	11.43

3.5. Meteorology and climate

The peculiarities of the western Enderby Land atmospheric circulation are predominated by interaction of pressure systems prevailing in the middle and high latitudes of the Southern Hemisphere.

The radiation environment in the area is determined by its position beyond the Arctic Circle, nature of the underlying surface, sunshine duration and ambient air conditions.

The annual ambient air temperature is characteristic for Antarctica, with maximum values in summer (January) and minimum values in winter (July). The average monthly air temperature drops by 7.3°C from February to July and increases by 0.9°C from July to September.

The second half of winter (July-September) is the coldest season, and almost all the absolute minimum temperatures were recorded in these months, reaching -42°C (Figure 3.10).

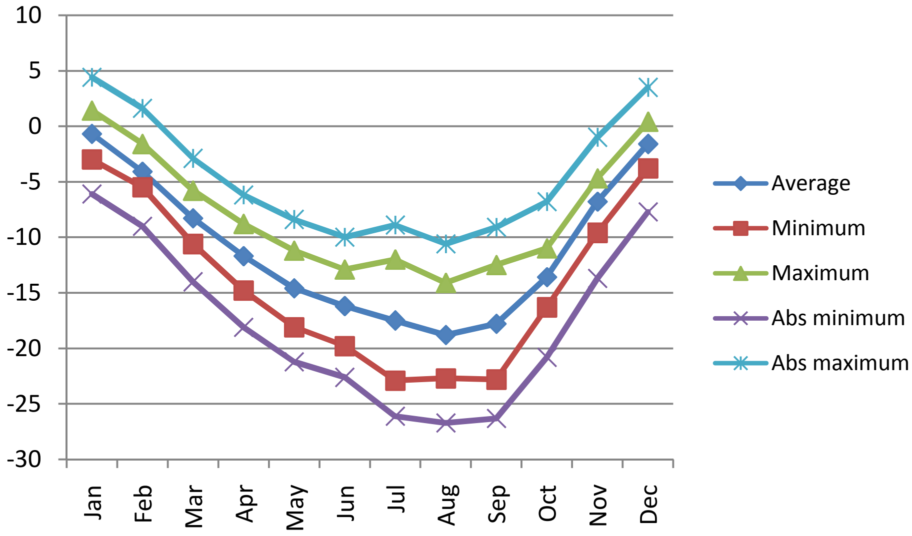


Figure 3.10 – Annual temperature ranges, ˚C, by data of Molodyozhnaya (1963-1999)

The given region is dominated by winds from the east-north-east to south-south-easterly direction with an annual frequency of occurrence of 85.7%. While east-north-eastern winds are associated with cyclones that prevail in the period from August to January, the south-south-eastern winds are of anticyclonic or katabatic origin, blowing in the period from February to July.

This area is dominated by winds from the east-north-east to south-south-easterly direction, their annual frequency - 85.7% (Figure 3.11). While east-north-eastern winds are associated with cyclones that prevail in the period from August to January, the south-south-eastern winds are of anticyclonic or katabatic origin, blowing in the period from February to July.

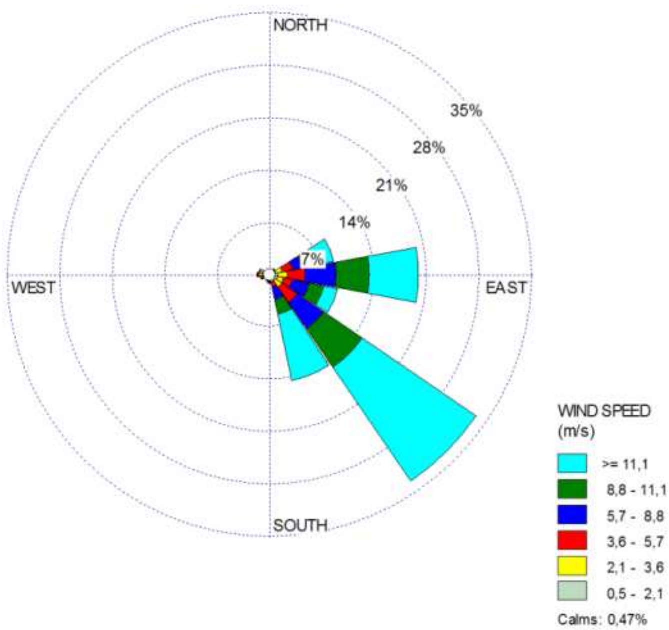


Figure 3.11 – Wind rose by data of Molodyozhnaya station

Calm weather is not typical, the maximum frequency of calms is reported in July-December, while in February-April they range only 0.2-1.0%. Calm weather is generally reported upon changing of the prevailing types of weather.

Both during long-term studies and at summer season monitoring, strong winds of 11 m/sec. and more are most frequently reported (Figure 3.12).

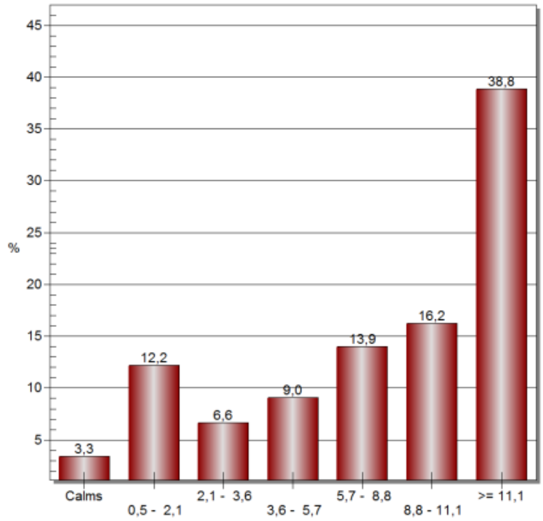


Figure 3.12 – Frequency of winds by data of Molodyozhnaya station (1994-1998 гг.)

The highest wind speed have been recorded in March and April; January and December are relatively less windy. The maximum average monthly wind speed has been recorded in April - 17.6 m/sec, and the minimum – in January (at 3.2 m/sec).

The air humidity values are subject to minor fluctuations, averaging 67%. June is most exposed to humidity variations, while August is the least variable in this respect.

Average annual precipitation is 270 mm. The main quantity of precipitation falls from March to September, with the average value in these months fluctuating between 48 and 71 mm. The most humid month is April; the absolute top record of precipitations was registered in this month in 1967 – 207.1 mm. The fewest amount of precipitation is recorded in January and December.

At all months the average cloudiness was reported above 6 points, more cloudy (in average) are March and April, least cloudy – June, July and December. The most of days with clear weather was registered in November 1990, the cloudiness was reported to be 1.4 points then.

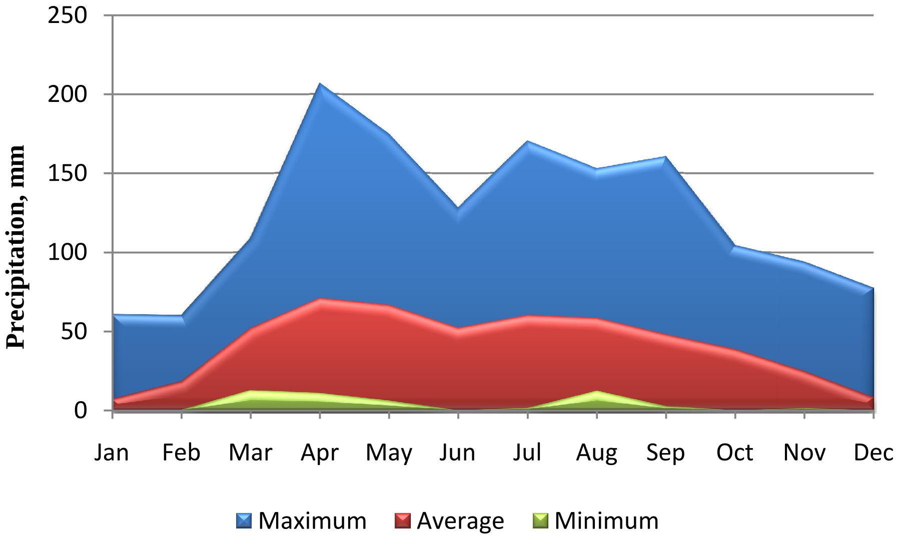


Figure 3.13 – Monthly precipitation values by data of Molodyozhnaya station (1963-1999)

The long-term average values of major meteorological parameters in the region (according to the monitoring values obtained at Molodyozhnaya station) are given in Table 3.3 below.

Table 3.3 – Long-term average values of major meteorological parameters
in the planned BAS deployment site (by data of Molodyozhnaya station)

Meteorological parameters, units of measurement	Value
Direct radiation, $kcal/cm^2$	45.0
Total radiation, $kcal/cm^2$	100.6
Radiation balance, $kcal/cm^2$	30.5
Absorbed radiation, $kcal/cm^2$	70.5
Average ambient air temperature (annual), $^{\circ}C$	-11.0
Average annual atmospheric pressure, mbar	988.5
Average wind speed, m/sec.	12.6
Prevailing wind direction	E, SE
Average annual relative humidity, %	58
Annual cloudiness (total), point	6.6
Annual precipitations, mm	270
Number of snowstormy days per year, days	190

The readings of manual and automated meteorological monitoring performed by BAE explorers during their seasonal work at Mount Vechernyaya field camp are shown in Table 3.4 below.

Table 3.4 – Average monthly and extreme values of major meteorological parameters performed by BAE explorers at Mount Vechernyaya field camp by manual and automated meteorological measurements

Meteorological parameter	2006-2009				2012	
	December	January	February	March	January	February
Average ambient air temperature, ^0C	- 1.9	- 2.5	- 9.2	- 10.4	-1.7	-6.3
Min. air temperature, ^0C	- 3.8	- 6.9	- 16.4	- 19.4	-10.3	-16.0
Max. air temperature, ^0C					7.0	3.4
Relative humidity, mean (%)	66	64	56	75	70.3	69.5
Wind speed, mean (m/sec.)	5.5	14	18	12	18.4	15.4
Max. wind blast, m/sec.	17	30	52.2	53.1	36.8	30.9

According to the BAE measurements, the average wind speed at summer at the Mount Vechernyaya area was reported to range 12.0-18.4 m/sec., which is slightly higher than the average annual wind speed at Molodyozhnaya station. The maximum recorded wind blasts reached 52-53 m/sec. The distribution of wind speeds is shown at Figure 3.14.

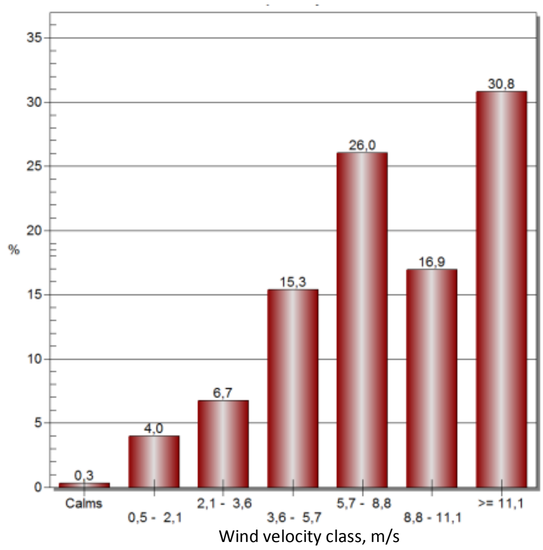


Figure 3.14 – Distribution of wind speeds by data of observations at Mount Vechernyaya meteorological station, summer season 2012-2013

The most frequently atmospheric phenomena (for the period of monitoring) were snow, drifting snow and snowstorms. In addition, during December - January an optical atmospheric phenomenon - halo - was also observed.

3.6. Flora and fauna

Living organisms at the eastern Tala Hills (in the vicinity of the Belarusian Antarctic station intended placement) are mainly found at the surface of rocky outcrops in clusters of melt water, freshwater lakes, in the bays of the Alasheeva Gulf, Cosmonaut Sea. Some species are spread around all the possible places for living, some species are found at certain locations only. In addition, there are several areas with the greatest biological diversity, as pointed for monitoring (see the map).

To the date, in the Mount Vechernyaya area 3 kingdoms of living organisms revealed. Plants and Fungi kingdoms are represented by lower groups only, i.e.: lichens (Lychenophyta) - 28 species of 3 groups, including 7 species being endemic to Antarctica; bryophytes (Bryophyta) - 3 species; seaweed (Algae) - 79 species of 8 groups. Fungi - 1 lichenophylic specie (living on lichens), Arthonia molendoi.

Almost constant low humidity, low temperatures and strong winds, causing withering and corrosive effect on the soil and plants, create very unfavorable conditions for plant organisms. Yet, where the appropriate conditions of permanent sufficient soil moisture exist in local landscapes, vegetation is more noticeable, as compared to dry places. Plants of one or more species settle separately in the area or form clumps ranging from several centimeters to several decimeters.

Lichens are widely spread. They settle not only in shelters, but also in parts of windward rocky ledges, sometimes close to ice. Observations have shown that the plants covered with snow are further blanketed by a protective layer of ice, which protects them from the corrosive effects. The substrates for lichens there are rock, loose soil, as well as other plants.

Crustaceous lichens, coloured dark gray or almost black, turn to be most common in the area. They are found on the surface of rocks in the form of individual spots, sometimes reaching several square meters. Due to the fact that the area is dominated by the southern and south-easterly winds, lichens are usually found on the northern and north-western slopes, sheltered from the wind. Here, lichens grow on mosses, but most of them accommodate on the rocky substrate.

The second substrate to settle widely Antarctic lichens are mosses, which usually live there on sandy, highly humid ground, often near the melting snow on the northern slopes. On the southern slopes of Mount Vechernyaya, no overgrown mosses are found.

The third substrate for lichen colonisation are sand pockets in the depressions between the stones, located on the northern slopes of Mount Vechernyaya.

Following the lichens, the most common component of the vegetation in the area are mosses. They settle in areas with constant and adequate moisture and are found at the bottom of the Nizhneye Lake (which does not freeze in winter).

At a distance of 20-30 m from the BAS deployment boundary, there is an integrated ecosystem (biocenose), represented by the colonies of lichens, mosses and terrestrial algae. The total biocenose area is approximately 150 m^2. Mosses, representing presumably only one group, occupy the area of about 10-12 m^2. Ground algae (one group) occupy the area of about 12-14 m^2. Mosses and algae are confined to the moraine with high content of fine soil (microprofile-developed soil). Lichens of crustose and foliose groups count at least eight species. The approximate area occupied is about 50 m^2. Lichens are widely spread both on melkozem substrates and on rocky outcrops, as well as on moss cushions. To avoid damage to the biocenose in the process of the nearby BAS performance, the area of vegetation is expected to enclose with special marking. At the same time, no complex community is located directly within the boundaries of the BAS deployment, which may be damaged as a result of human-caused performance. Scattered islands of lichens located within the BAS boundaries are represented by 4 species that are common and widespread in this oasis. Their total area of projective cover forms less than 1% of the BAS site area.

Large clusters of mosses, lichens and ground algae are reported at the foot of the Rubin Hill (height 78.7 m, approx. 600 m NE from BAS, point 1), at the foot of Mount Vechernyaya, east of the Gnezdovoy Cape (approx. 1 km NW from BAS, point 7), in the vicinity of Hill 46.8 (Adelie penguin colony at the Gnezdovoy Cape and nearby areas, approx. 1.5 km NW from BAS, point 4), in the vicinity of Hill 64.2 (approx. 3.5 km NW from BAS, point 8).

Examples of moss and lichens communities at Mount Vechernyaya are shown at Figure 3.15.

Figure 3.15 – Characteristic ecosystems (cenoses) at the planned BAS construction area: a) moss and lichen community in rock crevice, b) moss and lichen community at the bank of a temporary lake, c) lichen community at leeward slope of ravine, d) moss community

The animal kingdom (Animalia) is represented by 12 groups. Sponges (Spongia) - 3 species. Flatworms (Plathelminthes) - approx. 10 species, being fish parasites. Nematodes (Nematoda) - approx. 10 species. 1 of them is a free-living specie, the rest are fish parasites. Rotifers

(Rotatoria) - 3 species. Acanthocephala (Acanthocephala) - 2 species of fish parasites. Cnidarians (Cnidaria) - 9 species of two groups: hydroids (Hydrozoa) - 7 species and coral polyps (Anthozoa) - 2 species.

Annelida (Annelida) - 12-13 species of two groups: polychaetes (Polychaeta) - approx. 10 species; leeches (Hirudinea) - 2-3 species. Mollusks (Mollusca) - 5 species of class gastropods (Gastropoda).

Arthropods (Arthropoda) - approx. 30 species of 5 classes: crustaceans (Crustacea) - approx 15 species (included in both marine and freshwater plankton and benthos); sea spiders (Pantopoda) - 1 specie; arachnids (Arachnida) - approx. 10 species (mites that live in clusters of lichens and mosses); Entognatha insects (Enthognatha) - 2 species (collembola class (Collembola), inhabit clusters of mosses and lichens); Ectognatha insects (Ectognatha) - 1 specie (class Mallophaga (Malaphaga), skua parasites). Tardigrade (Tardigrada) - 1-2 species.

Echinoderms (Echinodermata) - approx. 10 species of classes: sea urchins (Echiuroidea) - approx. 4 species (some species form large clusters of up to 60 specimens per m^2); starfishes - approx. 4 species; brittles - 1 specie; holothurians - 1 specie.

Chordates (Chordata) - 13 species of three classes: bony fishes (Osteichtyes) - 5 species (all species, except for ploughmen, are found in large quantities), birds (Aves) - 6 species (Adelie penguins (Figure 3.16), 2 colonies (Gnezdovoy Cape and McMahon Islands), south polar skuas (Figure 3.17) and Wilson's storm petrels nest in the vicinity of the colonies; emperor penguins, snow and blue marked petrels are located sporadically). Mammals (Mammalia) - two species of seals (Weddell seal - common to the area - and crab-eater seal – single occasions) (Figure 3.18).

Figure 3.16 – Adelie penguins at Gnezdovoy Cape

Figure 3.17 – Polar skuas nestling

Figure 3.18 – Weddell seal

Wildlife species, which are trophically associated with the land and observed there during the BAE field work, are rather small (sized about 1 mm). They live under rocks, in cracks and plant sod. These are several species of mites found during biological sampling.

At the northern and north-eastern slopes of the Mount Vechernyaya there were small colonies of Adelie penguins found, counting 500 - 600 animals. A minor colony of nesting snow petrels and south polar skua gulls was also found there.

Among mammals found within the BAE biological research area range (25 km), there were crab-eater seals and Weddell seals, sometimes leopard seals and, rarely, sea elephants were reported there. Near the Vechernyaya Bay coast of Alasheeva Gulf, bagwhales and killer whales were also observed. Nototheniids were found to be most common for the Alasheeva Gulf fish colonies.

3.7. Initial environmental situation before BAS construction

3.7.1. On-site activities before starting of BAS construction

As it was previously noted in Section 2, the BAS is planned to be deployed near the Mount Vechernyaya field base territory (approx. 100-200 m south-west), which ensured functioning of airfield for many years.

Mount Vechernyaya aerodrome was designed to land IL-18D and IL-76TD cargo aircrafts. The first IL-18D plane landed at the aerodrome in February 1980, flying from Moscow (*Molodyozhnaya Station, 1994*).

The Vechernyaya field base infrastructure was built in 1979. It was designed for year-round accommodation of technical personnel. Residential and production facilities of the Mount Vechernyaya field base comprised of 13 individual and semi-detached buildings. The landing strip was 2790 m long and 100 m wide, located on compacted snow. Usually, flights were scheduled in October-November and February. An airfield platform sized 340x140 m was made to serve 4 aircraft. When building the landing strip (layout, alignment), a significant number of motor equipment was engaged, i.e.: motorised plough, air rollers, K-700, K-701 “Kirovec” wheel tractors. Upon arrival, the aircraft was served by a fleet of up to 10 vehicles: cargo conveyors, AC-40 fire truck, MTT tractor carriers, GAZ-71 trucks. The flights were controlled by a radio navigation system.

For 10 years, until the Molodyozhnaya station temporary closing-down, Mount Vechernyaya field base operated year-round independently. Mount Vechernyaya aerodrome was closed in 1991-1992 during RAE 37; the last IL-76TD flight was performed in November 1991.

Since 2006 the field base has been used by BAE to accommodate 2-6 staff scientists in summers. Nowadays, Mount Vechernyaya RAE field base residential and production premises compose of 7 individual and semi-detached buildings; the rest facilities were dismantled by the Russian Antarctic Expedition with participation of Belarusian specialists during the period 2006-2009. The location of the major facilities of the existing field base infrastructure is depicted at Figure 3.8. The major structures include: metal block module (MBM); airfield squad facilities, including diesel power plant building, workshop, warehouse, fuel storage sites, etc.

In 2006-2009 these structures were expanded by BAE facilities, i.e.: diesel power plants, fuel storage sites, vehicle parking facilities. Main elements of preserved infrastructure of field camp are shown at Figure 3.19.

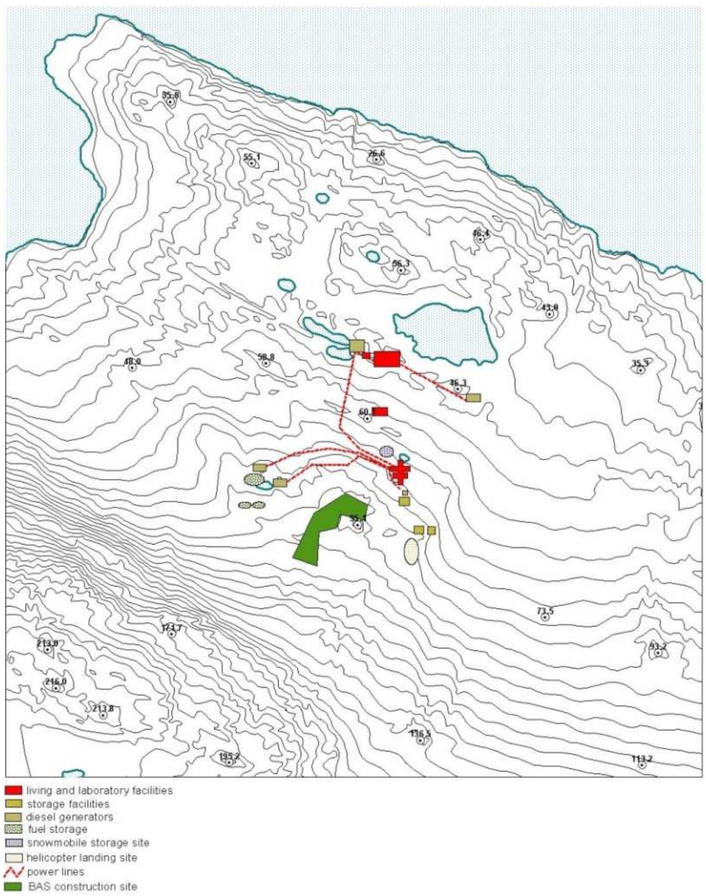


Figure 3.19 – Infrastructure of Mount Vechernyaya field camp used by Belarusian Antarctic Expedition

During the aerodrome operation, the environmental impact was caused by:
- emissions and noise from diesel generators;
- emissions from motor vehicles engaged in aerodrome services;
- emissions and noise produced by aircraft;
- mechanical impact on the ground and snow cover in connection with the preparation and operation of the landing strip, logistics and research activities;
- storage and distribution of fuels and lubricants;
- waste water, accumulation facilities and discharge points;
- solid wastes and their storage facility;
- radio navigation equipment.

Currently, the sources of exposure in connection with the field base structures operation by BAE include:

- emissions and noise from diesel generators;
- emissions and mechanical impact produced by motor vehicles;
- storage and distribution of fuels and lubricants;
- waste water, accumulation facilities and discharge points;
- solid wastes and their storage facility.

The other field base facilities, either operated or not, are also a source of pollution as a result of metal surface corrosion and destruction of other materials (Figure 3.20).

Figure 3.20 – View of the metal block module at Mount Vechernyaya field base

The paint peeling from the surfaces of facilities and equipment and metal corrosion results in release of contaminants into snow and open rocks and soil, followed by their dissolution in melt water and spreading into watercourses and ponds. Such contaminants may contain dangerous substances, such as heavy metals (lead, zinc, cadmium) that are normally included in the paints for coating metal structures for protective anti-corrosion properties.

As probable sources of pollution may serve fuel & lubricants for diesel generators, tractor and off-road equipment storage sites. Fuel (diesel, petroleum) and lubricants are supplied to the field base in standard barrels of 200 liters capacity. The storage was and is currently organised at outdoor platforms; the barrels stand on wooden pallets or directly on rocks (Figure 3.21). The fuel & lubricants consumption is about 2-3 tons per season (see Section 4.1).

А) Б)

Figure 3.21 – General view of the storage locations of metal barrels for fuel:
a) on rocks, and b) on wooden pallets

During the BAE field season, the estimated volume of wastewater counts 5-6 m^3 monthly; the sewage dumped into the sea, which had a definite impact on the marine environment.

As a result of BAE activities from 2006 to 2013 the following amount of wastes has been accumulated: empty fuel barrels - 80 pcs.; glass (broken), packed in barrels - 0.5 t; compacted cans (tins), packed in empty barrels - 0.5 t. A part of wastes was transferred to the mainland.

For the moment, it is difficult to assess and compare the current and past environmental impacts; however, accounting past and current staff and the number of motor vehicles involved, impacts can be considered to decrease significantly. The investigations held in 2011-2013 focused on the environmental assessment issues due to man-caused exposures at the field base location.

3.7.2. Environmental assessment investigations methodology

To assess the environmental conditions in the vicinity of the proposed BAS construction, the 4th BAE (2011-2012) and 5th BAE (2012-2013) performed environmental and geochemical studies in the area of the planned Belarusian Antarctic station deployment. The environmental and geochemical studies included sampling of snow, surface water, bottom sediments, soils / ground.

The research was aimed at establishing of the background concentrations of pollutants in the natural environment components prior to the Belarusian Antarctic station construction.

The sampling plan is given at Figure 3.22.

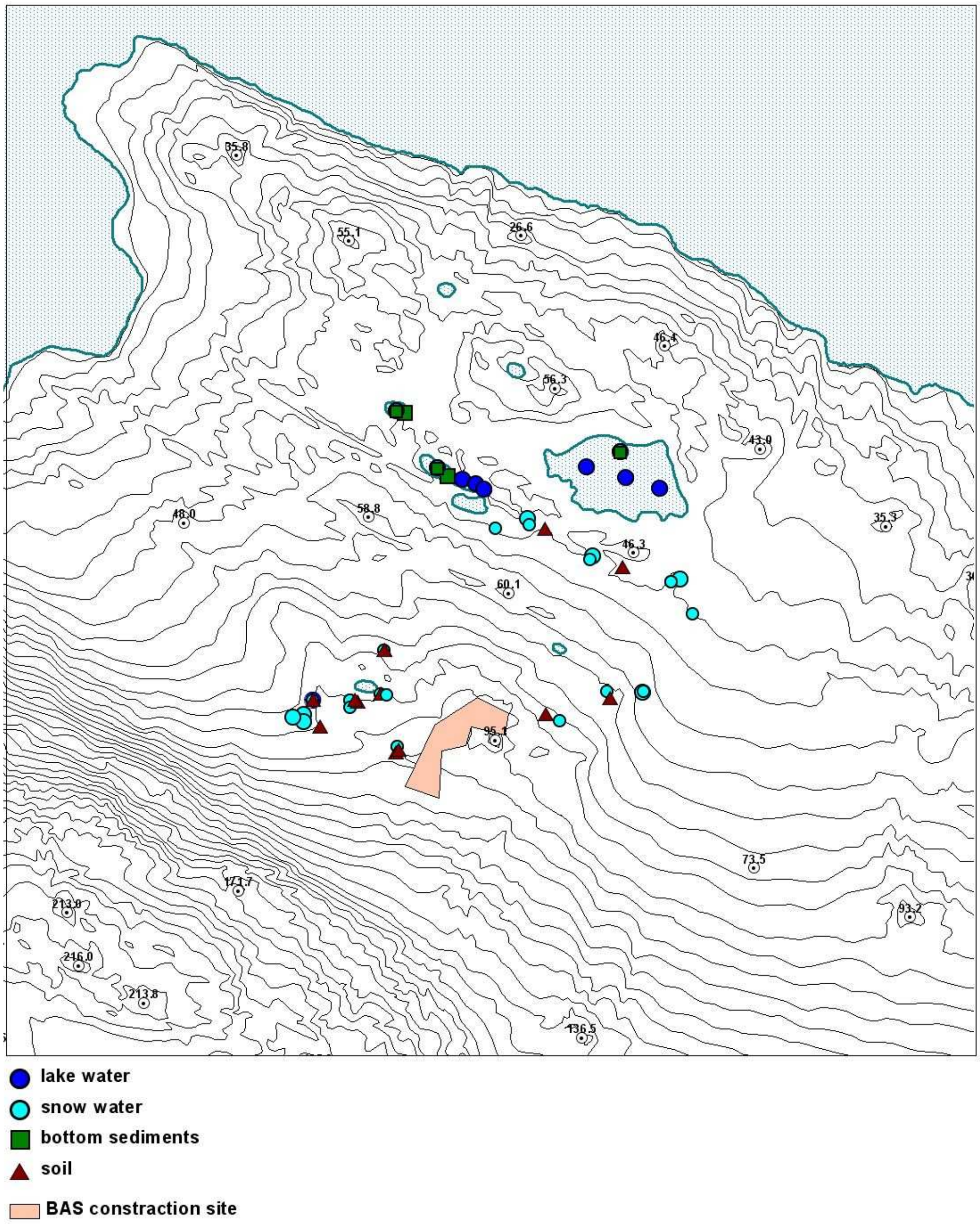


Figure 3.22 – Sampling plan of snow, surface water, bottom sediments and soils at the Mount Vechernyaya field base location

The sampling points were selected taking into account the locations of possible pollution sources.

In total at the 4th BAE in 2011-2012 17 samples at 8 points in the vicinity of the Mount Vechernyaya field base location, including 14 water samples (surface and snow waters), 2 bottom sediment samples, one soil sample were taken.

During the 5th BAE 23 samples of snow waters were taken, including 18 samples at the Mount Vechernyaya field base location and 5 samples at the ice cap slope at max. 5 km distance from the field base, 1 sample of water ice on the Hayes glacier. 4 samples of surface water from lakes, 3 sediment samples and 13 samples of solid substrates (soil, colluvial & dealluvial deposits, etc.) were also taken.

When sampling the precipitations, the determination of major ions and trace elements was performed. The surface water samples were tested for major ions, trace elements, oil products. The sediment samples and soil was investigated for contents of macro-elements, heavy metals, oil products, PAHs and PCBs. When performing the chemical tests, the scientists used the test methods, as generally approved for environmental analytical control in the Republic of Belarus (*Guidelines for pollution control..., 1991*).

3.7.3. Chemical composition of snow water

The content of major ions in snow water is shown in Table 3.2 below.

According to 2012 sampling, the pH value of snow waters ranged 5.96 to 6.39 (Table 3.5), conductivity values ranged 9.0 to 20.7 mS/cm.

The content of sulfates in snow waters ranges from 0.17 to 0.54 mg S/l (mean - 0.36 mg S/l), chlorides - 1.9 to 4.0 mg/l (mean - 2.9 mg/l), sodium ions – from 0.76 to 2.00 mg/l (mean - 1.41 mg/l).

According to the 2012 sample tests, the snow water mineralisation ranged 4.06 to 81 mg/l at 6.93 mg/l average.

According to the 2013 tests, the pH values of snow waters ranged 5.10 to 6.10, the conductivity values – 4.8 to 21.0 μSm/cm. The content of sulfates in snow waters ranged from values below the detection limit to about 0.20 mg S/l with 0.1 mg S/l average. In samples taken from the ice cap slopes (except Sample No. 35), the sulfate content was below the detection limit.

The chloride content varied in the range 1.1-2.4 mg/l, with 1.5 mg/l average value. In snow samples taken from the ice cap slopes, the average chloride content counted 1.5 mg/l.

The content of sodium ions in snow waters ranged 0.3 to 1.1 mg/l, with 0.57 mg/l average. In samples taken along the slope, the average sodium content was 0.46 mg/l.

Anions in all samples were dominated by chlorides (37.6-57.1%). Cations in most samples predominated by sodium ions (22.9-72.9%). The total mineralisation of snow waters in 2013 ranged 1.46 to 8.43 mg/l, with 3.08 mg/l average. The top mineralisation value was detected in Sample No. 26-2 taken from the snowfield behind the fuel depot. In samples taken along the slope, the average mineralisation value amounted to 1.82 mg/l.

Table 3.5 - Contents of major ions in snow water samples at the Mount Vechernyaya field base location, mg/l

Sample No.	Year	Cl^-	SO_4^{2-}, мг S	NO_3^-, N	NH_4^+, N	Ca^{2+}	Mg^{2+}	Na^+	K^+	pH	Electrical conductivity, mSm/cm
Field base territory											
9	2012	2.7	0.54	n.d.	n.d.	0.093	0.789	1.3	0.72	5.98	15
10	2012	3.7	0.33	n.d.	0.039	0.702	0.353	1.84	0.42	5.96	20.7
11	2012	1.9	0.167	n.d.	n.d.	0.24	0.43	0.76	0.26	6.05	9.0
12	2012	4.0	0.233	n.d.	n.d.	0.069	0.266	2.0	0.26	6.39	20.2
14	2012	2.4	0.517	n.d.	0.039	1.165	1.14	1.16	0.58	6.27	14
12	2013	1,5	0,166	n.d.	n.d.	0,12	0,03	0.5	0.2	5.66	6.3
14	2013	1,5	0,166	n.d.	n.d.	n.d.	0,04	0.6	0.26	5.61	7.5
16	2013	1,3	0,166	n.d.	n.d.	n.d.	n.d.	0.4	0,2	5.5	5.1
22	2013	1.2	0.166	n.d.	n.d.	0.11	n.d.	0.5	0.16	5.51	6.8
23	2013	1.6	0.2	n.d.	n.d.	0.39	0.023	0.6	0.26	6.03	7.1
23-2	2013	1.5	0.166	n.d.	n.d.	0.12	0.038	0.5	0.26	5.81	6.9
26	2013	1.5	n.d.	n.d.	n.d.	н.о.	0.024	0.6	0.26	5.58	5.8
26-2	2013	1.6	0.2	n.d.	4.076	0.28	0.067	0.4	0.26	5.74	7.1
28	2013	1.8	0.2	n.d.	0.077	0.11	0.024	0.9	0.2	5.1	12.5
28-2	2013	2.1	0.2	n.d.	n.d.	0.64	0.113	0.8	0.26	6.04	11.6
32	2013	2.4	0.2	n.d.	n.d.	n.d.	0.13	1.1	0.3	5.67	9.6
17	2013	1.1	n.d.	n.d.	n.d.	n.d.	0.012	0.4	n.d.	5.62	5.9
18	2013	1.8	n.d.	n.d.	n.d.	0	0.013	0.6	n.d.	5.4	7.8
19	2013	1.5	n.d.	n.d.	n.d.	0	0.033	0.6	n.d.	5.65	7.6
30-2	2013	1.6	n.d.	n.d.	0.054	0.22	0.05	0.3	n.d.	5.55	6.4
33	2013	1.2	n.d.	n.d.	n.d.	0.24	0	0.5	n.d.	5.8	6.4
20	2013	1.3	n.d.	n.d.	n.d.	0.14	0.016	0.4	n.d.	5.75	7.6
30	2013	1.6	n.d.	n.d.	n.d.	0.16	0	0.5	n.d.	5.8	6.4
Ice cap slope											
36	2013	1.5	n.d.	n.d.	n.d.	n.d.	0.04	0.4	n.d.	5.75	6.5
37	2013	1.5	n.d.	n.d.	n.d.	n.d.	0.026	0.4	n.d.	5.7	6.3
38	2013	1.4	n.d.	n.d.	n.d.	n.d.	0.018	0.5	n.d.	5.81	5.6
39	2013	1.2	n.d.	n.d.	n.d.	n.d.	0	0.3	n.d.	5.6	4.8
Hayes glacier											
40	2013	5.3	n.d.	n.d.	n.d.	0.22	0.29	2.4	0.2	6.1	21

n.d. – not detected

The snow water mineralisation, as sampled at the ice cap at 5 km distance from BAS, was found to be on average 20% lower than the mineralisation at the station site; the main ionic elements content were reported to be less as well.

Reference to the 2012-2013 sample tests, the total mineralisation of snow waters at Mount Vechernyaya was assessed to be 1.7 times lower than in 2011-2012 tests. The snow water anionic composition pertains to chloride (37.6–57.1 %). The snow water cationic composition is more diverse with prevail of sodium (22.9–72.9 %).

The snow chemical test results, as compared to other investigations in Antarctica (*Smagin ..., 2007*) demonstrated that the snow water composition in the planned BAS deployment location is basically typical to the coastal Antarctica areas.

No significant man-caused changes in the ionic composition of the Mount Vechernyaya snow waters were revealed.

Trace elements

29 samples of snow waters were analysed for trace elements content, including 23 samples taken within the field base area (close to potential sources of pollutants), 4 samples – at the slopes to the mainland direction at 5 km distance from the base, 1 sample - on the Hayes glacier. Among 25 elements tested no beryllium was detected in snow waters; also, iron, silver, thallium, thorium, uranium were found at the detection limits levels. The content of other trace elements in snow water samples differ significantly (Table 3.6).

Table 3.6 – Trace element content in the snow cover at the Mount Vechernyaya field base location

Element	Unit	At the field base territory			At the ice cap slopes			Hayes glacier
		min.	max.	mean	min.	max.	mean	
Be	µ/l	n.d	n.d	n.d	n.d	n.d	n.d	n.d
Na	mg/l	0.127	0.55	0.299	0.122	0.356	0.214	1.355
Mg	mg/l	0.007	0.074	0.023	0.003	0.021	0.013	0.120
Al	µ/l	n.d	45.4	8.504	0.630	8.5	3.666	n.d
K	mg/l	0.003	0.14	0.033	0.004	0.032	0.013	0.037
Ca	mg/l	0.022	0.46	0.124	0.012	0.091	0.064	0.173
V	µ/l	0.02	0.44	0.122	0.015	0.066	0.035	0.097
Cr	µ/l	0.009	1.76	0.293	0.006	0.043	0.025	0.013
Mn	µ/l	0.32	2.283	0.809	0.258	0.854	0.559	1.315
Fe	mg/l	n.d	0.016	0.002	n.d	n.d	n.d	n.d
Co	µ/l	0.002	0.05	0.017	0.005	0.011	0.008	0.013
Ni	µ/l	0.003	0.335	0.075	n.d	0.056	0.022	0.037
Cu	µ/l	0.008	6.872	1.022	0.000	0.403	0.220	0.126
Zn	µ/l	1.68	491.3	113.37	17.47	31.51	25.33	84.28
As	µ/l	0.004	0.427	0.084	0.002	0.016	0.009	0.028
Se	µ/l	0.006	1.29	0.533	0.035	0.63	0.349	0.976
Mo	µ/l	n.d	0.198	0.065	0.001	0.03	0.011	0.019
Ag	µ/l	n.d	0.029	0.002	n.d	n.d	n.d	0.001
Cd	µ/l	0.017	3.487	0.347	0.030	0.091	0.054	0.142
Sb	µ/l	0.003	0.06	0.017	0.005	0.01	0.007	0.018
Ba	µ/l	0.14	20.1	2.171	0.127	2.003	0.723	1.021
Tl	µ/l	n.d	0.005	0.001	0.001	0.001	0.001	0.001
Pb	µ/l	0.006	5.326	0.474	0.000	0.244	0.116	n.d
Th	µ/l	n.d	0.05	0.018	0.006	0.008	0.007	0.008
U	µ/l	n.d	0.01	0.002	n.d	n.d	n.d	0.001

Considerable variability of trace elements was found in the samples taken at the field base (close to the sources of exposure) and at the cap slopes.

The studies performed evidence the reduction of heavy metal content in the snow cover at certain distance from the base. At 5 km distance from the base, the trace elements concentration in snow is low, counting: lead - 0.24 μg/l, cadmium - 0.09 μg/l, arsenic - 0.003 μg/l, chromium - 0.04 μg/l, vanadium – 0.012 μg/l, nickel - 0.023 μg/l, zinc - 31.5 μg/l. The snow water samples collected at the field base territory and beyond contained 2 times more vanadium, chromium, nickel, copper, zinc, arsenic, molybdenum, cadmium and lead than samples taken at 2 km or more distance; the average ratio of trace element content in snow at the field base territory and at 2 km or more distance ranged 1.4 to 11.7 times (Figure 3.23).

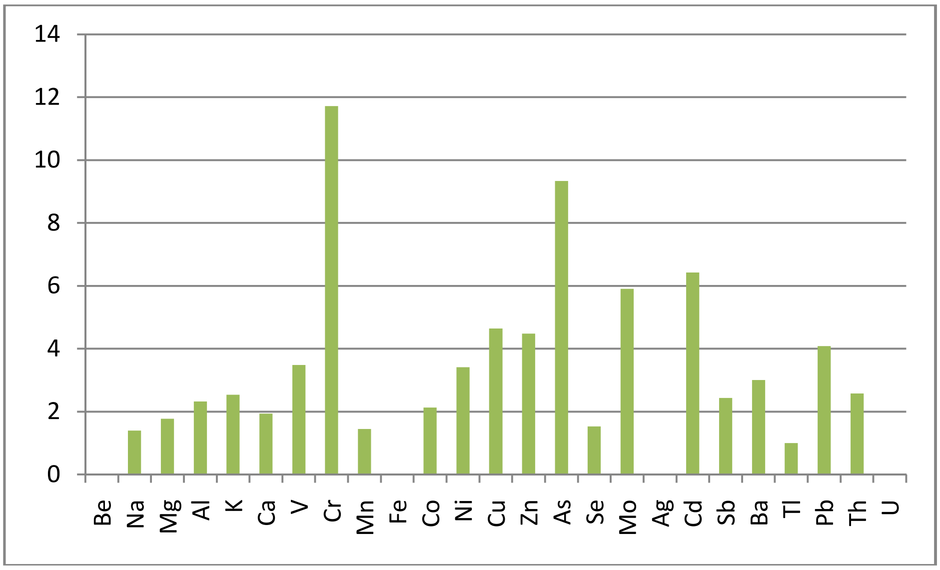


Figure 3.13 - Multiple excess of trace elements in snow water samples taken at the Mount Vechernyaya field base location, as compared to samples taken at 2 km or more distance from the field base

3.7.4. Chemical composition of surface waters

The major ions content in surface waters are given in Table 3.7 below.

Table 3.7 – Major ions content in the lake waters at the Mount Vechernyaya field base location, mg/l

Sample No.	Lake name	Year of sampling	Cl^-	SO_4^{2-}, мг S	NO_3^-, N	NH_4^+, N	Ca^{2+}	Mg^{2+}	Na^+	K^+	pH
13	Nizhneye Lake	2012	15.6	1.63	0.018	0.08	0.289	0.458	10	1.66	74.9
4	Nizhneye Lake	2013	6.3	0.63	n.d	0.00	0.31	0.43	3	0.34	26.4
15	Verkhneye Lake	2012	8.0	0.88	n.d	0.00	0.124	0.475	4.6	0.5	38.5
7	Verkhneye Lake	2013	4.2	0.37	n.d	0.05	n.d	0.3	2.4	0.3	19.3
4	No Name Lake	2012	18.1	1.50	n.d	0.19	0.61	1.29	15	2.3	95.8
10	No Name Lake	2013	9.9	0.60	n.d	n.d	0.26	0.59	4.7	0.4	37.2

Reference to the 2012 sample tests, pH values in the lake waters close to Mount Vechernyaya (Verkhneye Lake, Nizhneye Lake, No Name Lake) ranged 6.26 to 6.54, conductivity – 38.5 to 95.8 mSm/cm. The content of sulfates in the lake waters ranged 0.89 to 1.63 mg S/l (mean - 1.34 mg S/l), chlorides - 8.0 to 18.1 mg/l (mean - 13.9 mg/l), sodium ions – 4.6 to 15.0 mg/l (mean - 9.9 mg/l).

The average lake waters salinity was 29.3 mg/l, ranging 15.9 to 42.1 mg/l. Anions in all samples were dominated by chlorides, amounting to 62.5-86.4%, with sulfates being second among anions (13.6-16.4%). Cations in most samples predominated by sodium (67.0-81.2%). The magnesium content shared 7.0-16.2%.

According to the 2013 tests, pH value in the lake waters in the Mount Vechernyaya vicinity ranged 5.74-6.24, conductivity – 19.3-37.2 mSm/cm. The sulfate content ranged 0.37 – 0.63 mg S/l (mean - 0.53 mg S/l), chlorides - 4.2 to 9.9 mg/l (mean - 6.8 mg/l), sodium ions – 2.4 to 4.7 mg/l (mean - 3.4 mg/l).

Anions in all samples were dominated by chlorides (67.7-88.6%), cations are mainly represented by sodium ions (sharing 67.0-81.2%).

The total salinity of the lake waters in the Mount Vechernyaya vicinity ranged 11.5 to 27.0 mg/l, with an average of 16.9 mg/l, which is higher than that of snow waters.

In general, the level of salinity in the lakes near Mount Vechernyaya is somewhat similar to the salinity of low-mineralised waters of the Schirmacher oasis and slightly higher than the level of the Lagernoye Lake (Molodyozhnaya Station).

The total mineralisation of the lakes near Mount Vechernyaya in 2012-2013 was 2 times lower than the total salinity of surface waters in 2011-2012.

No significant man-caused changes in the ionic composition of lake waters at the Mount Vechernyaya were revealed.

All in all, the ion balance demonstrates a significant influence of the ocean water on the lake water chemical composition, which is explainable by their near-coast location.

Trace element content

The trace element content in the lake waters in the Mount Vechernyaya vicinity is given in Table 3.8 below.

Reference to the investigations made, the most trace elements content in water are reported to range from below the detection limit to 10 μg/l (lead – from below detection limit to max. 1.88 μg/l, cadmium – from 0.012 to 0.53 μg/l, nickel – from 0.21 to 0.69 μg/l, cobalt – from 0.02 to 0.29 μg/l, arsenic – from 0.06 to 0.39 μg/l, copper – from 0.48 to 2.17 μg/l, chromium – from 0.05 to 1.40 μg/l.

The iron content in the lake waters ranged 0.005 - 0.104 mg/l; the highest concentration of this element was traced in the Nizhneye Lake waters. Moreover, the Nizhneye Lake waters proved to reveal higher concentrations of manganese, aluminum, zinc, barium and some other elements, as compared to other lake waters (Table 3.8).

Table 3.8 – Trace element content in the lake waters at the Mount Vechernyaya field base location

Element	Unit	Nizhneye Lake		Verkhneye Lake		No Name Lake	
		2012	2013	2012	2013	2012	2013
Be	µ/l	n.d	n.d	n.d	n.d	n.d	0.004
Na	mg/l	2.574	2.405	1.651	1.614	4.357	3.089
Mg	mg/l	0.336	0.288	0.229	0.164	0.489	0.280
Al	µ/l	7.764	16.650	4.35	н.о.	9.655	11.462
K	mg/l	0.373	0.152	0.114	0.089	0.326	0.187
Ca	mg/l	0.24	0.438	0.139	0.185	0.256	0.333
V	µ/l	0.249	0.224	0.19	0.190	0.596	0.228
Cr	µ/l	1.051	0.066	0.321	0.044	1.395	0.046
Mn	µ/l	31.177	15.749	2.311	5.374	0.567	1.389
Fe	mg/l	0.104	0.046	0.017	0.005	0.031	0.018
Co	µ/l	0.286	0.070	0.016	0.046	0.024	0.027
Ni	µ/l	0.626	0.380	0.271	0.213	0.688	0.240
Cu	µ/l	1.109	0.716	0.665	0.482	2.171	0.651
Zn	µ/l	181.818	3.669	0.118	1.109	4.46	n.d
As	µ/l	0.18	0.052	0.102	0.058	0.391	0.071
Se	µ/l	0.032	1.476	0.064	1.739	0.2	1.314
Mo	µ/l	0.028	1.603	0.009	0.765	0.126	0.514
Ag	µ/l	0.003	0.027	0.003	0.013	0.006	0.011
Cd	µ/l	0.215	0.038	0.014	0.031	0.553	0.012
Sb	µ/l	0.022	0.036	0.007	0.022	0.018	0.014
Ba	µ/l	9.067	3.031	1.214	0.755	1.083	0.891
Tl	µ/l	0.003	0.030	n.d	0.008	n.d	0.010
Pb	µ/l	1.875	0.227	0.306	0.221	0.202	n.d
Th	µ/l	0.002	0.356	n.d	0.168	0.002	0.126
U	µ/l	0.003	0.012	0.001	0.007	0.004	0.011

Content of oil products

The chemical analysis results as related to oil product content in surface waters are shown in Table 3.9.

Oil content in the lake water in 3 of 4 samples appeared to be close to the maximum permissible concentration (MPC) for potable water (0.1 mg/l). The oil content in waters of the stream flowing out of the lake near the fuel depot was 1.4 times higher than in lake water.

Elevated concentrations of oil products in the lake waters are probably the result of the previous activities.

Table 3.9 – Oil product content in surface water samples taken at the Mount Vechernyaya field base location, mg/kg dry matter

Sample No.	Object of analysis	Year of sampling	Oil product content, mg/l
17	Nizhneye Lake	2012	0.017
4		2013	0.086
16	Verkhneye Lake	2012	0.076
7		2013	0.083
32	Stream flowing out of the lake near the fuel depot	2013	0.118

3.7.5. Chemical composition of bottom sediments and soils

Bottom sediments and soils (developing on colluvial and fluvioglacial sediments) were analysed on content of heavy metals, oil products and some POPs (PAHs and PCBs).

Bottom sediments

Heavy metals

Sediments from two lakes – Verkhneye Lake and No Name Lake – were subject to analysis. The content of heavy metals was tested by AAS method.

The content of heavy metals in the bottom sediments is shown in Table 3.10 below. The Verkhneye Lake sediments contained copper ranging 42.9-65.1 mg/kg, zinc – 139.7-162.8 mg/kg, nickel – 31.5-33.3 mg/kg, chromium – 12.5-32.7 mg/kg, lead - 33.9 -36.3 mg/kg, cadmium – 1.85-2.42 mg/kg. In the No Name Lake sediments, the copper content ranged 16.4-78.5 mg/kg, zinc – 65.4-89.0 mg/kg, nickel – 25.2-37.5 mg/kg, chromium – 42.0-43.5 mg/kg, lead – 15.8-18.2 mg/kg, cadmium – 1.22-1.57 mg/kg.

The differences found in the last two years of research indicate the heterogeneous nature of heavy metal accumulation in the lake sediments in the Mount Vechernyaya vicinity. Thus, the Verkhneye Lake sediments were reported to contain zinc 2-3 times, lead 2 times, cadmium 1.5 times more than in the No Name Lake sediments.

Table 3.10 – Concentration of heavy metals in the lake sediments in the Mount Vechernyaya field base vicinity, mg/kg dry matter

Sample No.	Place of sampling	Year	Cu	Zn	Ni	Cr	Pb	Cd
6	Verkhneye Lake	2012	42.9	139.7	31.5	12.5	36.3	1.85
8	Verkhneye Lake	2013	65.1	162.8	33.3	32.7	34.0	2.42
8	No Name Lake	2012	16.4	65.4	25.2	42.1	15.8	1.22
11	No Name Lake	2013	78.5	89.0	37.5	43.5	18.2	1.57

The content of heavy metals in the lake sediments were reported to be significantly higher than in the Mount Vechernyaya soils; e.g., the Verkhneye Lake sediments contained the excess of copper - 3.5 times, zinc - 2.2 times, nickel - 1.6 times, lead - 1.5 times and cadmium - 1.2 times. In the No Name Lake sediments, the copper content was tested to be 4.5 times, nickel - 1.8 times and zinc - 1.2 times higher than that in local soils.

High concentrations of oil products were also reported with the Verkhneye Lake sediment samples, resulting most probably from earlier activities.

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls

The following PAH compounds were identified in the Verkhneye Lake sediments, i.e.: naphthalene - 0.16 mg/kg, anthracene - 0.068 mg/kg, pyrene - 0.074 mg/kg (Table 3.11). Other PAH compounds and PCBs were not detected (below the detection limit).

Table 3.11 - Contents of PAHs and PCBs in the Verkhneye Lake sediments, mg/kg

Substance	Content
Naphthalene	0.16
Acenaphthene	n.d.
Fluorene	n.d.
Phenanthrene	n.d.
Anthracene	0.068
Fluoranthene	n.d.
Pyrene	0.074
Benzo(a)anthracene	n.d.
Chrysene	n.d.
Benzo(b)fluoranthene	n.d.
Benzo(k)fluoranthene	n.d.
Benzo(a)pyrene	n.d.
Dibenzo(a, h)anthracene	n.d.
Benzo(g, h, i)perylene	n.d.
Indeno(1.2.3-cd)pyrene	n.d.
PCB 28	n.d.
PCB 52	n.d.
PCB 101	n.d.
PCB 118	n.d.
PCB 138	n.d.
PCB 153	n.d.
PCB 180	n.d.
PCBs (total)	n.d.

Oil products

The Verkhneye Lake bottom sediments were found to contain elevated concentrations of oil products - 392.2 mg/kg; the No Name Lake sediments proved to have inconsiderable content (4.23 mg/kg) (Table 3.12). The findings suggest that man-caused oil spills fall into the Verkhneye Lake (a diesel power plant now empty which worked during operation of aerodrome base Mount Vechernyaya from 1979 to 1989 is located nearby).

Table 3.12 – Content of oil products in the lake bottom sediments of the Mount Vechernyaya field base location, mg/kg dry matter

Sample No.	Year	Place of sampling	Oil product content
8	2013	Verkhneye Lake	392.2
11	2013	No Name Lake	4.23

Soil and loose substrates

8 samples were tested to determine heavy metals content (by atomic absorption spectroscopy), 9 samples were analysed for oil content determination; 3 samples - the content of polycyclic aromatic hydrocarbons (PAHs), and 1 sample - PCBs.

Heavy metals

The results of heavy metal content determination are shown in Table 3.13 below.

Table 3.13 – Heavy metal content in soil samples, mg/kg

Year	Sample No	Cu	Zn	Ni	Cr	Pb	Cd
2012	1	21.85	77.37	27.24	57.93	17.58	1.32
2013	1	30.23	172.90	30.71	54.00	22.80	2.09
	13	17.38	82.84	20.87	46.67	21.47	1.93
	25	19.81	75.00	22.06	48.00	22.67	1.71
	27	19.37	69.78	20.95	44.00	22.27	1.75
	29	19.13	66.79	21.19	47.33	22.40	1.96
	31	17.67	83.02	21.75	48.00	22.40	2.00
	34	18.45	72.95	19.80	45.33	22.27	1.79

The zinc content in soils ranges 66.89 to 172.9 mg/kg of air-dry residue, chromium – 32.7 to 54.0 mg/kg, lead – 18.3 to 36.37 mg/kg, nickel – 19.80 to 31.54 mg/kg, copper – 17.38 to 42.9 mg/kg, cadmium – 1.57 to 2.09 mg/kg.

Among the solid substrate samples, one sample was taken from the temporary stream sediments, represented mainly by coarse sand, the rest samples - loose moraine substrate. According to the atomic absorption spectroscopy readings, the highest content of heavy metals was found to be characteristic to the temporary stream alluvial deposits: zinc content – 172.9 mg/kg, copper – 30.2 mg/kg, nickel – 30.7 mg/kg, chromium – 54 mg/kg, lead – 22.8 mg/kg, cadmium – 2.09 mg/kg. The detected values of heavy metals in the fluvioglacial sediments were similar to the content in the lake sediments tested. This may indicate a redistribution of pollutants by meltwater and their accumulation in depressions, hollows, lakes.

In general, the distribution of heavy metals in soils proved to be rather uniform, which apparently shows the decisive influence of heavy metals in soil-forming rocks (gneiss weathering products).

Polycyclic aromatic hydrocarbons and polychlorinated biphenyls

The soils samples were detected to contain inconsiderable amounts of two PAH compounds, i.e.: anthracene (ranging 0.003-0.006 mg/kg) and pyrene (from below the detection limit to 0.004 mg/kg) (Table 3.14). The other PAH and PCB compounds were found below the detection limit.

Table 3.14 – Contents of PAHs and PCBs in soils of the Mount Vechernyaya field base location, mg/kg

Substance	Sample No.		
	27	31	34
Naphthalene	n.d.	n.d.	n.d.
Acenaphthene	n.d.	n.d.	n.d.
Fluorene	n.d.	n.d.	n.d.
Phenanthrene	n.d.	n.d.	n.d.
Anthracene	0.006	0.003	0.005
Fluoranthene	n.d.	n.d.	n.d.
Pyrene	0.004	n.d.	0.004
Benzo (a) anthracene	n.d.	n.d.	n.d.
Benzo (b) fluoranthene	n.d.	n.d.	n.d.
Benzo (k) fluoranthene	n.d.	n.d.	n.d.
Chrysene	n.d.	n.d.	n.d.
Benzo (a) pyrene	n.d.	n.d.	n.d.
Dibenzo (a, h) anthracene	n.d.	n.d.	n.d.
Benzo (g, h, i) perylene	n.d.	n.d.	n.d.
Indeno (1.2.3-cd) pyrene	n.d.	n.d.	n.d.
PCB 28	n.d.	n.d.	n.d.
PCB 52	n.d.	n.d.	n.d.
PCB 101	n.d.	n.d.	n.d.
PCB 118	n.d.	n.d.	n.d.
PCB 138	n.d.	n.d.	n.d.
PCB 153	n.d.	n.d.	n.d.
PCB 180	n.d.	n.d.	n.d.
∑ of 7 PCBs	n.d.	n.d.	n.d.

Oil products

The oil product content in soil samples taken at the field base location is given in Table 3.15 below.

The oil product content in soils ranges from 2.5 mg/kg to 28.9 mg/kg. The oil product content in the vicinity of BAE diesel generators DG-20 and DG-60 and actual BAE fuel depot locations was found to be rather low, ranging 2.5-12.6 mg/kg. Elevated oil content (28.9 mg/kg) was detected in the soil substrate close to the MBM location.

The maximum values, reaching 7413.8 mg/kg, were recorded in the temporary stream alluvial sediments flowing close to AMRS into the Nizhneye Lake. Such levels of oil products are probably resulted from fuel leaks due to previous man-caused activities.

Table 3.15 – Oil product content in the soils of the Mount Vechernyaya field base location, mg/kg

Sample No	Oil content, mg/kg
1	9.42
2	7413.8
13	28.9
15	5.9
25	11.1
27	6.0
29	10.2
31	2.5
34	12.6

Basically, the environmental and geochemical studies performed have demonstrated that the chemical composition of snow and lake waters in the area of the planned BAS deployment do not revealed any significant anthropogenic changes, although the content of microelements increased. Presence of oil products in the lake waters, sediments and soils, as well as increased content of heavy metals in the lake sediments was also detected. High concentrations of heavy metals and oil products in some soil areas tested result most probably from previous man-caused activities: closely to MBM in 1979-1989 there were an open ground of heavy transport and temporary depot of fuel and lubricants in barrels for cross-country vehicles GTT, ATT.

3.7.6. Biotic components

Reference to investigations performed, the previous production and scientific activities at the Mount Vechernyaya field base location are proved to cause no visible damage to the local biotic components: nesting birds, mosses and lichens. Possibly, there were some changes in the composition of water cenoses, but no monitoring findings prior to the field base construction are available to reliably identify such changes, if any.

3.7.7. Aesthetic value of the landscape and natural surroundings

The aesthetic value of the landscape in the field base location and its naturalness declined slightly due to man-caused activities: e.g., construction works, waste accumulation. However, the aesthetic value of the area is still high.

3.7.8. Projection of the state of environment in absence of the proposed activity

As shown above, the Mount Vechernyaya surroundings were largely transformed by the influence of the past activities, and nowadays activities cause a lesser impact. In these circumstances, the absence of the proposed activity (BAS construction), while maintaining the environmental impact at the current level, will lead to changes comparable with the changes due to the proposed activity.

4. Environmental impact assessment of the planned activity

4.1. Sources of impact

4.1.1. Sources of impact at station construction

4.1.1.1. Station construction phases

Station design concept

As it was previously mentioned in Section 2.4, the construction technology involves the station to be installed on-site from pre-assembled block modules. The components (wagon sections, basements, stairs, ladders, etc.) are expected to be delivered to Molodyozhnaya Station raid by RAE vessels, then transported by helicopter to the station construction site (see Chapter 2). The modules are planned to be installed by helicopters directly on bedrocks without excavations, piling and other works that may cause a substantial impact on the environment.

No heavy construction equipment (bulldozers, cranes, etc.), trucks, snowmobiles and/or welding and paint works are planned to be performed on site.

Main construction phases:

- *preparatory phase*
- *first construction phase*
- *second construction phase*

At the preparatory and first construction phases applied and will keep on applying the Mount Vechernyaya RAE / BAE field camp infrastructure (MBM, power lines, warehouses, storage platforms, etc.), as well as the available equipment: diesel generators, motor vehicles, etc. (with relocation, if required).

The following works were fulfilled at the preparatory phase (2012-2013):

- station design elaboration;
- station site (alternative sites) selection;
- major facilities location;
- field environmental studies (environmental evaluation, on-site surveys of the deployment places for the planned facilities and guarded objects);
- IEE and CEE drafting.

Any impacts that may arise during the preparatory phase are mainly related to the scientific and domestic activities in the field camp (field studies) and will not practically differ from impacts during normal field seasons.

During the *first construction phase* (2014-2018), 8 residential & production modules and service-specific pavilions and boxes will be delivered and deployed: laboratory & residential building, single-storey; service & residential building, single-storey; laboratory & residential building, two-storey; production & residential building, two-storey; sanitary & hygiene premises; heated and unheated warehouses; garage & storage facilities. Modules specifications are given in Chapter 2.

The major activities, as planned for this period, shall be:

- site preparation for first-stage facilities installation (markings, removal of stones, etc.);
- delivery of station modules, equipment and materials on Academician Fedorov and Academician Treshnikov vessels of the Russian Federal Service for Hydrometeorology and Environmental Monitoring;
- transfer of facilities, equipment and materials to the construction site by helicopters;
- installation of the module basements;
- installation of modules to the basements, assembly works;
- relocation of the diesel generators.

During the period 2014-2018, fuel and lubricants will be stored in barrels at an outdoor platform. Fuel storage facilities are scheduled for the second construction phase.

At the *second construction phase* (2019-2020 and until 2025), the following facilities will be delivered and deployed, i.e.:

- non-magnetic geophysical pavilion;
- fuel & lubricant tanks (2 tanks of 50 m^3 each, 1 tank of 25 m^3, 2 tanks of 3-5 m^3 each);
- 2 diesel power stations of 100 kVA capacity each;
- incinerator (waste disposal burner);
- press for empty fuel barrels disposal;
- jet dump device with sewage collector for water waste disposal to the coastal marine area;
- water supply system (to buildings);
- 2 refuel pumps (diesel/petrol) for motor vehicles.

The major activities, as planned for the second construction phase:

- site preparation for second-stage facilities installation (markings, removal of stones, etc.);
- delivery of station modules, equipment and materials on vessels;
- transfer of facilities, equipment and materials to the construction site by helicopters;
- installation of the modules (facilities);
- assembly works;
- installation and assembly of life support systems (diesel generators, water supply and disposal systems, solid waste & wastewater storage and disposal systems);
- site preparation (platform construction) and installation of fuel storage tanks;
- site preparation and installation of an incinerator (waste disposal burner);
- piping (fuel supply, sewage).

4.1.1.2. Impacts on sea delivery of the station modules, equipment and cargo

For delivery purposes, Academician Fedorov and Academician Treshnikov vessels of the Russian Federal Service for Hydrometeorology and Environmental Monitoring are planned to be used.

The major characteristics of the vessels are given in Table 4.1 below. Referring to the environmental impact (emissions, wastes generation, discharge, etc.), the vessels comply with the requirements of the Protocol on environmental protection and MARPOL. The major cargo deliveries to the BAS construction site will be affected by the vessels to accompany the cargo deliveries to the Russian Antarctic stations.

Table 4.1 – Major characteristics of Academician Fedorov and Academician Treshnikov RAE vessels

Parameter	Academician Fedorov	Academician Treshnikov
Displacement	16 336 t	16 336 t
Length	141.2 m	133.59 m
Width	23.5 m	23.0 m
Height	13.3 m	13.5 m
Draft	8.5 m	8.5 m
Engines	2 x Wärtsilä 16V32D, 2 x Wärtsilä 6R32D	3 Wärtsilä main diesel generators
Capacity	2 x 6000 kW, 2 x 2250 kW	2x6300 kW, 1x4200 kW
Speed	16.5 knots	16.0 knots
Crew	90 people	60 people

4.1.1.3. Impacts at cargo vessel-to-site transfers and station assembly works

Given the planned construction technology, the environmental impact caused by the major source of exposure, Ka-32 helicopter, as well as by activities related to fuel storage facilities and wastewater discharge collector construction, was subject to assessment.
The impact caused by auxiliary tools during the BAS construction (drills, motorised saws, screwdrivers, perforators, etc.) will be insignificant and was not subjected to assessment.

Sources of pollutants emission

The main source of air polluting emissions during the BAS construction will be the helicopter to deliver the modules from Molodyozhnaya Station. The calculation of helicopter-caused emissions is based on the helicopter's specifications, number of takeoff and landing cycles, specific fuel consumption in accordance with the Calculation Methodology (*Calculation Methodology..., 2008*). The Ka-32 helicopter performance characteristics are given in Table 4.2 below.
Ka-32 helicopter is equipped with two 2200 HP TV3-117 engines, fueled by T-1, TS-1, RT aviation kerosene (Table 4.3).
Engine's specific fuel consumption, kg/hp•h: takeoff mode – 0.21-0.23, cruise mode – 0.25-0.27.

Table 4.2 – Ka-32 helicopter major performance characteristics (*Ka-32 Helicopter Flight Manual*)

Parameters	Unit	Ka-32
Maximum takeoff weight	kg	11000
Empty weight	kg	3240
Number and diameter of rotors	n x m	2x15,9
Helicopter's total length with rotors	m	15,9
Main fuel tank capacity	l	3450
Extra fuel tank capacity	l	1310
Type of engines	-	TVZ-117
Number and takeoff capacity of engines	n x HP	2x2200
Hourly fuel consumption at cruising speed (h=500 m)	kg/h	270
Cruising range fuel capacity (30 min. flight)	kg	140
Cruising speed (h = 500 m)	km/h	220
Maximum speed	km/h	230
Flight range without extra fuel tanks added (h=500 m)	km	600
Flight range with extra fuel tanks (h=500 m)	km	1100
Maximum flight altitude	m	3500
Maximum cargo weight:		
- on-board load	kg	3700
- external load	kg	5000

Table 4.3 – Major performance characteristics of Ka-32 helicopter's TVZ-117 engines (*according to manufacturer's specifications*)

Parameter	TVZ-117B	TVZ-117BMA
Power at emergency mode	2200 HP	2400 HP
Power at takeoff	2000 HP	2200 HP
Specific fuel consumption	0.220 kg/HP•h	0.215 kg/HP•h
Power at cruising	1500 HP	
Dry weight	295 kg	
Assigned life	7500 flight hours	

Emission calculation

The calculation of helicopter emissions is made in accordance with the (*Calculation Methodology..., 2008*). The emission factors applied are given in Table 4.4 below.

Table 4.4 – Ka-32 helicopter emission factors, based on ICAO standard (*Calculation Methodology..., 2008*)

Engine type	Polluting emissions per standard flight cycle (kg)			
	CH	CO	NO_x	Smoke (particulate matter)
TVZ-117	0.17	0.95	1.5	0.032

Each helicopter run (flight cycle) is assumed to deliver and install one module platform or one wagon section of production & residential or laboratory & residential module. Consequently, two flights will be required to transfer one complete module. Thus, during the station construction 4-6 helicopter flights will be performed annually for module deliveries and 3-5 extra flights to deliver procurement & instrumentation. The average total for the first construction phase will be about 10 Ka-32 helicopter flights annually. Based on this number of flights, polluting emissions during the construction phase is assessed (per year) as follows: nitrogen oxides - 30 kg, carbon oxides - 19 kg, hydrocarbons - 3.4 kg, particulate matter - 0.64 kg (Table 4.5).
Thus, the share of this air polluting source is assessed to be minor.

Table 4.5 – Ka-32 helicopter emissions during the BAS construction (first phase), kg/year

Engine type	Polluting emissions per standard flight cycle (kg)			
	CH	CO	NO_x	Smoke (particulate matter)
TVZ-117	3.4	19	30	0.64

Mechanical impact

The mechanical impact on soils, ground and rocks at the construction stage will be associated with placement of the station structures: block modules, platforms for fuel tanks, as well as central collector piping.

For installation of block modules, platforms, metal tanks, movement of collector pipes and supports, motor vehicles will be used. During the construction works, no extraction (disturbance) of rocks is planned to be effected.
The mechanical impact during the construction works will be limited in time.

Noise

Noise during the construction works will be primarily caused by machinery and equipment. The sources of noise comprise of:
- noise that comes from moving components of engines (mechanical noise) due to constant vibration;
- noise of exhaust gases;
- noise of air circulation in engine’s forced air cooling system;
- electromagnetic noise and other noise sources.

The most significant source of noise during the BAS construction will be helicopter, used to transfer the station modules and other cargo.

The Ka-32 helicopter noise characteristics are acknowledged to be permissible and complying with the applicable requirements of the international environmental standards.

Reference to EASA certificate issued in 2009, the effective perceived noise level (EPNL) of this helicopter conforms to the permissible limits and amounts to 100.4 dBA for takeoff, 99.4 dBA for cruising and 101.4 dBA for landing. These parameter readings were obtained during the Ka-

32 helicopter flight tests in the operating modes and flight path patterns, as regulated by ICAO, and did not exceed the limits as applicable for helicopters with full flight weights of 11.000 kg (Table 4.6).

Table 4.6 – EASA noise certificate, issued to Kamov manufacturers for Ka-32 helicopter *(EASA Type-Certificate.., 2009)*

EASA file No.	Max. weight		Takeoff, EPNL		Cruising, EPNL		Landing, EPNL	
	Takeoff (kg)	Landing (kg)	Value*	Limit	Value*	Limit	Value*	Limit
D302	11000		100.4	100.4	99.4	99.4	101.4	101.4

The noise caused by helicopters can be harmful, if flying over the places of nesting penguins and other birds. In this connection, the routes shall be scheduled most optimally (see Section 4.2).

The impact caused by auxiliary tools during the BAS construction (drills, motorised saws, etc.) will be insignificant and local.

Wastes generation

According to the station construction plan modules of station will be build in parallel with their functioning with minimal attract of additional builders. Therefore estimate of household wastes generation (and wastewaters) at station operation account their formation at station construction on the assumption of BAE staff for 2014-2018 – 5-6 man in seasonal variant of station operation; part of them will be involved in construction of station (chapter 4.1.2).

During the construction a certain amount of other wastes will be generated, mainly from packing and fastening materials. However, the amounts are assessed to be insignificant. The wastes will be sorted out and stored (or disposed of) separately with subsequent transportation of residues to the mainland or partially transported to the vessel by helicopter during unloading operations.

Fuel and lubricant spills upon helicopter refuel and maintenance

The helicopters are expected to be refueled and maintained on board the vessels; in this connection, the possibility of fuel spills or other leaks at the BAS construction territory trends to minimum.

Sewage

Any sewage will be generated basically from operation of the staff engaged in the station construction. For waste water storage and treatment, the appropriate tanks currently existing at the BAE field base will be used. As mentioned above an estimate of waste water load for 2014-2018 was made in assumption of the BAE staff 5-6 men in seasonal mode. The expected increase of sewages will be basically proportionate to the staff increase, as compared to the current amounts.

Impact on the aesthetics of the landscape and natural surroundings

Given the significant disturbance of the natural landscape at the BAS construction site, the planned construction will not deteriorate, but is expected to improve the aesthetic features of the landscape. The station construction is anticipated to blend seamlessly into the Mount Vechernyaya landscape.

Generally, the construction works will impact:

- soils, ground, rocks (upon block module deployment); the aggregate hard surface area to be covered by the residential & production facilities of the 1st stage of station will amount to approx. 150 m^2; certain area will be covered by auxiliary facilities, platforms and communications;
- ambient air (due to emissions from cargo deliveries by helicopters);
- snow & ice cover (upon cargo transportations, fuel and collector piping).

The block modules and other structures are not planned to be installed at areas with developed lichens or mosses; in this respect, the impact on biota will be minimal.

The overall impact during the construction works (except for polluting emissions and noise) will be localised within the site boundaries.

4.1.1.4. Activities for reduction of impacts during station construction

At station construction the following measures on impacts reduction will be applied:

- on board of the vessels, during cargo and module deliveries: compliance with MARPOL and other regulatory requirements, time-saving schedule to reduce the duration of stay in the Antarctic waters;
- at helicopter operation: flight route optimisation, tough scheduling of the construction and handling operations, optimal helicopter loads, flight time minimisation, reduced flight cycles;
- at site preparation: prevention of dust generation upon site ground works, drilling holes;
- mechanical assembly works: high efficiency, speed and quality of works being performed, which would benefit to reduction of polluting emissions and noise exposure;
- piping and power cable line laying: soil and ground disturbance minimisation, in particular, in respect of vegetation-covered areas;
- use of motor vehicles: optimal routes scheduling;
- sewage treatment, waste management: solid and liquid wastes minimisation, waste transfers to the mainland.

4.1.2. Sources of impacts during the station operation

When operating the station, the following devices will serve as sources of environmental impact, i.e.:

a) power supply systems and mechanisms (diesel generators, heating devices);
b) motor vehicles;
c) fuel storage and distribution facilities (storage tanks, fuel pipes, refuel systems);
d) water supply and sewerage systems;
e) solid waste management systems;
f) scientific equipment and instrumentation;
g) communication facilities;
h) auxiliary mechanisms;
i) station supply and procurement systems (vessels, helicopters).

The operation of most equipment and machinery will be accompanied by emissions, discharges, waste generation, noise, electromagnetic exposures. In addition, spills and leaks of fuel, lubricants, coolants, wastewaters and liquid wastes are also possible.
The environmental impact analysis was done by types of exposure and includes both quantitative and semi-quantitative assessment of air pollution, impact on surface waters due to discharges and leaks, impact on soil due to leaks and accumulation of wastes, impact of noise and electromagnetic interference, mechanical (physical) impact on the ground (soils).

4.1.2.1. Air emission sources

The impact assessment at the first years of station operation is based on the planned use of basically the same mechanisms that are currently available at the Mount Vechernyaya field base:
- diesel generators - 3 pieces, currently in operation; diesel generator types: DG-20 AD16-T400-2RP, DG-60 AD60-T48C-2RP and GEKO 6401 (Figure 4.1); specific fuel consumption – 1.43 to 15.5 l/h, diesel-fueled;
- generators with petrol engines (3 pcs.), in occasional operation, basically in standby mode;
- diesel-operated blow heaters, occasional operation;
- motorised saw, occasional operation.

The specifications of the permanent sources of pollution are given in Tables 2.2-2.3 (Section 2).
The second construction phase will involve additionally the startup and commissioning of wastes incinerator of 50 kg/h capacity (presently, KTO50.K20 type incinerator is planned to be installed) (Figure 4.2); operation frequency – once a week (5-8 operating hours). Two DG-100 diesel generators will be additionally installed and will work alternately.

Figure 4.1 Diesel generators at Mount Vechernyaya field base

Figure 4.2 Incinerator KTO50 (picture from producer site)

BAS will also use the following motor vehicles: petrol-propelled Lynx YETI PRO-800 and YETI TUV-1300 snowcats and Outlander MAX 4X-800 quadricycle, as well as diesel-propelled GAZ-3409 BOBR all-terrain vehicle.

The specifications of the mobile sources of pollution are given in Table 4.7 below.

The wastes will be incinerated in compliance with Annex III to the Protocol on Environmental Protection.

Table 4.7 – Characteristics of motor vehicles and machinery used at Mount Vechernyaya BAE field camp

Type of motor vehicle or machinery	Fuel consumption, depending on output, ref. to the manufacturer's specifications		Type of fuel	Actual fuel consumption in Antarctic conditions
	% output/kW	l/h		
GAZ-3409 BOBR all-terrain vehicle	l/h per 100 km	5.0 61.5	diesel	6.00 79.8
YETI PRO-800 snowcat	per 100 km		petroleum	50.0
YETI TUV-1300 snowcat	per 100 km		petroleum	70.0
MAX 4X-800 quadricycle	per 100 km		petroleum	60.0
2.4 kW MAKITA saw		0.75	petroleum	0.83

The consumption of various fuels at Mount Vechernyaya field base for 2011-2012 field season is shown in Table 4.8 below.

Pollutants emission assessment

The main sources of emissions during the station operation are combustion processes of the stationary engines and motor vehicles, and in future - burning of solid wastes. Fuel storage and distribution, liquid waste and sewerage systems are also considered as sources of emissions; however, their contribution to the total emissions is insignificant due to the Antarctic climatic conditions and was not counted.

Table 4.8 – Consumption of fuel by vehicles and mechanisms for 2011-2012 BAE field season *(according to the 4th BAE Report)*

Fuel type and grade	Motor vehicle or mechanism	Run (km), operation (hours)	Fuel & lubricant consump-tion, l (actual value)
Diesel fuel	GAZ-3409 BOBR	30	24
	DG-20 (kVA-20)	350	1396
	DG-60 (kVA-60)	12	96
	Geko 6401ED-AA	310	620
	20 kW blow heater	37	70
	44 kW blow heater	37	150
	Total		2356
Petroleum A-95	Quadricycle	14	4
	V-1300 snowcat	-	-
	V-800 snowcat	1320	354
	V-800 snowcat	962	260
	Geko 7401	26	50
	Geko 1001	44	28
	Total		696
Petroleum H-80	2.4 kW motorised saw	8	6
	Geko 7401	58	194
	Total		200

For CEE purposes, gross emissions (per field season and per year) and maximum emission values (g/season) were calculated. Gross emissions are used for general and comparative characteristics of the sources of exposure, maximum emissions are applied to assess the impact on the environment using AERMOD model (Section 4.2).

The emissions are calculated subject to two different scenarios:

- Scenario 1 – station seasonal operation; the overall fuel consumption by the stationary and mobile sources per field season is assumed as 2:1 ratio to the current consumption values;

- Scenario 2 – year-round operation; the overall fuel consumption by the stationary and mobile sources per field season is assumed as 8:1 ratio to the current consumption values.

According to the first scenario, the fuel consumption will be as follows: diesel - 4.2 thous. litres; petroleum - 1.2 thous. litres, waste incineration – 300 kg (wastes will be not incinerated on-site at the first stage - see chapter 4.2.6). According to the second scenario: diesel - 16.8 thous. litres, petroleum - 4.8 thous. litres, waste incineration - 1600 kg.

The calculation of pollutants emission from diesel generators is made by the approved method (*Calculation methodology..., 2001*) (Table 4.9). The emissions from mobile sources and incinerator are based on emission factors, as specified by the EMEP/EEA Emission Inventory Guidebook (*Atmospheric Air Pollutant Emission ..., 2009*) (Table 4.10 - 4.11); Tier 1 approach used. The emissions from petrol-fueled generators, blow heaters, motorised saw was not counted due to their occasional operation.

Table 4.9 – Emission factors for stationary diesel installations, g/kg fuel (*Calculation methodology..., 2001*)

Group	Emission factor, g/kg fuel					
	CO	NO_x	CH	Particulate matter	SO_2	Benzo(a)pyrene
A	30	43	15.0	3.0	4.5	$5.5\ 10^{-5}$

The methodology states that any fixed diesel installation of foreign brands, meeting the requirements of the environmental laws of EEC, United States, Japan the emission factors can be reduced for CO – 2 times; NO_2 and NO – 2.5 times; CH, particulate matter and benzo(a)pyrene - 3.5 times respectively. Therefore, the actual emissions can be significantly lower than those as estimated.

Table 4.10 – Emission factors for domestic waste combustion (*Atmospheric Air Pollutant ..., 2009*)

Substance	Measurement unit	Tier 1 emission factor
CO	g/kg	0.7
NO_x	g/kg	1.8
CH	g/kg	0.02
SO_2	g/kg	0.4
TSP	g/kg	0.3
PM10	g/kg	0.23
PM2.5	g/kg	0.15
Pb	g/kg	0.0008
Cd	g/kg	0.0001
Hg	g/kg	0.0011
PCDD/F	µg TEQ/kg	0.35

Results of emission calculations are summarised below in Tables 4.12 and 4.13.

In total during the BAS operation the total air pollutants emissions will amount to 1090.6 kg/season (seasonal mode) or 4363.6 kg/year (wintering mode), sharing 72.5% for motor vehicles and 27.3% for diesel generators.

The main pollutants are: carbon monoxide (60% of total emissions), volatile organic compounds (24%) and nitrogen oxides (12%). Particle matter emissions are expected to amount to 8.4 kg/season or 33.5 kg/year.

Table 4.11 – Emission factors for non-road transport
(*Atmospheric Air Pollutant ..., 2009*), g/t

Substance	Emission factor
CH_4	2200
CO	620793
NH_3	3
VOC	242197
NOx	2765
TSP	3762
PM10	3762
PM2.5	3762
Cd	0.01
Benzo(a)pyrene	0.04
PCDD/F	0.1 µg I-TEQ

*- Standardised Toolkit for Identification and Quantification of Dioxin and Furan Releases, 2005

Among toxic pollutants a particular place belongs to PAHs and dioxins/furans, which will be are emitted from fuel combustion and waste incineration, but their emissions due to expected low amounts of incinerated wastes will be negligible.

Table 4.12 – Pollutants air emission at BAS operation, kg/season
Scenario 1, seasonal mode

Substance	Diesel generators	Motor vehicles	Incinerators	Total
CO	90.3	558.7	0.21	649.2
NOx	125.0	2.49	0.54	128.0
SO_2	15.9	-	0.12	16.0
VOC	41.8	218.0	0.006	259.8
TSP	8.4	3.39	0.09	11.9
PM10	8.4	3.39	0.069	11.9
PM2.5	8.4	3.39	0.045	11.8
NH_3	-	0.003	-	0.0
CH_4	-	1.98	-	2.0
Pb	-	-	0.24 g	0.24 g
Cd	-	0.01 g	0.003 g	0.013 g
Hg	-	-	0.033 g	0.033 g
Benzo(a)pyrene	1.5 г	0.036 g	0.001 g	1.537 g
PCDD / F		0.09 µg I-TEQ	0.105 µg I-TEQ	0.195 µg I-TEQ
Total	**298.2**	**791.3**	**1.1**	**1090.6**

Maximum emissions

The maximum emission levels are calculated for main stationary sources that make a considerable contribution to total emissions. Primarily, these are diesel generators. The calculation is performed for the maximum actual fuel consumption (full capacity operation).

Table 4.13 – Pollutants air emission at BAS operation, kg/year
Scenario 2, wintering mode

Substance	Diesel generators	Motor vehicles	Incinerator	Total
CO	361.2	2234.9	1.12	2597.22
NOx	499.9	9.95	2.88	512.73
SO_2	63.5	-	0.64	64.2
VOC	167.4	871.9	0.032	1039.33
TSP	33.5	13.5	0.48	47.48
PM10	33.5	13.5	0.368	47.368
PM2.5	33.5	13.5	0.24	47.24
NH_3	-	0.01	-	0.01
CH_4	-	7.92	-	7.92
Pb	-	-	1.28 g	1.28 g
Cd	-	0.04 г	0.016 g	0.056 g
Hg	-	-	0.176 g	0.176 g
Benzo(a)pyrene	6.1 г	0.14 г	0.007 g	6.147 g
PCDD / F	-	0.36 µg I-TEQ	0.56 µg I-TEQ	0.92 µg I-TEQ
Total	**1192.5**	**3165.2**	**5.8**	**4363.5**

Measures to reduce the air pollutant emissions and impacts

Measures to reduce the air emissions and to minimise the negative impact include:

- organisational measures;
- primary and secondary measures.

Organisational measures:

- transport route optimisation to reduce the vehicle mileage travelled;
- consideration of factors influencing pollutant dispersion;
- consideration of emission sources placement in respect of sensitive ecosystems;
- emission control (monitoring).

The primary measures shall include:

- use of high-quality fuel, regular maintenance;
- fuel, power and heat saving technologies.

The secondary measures shall include:

- the emission sources to be equipped with emission abatement systems;
- installation of stacks of optimum height.

4.1.2.2. Noise exposure sources

The major and permanent noise exposure sources at the BAS territory are diesel generators, primarily, DG-60 AD60-T48C-2RP. Geko 6401ED-AA and DG-20 AD16-T400-2RP generators were not taken into account, as they will operate as standby for DG-60 reserve. The other stationary sources (pumps, motorised saw, etc.) will produce considerably lower and irregular emissions, and they were also neglected for calculation purposes. In future, DG-100 plant is expected to be installed, having noise parameters similar to those of DG-60. The equipment noise characteristics are summarised in Table 4.14 below.

Table 4.14 - Noise characteristics of diesel generators, dB

Octave bands, Hz	63	125	250	500	1000	2000	4000	8000	дБ(А)
Sound pressure levels, dB	74.9	74	67.5	62	57.7	53.4	48.6	44.3	65

Noise exposure, as generated by motor vehicles, will be spread out over a large territory and will be not too high. Nesting birds will be out of the range of influence.

Helicopter noise impact in the station operation range will be short in time (cargo deliveries to the station early in the season and waste removal at the season closing) and will cover the area approximately coincident to the construction impact area. The Ka-32 noise characteristics are shown in Table 4.6 above.

Measures to reduce the noise exposure

The noise-reducing measures can be grouped into:

1. Organisational
2. Architectural
3. Engineering

Engineering measures can be divided into 2 groups:

1) reduction at the source of generation;
2) reduction on the noise pathway.

Organisational activities shall include control and limitation of traffic routes (primarily, helicopter flights, in particular, in areas sensitive to noise - for example, nesting birds) - flight routing, scheduling and altitude selection, taking into account the impact on birds, optimal arrangement of noise sources in relation to the sensitive receptors, optimal placement of production and residential buildings with respect to noise sources.

Architectural measures shall include: zoning, avoidance of redundant transport routes, creation of noise barriers (if necessary).

The methods aimed at noise spreading reduction shall include acoustic insulation and sound absorption applications.

Engineering measures to apply depend on the nature of the noise produced. Mechanical noise is reduced by top precision machining and assembly of components, use of protective covers. Aerodynamic noises are suppressed by mufflers.

Noise spreading suppression can be achieved by:

1. Acoustic insulation. The technology is based on noise reduction features due to reflection of sound waves from an obstacle. For this purpose, partitions can be established at the noise paths.

2. Sound absorption. The technology is based on noise reduction features due to transfer of sound energy into heat in absorbing material pores. It can be applied in residential and production module construction. Noise produced by constant engine vibration, mechanical noise, forced cooling system operation noise can be reduced by use of sound-absorbing jackets or by application of sound absorbing materials for the premises decoration, i.e.: foam, wooden lining, perforated soundproof panels.

Noise produced by exhaust gases can be reduced by using various extra mufflers: standard mufflers for diesel engines can reduce the exhaust noise by 29 or 40 dB. DG-60 is equipped with soundproof enclosure (Euro-cover) and standard silencer (29 dB). Besides, it features a low-speed design with relatively low noise exposure.

4.1.2.3. Fuel storage and distribution

Presently, fuel and lubricants (diesel, gasoline) are stored in 200-litre barrels located at two open-air platforms areas on pallets and on rocks in the vicinity of the planned BAS deployment site (see Section 3). Lubricating oils and antifreeze liquids are stored in 5 and 20 liters canisters in indoor warehouse; diesel generators and other equipment will be refueled manually. This fuel storage and distribution plan will be used for the entire first phase operation of the station.

For the BAS seasonal operation, it is planned to install special tanks for diesel fuel of 50 m^3 and 25 m^3 capacity and to use metal barrels for petroleum storage on a specially equipped platform. Oil, antifreeze, brake fluid and other oil products will be stored in specially designed closed (storage) facilities. The expected storage amounts of diesel fuel – max. 20 t, petroleum – max. 2 thous. l, lub oil – max. 0.5 t, antifreeze and other commercial fluids – max. 0.2 t.

In case of year-round (wintering) option of the BAS operation, it is planned to install an extra tank for diesel fuel of 50 m^3 capacity; the expected storage amounts will increase substantially: diesel fuel - up to 180 t, petroleum – max. 5,000 l, lub oil – max. 1 t, antifreeze and other commercial fluids – max. 200 l.

Oil spills and leaks

When operating the station, leaks and spills of diesel fuel, petroleum, lub oils, oil sludge may occur. The most likely locations of leaks are on-site fuel & lubricant storage tanks, vehicle refuel points. To prevent leaks and spills, special measures will be taken during vehicle refueling and fuel supply to the diesel generators. In case of accidental spills and unauthorised use of oil products, oil sorbents are expected to be applied, in particular, Oil Split agent in various forms - granules, powder, liquid, as well as installation of protective barriers and other facilities to localise and neutralise fuel spills. It is also planned to have some reserves of peat-based oil sorbent, as developed by the Institute for Nature Management of the National Academy of Sciences of Belarus. These measures and other remedies will ensure:

- prevention of oil infiltration deep into the soils and grounds, rapid elimination of leaks, collection of spilled oil products;
- prevention of oil products migration into surface waters and sea.

As evidenced by the investigations made (Section 3), oil spills used to occur during previous operations of Soviet Antarctic Expeditions in 1979-1989.

4.1.2.4. Water supply and sewage disposal

Water consumption

Water consumption estimated according to applicable rules and regulations in force, depending on the internal sanitary and engineering arrangement of the station premises, as well as based on the previous experience of the Vechernyaya Field Base operation.

According to the station layout and based on the field base operation practice, the required minimum amount of fresh water during the BAS seasonal operation (5-6 people) will be 5-6 m^3 per month, water consumption may increase to 10-12 m^3; the required minimum amount of water for 10-12 people during all-year-round operation will be 9-10 m^3 per month, while, under certain circumstances, it may raise up to 18-20 m^3 per month.

Intake, pumping and water management facilities

Potable and domestic use water will be basically supplied from the Nizhneye Lake, being selected the principal water supply source. During two months (December-January), water will be pumped from the nearby temporary lakes into water storage metal containers. During the other months, water will be transported in tanks from the Nizhneye Lake. The water pumping and management containers are specified in Section 2 above. The potable water quality generally complies with the applicable sanitary standards. The Nizhneye Lake waters will be subject to certain impact due to water intake.

Wastewater disposal

The first-phase station operation will apply the local (independent) sewerage system. Pursuant to the existing building rules and regulations, self-contained sewage systems shall provide for the wastewater collection from residential and other premises, wastewater transfer to the accumulation or treatment facilities, as well as storage or treatment in accordance with the sanitary and environmental requirements and further disposal.

Wastewater disposal standards

Pursuant to the applicable standards, the average daily volume of domestic wastewater shall be equal to the estimated average daily water consumption; however, these values may be adjusted to suit the particular arrangements of the house, individual arrangements and household specifics. The possibility of separate domestic wastewater (from kitchen sinks, bathtubs, sinks, etc.) and fecal sewage shall be ensured. Fecal sewage volume shall be approximately assumed to count 30% of the standard wastewater disposal volume.

Wastewater volume for 5-6 explorers and BAS seasonal operation wastewaters are estimated to range 4.5-5.0 m^3 to 9-10 m^3 per month; for 10-12 explorers at BAS year-round operation – ranging 7.5-9.0 m^3 to 15-18 m^3 per month.

Sewage facilities and external pipelines

Sewage facilities and external pipelines will be designed in accordance with the sanitary standards SNiP 2.04.01-85 and SNiP 2.04.03-85.

According to the station construction design, wastewaters will be collected in heated storage tanks of 200-250 or 400 l capacity, fitted under each module. Each tank will be equipped with self-contained hydraulic pump, and, upon accumulation, domestic wastewaters will be transported to the seacoast and discharged via special hose-pipe (up to 100 m long) into the sea at places of adequate mixing and rapid dissipation.

In future, storage tanks of individual modules will be connected in an integrated sewerage system with automatic discharge of domestic wastewaters into the central collector.

Wastewater collectors and treatment facilities

Wastewater discharges will comply with the sanitary standard SanPiN 2.1.2.12-33-2005 – Sanitary requirements for surface waters protection from pollution, as well as the requirements of SanPiN 4630-88 and Protocol on Environmental Protection to the Antarctic Treaty.

Pursuant to Article 5 of the Protocol on Environmental Protection, sewage and domestic liquid wastes may be discharged directly into the sea, taking into account the assimilative capacity of the receiving marine environment, provided that:

a) such discharges are organised, if possible, in areas, which are reported to fit for waste waters initial dilution and rapid dispersal; and

b) large quantities of such wastes (generally produced at the station at austral summers with weekly average staff of 30 people or more) are treated at least by maceration.

The first-phase BAS operation does not plan to engage construction of wastewater treatment facilities. Wastewaters will be discharged from the collecting tanks into the central collector. The collector is expected to be piped to a streambed (natural ravine), which entry into the Terpeniya Bay near the Dostupny Cape, which is consistent with the provisions of Article 5, Schedule 3 of the Protocol. In such case, the sewerage pipe will be 150-200 m long (Figure 4.3).

The collector's alternative option shall be piping directly from the collector site to the seacoast at the Terpeniya Bay near the Dostupny Cape. In this case, the length of collector pipeline might range 800 to 1000 m. The pipeline will be laid at the top surface points, with supports mounted on bedrocks. The second (alternative) option increases the project costs significantly, and contributes to the risk of pollution in case of emergencies, such as ruptures and freezing of pipes due to adverse natural effects - landslides, erosion and thawing of moraine deposits, mud snowfields, major snowdrifts etc.

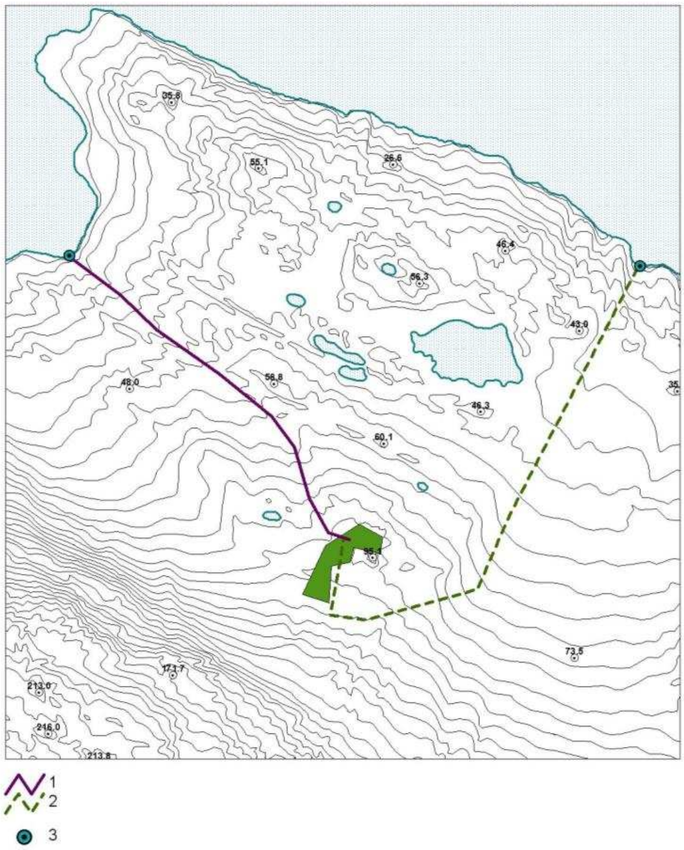


Figure 4.3 – BAS domestic wastewater collector layout (1 – main option, 2 – alternative option, 3 – discharge point)

Pursuant to the construction regulations, the adequate insulation system to prevent freezing will be arranged.

When designing self-contained (local) sewage systems, the applicable sewage sanitary requirements for self-contained (local) water supply systems and engineering solutions of the facilities subject to sewage will be taken into consideration. In particular, it will be necessary to avoid any possible sewage contamination (either from storage tanks or pipelines due to leaks) of ponds, glaciers and snowfields, as stipulated by the applicable regulations.

Fecal wastes treatment

Every person produces annually about 50 l of faeces and 500 l of urine in average. A conventional toilet system consumes 12,000 l of water to drain these wastes annually. Every person annually excretes about 60 l of faeces, if added with toilet paper, which contain 0.55 kg of nitrogen and 0.18 kg of phosphorus.

Fecal wastes will be burned by Incinolets, being installed at each module. The planned amounts of fecal wastes to be incinerated for 5-6 staff explorers are assessed to be 25-30 kg/month., or

100-120 kg per season (in case of BAS seasonal operation option), or 300-360 kg/year (in case of all-year-round operation).

Incinolets will have some impact on the environment, but no quantitative estimation of emissions was performed due to unavailable reference data.

4.1.2.5. Assessment of the environmental impact due to wastewater generation and discharge

To assess the environmental impact, as related to wastewater generation, the content of pollutants in wastewater is required. No sampling of wastewaters at the BAE field camp was made. When assessing the environmental impact, the averaged composition of wastewaters was taken into consideration according to the (*Methodological Recommendations for calculations.., 2001*) (Table 4.15).

Table 4.15 – Averaged characteristics of domestic wastewaters from settlements (*Methodological Recommendations for calculations.., 2001*)

Pollutant	Concentration, mg/l
Suspended solids	110
$BOD_{complete}$	180
COD	250
Fats	40
Ammonia nitrogen	18
Chlorides	45
Sulfates	40
Dry residue	300
Oil products	1.0
Surfactants (anionic)	2.5
Phenols	0.005
Iron, total	2.2
Copper	0.02
Nickel	0.005
Zinc	0.1
Chromium (+3)	0.003
Chromium (+6)	0.0003
Lead	0.004
Cadmium	0.0002
Mercury	0.0001
Aluminum	0.5
Manganese	0.1
Fluorides	0.08
Phosphorus in phosphates	2.0

Assumed volume of wastewaters – 40 m^3 for seasonal option and 216 m^3 for wintering option. The results of calculation are shown in Table 4.16.

Table 4.16 - Estimated gross pollutants discharges into the sea with sewage during BAS operation, kg/season and kg/year

Pollutant	Seasonal mode	Wintering mode
Suspended solids	4.4	23.76
$BOD_{complete}$	7.2	38.88
COD	10	54
Fats	1.6	8.64
Ammonia nitrogen	0.72	3.888
Chlorides	1.8	9.72
Sulfates	1.6	8.64
Dry residue	12	64.8
Oil products	0.04	0.216
Surfactants (anionic)	0.1	0.54
Phenols	0.0002	0.001
Iron total	0.088	0.475
Copper	0.0008	0.0044
Nickel	0.0002	0.001
Zinc	0.004	0.0216
Chromium (3+)	0.0002	0.001
Chromium (6+)	0	0
Lead	0.0002	0.001
Cadmium	0	0
Mercury	0	0
Aluminum	0.02	0.108
Manganese	0.004	0.0216
Fluorides	0.0032	0.0172
Phosphorus in phosphates	0.08	0.432

Reference to the calculations made, the wastewaters, as generated by the first-phase BAS operation, will be produce 4.4 kg of suspended solids, 7.2 kg of organic matters ($BOD_{complete}$), 0.72 kg of ammonium nitrogen, 1.8 kg of chlorides, 1.6 kg of sulfates, 0.04 kg of oil products, 0.1 kg of surfactants, 0.09 kg of iron, and other pollutants. For the BAS wintering operation, the amounts of pollutants will increase in 5.4 times. The assessment of the environmental impact, as resulted from such amounts of pollutants, on the sea water composition is described in Section 4.2.

Measures to reduce the impact of wastewaters on the environment

The wastewater management system as implemented will be aimed at:

- reduction of water consumption, water-saving solutions, water recycling, in future;
- separate collection of different types of wastewaters;
- wastewater accumulation and sedimentation before discharge;

- monitoring of dilution parameters in the wastewater discharges;
- prevention of wastewater penetration (infiltration) into surface waters.

When elaborating the internal rules for sewage system use, measures to avoid the discharge of large-scale food wastes, waters from vehicle washing, hazardous chemicals, single large amounts of surfactants from laundry, cleaning, dishwashing, etc. into the sewage system will be implemented.

When selecting the point of wastewater discharge into the sea, the wastewater mixing conditions at the discharge point will be taken into consideration.

4.1.2.6. Solid wastes generation and disposal

The station operation will be accompanied by solid wastes formation. In failure to properly organise a waste management system, their accumulation can cause environmental problems.

Domestic wastes

The structure of municipal solid wastes was assumed according to TCP 17.11-02-2009 as follows: food wastes - 30-38%, paper and cardboard - 25-30%, other wastes - 32-45%. According to estimates volumes of domestic wastes generation may be up to 1.2-1.3 kg per day per person, including food wastes 0.3-0.4 kg per day per person, wastes which can be utilized by combustible according to the Article 4 of the Annex 3 to the Protocol on Environmental Protection – 0.4-0.5 kg per day per person. For 5-6 person staff the volume of domestic wastes will amount 700-1000 kg per season, including food wastes 180 – 290 kg, combustible wastes – 240-300 kg (Table 4.17). At wintering mode and 10-12 person staff the volume of wastes will be approximately 6 times higher. Assuming average density of domestic wastes as 200 kgr/m^3 *(according to TCP* 17.11-02-2009), accumulation of domestic wastes in volume units will amount 3.6-5.0 m^3 per season (seasonal mode) or 21.6-30.2 м^3 per year (wintering mode) (Table 4.17).

Table 4.17 – Projected amount of domestic wastes generation at BAS

Type of waste	Seasonal variant		Wintering variant	
	Wastes weight, kg	Wastes volume, м^3	Wastes weight, kg	Wastes volume, м^3
Domestic	720-1008	3.6-5.04	4320-6048	21.6-30.24
Food wastes	180-288		1080-1728	
Combustible	240-300		1440-1800	

It should be noted that values of wastes generation shown above mark the upper limit of their accumulation; in Antarctic conditions according to experience wastes accumulation is usually lower.

Other wastes

In addition to domestic wastes, a certain amount of other wastes will be produced during the BAS operation.

For equipment and vehicles operation and maintenance, a significant amount of industrial wastes, including packaging of fuel, lubricants, antifreeze, defective parts of engines and equipment, etc., will be produced. In particular, the annual accumulation of empty fuel barrels is expected to count 15-20 pieces for the first-phase operation of the station.

Resulting from diesel generators and mobile equipment maintenance, oil sludge (waste oils) and antifreeze will be generated. The total amount of sludge is estimated at 100 l per month; about the same amount of waste antifreeze is additionally expected.

Small amounts of medical wastes are estimated to generate. No mercury wastes are expected due to avoidance of fluorescent lamps and/or mercury containing devices at the station. No radioactive wastes are expected either.

Wastes of scientific activities (laboratory wastes, batteries, failed equipment, etc.) will be generated from time to time and basically in low quantities.

It is planned to organise separate waste collection, including food, combustible, non-combustible, medical, oil sludge, fuel barrels, etc., in accordance with the requirements of the Protocol on Environmental Protection. Combustible wastes that can be disposed of by incineration in accordance with the Protocol on Environmental Protection, will be incinerated upon accumulation; non-combustible wastes, including hazardous substances, will be stored on-site in containers and barrels, followed by subsequent transfer to the mainland. Food wastes will be dumped into the sea, subject to the requirements of the Protocol on Environmental Protection. Waste antifreeze will also be accumulated and transported to the mainland.

For waste incineration KTO50.K20 incinerator is planned to be installed (manufactured by Bezopasnye Tekhnologii JSC, Saint Petersburg, Russian Federation), equipped with two-stage waste gases abatement system. Incinerator's maximum capacity – 50 kg/h, operation periodicity – once a week (5-8 hours). The incinerator specifications are shown in Chapter 4.2.2.

Ash will be generated from wastes combustion; its amount will depend on ash content in wastes. Assuming average ash content 10-20%, anticipated generation of ashes from incineration will be 24-60 kg per season (seasonal mode) and 144-360 kg per year (wintering mode). The accumulated ash will be transported outside the Antarctic aboard on-board of vessels.

Until the waste incinerator installation, combustible wastes are supposed to be burnt at Molodyozhnaya RAE field base incinerator.

Measures to reduce the environmental impact from solid waste disposal

- Waste Management Plan (instruction) elaboration, waste reporting;
- prevention of waste dispersal/liquid waste leakage to the environment;
- separate collection and storage, compaction;
- waste temporary storage arrangement;
- regular removal of wastes;
- incineration of non-hazardous combustible waste, subject to the provisions of Article 3, Schedule 4 of the Protocol on Environmental Protection.

4.1.2.7. Other impacts

Electromagnetic radiation
Diesel generators, radio equipment, particularly, radio stations, will serve as sources of electromagnetic radiation. However, large sources of electromagnetic radiation will not be operated at the station. The radiation will not exceed the established limits.

Measures to reduce electromagnetic impacts on the environment

These measures will basically include strict compliance with the regulations of tools and devices operation and regular maintenance.

Physical (mechanical) disturbances
The station will cover the area of about 7.15 thous. m^2, including first-phase laboratory & residential and production & residential modules and utility modules - 154.4 m^2. The aforesaid territory will be subject to irreversible environmental changes. In addition fuel storage facilities, open-air storage platforms, pipelines and power transmission lines will occupy the area of a few hundred m^2. At the same time, reference to the approved construction layout, the disturbance will affect only rock surfaces.
When engaging in research activities, a mechanical impact on snow & ice cover and soil will be observed. However, this impact will be negligible due to use of light snowmobiles when driving on snow and ice; bare surfaces will be walked on feet only.

Measures to reduce the mechanical impact to the environment
- compact arrangement of the station premises, thus minimising the station infrastructure area;
- use of environmentally friendly vehicles (snowcats), minimising the impact on the snow and ice cover;
- route optimisation;
- monitoring of mechanical impact (erosion) of soils and snow & ice cover.

4.2. Exposure analysis

4.2.1. Exposure identification at the station construction

The identification of the environmental impact during the station construction embraces the analysis of all the changing elements or environmental issues affected by the station operation.

4.2.1.1. Ambient air exposure

The main source of air pollutants emission during the BAS construction will be Ka-32 helicopter, which planned to be used for delivering of the modules from shipboards. The calculation of helicopter-caused emissions is based on the helicopter's specifications, number of takeoff and landing cycles, specific fuel consumption and emission factors (Section 4.1.1).

As depicted in Section 4.1.1, based on the assumed Ka-32 helicopter 10 flights annually during the first-phase construction, pollutants emission from the construction phase is assessed as follows: nitrogen oxides – 30 kg, carbon oxide – 19 kg, hydrocarbons – 3.4 kg, particulate matter – 0.64 kg. The helicopter flight share for the field base construction is minor, as compared to the total number of helicopter flights during RAE ship unloading. Thus, the contribution of this source in air pollution will be minor and limited in time. The expected increase in pollutant concentration will not get to the surface air layer, and will be limited in time as well.

4.2.1.2. Noise exposure

Noise is one of the environmental factors which affect adversely the health conditions of humans and living organisms.

Due to the adverse effects of noise exposure, specific rules and regulations were adopted to control noise exposure. They establish mandatory requirements to be met in the design, construction and operation of various buildings, planning and development of settlements in order to protect from noise and ensure the standard acoustic environment in industrial, residential and public buildings and residential areas.

The most significant source of noise during the BAS construction (and in future operation) will be helicopter. In this regard, when quantifying the noise exposure during the BAS construction, a particular attention is paid to helicopter-caused noise estimation, using the NMSim model.

Calculation of helicopter-caused noise exposure with NMSim model

To assess the helicopter-caused noise impact, NMSim v.3.0 model was applied. NMSim (Noise Model SIMulation) was developed by Wyle Laboratory. This model generates time-based diagrams of noise exposure from moving or stationary sources, taking into account the influence of terrain environments on sound propagation.

The reference data for calculating the sound level using NMSim model are:

- hypsometric map, based on 1:25000 topographic map;
- conventional flight route, with start (takeoff) on-board the ship standing at 3-4 km distance from the shore, hangover at the BAS construction site and return on board the ship, with the readings of the flight speed, altitude, engine operation, route being applied. The flight route was selected with approximation, based on the actual conditions of discharge at BAE site in 2011-2012 (Section 2.1).

The checkpoints to assess the noise pollution parameters: BAS and Gnezdovoy Cape.

Calculation results

The noise level simulation yielded the following results:

- noise level charts (Figures 4.4-4.7);
- noise-changing graphs at the checkpoints: BAS site, Gnezdovoy Cap (Figures 4.8-4.9);
- noise spectra in 1/3-octave bands at the checkpoints (Figures 4.10-4.11).

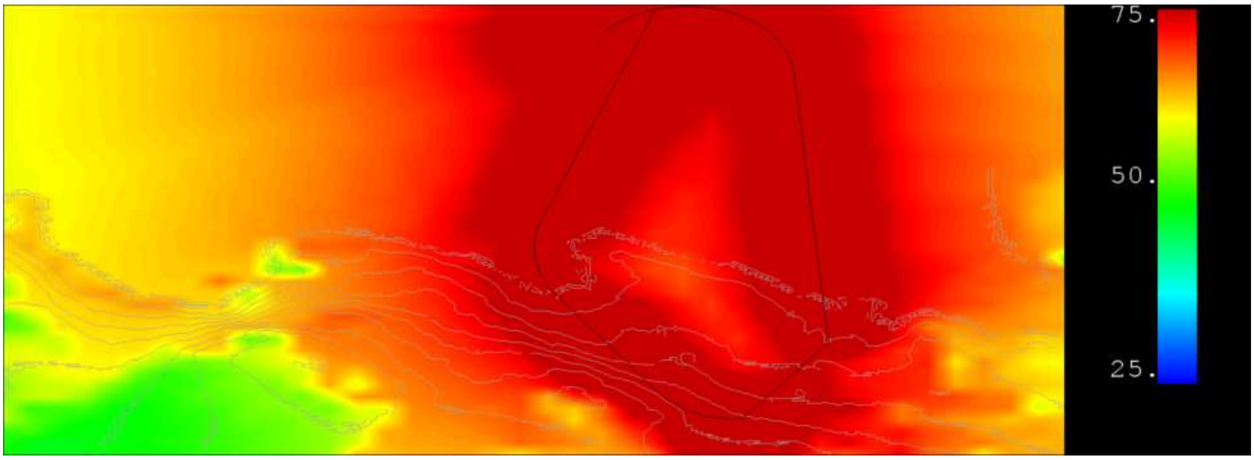


Figure 4.4 - Flat -weighted helicopter noise level chart at delivering cargo to BAS, single flight, max.

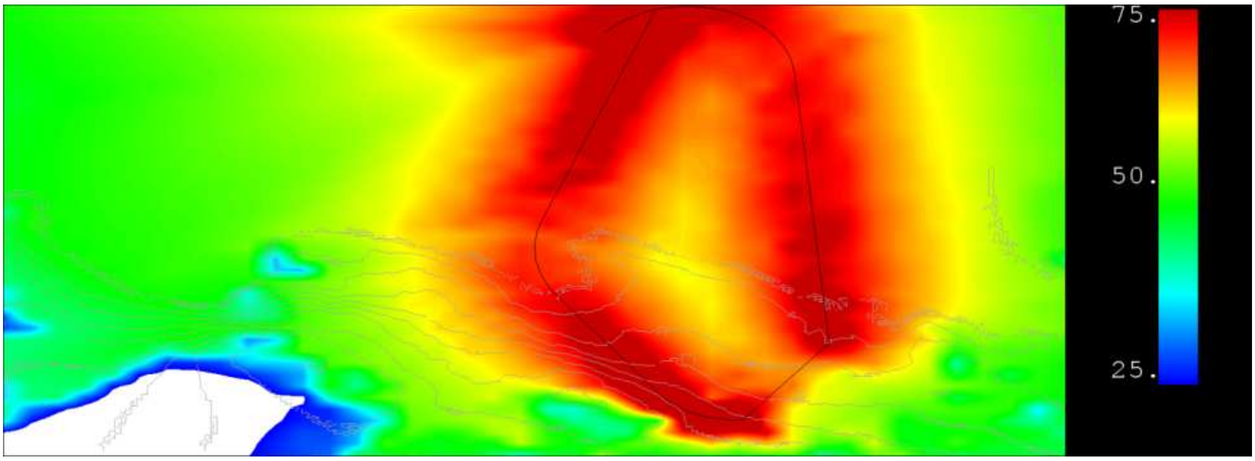


Figure 4.5 – A-weighted helicopter noise level chart at delivering cargo to BAS, single flight, max.

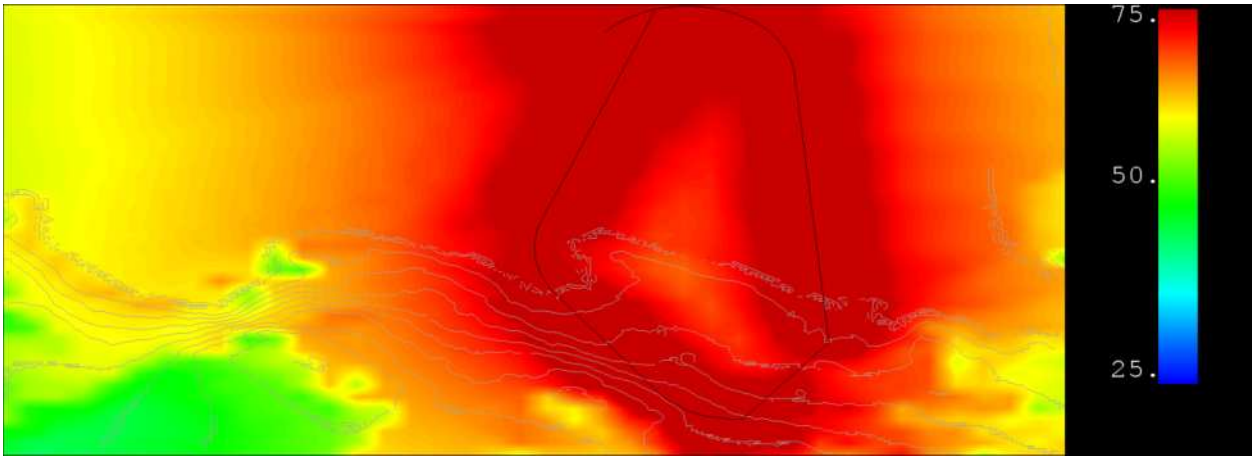


Figure 4.6 – C -weighted helicopter noise level chart at delivering cargo to BAS, single flight, max.

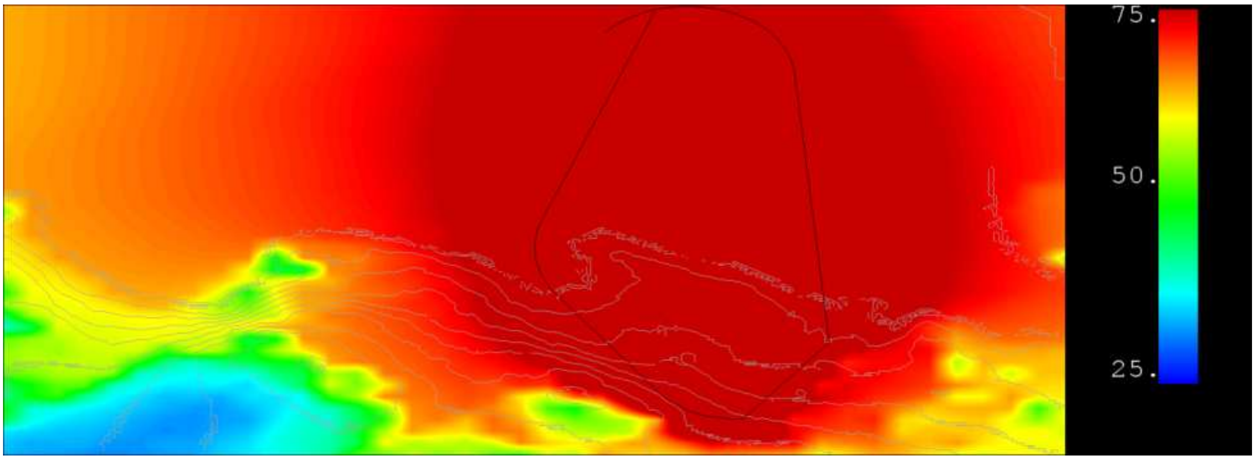


Figure 4.7 - Noise exposure chart (1 sec. scale) (SEL) at delivering cargo to BAS, single flight

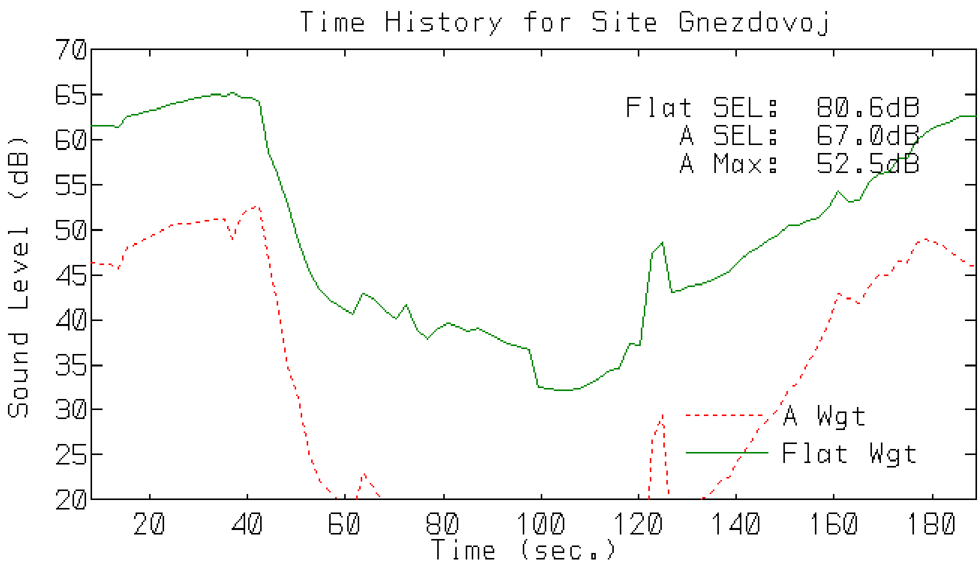


Figure 4.8 – Noise level graph at helicopter flight, Gnezdovoy Cap vicinity

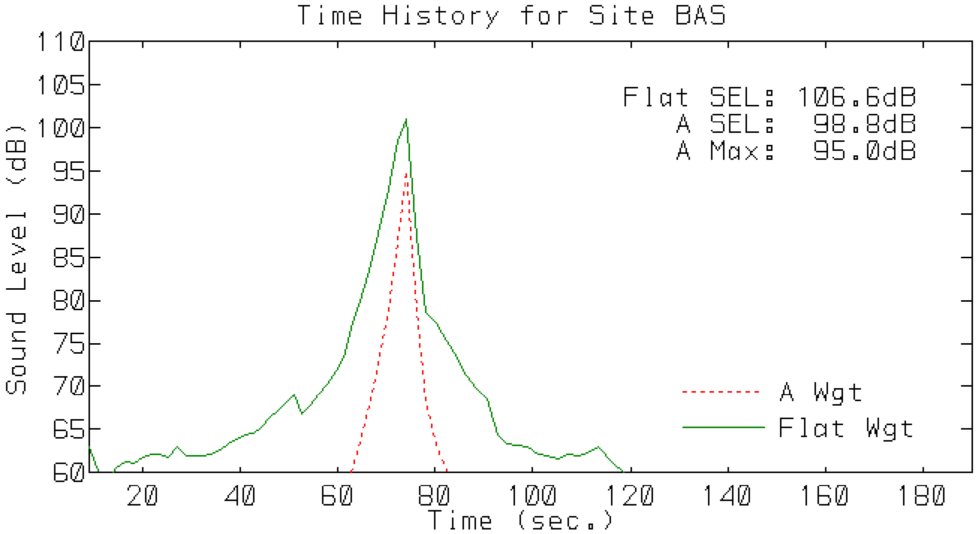


Figure 4.9 – Noise level graph at helicopter flight, BAS site

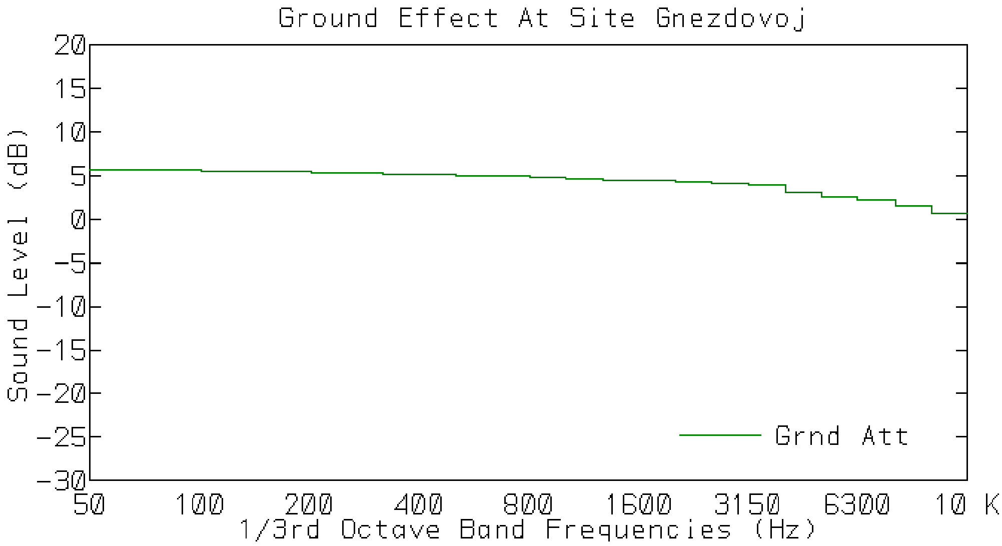


Figure 4.10 – Noise spectra at helicopter flight, Gnezdovoy Cap vicinity

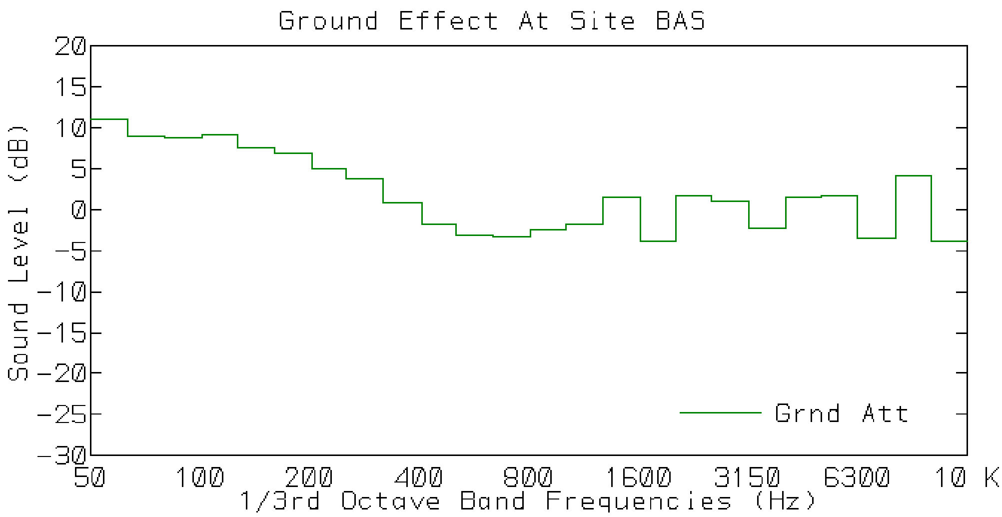


Figure 4.11 –- Noise spectra at helicopter flight, BAS site

Reference to the calculations made, the linear-weighted noise levels at Gnezdovoy Cap vicinity (where the penguin colony is situated and which is potentially prone to noise exposure) will not exceed 65 dB, A-weighted - 55 dB. The maximum noise levels at BAS site can reach 95 dBA, but these levels will be short-timed, and therefore the equivalent noise level Leq and LDN levels will not exceed 50-60 dBA, which meet the existing standards applicable to residential areas.

The impact caused by auxiliary tools during the BAS construction (drills, motorised saws, etc.) will be minor (and exposed locally).

4.2.1.3. Exposure on soils and rocks

Deposition of pollutants on ground surface during the station construction will be minimal (less than minor). This is due to small amounts of pollutants emission and their dissipation; in general, the exposure will result only to a very slight increase in contaminant content in soils.

Mechanical impact on soils, ground and rocks at the first construction phase will be associated with placement of the station block modules, while the second phase will engage the construction of platforms for fuel tanks, as well as central collector piping.

For installation of block modules, platforms, metal tanks, movement of collector pipes and supports, motor vehicles (helicopter) will be used.

During the construction works, no extraction (disturbance) of rocks is planned to be effected.

The mechanical impact during the construction works will be limited in time.

Solid wastes exposure during the station construction will be minor and limited in time. During the construction a certain amount of solid wastes will be generated, mainly from packing and fastening materials and food wastes. The wastes will be sorted out and stored (or disposed of) separately with subsequent transportation of residues to the mainland.

Any sewage will be generated basically from operation of the staff and equipment engaged in the station construction. For wastewater treatment, the appropriate tanks currently existing at the BAE field base will be used. The possibility of leaks will be minimised.

Oil spills / leaks on helicopter refuel and maintenance. The helicopters are expected to be refueled and maintained on board the vessels; in this connection, the possibility of fuel spills or other leaks at the BAS construction territory trends to minimum.

4.2.1.4. Exposure on surface waters, snow and ice cover

Impact on surface waters will be caused mainly through the water intake for domestic purposes, but water consumption per season during the construction stage is assessed to be minor. No sewage is expected to penetrate surface waters, and therefore the impact on ponds and snow & ice cover during the construction will be minimal. The risk of leaks and washing contaminants from soils and their penetration into ponds and snow & ice cover during the station construction will be insignificant.

During the station construction, direct mechanical impact on the ice sheet will not be made due to helicopter-engaged construction technology. Negligible impact on the snow & ice cover is expected only in the immediate vicinity of the construction site.

Exposure to water ponds and snow & ice cover due to pollutant-carrying atmospheric precipitations during the station construction will be minor and limited in time.

Wastes, noise, heat and electromagnetic exposure during the construction are expected as having less than a minor and limited in time impact on waters and snow & ice cover.

4.2.1.5. Exposure on biota, marine environment and marine ecosystems

The station's major facilities will be built beyond the existing moss and lichen cenoses and/or nesting birds. The mechanical destruction of epiphytic lichen cenoses will only occur directly at the construction site.

Atmospheric depositions to the marine area will be negligible. No substantial increase of wastewaters dumping into the sea is expected, therefore, the impact on marine ecosystems during the construction stage will be minimal.

Pollutant penetration into the sea due to leaks and/or washing from contaminated surfaces is possible, but will be minimised through remedial actions being implemented.

As described in Section 4.2.2.2, noise impact will be limited in time. Heat and electromagnetic exposures are identified as having less than a minor impact on biota, marine environment and marine ecosystems.

4.2.1.6. Impact on aesthetic features of the landscape and natural surroundings

Given the significant disturbance of the natural landscape at the BAS construction site, the planned construction will not deteriorate, but is expected to improve the aesthetic features of the landscape. The station construction is anticipated to blend seamlessly into the Mount Vechernyaya landscape.

The overall impact during the construction works (except for polluting emissions and noise) will be localised within the site boundaries. The block modules and other structures are not planned to be installed at areas with developed lichens or mosses; in this respect, the impact on biota will be minimal.

Measures to reduce the environmental impact during construction:

- on board the vessels: compliance with MARPOL requirements, time-saving schedule to reduce the duration of stay in the Antarctic waters;
- helicopter operation: flight route optimisation, tough scheduling, optimal helicopter loads, flight time minimisation, reduced flight cycles;
- site preparation: prevention of excess dust generation upon site ground works, drilling holes;

- mechanical assembly works: high efficiency, speed and quality of works being performed, which would benefit to reduction of polluting emissions and noise exposure;
- piping and power cable line laying: soil and ground disturbance minimisation, in particular, in respect of vegetation-covered areas;
- use of motor vehicles: optimal routes scheduling;
- sewage treatment, waste management: solid and liquid wastes minimisation, waste transfers to the mainland.

4.2.2. Identification of environmental exposure at station operation

The environmental impact identification involves the analysis of all the major characteristics of environmental components and valuables that are subject to change due to various exposures caused by the Mount Vechernyaya Belarusian Antarctic station operation.

4.2.2.1. Ambient air exposure

When operating the station, the ambient air will be subjected to pollutants emission from diesel generators, vehicles, incinerator. To assess the ambient air impact caused by the Mount Vechernyaya BAS operation, simulation-based calculations of pollutant dispersion in ambient air, caused by major permanent sources, were performed. Atmospheric dispersion of emissions from mobile sources was not subject to quantitative assessment due to rather limited number of all-terrain sources to be used (mainly snowmobiles), and such emissions will be spread over a large area.

<u>Modelling of dispersion of pollutants emission from stationary sources at the BAS operation using AERMOD</u>
The dispersion of pollutants from stationary sources was assessed using the AERMOD model, Version 12345, developed by the U.S. Environmental Protection Agency (US EPA) and the American Meteorological Society in collaboration with Lakes Environmental (Canada) and BREEZE (USA) companies.

Computational grid
The simulation of pollutant dispersion in the atmospheric air surface layer during the BAS operation was performed using the Cartesian coordinate system. A uniform grid 3000 x 1800 m with 20 m grid sells was taken for analysis. As its reference point (bottom left corner of the lattice) became the point with geographic coordinates -67°40’00” S and 46°07’00” E, and, accordingly, 547350.6518 m and m 2493871.8114 of the UTM coordinate system. The major sources of emission and assumed BAS deployment site are located close to the model area grid centre.

Exposed objects (receptors)

A network of 20x20 m grid cells (total number – 1350) was considered as the major objects (receptors) of pollutants dispersion modeling. In addition pollutant concentrations were also estimated for a number of locations within the grid specifically sensitive to air quality. As such locations the laboratory & residential and production & residential modules and protected area (moss and lichen cenose) were selected. The calculated coordinates of the receptors' centre points in the UTM system and conventional coordinate system are shown in Table 4.18 below.

Table 4.18 – Receptors' centre points in the UTM system and conventional coordinate system

Receptor description	Longitude, UTM coordinates, m	Latitude, UTM coordinates, m	X-axis distance in the conventional coordinate system, m	Y-axis distance in the conventional coordinate system, m
Service & residential module, single-storey (module 1)	548750.8	2494550.2	1400.1	678.4
Laboratory & residential and production & residential block module, two-storey (module 2)	548777.3	2494531.3	1426.7	659.5
Laboratory & residential module, single-storey (module 3)	548746.3	2494532.8	1395.7	661.0
Production & residential module, two-storey (module 4)	548731.4	2494510.5	1380.8	638.6
Protected area	548758.4	2494509.3	1407.7	637.5

Emission sources

During the BAS operation, pollutants will be emitted due to fuel combustion by stationary engines and vehicles, as well as incineration of domestic wastes.

The major sources of air pollutants at the BAS first-phase construction and operation will be the existing 2 diesel generators of 60 and 20 kVA capacity in alternate operation, i.e.: DG-20 AD16-T400-2RP and DG-60 AD60-T48C-2RP. At later stages, 2 diesel generators (DG-100 ADS) of 100 kVA capacity and KTO50.K20 incinerator will be installed. Initially, the pollutant concentrations are calculated with adjustment to the said stationary emission sources, i.e. diesel generators and incinerator.

The performance characteristics were obtained from the devices' engineering specifications and manufacturer's manuals. Some parameters were estimated based on the engineering specifications and operation logs; certain parameters for KTO-50.K20 incinerator were based on performance data of similar installations.

Parameters of buildings and structures

Reference to the station design, the laboratory & residential and production & residential modules will be single-storey or two-storey. The modules' heights are estimated to be 2.4 m for single-storey modules and 4.9 m for two-storey modules. The modules' low-fit design will not significantly affect the pollutant dispersion parameters. In this regard, BPIP application for building / structure parameters assessment is not required at this stage.

Meteorological data

The AERMOD model uses 3 groups of initial reference meteorological data, i.e.: 1 – surface weather station monitoring data, 2 – atmospheric edge-reading sounding data, 3 – data obtained from specialised local instrument observations (*on-site data*).

Atmospheric sensing is not performed by all meteorological stations, or such data are not available. Among WMO network stations dealing with such scientific observations, the Japanese Antarctic station Syowa (WMO index 895320) stands most close to the proposed BAS construction site. It is located about 308 km from the proposed BAS site. This station has been dealing with a series of scientific observations since 1994.

Data obtained from ground-based observations are more detailed. The possibility to use observation data obtained by two WMO Antarctic stations was considered: Japanese Syowa and Russian Molodyozhnaya. Data communicated by M-49M automatic weather station (AWS), located at the Vechernyaya field base of BAE in the immediate vicinity of the proposed BAS construction site was also accounted.

Reference to several AERMOD test runs using different meteorological information the choice was made in favor of Molodyozhnaya station data.

Surface characteristics

For AERMET pre-processor calculation such simulated area characteristics as annual average surface roughness, diffuse reflectance (albedo) and Bowen ratio should be introduced. This work phase was performed subject to simplified pattern. The adjacent area was divided into four sectors, having different combinations of rocky areas, glaciers and snowfields. Albedo, Bowen ratio and roughness coefficient for each sector were identified under AERSURFACE Guide (*EPA, 2008)*.

Resulting from this phase of work, AERMET made several pairs of meteorological SFC and PFL-files, containing the reference meteorological data for AERMOD simulation. The files were obtained for different time periods: summer season, a year, five-year.

Digital description of the topography of territory adjacent to the BAS site

Topographic features have a significant impact on pollutant dispersion in the atmospheric air. For the Mount Vechernyaya BAS construction site no necessary DEM-data with the required resolution (20 m) was available. Therefore the AERMAP phase was preceded by a preparatory stage, including a digital elevation model generation. Topographic map of 1:25000 scale (hypsometry layer) became the basis for the digital elevation model.

Results of pollutant dispersion modeling from BAS emission sources

The dispersion of pollutants from the BAS emission sources in the ambient air over the adjacent territory was calculated under two scenarios. For the both scenarios, concentrations of the following substances were calculated, i.e.: NO_2, SO_2, CO, soot as PM10, hydrocarbons.

The topographic features of the receptor territories were taken into consideration. Any influence of the existing buildings and structures in respect of pollutant dispersion was ignored. The initial (background) concentration was assumed to be equal to zero for all substances.

The estimations were made in respect of the following exposed objects (receptors): four laboratory and residential, service & residential and production & residential modules and protected area, as well as for the regular receptor network with 20 m grid sells.

The maximum hourly, 8-hourly and daily concentrations of pollutants, as well as hourly mean, 8-hour mean, daily and monthly mean concentrations were calculated for the reporting period. The scenario-based simulation results description is given below.

Scenario 1

Source of pollution – 1: diesel generator DG-60 AD60-T48C-2RP of 60 kVA capacity; reference to the scenario, the diesel generator will operate daily and continuously at full power. In fact, a diesel generator DG-20 AD16-T400-2RP of 20 kVA capacity will operate alternately, but, to estimate the maximum possible levels of ambient air impacts, the calculation was performed for full-time DG-60 operation.

DG-60 power station parameters are as follows:

Stack height - 3.5 m;
Stack diameter - 0.08 m;
Flue gas temperature - 350ºC;
Flue gas flow - 39.8 m/sec.

The reporting period shall be the summer season (December-March). This scenario is valid for the seasonal BAS operation mode.

The maximum short-term and long-term evaluations of the surface pollutant concentrations at the BAS site, reference to Scenario 1, are presented in Tables 4.19 (5 receptors) and 4.20 (for the regular grid of receptors), as well as at Figures 4.11-4.25. The regulatory standards for ambient air pollutant concentrations, as applicable in Belarus, EU and United States, are given in Table 4.21 below.

Table 4.19 – Modelled air pollutants concentrations for selected receptors from the BAS stationary emission sources operation. Scenario 1, μg/m^3

Parameter and averaging period	Module 1	Module 2	Module 3	Module 4	Protected area
Carbon oxide (CO)					
Maximum 1-hour average	55.53	55.96	67.42	82.50	100.86
Mean 1-hour average	1.09	1.02	1.44	1.98	1.65
Maximum 24-hour average	13.26	14.78	17.42	23.38	23.62
Mean 24-hour average	1.35	1.27	1.78	2.44	2.06
Maximum 1-month average	2.82	2.88	3.77	5.01	4.58
Mean 1-month average	1.40	1.32	1.85	2.55	2.13
Nitrogen dioxide (NO_2)					
Maximum 1-hour average	67.04	61.00	77.23	73.79	101.21
Mean 1-hour average	1.54	1.33	1.99	2.68	2.09
Maximum 24-hour average	16.41	15.95	21.52	27.84	24.77
Mean 24-hour average	1.92	1.66	2.47	3.31	2.61
Maximum 1-month average	3.97	3.55	5.12	6.64	5.44
Mean 1-month average	1.98	1.72	2.56	3.45	2.70
Sulfur dioxide (SO_2)					
Maximum 1-hour average	8.15	8.21	9.90	12.11	14.80
Mean 1-hour average	0.16	0.15	0.21	0.29	0.24
Maximum 24-hour average	1.95	2.17	2.56	3.43	3.47
Mean 24-hour average	0.20	0.19	0.26	0.36	0.30
Maximum 1-month average	0.41	0.42	0.55	0.74	0.67
Mean 1-month average	0.21	0.19	0.27	0.37	0.31
PM10					
Maximum 1-hour average	5.60	5.65	6.80	8.33	10.18
Mean 1-hour average	0.11	0.10	0.14	0.20	0.17
Maximum 24-hour average	1.34	1.49	1.76	2.36	2.38
Mean 24-hour average	0.14	0.13	0.18	0.25	0.21
Maximum 1-month average	0.29	0.29	0.38	0.51	0.46
Mean 1-month average	0.14	0.13	0.19	0.26	0.21
Hydrocarbons (CH)					
Maximum 1-hour average	27.51	27.72	33.40	40.87	49.97
Mean 1-hour average	0.54	0.51	0.71	0.98	0.82
Maximum 24-hour average	6.57	7.32	8.63	11.58	11.70
Mean 24-hour average	0.67	0.63	0.88	1.21	1.02
Maximum 1-month average	1.40	1.42	1.87	2.48	2.27
Mean 1-month average	0.70	0.65	0.92	1.26	1.05

Table 4.20 – Maximum modelled air pollutants concentrations for selected receptors during the BAS stationary emission sources operation. Scenario 1, μg/m^3

Pollutant	Maximum concentrations			Maximum average concentrations		
	1 h	24 h	Month	1 h	24 h	Month
Carbon monoxide (CO)	234.0	106.4	42.2	24.6	26.7	29.3
Nitrogen dioxide (NO_2)	272.0	145.4	60.3	35.2	38.2	41.9
Sulfur dioxide (SO_2)	34.5	15.6	6.2	3.6	3.9	4.3
PM10	23.7	10.7	4.3	2.5	2.7	3.0
Hydrocarbons	116.4	52.7	20.9	12.2	13.2	14.5

As calculated on the regular grid, the maximum hourly concentrations for all substances, except NO_2, was observed at the point with coordinates: x = 1320, y = 560, and for NO_2 - at x = 1320, y = 580. The maximum 24-h and monthly averaged concentrations for all substances were found at x = 1320, y = 600; the same point was reported to have the maximum gain of the average concentrations of these substances for all the averaging periods.

Table 4.21 - Regulatory standards for ambient air pollutant concentrations, μg/m^3

Substance	Belarus		EC		United States	
	Reference value	Averaging period	Reference value	Averaging period	Reference value	Averaging period
NO_2	250	20 min.	200	1 hourc	100 ppb	1 hour
	100	24 hours	40	1 year	53 ppb	1 year
	40	1 year	-	-	-	-
SO_2	500	20 min.	350	1 hour	75 ppb	1 hourc
	200	24 hours	125	24 hour	-	-
	50	1 year	-	-	-	-
PM10	150	20 min.	50	24 hours	150	24 hours
	50	24 hours	40	1 year	-	-
	40	1 year	-	-	-	-
CO	5000	20 min.	10000	8 hours	35 ppm	1 hourc
	3000	24 hours	-	-	9 ppm	8 hours
	500	1 year	-	-	-	-

Carbon monoxide

Hourly average concentrations

The maximum hourly carbon monoxide concentration is expected to be 234.9 μg/m^3 and possibly detectable on a small area at 110-130 m distance SSW of the emission source (Figure 4.11). This area is also characterised with the maximum mean hourly average concentrations - up to 24.7 μg/m^3.

At the laboratory & residential modules territory, the maximum hourly concentrations of carbon monoxide will amount 55.5-82.5 μg/m^3, at the protected area - 100.9 μg/m^3 (Figure 4.12), the average hourly CO concentrations at these sites - 1.0-2.0 μg/m^3.

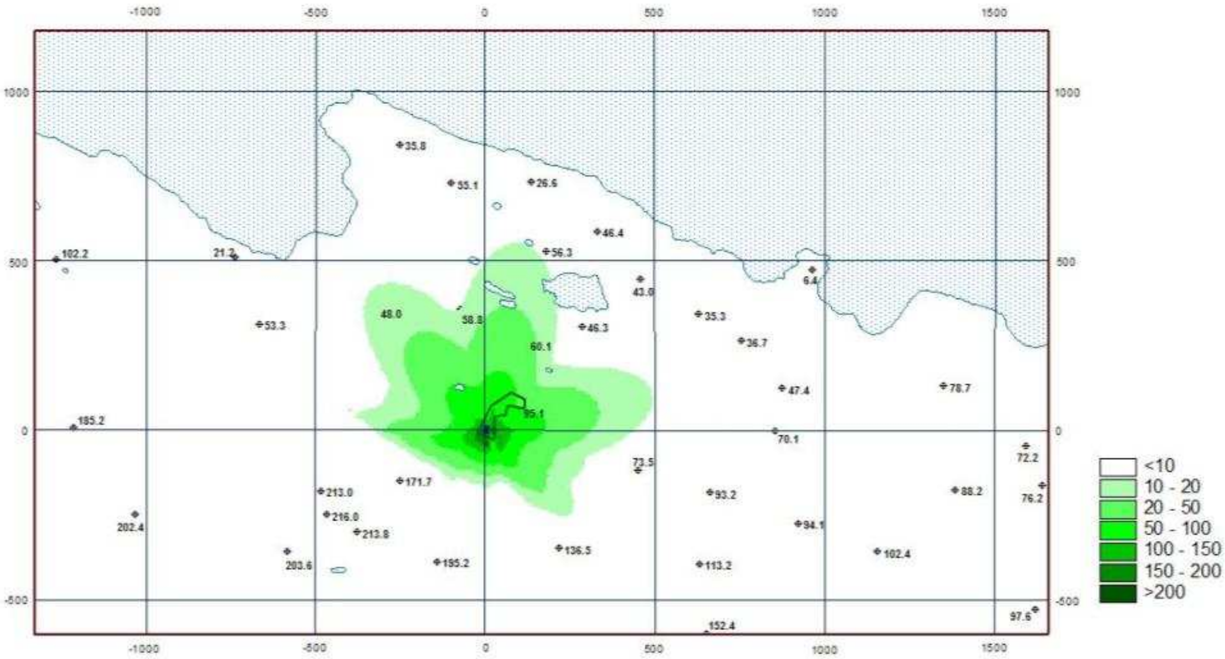


Figure 4.12 - Distribution of maximum 1-hour CO concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

The calculated values of the maximum hourly CO concentrations at the receptor locations are negligible: their maximum level will reach 1-2% of the Maximum Permissible Concentration (MPC), as effective in Belarus (5000 μg/m^3).

Daily average concentrations

The highest 24-hour CO concentration was assessed to reach 106.4 μg/m^3; it will be registered 20-30 m SSW of the emission source (Figure 4.12). The maximum daily concentration (26.7 μg/m^3) is also expected there.

At the laboratory & residential module locations, reference to Scenario 1 calculations the mean daily CO concentration shall not exceed 13.3-23.4 μg/m^3, at the protected area – 23.6 μg/m^3 (Figure 4.13). On average the 24-hour CO air concentration at these sites will increase by 1.4 - 2.4 μg/m^3.

The calculated values of the 24-hour CO concentrations can be assessed as less than minor, as their maximum level will not exceed 1% of the Maximum Permissible Concentration (MPC) value, as established in Belarus (3000 μg/m^3).

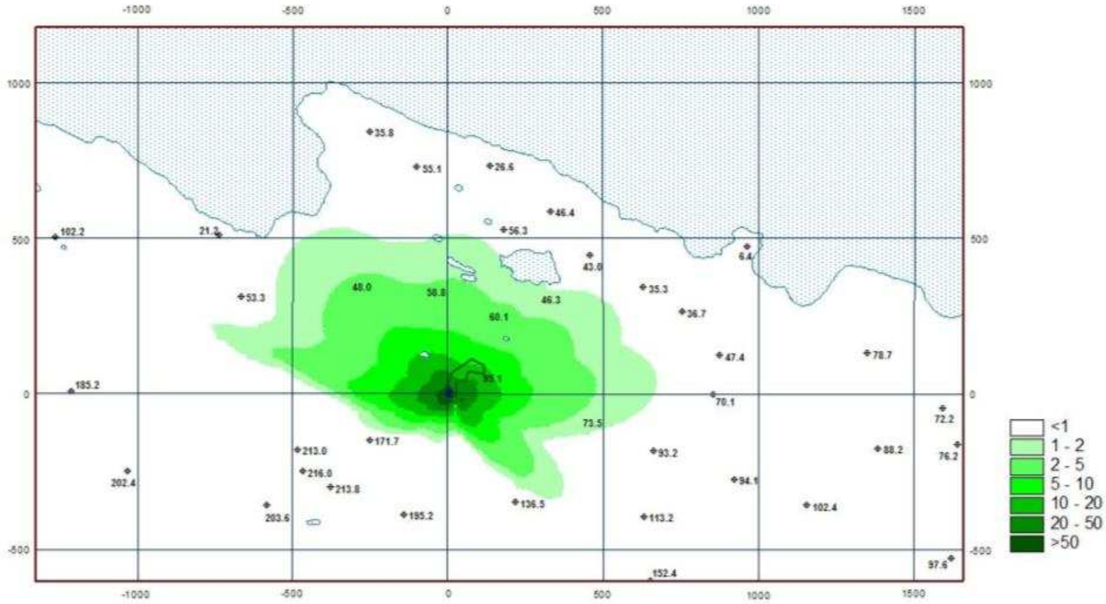


Figure 4.13 – Distribution of maximum 24-hour CO concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

At summer seasons (December-March), the maximum monthly average CO concentration will amount to 42.2 μg/m^3 (Figure 4.14) and can be detected 20-30 m SW from DG-60. The monthly average CO concentration at this point will be 29.3 μg/m^3.

At the receptor site locations, the maximum increase of monthly average CO concentrations can make 2.8-5.0 μg/m^3, mean - 1.4-2.6 μg/m^3 (Figure 4.14). These values are significantly below the MPC values, as established for the yearly average values (500 μg/m^3).

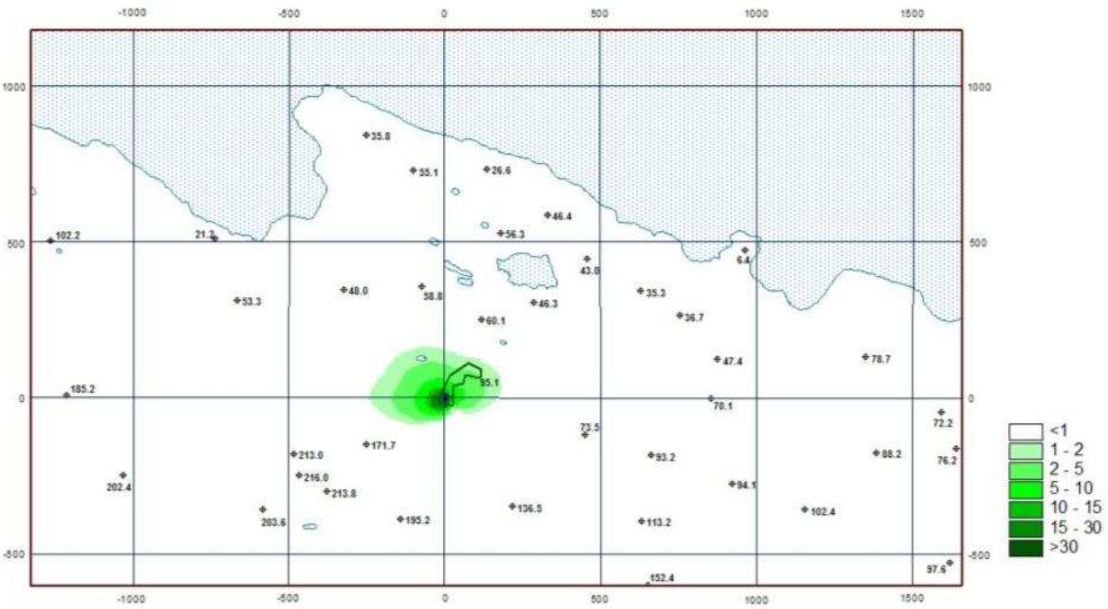


Figure 4.14 – Distribution of monthly average CO concentrations in atmospheric air from BAS stationary sources operation, averaged for summer seasons (December-March), μg/m^3, Scenario 1

Nitrogen dioxide

Hourly average concentrations

The maximum hourly nitrogen dioxide concentrations can reach 272 μg/m^3, exceeding the MPC limit as established in Belarus (250 μg/m^3). Excessive hourly nitrogen dioxide concentrations may be observed in 4 cells of the receptor grid (i.e., within the area of 160 m^2) at several sites SSW and SE from the emission source. The repeatability of such high concentrations is assessed as minor. Thus, at point (x = 560; y = 1320), the hourly NO_2 concentrations above 250 μg/m^3 can occur twice during summer seasons, at point (x = 1320; y = 580) – 4 times, at point (x = 1320; y = 600) - 7 times, at point (x = 1340; y = 600) – 14 times.

At the other points of the regular receptor grid, no MPC elevation will be registered (Figure 4.15). The maximum hourly NO_2 concentrations are estimated for point with coordinates x = 1320; y = 600, at 20-30 m distance SW from DG-60 location (35.2 μg/m^3).

The maximum hourly nitrogen dioxide concentrations at the laboratory & residential module locations will be 67.0-77.2 μg/m^3, at the protected area – 101.2 μg/m^3 (Figure 4.15), which is 2.5-3 times lower than MPC. The average hourly NO_2 concentrations for these objects – 1.3-2.7 μg/m^3.

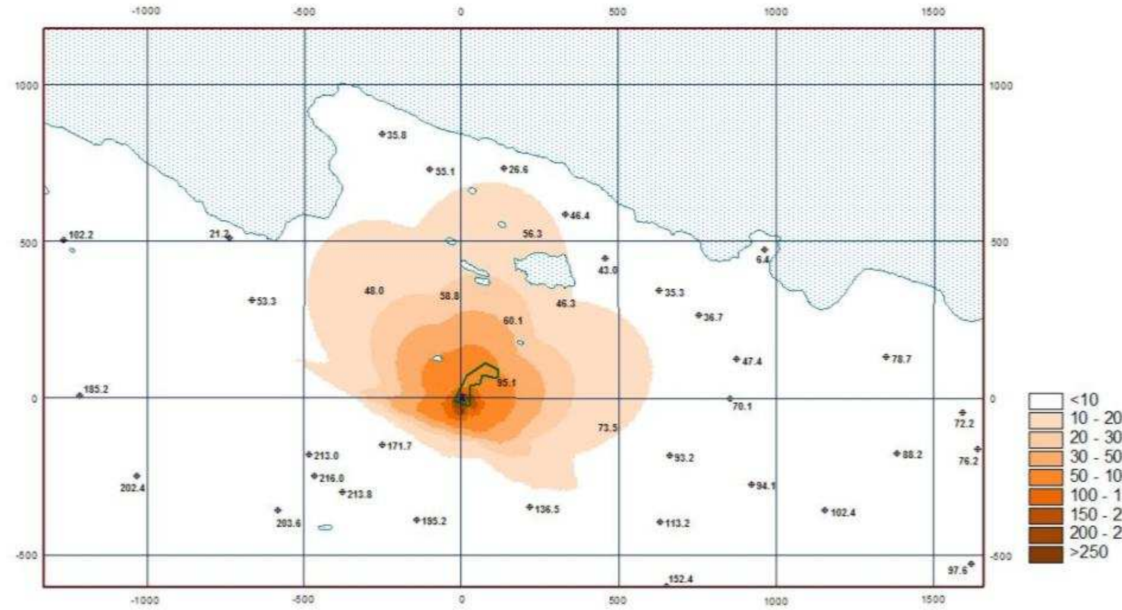


Figure 4.15 – Distribution of maximum hourly NO_2 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

24-hour average concentrations

The maximum daily NO_2 concentration as calculated for the regular grid is 145.4 μg/m^3, which exceeds the MPC value (100 μg/m^3). The area of highest NO_2 concentration will be located southwest of the emission source, starting in the immediate vicinity and extending to about 100 m distance (Figure 4.16). The highest repeatability of such concentrations will be at points with coordinates (x = 1320; y = 580) and (x = 1320; y = 600) and will not exceed 8 days.

At the laboratory & residential module locations the average daily NO_2 concentrations may increase by max. 15.9-27.8 μg/m^3, at the protected area – 24.8 μg/m^3 (Figure 4.16). These values are several times lower than the MPC values. The mean daily NO_2 concentrations for the receptor sites at DG-60 operation will increase by 1.7 - 3.3 μg/m^3.

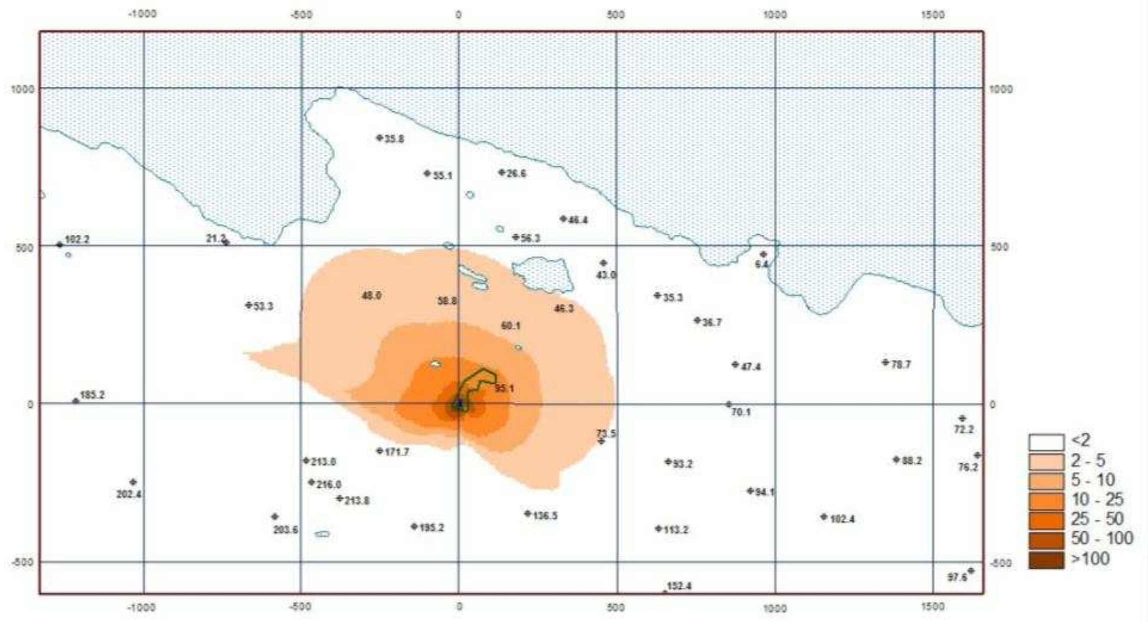


Figure 4.16 - Distribution of maximum 24-hour NO_2 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

The maximum monthly average NO_2 concentrations during summer seasons (December-March) will amount to 60.3 μg/m^3, which exceed the established MPC for year mean. The values which excess the established limit of 40 μg/m^3 is expected SW of DG-60 location at four points of the regular grid (Figure 4.17). At the laboratory & residential module locations and within the protected area, the maximum monthly average NO_2 concentrations will reach 3.6 - 6.6 μg/m^3 (Figure 4.17), being significantly lower than MPC.

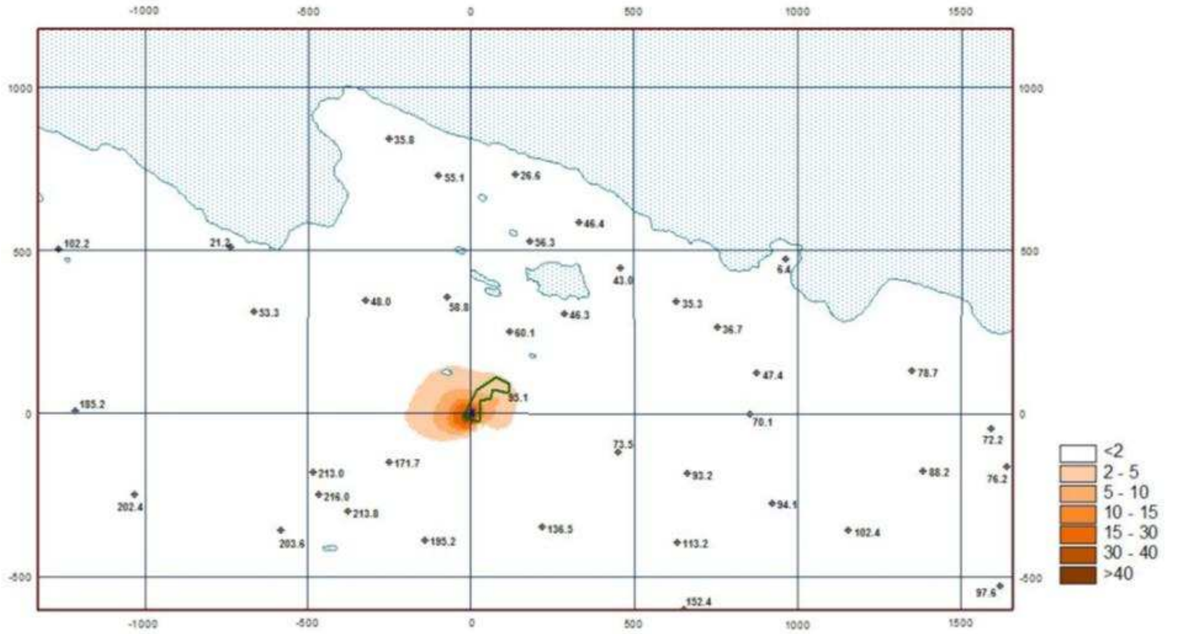


Figure 4.17 – Distribution of monthly average NO_2 concentrations in atmospheric air from BAS stationary sources operation, averaged for summer seasons (December-March), μg/m^3, Scenario 1

Fine suspended solid particles (PM10)

Hourly average concentrations

The maximum estimated hourly PM10 concentration – 23.7 μg/m^3, which is significantly lower than the established MPC (150 μg/m^3). Such value is expected 110-130 m SSW from DG-60 (Figure 4.18). The average hourly PM10 concentrations at this site – 2.5 μg/m^3.

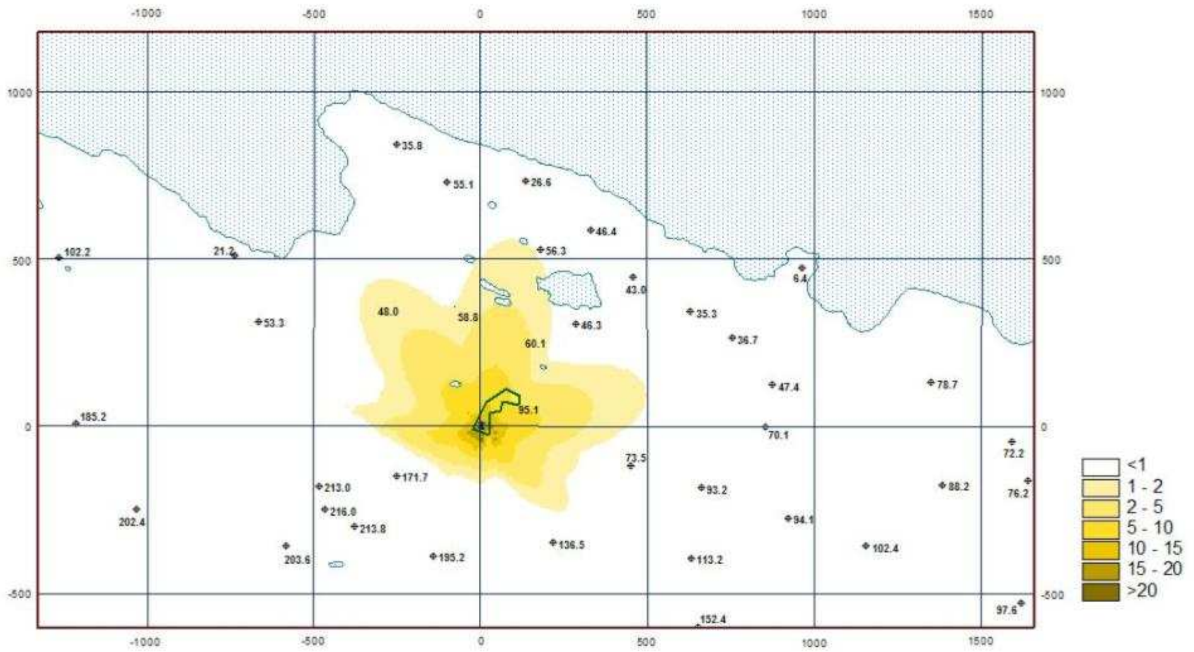


Figure 4.18 – Distribution of maximum hourly PM10 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

The maximum hourly PM10 concentrations will make 5.6-8.3 μg/m^3 at the laboratory & residential module locations and 10.2 μg/m^3 at the protected area (Figure 4.17), which is more than tenfold less than the reference value. The average hourly PM10 concentration in the surface air at 5 receptor sites – 0.1-0.2 μg/m^3.

24-hour average concentrations

The maximum daily PM10 concentration (10.7 μg/m^3) is expected 20-30 m SW from DG-60 (Figure 4.19); the average daily PM10 concentrations at this site will be 2.7 μg/m^3.

At the laboratory & residential module locations the maximum daily PM10 concentrations will amount to 1.3-2.4 μg/m^3, at the protected area – 2.4 μg/m^3 (Figure 4.19). The average daily PM10 concentrations at these sites will be 0.1-0.3 μg/m^3.

The calculated maximum daily PM10 concentrations are several times lower than the daily average MPC (50 μg/m^3).

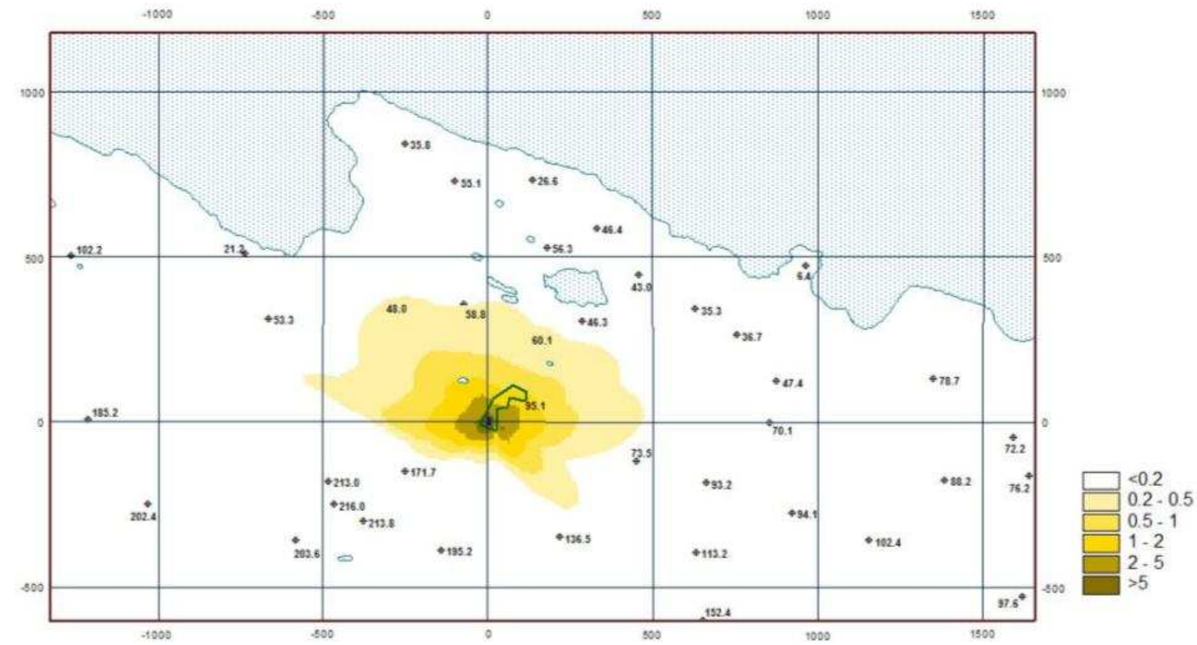


Figure 4.19 – Distribution of maximum 24-hour PM10 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

During summer seasons (December-March) the maximum monthly average PM10 concentrations can reach 4.3 μg/m^3 and similarly to the daily average concentrations is expected at the site located 20-30 m SW from DG-60 (Figure 4.20). At the laboratory & residential module locations and within the protected area the maximum monthly average PM10 concentrations will be 0.3-0.5 μg/m^3, mean – 0.13-0.26 μg/m^3 (Figure 4.20).

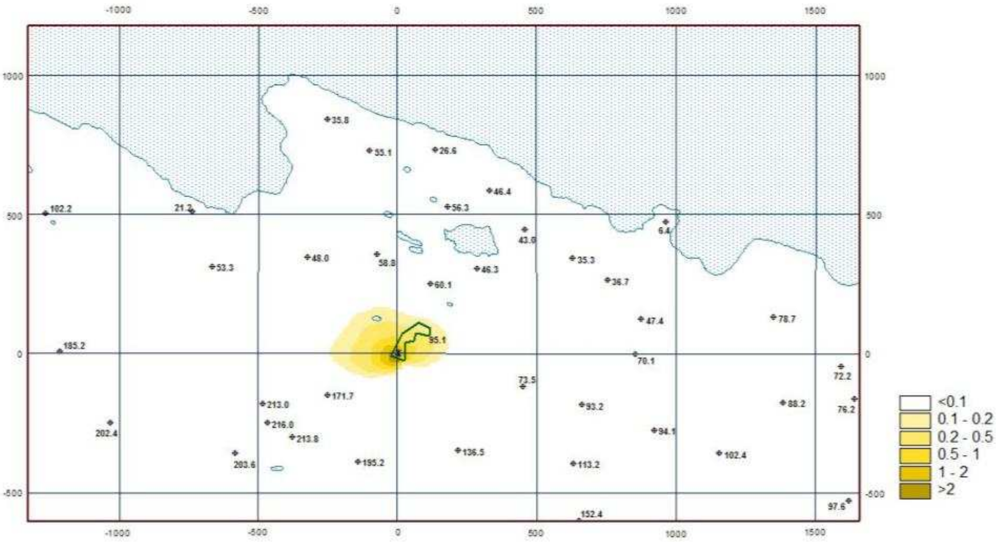


Figure 4.20 – Distribution of monthly average PM10 concentrations in atmospheric air from BAS stationary sources operation, averaged for summer seasons (December-March), μg/m^3, Scenario 1

The maximum monthly average concentrations can be considered negligible, since they account for less than 1.3% MPC (40 μg/m^3).

Sulfur dioxide

Hourly average concentrations

The maximum hourly sulfur dioxide concentration will be 34.5 μg/m^3 and is expected at 120-125 m distance SSW of the DG-60 location (Figure 4.21).

At the laboratory & residential module locations the maximum hourly SO_2 concentrations will amount to 8.2-12.1 μg/m^3, in the protected area – 14.8 μg/m^3 (Figure 4.21). On average for the receptor sites the hourly sulfur dioxide concentrations may increase by 0.15-0.29 μg/m^3.

The calculated maximum hourly sulfur dioxide concentrations at DG-60 location can be considered as minor (20-min. averaged MPC – 500 μg/m^3).

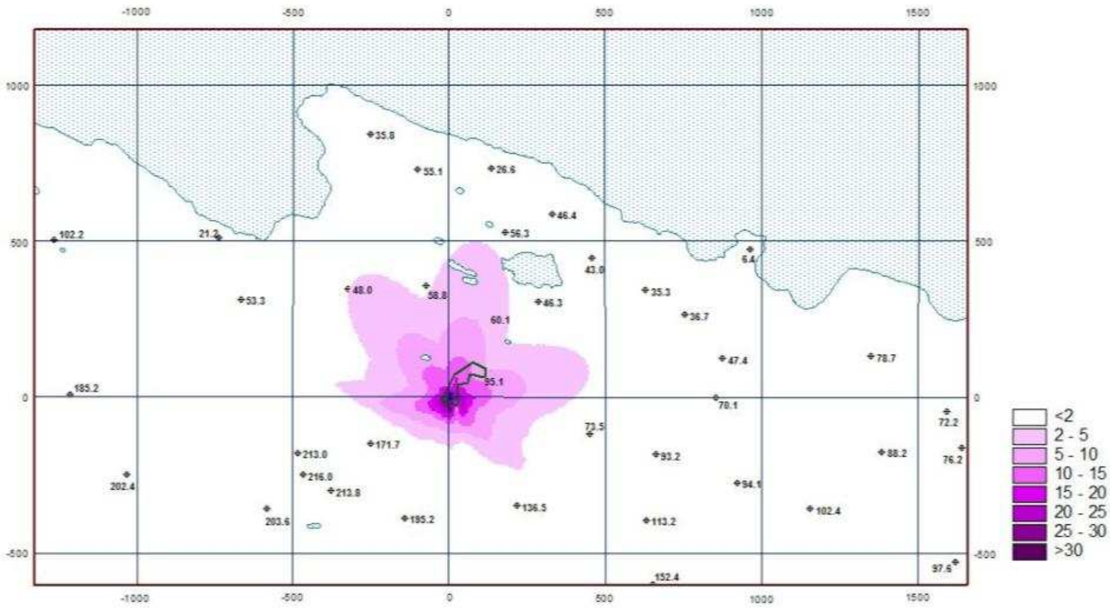


Figure 4.21 – Distribution of maximum hourly SO_2 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

24-hour average concentrations

The maximum daily SO_2 concentrations are expected 20-30 m southwest of DG-60 and amount to 15.6 μg/m^3 (Figure 4.22). The average daily sulfur dioxide concentrations in this area – 3.9 μg/m^3.

At the laboratory & residential module locations the maximum daily SO_2 concentration will be 2.0-3.4 μg/m^3 and at the protected area – 3.5 μg/m^3 (Figure 4.22). On average the daily sulfur dioxide concentration at these sites will increase by 0.2-0.4 μg/m^3.

The sulfur dioxide concentrations as calculated for the receptor sites are several times less than the maximum permissible concentration (100 μg/m^3, daily average).

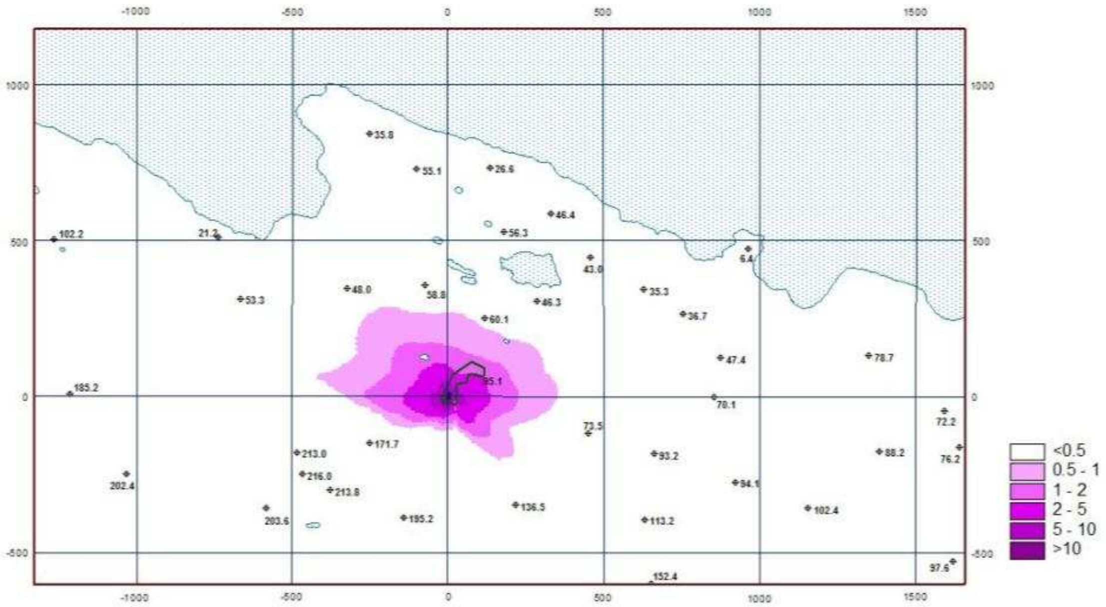


Figure 4.22 – Distribution of maximum 24-hour SO_2 concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

The maximum monthly average sulfur dioxide concentration of 6.2 μg/m^3 (for summer seasons) can be expected at 20-30 m distance SW of the DG-60 location (Figure 4.23).

At the laboratory & residential module locations the maximum monthly average SO_2 concentrations will be 0.4-0.7 μg/m^3, at the protected area – 0.67 μg/m^3 (Figure 4.23). The monthly average sulfur dioxide concentrations at these sites – 0.2-0.4 μg/m^3.

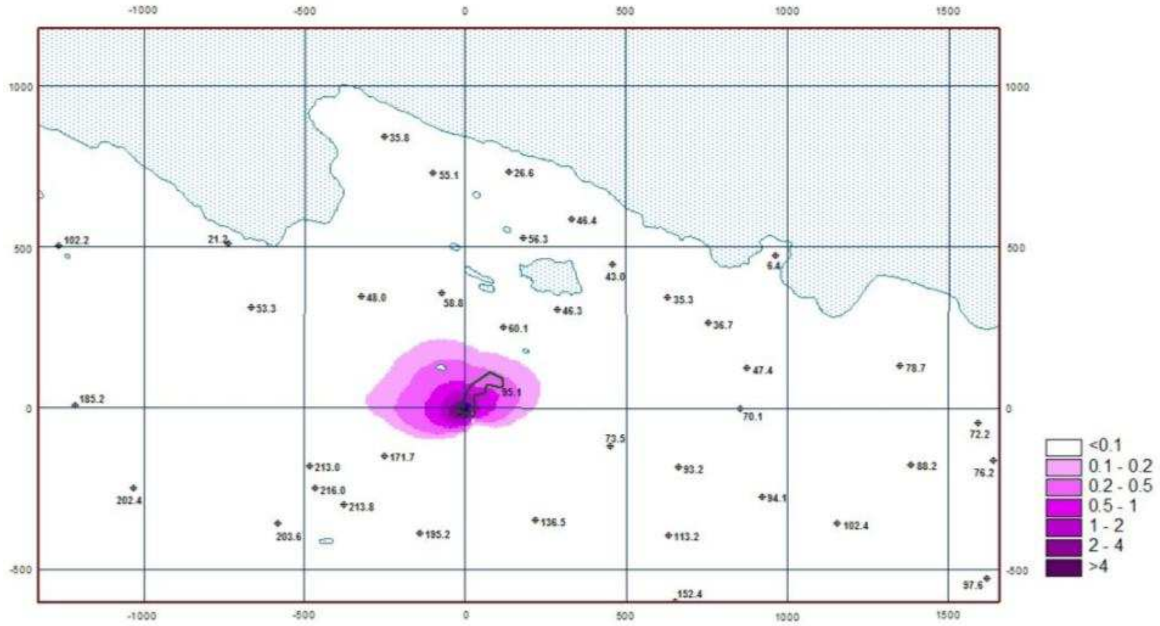


Figure 4.23 – Distribution of monthly average SO_2 concentrations in atmospheric air from BAS stationary sources operation, averaged for summer seasons (December-March), μg/m^3, Scenario 1

The monthly average SO_2 concentration due to DG-60 emission can be assessed as minor; its value at the receptor sites will not exceed 1.3 percent of MPC (50 μg/m^3, year average).

Hydrocarbons

Hourly average concentrations

At the most adverse weather conditions the maximum increase of hourly hydrocarbon concentrations as may result from the DG-60 operation will be 116.4 μg/m^3. Such concentration may be expected at 110-130 m SSW from the emission source location (Figure 4.24). The average hourly average hydrocarbon concentrations in this area will amount to 12.2 μg/m^3.

At the laboratory & residential module locations the maximum daily concentration of hydrocarbons is estimated to increase up to 27.5-40.9 μg/m^3, at the protected site – up to 50.0 μg/m^3 (Figure 4.24). The average hourly hydrocarbon concentrations at these sites will be 0.5-1.0 μg/m^3.

No reference values for hydrocarbon concentrations in the ambient air are currently available.

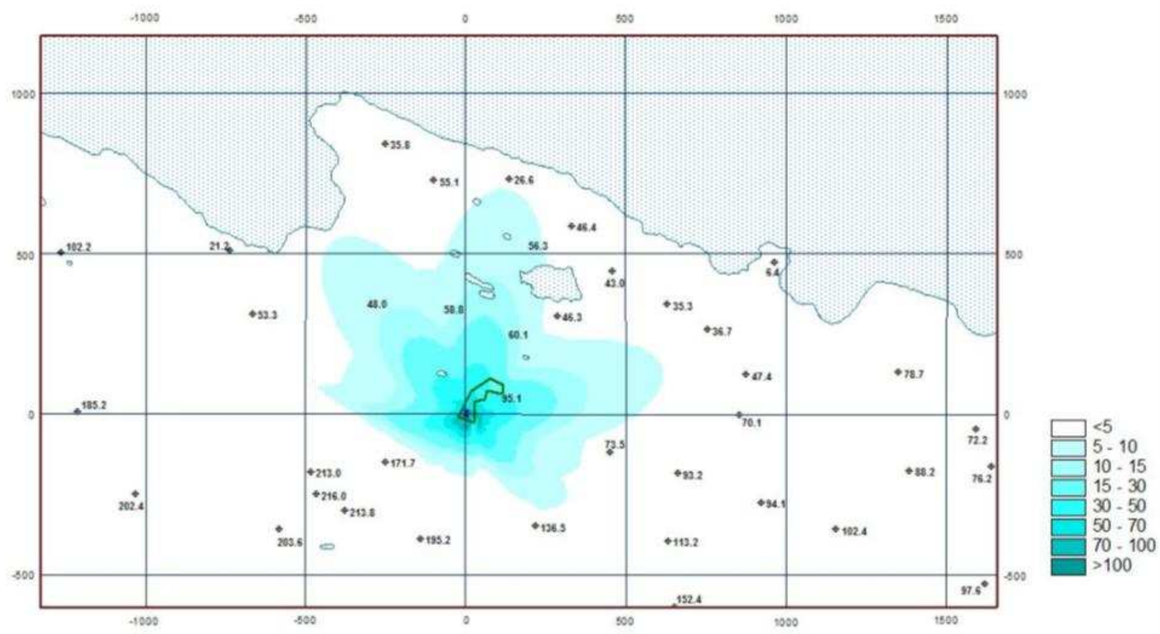


Figure 4.24 – Distribution of maximum hourly hydrocarbon concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

24-hour average concentrations

The highest value (52.7 μg/m^3) of the daily hydrocarbon concentrations can be expected at a point located 20-30 m southwest from DG-60 (Figure 4.25). The average daily average hydrocarbon concentrations at this point will be 13.2 μg/m^3. The maximum values of daily concentrations of hydrocarbons at the laboratory & residential module locations will make 6.6-11.6 μg/m^3, at the protected area - 11.7 μg/m^3 (Figure 4.25). The average daily hydrocarbon concentrations at these sites will be 0.6-1.2 μg/m^3.

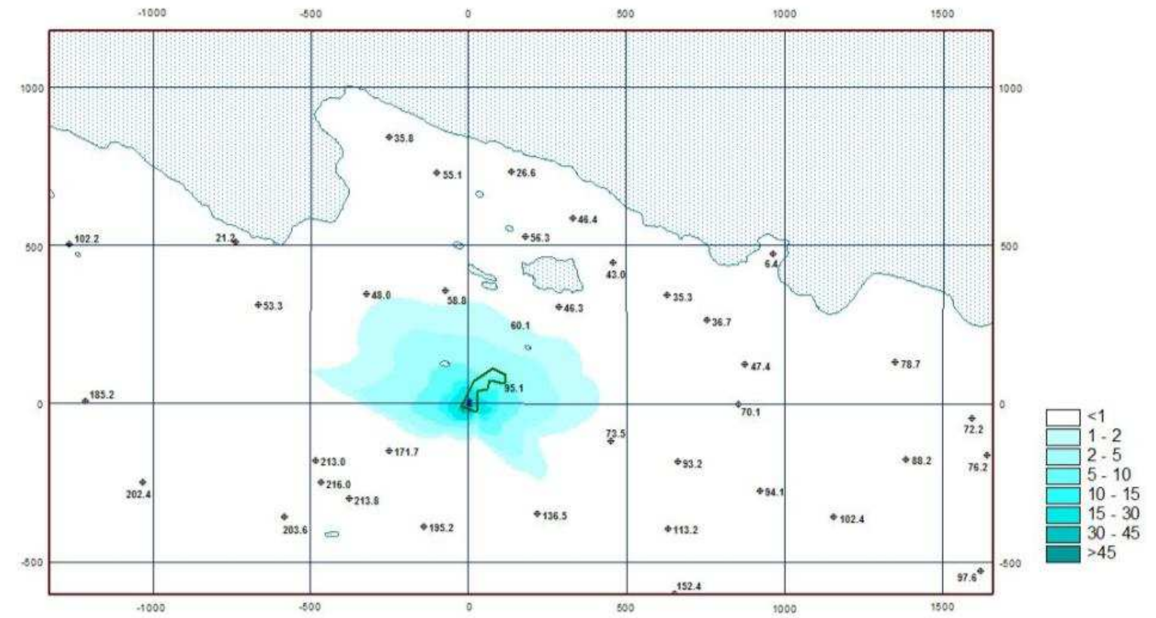


Figure 4.25 – Distribution of maximum 24-hour hydrocarbon concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 1

Monthly average concentrations

The maximum estimated increase of monthly average hydrocarbon concentrations – 20.9 µg/m^3; it is expected 20-30 m southwest of the DG-60 location (Figure 4.26). Close to the laboratory & residential modules and within the protected area the maximum increase of monthly average concentrations of hydrocarbons – 1.4-2.5 µg/m^3, average – 0.7-1.3 µg/m^3 (Figure 4.26).

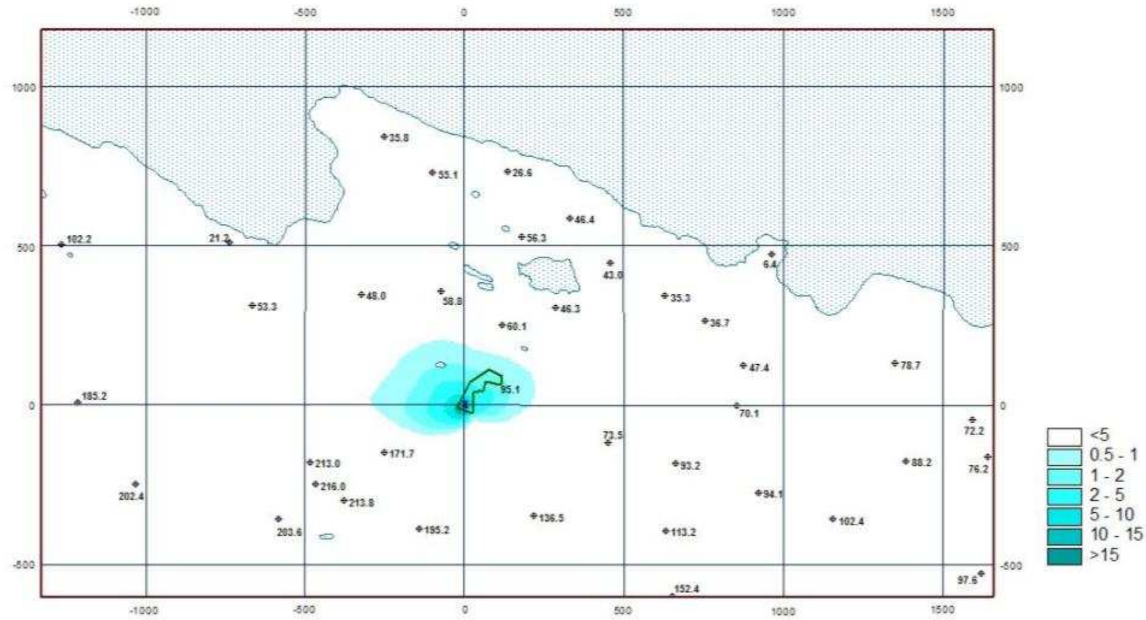


Figure 4.26 – Distribution of monthly average hydrocarbon concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 1

Conclusions to Scenario 1

The simulation results of Scenario 1 pollutant dispersion demonstrated that under the most adverse weather conditions the DG-60 operation will not result in exceeding the ambient air quality standards at the receptor sites in respect of any pollutant assessed.

Within the territory adjacent to the source of contamination, the MPC values may be exceeded only by nitrogen dioxide. Such excess will be local, and its recurrence is assessed to be low.

The calculated short-term and long-term concentrations of other pollutants will not exceed the limit values.

<u>Scenario 2</u>

Exposure sources:

- DG-100 kVA diesel generator, full-power operation;
- KTO-50.K20 wastes incinerator, full-power operation once a week.

DG-100 power station parameters are as follows:

Stack height - 3.5 m;

Stack diameter - 0.08 m;

Flue gas temperature - 478ºC;

Flue gas flow - 54.4 m/sec.

KTO-50.K20 incinerator parameters are as follows:

Stack height - 9 m;

Stack diameter - 0.3 m;

Flue gas temperature - 200ºC;

Flue gas flow - 12 m/sec.

Calculation parameters:

- reporting period – calendar year;
- source files with weather information obtained from the boundary atmospheric layer monitoring at Molodyozhnaya Antarctic station (WMO index 895420) for 1995, and atmosphere morning sensing data, as obtained by Syowa Japanese Antarctic station (WMO index 895320) for 1995 were obtained for analysis;
- the topographic features of the receptor territories for the regular receptor network sized 2980 x 1780 m with 20 m increments were taken into consideration;
- any influence of the existing buildings was ignored;
- maximum and average hourly, 8-hour, 24-hour and monthly concentrations were modelled;
- pollutants: NO_2, SO_2, CO, PM10, hydrocarbons.

The maximum short-term and long-term evaluations of the surface pollutant concentrations at the BAS site, reference to Scenario 2 are presented in Table 4.22 (5 receptors), as well as at Figures 1-15 of Annex 2.

The area – specific distribution of the pollutant concentrations, as obtained for Scenario 2, is a bit different from those for Scenario 1. However, the MPC limits of pollutant concentrations at the locations of 5 key receptors (laboratory & residential modules and protected area) are not expected to be exceeded.

Carbon monoxide

In the case of Scenario 2 and the most unfavorable surface air meteorological conditions, the hourly carbon monoxide concentrations can reach 301 μg/m^3. The top CO concentrations exceeding 250 μg/m^3 may be expected at 4 local areas SE, N, SW and SSW of DG-100 at 45-130 m distance (Annex 2, Figure 1). The average maximum hourly CO concentration will reach 47.2 μg/m^3.

At the laboratory & residential module locations the maximum hourly CO concentrations will amount to 43.5-80.6 μg/m^3, at the protected area – 63.0 μg/m^3 (Annex 2, Figure 1), the average hourly concentrations of carbon monoxide at these objects – 0.6-1.2 μg/m^3. The calculated hourly CO concentrations at the receptor locations can be assessed as minor: their maximum level makes 0.9-1.6% of the MPL as established in Belarus.

The maximum daily CO concentrations according to Scenario 2 calculations may increase up to

186.8 μg/m^3 and is expected 80-85 m SW of DG-100 location (Annex 2, Figure 2). The average daily CO concentration at this point will be 26.7 μg/m^3.

Table 4.22 – Estimated concentrations of air pollutants for the laboratory & residential and protected area locations (Scenario 2), μg/m^3

Parameter and averaging period	Module 1	Module 2	Module 3	Module 4	Protected area
Carbon oxyde (CO)					
Maximum 1-hour average	49.17	43.54	64.11	80.59	63.01
Mean 1-hour average	0.60	0.48	0.78	1.22	0.78
Maximum 24-hour average	17.28	16.91	23.43	32.07	26.41
Mean 24-hour average	0.96	0.85	1.28	1.93	1.35
Maximum 1-month average	3.02	2.66	3.95	5.46	3.92
Mean 1-month average	1.01	0.89	1.34	2.03	1.42
Nitrogen dioxide (NO_2)					
Maximum 1-hour average	70.64	62.55	92.09	115.25	89.56
Mean 1-hour average	0.86	0.68	1.13	1.75	1.12
Maximum 24-hour average	24.83	24.29	33.65	46.07	37.93
Mean 24-hour average	1.37	1.22	1.83	2.76	1.94
Maximum 1-month average	4.33	3.81	5.66	7.84	5.63
Mean 1-month average	1.44	1.28	1.93	2.91	2.04
Sulfur dioxide (SO_2)					
Maximum 1-hour average	7.49	6.63	9.76	12.46	9.94
Mean 1-hour average	0.09	0.07	0.12	0.19	0.12
Maximum 24-hour average	2.63	2.57	3.57	4.88	4.02
Mean 24-hour average	0.15	0.13	0.20	0.29	0.21
Maximum 1-month average	0.46	0.41	0.60	0.83	0.60
Mean 1-month average	0.15	0.14	0.21	0.31	0.22
PM10					
Maximum 1-hour average	4.99	4.42	6.51	8.16	6.35
Mean 1-hour average	0.06	0.05	0.08	0.12	0.08
Maximum 24-hour average	1.75	1.72	2.38	3.26	2.68
Mean 24-hour average	0.10	0.09	0.13	0.20	0.14
Maximum 1-month average	0.31	0.27	0.40	0.55	0.40
Mean 1-month average	0.10	0.09	0.14	0.21	0.14
Hydrocarbons (CH)					
Maximum 1-hour average	1.97	1.75	2.57	3.23	2.52
Mean 1-hour average	0.02	0.02	0.03	0.05	0.03
Maximum 24-hour average	0.69	0.68	0.94	1.29	1.06
Mean 24-hour average	0.04	0.03	0.05	0.08	0.05
Maximum 1-month average	0.12	0.11	0.16	0.22	0.16
Mean 1-month average	0.04	0.04	0.05	0.08	0.06

In the laboratory & residential module areas the maximum daily concentration of carbon monoxide may reach 16.9-32.1 μg/m^3, at the protected area – 26.4 μg/m^3 (Annex 2, Figure 2). On average the daily CO concentrations at the receptor sites will increase by 0.9 – 1.9 μg/m^3.

The calculated maximum CO concentrations at the receptor sites will be less than 1.1% of the average daily MPL as established in Belarus.

By Scenario 2 maximum monthly average CO concentrations will be 92.0 μg/m^3 and may be expected 80-85 m southwest of DG-100 (Annex 2, Figure 3).

At the receptor locations the maximum monthly average CO concentrations can reach 2.7-5.5 μg/m^3 with an average increase by 0.9 - 2.0 μg/m^3 (Annex 2, Figure 3), which is significantly below the MPC values, as established in Belarus for annual averages.

Nitrogen dioxide

According to Scenario 2, the maximum hourly concentration of nitrogen dioxide may be expected 80-85 m SE of DG-100 location and will amount to 398.7 μg/m^3, thus exceeding the MPC values.

Hourly average concentrations above the established limits can be observed at 10 locations of the regular grid at 150 m SE, S and SW of DG-100. At the other locations of the regular grid MPC will not be exceeded (Annex 2, Figure 4). The maximum average hourly NO_2 concentration – 47.2 μg/m^3 and is reported for the point with coordinates x = 1320; y = 600.

The maximum hourly nitrogen dioxide concentrations at the laboratory & residential module area will be 62.6-115.3 μg/m^3, and at the protected area – 89.6 μg/m^3 (Annex 2, Figure 4), which is significantly lower than the MPC limits. On average for 5 receptor sites hourly nitrogen dioxide concentrations will reach 0.7-1.8 μg/m^3.

The maximum daily NO_2 concentration – 259 μg/m^3 at 80-85 m SW of DG-100, exceeding the established MPC limit. The area of highest concentrations will be located southwest of the pollution source, extending over a distance of approximately 150 m from it (Annex 2, Figure 5).

At the laboratory & residential module locations the daily nitrogen dioxide concentration may increase by max. 24.3-46.1 μg/m^3, at the protected area – by 37.9 μg/m^3 (Annex 2, Figure 5). These values are less than the established standards. The mean daily nitrogen dioxide concentrations for the receptor sites at the DG-100 and KTO-50.K20 joint operation will increase by 1.2 - 2.8 μg/m^3.

The maximum monthly average nitrogen dioxide concentration – 92.0 μg/m^3, which is higher than MPC. Excessive concentrations may be expected at a small area SW of DG-100 (Annex 2, Figure 6).

At the laboratory & residential module locations and within the protected area the maximum average NO_2 concentrations will be 3.8 - 7.8 μg/m^3 (Annex 2, Figure 6), which is significantly lower than MPC.

Fine suspended solid particles (PM10)

The maximum hourly PM10 concentrations under Scenario 2 are expected at a location 80-85 m SW of DG-100 and amount to 30.6 μg/m^3, which is several times lower than the MPC level (Annex 2, Figure 7). The maximum hourly PM10 concentration at this point – 4.8 μg/m^3.

The maximum hourly PM10 concentrations at the laboratory & residential module locations are assessed at 4.4-8.2 μg/m^3, within the protected area – 6.4 μg/m^3 (Annex 2, Figure 7), which is significantly lower than MPC. The average hourly PM10 concentrations for the receptor sites is estimated at 0.05-0.1 μg/m^3.

The maximum daily PM10 concentration is expected 80 m southwest of DG-100, reaching 19.0 μg/m^3 (Annex 2, Figure 8); the maximum hourly PM10 concentration will be 5.0 μg/m^3.

At the laboratory & residential module locations the maximum daily concentrations will increase up to 1.7-3.3 μg/m^3, at the protected area – up to 2.7 μg/m^3 (Annex 2, Figure 8).

The calculated maximum daily PM10 concentrations will be significantly lower than MPC.

The maximum monthly average PM10 concentrations could reach 9.3 μg/m^3 and will be possibly detected at the site located 45-50 m WSW of DG-100 (Annex 2, Figure 9).

Close to the laboratory & residential module locations and within the protected area the maximum monthly average PM10 concentrations will be 0.3-0.6 μg/m^3 (Annex 2, Figure 3).

The maximum monthly average PM10 concentrations at the receptor sites will be less than 1.5 percent of MPC.

Sulfur dioxide

The maximum hourly sulfur dioxide concentration according to Scenario 2 calculations – 45.9 μg/m^3 and may be expected at a site located 80-85 m southwest of DG-100 (Annex 2, Figure 10). At the laboratory & residential module locations the maximum hourly SO_2 concentrations will amount to 6.6-12.5 μg/m^3, at the protected area – 9.9 μg/m^3 (Annex 2, Figure 10). On average for the receptor sites the hourly average sulfur dioxide concentration will increase by 0.1-0.2 μg/m^3.

The maximum daily sulfur dioxide concentration at the receptor sites in case of DG-100 and KTO-50.K20 joint operation will be significantly lower than MPC. The maximum daily sulfur dioxide concentration – 28.4 μg/m^3 – may be observed 80-85 m southwest of DG-100 location (Annex 2, Figure 11). The average daily SO_2 concentration at this area will be 7.5 μg/m^3.

At the laboratory & residential module locations the maximum daily SO_2 concentrations will be 2.6-4.9 μg/m^3, at the protected area – 4.0 μg/m^3 (Annex 2, Figure 11). The average daily sulfur dioxide concentrations at the receptor sites is estimated at 0.1-0.3 μg/m^3.

The calculated maximum daily SO_2 concentrations are expected to be much lower than MPC.

The maximum monthly average sulfur dioxide concentration will be 9.3 μg/m^3 and is expected 80-85 m SW of DG-100 location (Annex 2, Figure 12).

At the laboratory & residential module locations the maximum monthly average SO_2 concentrations may reach 0.4-0.8 $\mu g/m^3$, at the protected area – 0.6 $\mu g/m^3$ (Annex 2, Figure 12). The average monthly average sulfur dioxide concentrations for these objects will be 0.1-0.3 $\mu g/m^3$. The average monthly average sulfur dioxide concentration resulting from DG-100 and KTO-50.K20 operation will be minor and is expected to reach less than 1.6 percent MPC.

Hydrocarbons

At the most adverse weather conditions the maximum hourly concentration of hydrocarbons according to Scenario 2 will be 12.1 $\mu g/m^3$ 80-85 m SW of DG-100 (Annex 2, Figure 13). The average hourly concentrations at this sector will be 1.9 $\mu g/m^3$. At the laboratory & residential module locations the maximum hourly concentrations of hydrocarbons are estimated to increase up to 1.7-3.2 $\mu g/m^3$, and at the protected site – to 2.5 $\mu g/m^3$ (Annex 2, Figure 13). The average hourly hydrocarbon concentrations at these sites will be 0.05-0.12 $\mu g/m^3$.

The highest daily average concentration value – 7.5 $\mu g/m^3$ – may be expected 80 m SW of DG-100 location (Annex 2, Figure 14). The average concentration there will be 2.0 $\mu g/m^3$.

At the laboratory & residential module locations the maximum daily concentrations of hydrocarbons will be 0.7-1.3 $\mu g/m^3$, at the protected area – 1.1 $\mu g/m^3$ (Annex 2, Figure 14). The average daily hydrocarbon concentrations at these sites is expected to range 0.03-0.08 $\mu g/m^3$.

The maximum monthly average concentrations of hydrocarbons may be expected 80 m southwest of DG-100 (3.7 $\mu g/m^3$) (Annex 2, Figure 15). At the laboratory & residential module locations and within the protected area the maximum monthly concentrations may be 0.1-0.2 $\mu g/m^3$ (Annex 2, Figure 15), average – 0.04-0.08 $\mu g/m^3$.

Conclusions as related to Scenario 2

The simulation results of pollutant dispersion under Scenario 2 demonstrated that the joint operation of DG-100 and KTO-50.K20 under the most unfavorable weather conditions for 5 receptor sites will not result in any pollutant concentration to exceed the air quality standards.

At the territory adjacent to DG-100 and KTO-50.K20 locations the maximum permissible concentrations may be exceeded at several areas only for nitrogen dioxide.

It should be noted that the excessive concentration values can be avoided by extending the DG-100 stack height by 2 meters.

The calculated short-term and long-term values of the other pollutant concentrations will not exceed the MPC values.

Increased concentrations of pollutants will refer due to emissions generated by the stationary sources and will be peculiar to the BAS territory only; the emissions will not be transferred at large distance from the station and will be generally assessed as minor.

4.2.2.2. Noise exposure

General methodological approaches

Noise calculations were made under the algorithms in compliance with:

- Standard TCP 45-2.04-154-2009 (02250) – Noise protection. Building design standards;
- International Standard GOST 31296.1-2005 (ISO 1996-1:2003) – Acoustics. Description, measurement and assessment of environmental noise. Part 1: Basic quantities and assessment procedures;
- International Standard GOST 31295.2- 2005 (ISO 9613 - 2:1996) – Acoustics. Description, measurement and assessment of environmental noise. Part 2: Determination of environmental noise attenuation, with reference to Standard SP СП 51.13330.20 – Noise protection.

The major national technical regulation on noise impact assessment during construction is TCP 45-2.04-154-2009 (02250) – Noise protection. Building design standards. This technical code of practice (hereinafter - TCP) stipulates the mandatory requirements that must be met in the noise protection design of residential, public and industrial buildings for various purposes, in planning and development of settlements to ensure the regulatory parameters of the acoustic environment in the industrial, residential and public buildings and residential areas. TCP also sets the standards for noise exposure in industrial, residential and public buildings and residential areas.

Noise exposure sources

The major and permanent sources of noise exposure at the BAS site are diesel generators, primarily DG- 60. Geko 6401ED-AA and DG-20 diesel generators were not taken into account for calculation purposes, since they are expected to alternate the DG-60. Other permanent sources (pumps, motorised saw, etc.) will have significantly lower and irregular noise generation, and they were neglected for calculations. DG-100 diesel generator will have noise parameters similar to DG-60. The noise impact of mobile sources was partly taken into account in calculations of noise exposure during the BAS construction (particularly, helicopter) (Section 4.2.2). Noise from snowmobiles, due to the peculiarities of their operation (off-road routes, scattering around a large area), will not exceed the established standards and has not been evaluated quantitatively.

Reference data

- DG-60 noise performance, reference to the manufacturer’s specifications, references and manuals;
- DG-60 noise parameters in octave bands, according to similar diesel generator parameters (*Reconstruction of the passenger berth*...);
- distance from the nearest residential module - 90 m.

Calculation procedure

Octave sound pressure levels L, dB, at reference points were calculated according to the method specified by TCP 45-2.04-154-2009 under equation 4.1 below.

$$L = 10\lg\left(\sum_{i-1}^{m} \frac{10^{0.1Lwi} \cdot \chi_i \cdot \Phi_i}{\Omega r_i^2} + \frac{4}{kB}\sum_{i-1}^{n} 10^{0.1Lwi}\right) \quad (4.1)$$

where L_{wi} – the octave sound pressure level of i-th source, dB;

Φ – the noise source direction factor;

Ω – the solid angle of the exposure source, rad;

r_i – the distance from the source's acoustic centre to the calculation point, m;

β_a – atmospheric attenuation, dB/km;

m – the number of noise sources, the nearest to the calculation point at distance r_i <= 5 r_{min}, where r_{min} means the distance from the calculation point to the acoustic centre of the nearest noise exposure source;

n - total number of noise sources.

The following factors affecting the sound pressure were further taken into account, i.e.: area-related dispersion, atmospheric attenuation (which, in its turn, is dependent on air temperature, humidity, and several other parameters). The underlying surface influence was ignored.

The calculation points were selected at 20, 50, 100, 200 m distances from the source and close to the residential module (nearest point - 90 m distance).

Results

The calculation results are given in Table 4.23 below.

Thus, the sound pressure levels, as exposed by DG-60 at calculation point 3 (area adjacent to the laboratory & residential modules), will not exceed the established standards for the territory itself and for the residential and production premises. The radius of major noise exposure, exceeding significantly the permitted level (> 50 dB), is less than 50 m (Figure 4.27).

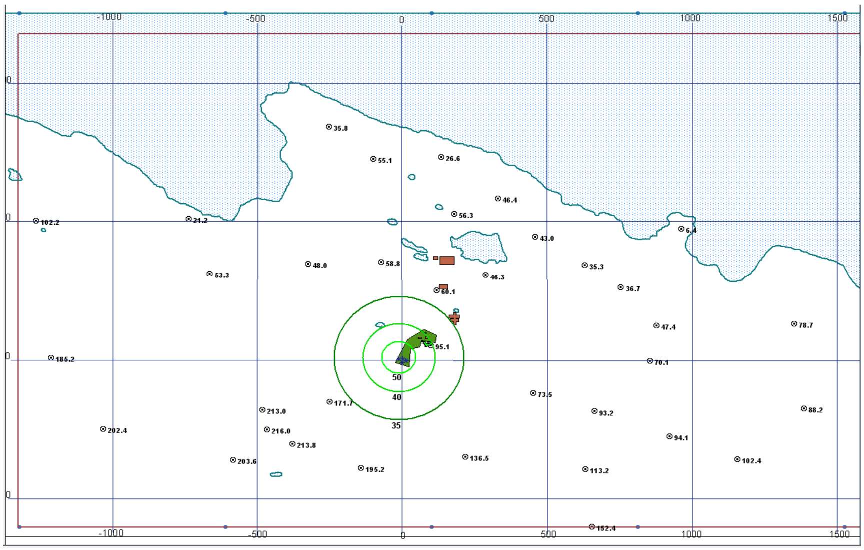


Figure 4.27 – Calculated areas of the equivalent sound levels, as related to DG-60 diesel generator operation at BAS, dBA

Table 4.23 – Sound pressure calculation results for DG-60 diesel generator at specific calculation points, dBA

Calculation point and distance from the exposure source	Octave band, Hz								
	63	125	250	500	1000	2000	4000	8000	дБ(А)
1 (30 m)	62.3	61.3	54.8	49.3	44.9	40.1	34.0	27.7	52.4
2 (50 m)	57.8	56.9	50.3	44.9	40.3	35.7	30.3	24.8	47.9
Calculation point and distance	63	125	250	500	1000	2000	4000	8000	дБ(А)
3 (90 m)	52.7	51.8	45.2	39.5	35.0	30.1	24.3	17.8	42.8
4 (200 m)	45.8	44.7	38.1	32.3	27.4	21.9	14.7	5.6	35.9
(90 m), with closed sound-proof window (-25 dB), dB	27.7	26.8	20.2	19.5	10.0	5.1	-	-	17.8
Ref. value acc. to TCP 45-2.04-154-2009 (hostel) day night	67 59	57 48	49 40	44 34	40 30	37 27	35 25	33 23	45 35
Ref. value acc. to TCP 45-2.04-154-2009, offices Category A	67	57	49	43	40	37	35	33	45
Ref. value acc. to TCP 45-2.04-154-2009 – areas adjacent to hotels and hostels day night	79 71	70 61	63 54	59 49	55 45	53 42	51 40	49 39	60 50

4.2.2.3. Exposure on soils and rocks

Soils, ground and rocks will be subjected to mechanical impacts during the station operation due to use of motor vehicles and walking of explorers. This impact will be limited to the station boundaries and surrounding areas (for geological, biological, environmental and other investigation) with sampling of rocks, snow, biota, etc. However, the impact will increase following the growth of the station staff engaged and scope of research works to be performed. At places of the most active mechanical loads, soil erosion may occur.

No drilling or other impact on rocks is expected to be involved.

Deposition of pollutants on snow/ice-uncovered surfaces at the operation stage will be minor. This is due to small amounts of polluting emissions and their dispersion; in general, this will not result in any significant increase in pollutant content in soils. However, some persistent pollutants may be accumulated in soils, e.g. products of fuel combustion (soot).

Wastewater impact on soils during the station operation may occur due to possible leakages and/or emergency spills of sewage. However, their effect will be minor, local and short-timed. Special measures to prevent wastewater leakages and to localise the possible impacts will have to be implemented.

Impact due to fuel leaks from storage tanks may occur, but they would not be regular. Special measures to prevent fuel leaks and to improve fuel transfer systems will have to be implemented.

During the station operation, the impact of solid wastes is also expected to be minor. It will be mostly from packages of fuel and lubricants, domestic wastes (non-hazardous, according to the wastes classification), which are not dangerous in terms of toxic substances accumulation in soils. Temporary storage of solid wastes and their further transfer is planned to be performed. Whereas some part of such wastes is expected to be incinerated, a particular attention will be paid to ash handling to avoid its dispersion in the environment (when removing the ash from the incinerator, packing in a container for subsequent transfer to the mainland).

Noise, heat and electromagnetic exposure during the station operation are not expected to have any impact on soils and rocks.

4.2.2.4. Exposure on surface waters, snow and ice cover

As stated in Section 2, potable and domestic purpose waters will be supplied from temporary lakes (in December-January) and from the Nizhneye Lake. As specified in Section 4.2.1.3, water intakes per month for the station's seasonal option will range 5-6 to 10-12 m^3. Small amounts of water intake will not have a negative impact on the hydrological situation.

Emissions and deposition of pollutants to surface waters and snow & ice cover during the operation stage will be negligible.

During the station operation, the system of wastewater collection and discharge into the sea is expected to be build; however, the risk of leaks and spills of wastewater and sewage and their fall into water basins may not be excluded. At the same time, due to the small amount of wastewater generated (and small capacity of tanks to collect them), the impact on the lakes will be minor and limited in time.

Impact due to pollutants exposure from fuel leaks may occur, but it will not be regular. Special measures will be taken to prevent leaks from fuel storage tanks and their spreading in case of accidental spills. If get into water basins, pollutant may be deposited in bottom sediments.

No solid waste impact is expected to water basins and/or snow & ice cover.

Noise, heat and electromagnetic exposure during the station operation are not expected to have any impact on surface waters and glaciers.

During the station operation, mechanical impact on the icecap will occur mainly in the process of vehicle driving and transportation of goods. This impact will be minor and transitory. In the course of research activities at the station location, impact on ice sheet will include the impact of snowmobiles when moving off the main roads, ice sampling. Such impacts would be episodic and transitory.

4.2.2.5. Impact on aesthetic features of the landscape and natural surroundings

Accumulation of wastes, fuel leaks, wastewater spills may affect the aesthetic appearance of the landscape. However, their impact will be minor, considering the actual transformation of the surroundings. Special measures will be implemented to reduce the negative impact on the aesthetic value of the landscape. The construction of new BAS production and residential complexes, which are designed to apply the modern architectural and construction solutions, is anticipated to harmonise with the Mount Vechernyaya landscape, taking into account the natural features of the Antarctic topography and environmental conditions, and will benefit to the aesthetic values of the area.

4.2.2.6 Exposure on biota

Air emission impact. Air pollutants, as generated by stationary and mobile sources during the BAS operation, may impact the vegetation habitat (mosses, lichens) adjacent to the construction site areas and seabird colonies located close to the station (at 1-2 km distance to the west). However, as shown in Section 4.2.2.1, due to low levels of polluting emissions, their dispersion due to strong winds with predominant south-eastern blasts, specific topography of the area, the impact will be limited and minor. Potential impacts on birds due to their seasonal migration are assessed to be temporary.

Critical levels of sulfur dioxide for the natural vegetation, as recommended by WHO, amount to 15-20 $\mu g/m^3$ (average annual and winter), for lichens – 10 $\mu g/m^3$ (Table 4.24).

Table 4.24 – Critical levels of sulfur dioxide exposure on the natural vegetation *(WHO Air Quality Guidelines, 2000)*

Vegetation group	Critical level, $\mu g/m^3$	Period	Limitations
Forests and natural vegetation	20	Average annual and winter	
	15	Average annual and winter	Accumulated temperatures above +5°C <1000°C days per year
Lichens	10	Average annual	
Forests	1.0	Average annual	In areas where the near-surface clouds are present at least 10% of time

The calculations of emissions from stationary sources (Section 4.2.2.1) demonstrated that such annual average concentrations of sulfur dioxide in the area of BAS emission sources are not expected.

According to the WHO recommendations, the critical level of nitrogen oxides in the atmosphere for the vegetation is established to be 20 μg/m^3, based on NO_2 (annual average). Reference to the calculations made, such high concentrations of nitrogen dioxide due to permanent emission source operation can be observed only at a very limited area.

Mechanical impact. New elements of the station and vehicles, as required for the construction and operation, may have a minor impact on vegetated areas near the station. Motor vehicles (snowmobiles) are routes to move mainly on snow, where no plants and/or animals exist. Compact station design and proximity of field study points provide for minimal use of mechanical facilities. Walking can cause minor disturbance to vegetation and micro-fauna habitats in the areas adjacent to the station. Driving and walking may cause minor disturbance to birds, when they move in the station vicinity. No impact on areas of major biological diversity will be expected due to their remote location.

The expected soil contamination impact on the biota is estimated as minor. No significant contamination of soils in the BAS deployment area, as may be caused by leaking fuel, lubricating oils, wastewater, atmospheric depositions, waste exposure, is eventually expected. Some small areas of soil and growing lower vegetation and plant-based micro-organisms may be subject to minor pollution.

Wastewaters may potentially affect the flora and fauna in the vicinity of the station due to emergencies only, since the station design provides for water collection system with subsequent discharge into the sea. Given the nature of the station location, the absence of major natural ecosystems in the immediate vicinity of the construction site, a small number of BAE staff (max. 10-12 people), the impact on the biota will be minor even in the event of emergency.

Solid wastes. Accumulation of solid wastes may potentially affect the lower plants and micro-fauna at the base location only at the places of storage and pre-processing. Whereas the storage facilities will located in areas with little biodiversity, the solid waste impact on the biota can be assessed as minor.

Noise exposure. Given the remoteness of flocks of birds and marine mammals, the noise impact, as may be caused by BAS, will not be expected. The potential factor of concern will be short-term noise from the aircraft involved (airplanes and helicopters). Due to the landscape profile, land motor vehicles (snowmobiles, ATVs) can not be used to move people and equipment in the immediate vicinity of vertebrates and, as a result, will cause no noise impact on them. For lower plants and invertebrates, this human factor, due to the climatic features of the area (constant noise from winds) will make no effect.

Heat and electromagnetic effects are assessed to have less than a minor impact on the biota.

Microorganisms and diseases. Human activity can potentially result in introduction of alien microorganisms, including pathogens, to the local ecosystem, as well as in invasion of alien species and lower fungi. In freshwater lakes, minimum content of microorganisms is detected, thus making it possible to use it for potable water supplies. In small temporary lakes (accumulation of waters in hollows of rocks formed by melting snow in springs and summers), the number of microorganisms reaches high values, but this water is not used for drinking or catering purposes.

4.2.2.7. Exposure on marine environment and marine ecosystems

The planned BAS site deployment located at a distance of about 0.5 km from sea cost and will not be connected directly with the sea by watercourses, a direct impact on the marine environment and marine ecosystems is not expected. Minor impact will be through the discharge of domestic wastewaters to the Terpeniya Bay area near the Dostupny Cape. The calculations show (Section 4.1) that about 40 m^3 of BAS wastewaters will be discharged during the first phase operation for the season, thus dissolving about 4.4 kg of suspended solids, 7.2 kg of organic matter (BOD), 0.72 kg of ammonia, 1.8 kg of chlorides, 1.6 kg of sulfates, 0.04 kg of oil products, 0.1 kg of surfactants, 0.09 kg of iron, and other pollutants. During the all-year-round operation, the amounts of pollutants will increase 5.4 times.

The dilution rate of wastewater discharges to the sea was evaluated using U.S. EPA Visual Plumes model (*Dilution Models for Effluent Discharges, 2003*). It is assumed that the discharges will take place at 4 m depth and about 1 m above the bottom. According to the calculations, the BOD concentration will reduce from 180 mg/l in the effluent waters to 1.93 mg/l, or 91 times less at 1.5-5.5 m distance from the discharge point.

Impact on marine ecosystems may be affected also during scientific research activities, but it will be minimal. Marine fauna sampling for scientific purposes will be negligible. The maximum impact on flora and fauna of marine ecosystems can be expected only from icebergs as they drift in the area. A minor impact on marine ecosystems is expected at shoals and shallow shelf, where the iceberg drifts are practically excluded. A minor impact on benthic communities may be expected during the formation of anchor ice, which may slightly change the bottom ecosystem, but the restoration of species and quantities happens fast, due to the migration of moving forms (sea urchins, starfish, fish, shellfish).

4.2.2.8. Specially Protection Areas (ASPA), Specially Managed Areas (ASMA), Historic Sites and Monuments (HSM), Sites of Special Scientific Interest (SSSI)

No SPA, SSSI and/or SMA are reported at the planned BAS construction location. In this regard, no development of any management plans for such objects is required. The area is not included in any Antarctic Specially Managed Area (marked out for possible conflicts of interest or danger of cumulative impacts on the environment) either.

4.3. Risk level matrix related to the BAS construction and operation

The levels of risk associated with exposure on each of the environmental components are given in the risk matrix (Table 4.25), where the lines display the exposure types and the columns specify the environmental components.

The exposure-associated risk levels were assessed under the 4-point scale as follows:

- *None* - no impact is expected;
- *Low* - irregular adverse effects of low intensity;
- *Moderate* - regular exposure of low intensity or irregular effects of moderate intensity;
- *High* - regular exposure of moderate intensity or high-intensity irregular effects.

Table 4.25 – Evaluation matrix of the levels of risk for the environmental components associated with the Mount Vechernyaya BAS construction

Exposure	Environmental components / valuables						
	Flora	Fauna	Ice-free surface (soils, rocks)	Ambient air	Ice	Fresh water ponds and sea	Aesthetic values
Air pollutant exposure	X (moderate) In certain cases, pollutants can potentially reach places with vegetation in the surrounding areas, but, due to small amounts of emissions, dispersion and prevailing wind directions, the impact is assessed as transitory and minor.	X (low) In certain cases, pollutants can poten-tially reach the seabird colonies in the imme-diate vicinity of the station, but the concentration will increase slightly due to small amounts of emissions, dispersion and prevailing wind directions. The impact will be seasonal due to migration of birds.	X (low) Pollutant emissions will continue as long as the station is in operation. Ice-free areas will be less affected due to remoteness and pre-vailing wind direc-tions. The exposure may increase upon construction of new structures of the station.	X (moderate) The ambient air in the vicinity of the station will be exposed to emissions from permanent sources and vehicles. The exposure may increase upon new exposure sources commissioning.	X (low) Some products of combustion can get on the snow & ice surface. The exposure may increase upon new exposure sources commissioning.	X (low) Emission growth may lead to some increase in atmospheric pollutant depositions.	None
Soil conta-mination	X (low) Some small areas with (lower) vegetation may be contaminated. Pollutant leaks with wastewaters (due to accidental fuel spills) may affect vegetation micro-depressions and streams with vegetation.	X (low) Some micro-fauna species may be exposed to contamination	X (moderate) Possible contamination of soils due to fuel spills during transportation, refueling; pollution will be local. Possible redistribution of pollutants from local sources and local areas of contamination.	None	X (low) Soil pollution due to fuel spills (caused by mechanical transfer) can lead to contamination of the adjacent ice.	X (low-moderate) Fuel spills near the station can lead to penetration into freshwaters and sea.	X (low) Spills can affect the visual aesthetics, but the impact will be limited.
Solid wastes	X (low) Accumulation of solid wastes can affect the micro-flora at the station location. Increased exposure is expec-ted due to the base expansion, longer seasons and expected growth in solid waste amounts.	X (low) Accumulation of solid wastes can affect the micro-fauna at the station location. Increased exposure is expected due to the base expansion, longer seasons and expected growth in solid waste amounts.	X (moderate) As a result of the station operation and maintenance, solid wastes will trend to accumulate. Possible contamination of soils at the wastes storage locations.	None	X (low) The impact of wastes on ice is expected to be minor.	None	X (moderate) Pollution affects the visual aesthetics of the landscape.

Continuation of Table 4.25

Exposure	Environmental components / valuables						
	Flora	Fauna	Ice-free surface (soils, rocks)	Ambient air	Ice	Fresh water ponds and sea	Aesthetic values
Wastewaters	X (low) Wastewaters can potentially affect the micro-flora in the vicinity of the station (in case of emergency leaks) and aquatic plants on discharge of wastewaters into the sea. The exposure may increase due to longer seasons and expected increase in wastewater discharge amounts.	X (low) Wastewaters can potentially affect the micro-fauna in the vicinity of the station (in case of emergency leaks) and marine fauna on discharge of wastewaters into the sea. The exposure may increase due to longer seasons and expected increase in wastewater discharge amounts.	X (low) Resulting from the station operation and maintenance, wastewater leaks may happen; any possible adverse effects will be local.	None	X (low) Resulting from the station operation and maintenance, wastewater leaks may happen. The probability of impact on snow and glacier surfaces is low.	X (moderate) Wastewaters can potentially affect the chemical composition of lake waters and sediments (in case of emergency leaks). Wastewater discharges into the sea will cause localised and transitory pollution.	None
Noise	None	X (moderate) Birds from the neighboring colonies may be exposed to noise, but it will be limited due to remote distance and prevailing routes as scheduled. Seasonal effects due to migrations.	None	None	None	None	None
Mechanical impact	X (moderate) New elements of the base and transport due to the station construction and operation can disturb the areas of vegetation adjacent to the station. Walking may cause disturbance to vegetation near the station. Due to small area of vegetation, the impact will be transitory.	X (moderate) New elements of the base and transport due to the station construction and operation can disturb the micro-fauna areas adjacent to the station. Walking may cause disturbance to micro-biocenoses near the station. Due to small area of zoocenoses, the impact will be transitory.	X (moderate-) The station construction will cause some load on the ground. Scientific and logistic activities will require the use of vehicles in the vicinity of the station and thereby erode soils. Walking can lead to soil erosion due to increased activity.	None	X (low) Increased impact on glaciers due to the use of vehicles.	Low Some impact on water bodies will be observed due to water intake and research activities.	x (low) As a result of mechanical impact, the aesthetic value of the landscape can be affected.
Micro-organisms and diseases	X (low) Activity can potentially lead to introduction of alien microorganisms. The invasion of non-native species or diseases may occur, but the probability is low.	X (moderate) Activity can potentially lead to introduction of alien microorganisms. The invasion of non-native species or diseases may affect the local species, but the probability is low.	None	None	None	None	None

Thus, the analysis performed evidences that the BAS construction and further operation will be accompanied by emissions, discharges, waste accumulation, mechanical impact on the ground and ice, as well as heat, noise, electromagnetic exposure and possible microorganism introduction. However, the consequences of such impacts on the environmental components are considered to be low due to seasonal operation of the station, small number of staff engaged, minimum scope of construction works involving the landscape transformation, small amounts of fuel combustion. In general, the level of impact can be assessed as "minor or transitory".

4.4. Exposure matrix related to the BAS construction and operation

Level of exposure in connection with BAS construction and operation are summarized in exposure matrix (Table 4.26) by four main indicators: probability, scale, duration, significance. Scales applied are shown below.

Probability

- unlikely
- low
- medium
- high
- very high (certain)

Scale

- local
- subregional
- regional
- continental
- global

Duration

- very short – days
- short – weeks-month
- medium – years
- long – decades
- very long – centuries

Significance

- very low – impact practically absent
- low – insignificant impact
- medium – medium-level impact
- high – significant impact

- very high – serious impact

Table 4.26 – Exposure matrix related to the BAS construction and operation

Activity	Result	Stressors	Impact	Probability	Scale	Duration	Significance	Measures
Ships	Transportation and unloading	Atmospheric emission	Ambient air	High	Regional	Short	Vey low	Adherence to the IMO requirements Usage of low-sulfur fuel according to MARPOL
			Snow cover, glaciers, marine environment, soils, ecosystems	Low	Regional	Short	Vey low	
		Leaks of fuel and wastewaters	Marine environment	Medium	Local	Short	Medium	Plan to prevent leaks Absorbents stock
		Solid wastes and wastewaters		Low	Local	Short	Vey low	Wastes and wastewaters management according to MARPOL
Helicopters	Take-off, flight, landing	Atmospheric emission	Ambient air	Low	Subregional	Short	Vey low	Optimal routes
		Noise	Birds	High	Subregional	Very short	Средняя	Optimal routes and terms
	Service	Leaks of fuels and lubricants	Marine environment	Low	Local	Very short	Very low	Plan to prevent leaks Absorbents stock
Construction	Construction of labora-tory & living and pro-duction & living mo-dules and infrastructure	Mechanical impact	Soils, snow cover, glaciers	High	Local	Short	Low	Construction technology without area planning Reduction of the area of construction site
			Biota	Very low	Local	Short	Low	Construction outside valuable ecosystems
		Atmospheric emission	Ambient air	High	Local	Short	Low	Regular maintenance of equipment Usage of certified helicopters
			Soils, snow cover, glaciers, lakes	Very low	Local	Short	Vey low	
			Biota	Very low	Local	Short	Vey low	Emission sources outside valuable ecosystems
		Noise		Medium	Local	Short	Low	Regulation of helicopters application in certain periods
		Solid wastes	Soils, snow cover, glaciers	High	Local	Short	Low	Separate collection and storage Minimisation of wastes generation Wastes transmission
			Biota	Low	Local	Short	Low	Introduction of alien species control
		Wastewaters	Soils, snow cover, glaciers, lakes	Low	Локальный	Short	Low	Control and prevention of leaks
			Marine environment	High	Local	Short	Low	
			Biota	Low	Local	Short	Low	
		Fuels and lubricants management, spills	Soils, snow cover, glaciers, lakes	Medium	Local	Short	Medium	Plan to prevent leaks, leaks control Absorbents stock
			Biota	Medium	Local	Short	Low	

Continuation of Table 4.26

Activity	Result	Stressors	Impact	Probability	Scale	Duration	Significance	Measures
Station operation	Station's activity in operation mode	Mechanical impact	Soils, snow cover, glaciers	High	Local	Short	Low	Moving on routes Erosion control
			Biota	Medium	Local	Short	Low	Prevention of damage of valuable ecosystems
		Atmospheric emission	Ambient air	High	Local	Medium	Low	High-quality fuel doe diesel generators Regular technical maintenance of diesel generators Ecologically sound vehicles
			Soils, snow cover, glaciers, lakes	Low	Local	Medium	Very low	
			Biota	Low	Local	Medium	Low	Emission sources outside valuable ecosystems
		Noise	Biota	Medium	Local	Medium	Low	Regulation of equipment application in certain periods
		Solid wastes	Soils, snow cover, glaciers	High	Local	Medium	Low	Wastes management plan Separate collection and storage Minimisation of wastes generation Wastes transmission
			Biota	Low	Local	Medium	Low	Introduction of alien species control
Station operation	Station's activity in operation mode	Wastewaters	Soils, snow cover, glaciers, lakes	Low	Local	Short	Low	Control and prevention of leaks Account of dispersion conditions in discharge point
			Marine environment	Very high	Local	Medium	Low	
			Biota	Low	Local	Medium	Low	
		Fuels and lubricants management, spills	Soils, snow cover, glaciers, lakes	High	Local	Short	Low	Plan to eliminate leaks Absorbents stock
			Biota	Низкая	Local	Short	Low	
Scientific investigations	Observation at the territory of station and outside	Birdwath-ching	Biota	High	Local	Short	Low	Limitation of concern
		Licheno-metric and bryometric observations		High	Local	Short	Low	Optimal routes
		Observations of marine faune		Medium	Local	Short	Low	Limitation of concern
		Hydro-chemical investiga-tions		High	Local	Short	Low	Sampling plans
		Soil and geochemical investigations		High	Local	Short	Low	Sampling plans
		Snow and atmospheric depositions observations	Snow cover, glaciers	High	Subregional	Short	Low	Optimal routes

4.5. Possible indirect or secondary impacts

Electromagnetic exposure, as evaluated above, can be considered to cause a secondary impact. Each of the types of impacts on the natural components forms the chain, with its first component to be subject to direct exposure and the other – to indirect exposures. Thus, atmospheric depositions, in addition to direct impact on the biota, affect it indirectly by accumulation of pollutants in soil and water. Contamination of soils due to atmospheric precipitations, leaks, spills, waste discharges will have an indirect impact (in addition to the biota) on surface waters and marine environment. Accumulation of wastes has a direct impact on soils at storage site locations and an indirect impact through redistribution of pollutants on the adjacent soils, surface waters, marine environment and biota. The major indirect effects on the environment, along with the direct impacts, were discussed in Sections 4.2-4.3. In particular, contamination of soils, surface waters, marine environment can be considered an indirect impact on the biota.

4.6. Cumulative exposure

Cumulative impact is defined as the resulting superposition of impact from certain activities in concern on the impacts from the activities that is already in process at the same area. The station construction will increase man-caused activities at the area, especially during summer seasons: increased amounts of air emissions, wastewater generation and discharge, solid waste accumulation. It should be taken into account that the station construction site had been subjected to RAE and BAE scientific and logistic activities for a long time (over 30 years). The evidences of the environmental transformations are given in Section 3. Referring to the prior environmental impact, the contribution of the station construction and operation in the total transformation of the local natural components will be minor, as shown in Section 4. Extra research is needed in respect of a number of sensitive natural systems, i.e.: lakes, moss and lichen cenoses, soils.

4.7. Effect of proposed activity on scientific investigations and other types of activities and valuables

The proposed activities (station construction) will benefit to scientific investigations in the Mount Vechernyaya surroundings both for BAE explorers and scientists of other countries: the station will provide comfortable conditions for accommodation and work for 5-6 people in summer seasons at the first phase and 10-12 people in year-round periods at the second phase. No other activities are expected to be performed in the area.

5. Measures to mitigate or remediate the impacts of the proposed activity and monitoring programs

5.1. Mitigation and remediation measures

The impact on the environment during the BAS construction and operation is expected to mitigate as a result of the following actions.

Referring to the exposure factors:

Air emission reduction will be achieved due to regular maintenance of diesel generators and motor vehicles, route optimisation, improved quality of fuel to be used. Reduced emissions from waste incineration will be implemented through careful monitoring of combustible substrates, compliance control of waste feeding and burning, dust & gas abatement performance control.

Wastewater discharge reduction will be achieved by decrease of wastewater generation through the use of more efficient water-consuming systems, as well as the introduction of new systems for wastewater discharge collection, storage and sewage.

Reduction of the impacts due to the formation and accumulation of wastes will be attained by improving the waste management system. A specific Waste Management Plan will be developed to distribute the functions and responsibilities of BAE staff for wastes handling, to specify the procedures related to wastes collection, separation, storage, incineration and other actions aimed at minimisation of wastes impact on the Antarctic environment.

Special measures will be implemented to prevent oil spills during storage, loading and refueling. A specific Oil Spills Control Program (Plan) will be developed to determine the functions and responsibilities for oil spills control and prevention, as well as for timely removal of oil spills, if occurred, oil product absorption procedure, recommended materials (sorbents), polluted substrate storage conditions.

Referring to the types of exposure and components (recipients):

Mitigation of mechanical impact on soils, snow & ice cover:

- optimised use of off-road vehicles, purchase of modern snowmobiles, optimised transportation routes.

Mitigation of impact on water basins:

- prevention of sewage and wastes discharges into lakes, optimised water intake, environmental protection measures in studies of lakes, in deep-sea diving; avoidance of coastal area pollution and littering.

Mitigation of impact on biota (phyto- and zoocenoses), biota protection:

- route optimisation to reduce the impact on phyto- and zoocenoses, protection of rare species, identification of areas with limited access (protected ecosystems), restricted access in certain seasons.

In order to preserve the biological diversity at the BAS location and at the surrounding areas, a continuous monitoring of environmental impacts will be performed by the expedition staff members and station technicians. The BAS explorers will undergo regular briefings on environmental safety and biological ethical conduct in Antarctica. The area of major biological diversity will be monitored at monitoring points and will be placed under protection. Besides, single localities of flora and fauna (local detached colonies of mosses and lichens) will also be subject to protection measures. Colonies of nesting birds and mammals in that area will also be protected and subjected to monitoring. In particular, the moss and lichen cenose near the BAS construction site will be secured, as described in Section 3.1.

5.2. Monitoring programs

An environmental monitoring program will be developed and implemented at the BAS site to establish the relationships between the current environmental situation, its forecast indicators and actual values in the future, following the station construction and operation startup. It will help to implement measures in remediating the negative effects of activities. An environmental monitoring lab will be established and equipped for monitoring of chemical, physical and biological indicators.

The monitoring program will be developed in accordance with the Practical Guidelines for Developing and Designing Environmental Monitoring Programs in Antarctica (2005).

<u>Meteorological observations</u>

A BAS weather station will perform observations under WMO - recommended surveillance programs.

<u>Ambient air</u>

The ambient air will be monitored for surface ozone concentrations, as well as for content of particulate matter and gas components.

<u>Ice cover and atmospheric precipitations</u>

It is planned to proceed with the observations of the chemical composition of snow waters both at the BAS site and at exposed areas. Snow waters will be monitored for content of major ions and heavy metals as indicators of anthropogenic impact. Such procedures will also help to control the composition and level of atmospheric deposition of pollutants.

Surface water monitoring

Monitoring of the hydro-chemical situation of the Verkhneye and Nizhneye Lakes is planned to continue. The content of major ions, oil products, heavy metals in water, as well as heavy metals and oil products in sediments as indicators of anthropogenic impact on the environment, will be subject to further control.

Monitoring of soils

Reference sites (points) for soil monitoring have been selected. It is planned to expand the network of the observation points to cover the entire diversity of soils around the station. The main types of soils and their properties will be subject to analysis. The content of oil products, heavy metals, PAHs will be tested.

Monitoring of biota (lichens, mosses, tardigrades, plankton, benthos)

The aim of monitoring is to assess the status of populations and communities of the most representative species of plants and animals, to measure changes in biodiversity both in the entire Antarctic ecosystem and at specific areas, particularly at the BAS location.

The monitoring activities are mainly aimed at:

- control of flora and fauna complexes and specific plant and animal species in different types of natural and modified biogeocenoses at the BAS deployment area;
- monitoring the situation and use of commercial species (fish, krill, algae, etc.), having the most important resource value;
- tracking the changes of rare and endangered species of animals and plants;
- monitoring of selected indicator species and groups of plants and animals in terrestrial and aquatic ecosystems, which serve the best reflectors of the environment quality;
- creation of computer databases for the purpose of monitoring data online processing, analysis and output for making decisions and forecast estimates.

Major actions to achieve the enlisted targets and objectives will be:

- selection of indicator species and groups of plants and animals, being representative for the entire situation and dynamics of flora and fauna (lichens, phytoplankton, zooplankton, etc.);
- selection of representative characteristics of populations and communities, which will be dealt with in future bio-monitoring procedures (number of species, density, additionally for mosses and lichens - accumulation of heavy metals and radionuclides);
- selection of specific areas that reflect the diversity of the main types of terrestrial and aquatic ecosystems (including types of terrains and degree of anthropogenic exposure);
- creation of a reference network for environmental control via flora and fauna representatives.

Since the organic life variability is extremely high, it is essential to select organisms that serve the best indicators of trends in environmental changes. In Antarctica, objects of monitoring may include lichens, mosses, tardigrades, plankton, benthos, birds, pinnipeds.

As it was previously mentioned in Section 3, there is a plot of land occupied by the community of lower plants in the vicinity of the BAS construction site (Figure 5.1, point 6), having the total area of approximately 150 m^2. Similar sites selected for monitoring are located at a considerable distance from the BAS site. Large patches of mosses, lichens and algae are located at the foot of the Rubin Hill (78.7 m high, about 600 m NE from BAS, point 1), at the foot of Mount Vechernyaya on the east of the Gnezdovoy Cape (about 1 km NW from BAS, point 7), near Hill 46.8 (Adelie penguin colony at the Gnezdovoy Cape and surroundings, about 1.5 km NW from BAS, point 4), near Hill 64.2 (about 3.5 km W from BAS, point 8).

Freshwater ecosystems of major interest include cenoses of the Nizhneye Lake (about 400 m S from BAS), the lake at the Gnezdovoy Cape (within the boundaries of Adelie penguin colony and in the immediate vicinity).

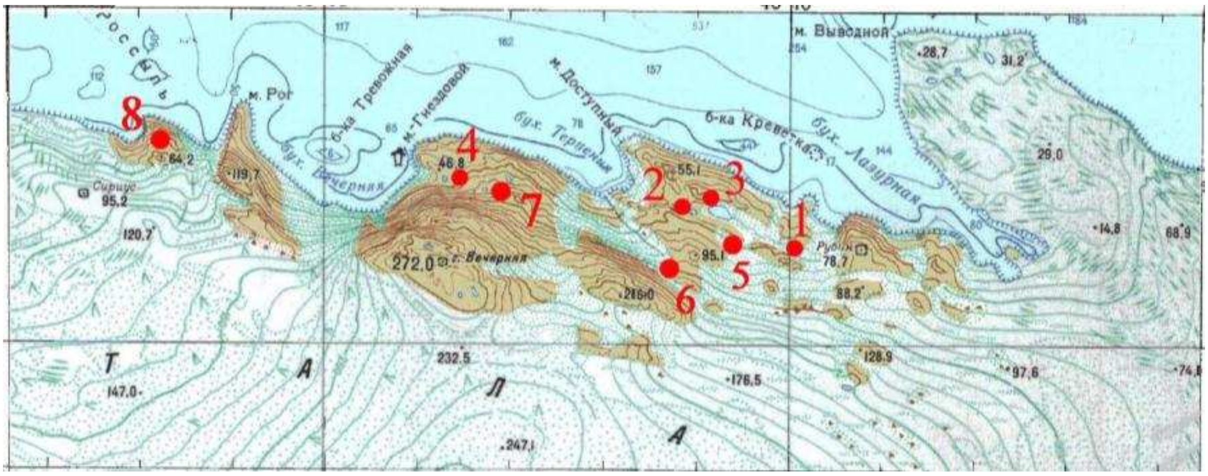


Figure 5.1 – Locations of the major types of ecosystems, most valuable ecosystems and ecosystems recommended for protection and monitoring at Mount Vechernyaya

5.3. Operational monitoring and actions in emergency

In addition to monitoring of the natural surrounding situation and impacts, an operational monitoring system will be established to monitor the major ecologically dangerous objects, primarily, fuel storage facilities, sewage ponds, pipelines, diesel generators, etc. Detailed protocols (instructions) will be developed to specify the service & maintenance procedures, minimising the possibility of accidents and leakages. The volumes of emissions, discharges, wastes generation, accumulation and disposal, scheduled equipment maintenance works will be properly controlled. The protocols will also regulate the actions in case of emergency: leakages, spills, fires, etc. All such cases will be recorded; any measures implemented will be reported. For emergency purposes, accident-eliminating facilities, e.g., sorption materials and other aids of preventing leakages will be stored on site, as minimally required.

Monitoring and control of alien species introduction will also be organised and implemented.

6. Gaps in knowledge and uncertainties

A number of factors introduce uncertainty in the prepared Draft Comprehensive Environmental Evaluation.

One of the factors are knowledge gaps about some natural elements of the environment due to insufficient study of the natural conditions of the station location, such as the dynamics of snow and ice cover, Cosmonauts Sea hydrology in the area, lakes hydrology, soil processes and their transformation conditions due to long-term operation of the Mount Vechernyaya field base.

The information about inputs, accumulation and migration of chemical elements in soils, bottom sediments due to the previous activities in the Mount Vechernyaya field base areas is limited.

We have got only the initial data on biodiversity of marine biota in the Vechernyaya, Terpeniya and Lazurnaya Bays (Alasheeva Gulf, Cosmonaut Sea). No information about the areas of potentially greatest biological diversity – Trevozhnaya Bank (Vechernyaya Bay) and Shrimp Bank (Lazurnaya Bay) – is currently available. These gaps in knowledge will be filled up in the process of further research in this area.

The prepared Draft Comprehensive Environmental Evaluation is based on the existing design materials, including specifications for the equipment and tools to be used, but there is a possibility of modifications, particularly in connection with a rather long period of BAS construction. There is also the probability of deviations from the schedule due to unforeseen circumstances, “last minute” changes, etc.

A number of forecast data, in particular, the dispersion of pollutants, are based on simulations and predicted environmental parameters (such as weather conditions), which are characterised by variability.

During the lifetime of the station, scientific and domestic activities may change the equipment used, and the level and composition of exposure sources, their characteristics, scientific programs. These changes will require the preparation of specific impact assessments.

7. Conclusions

The Republic of Belarus intends to establish a research station at the Tala Hills, Enderby Land, in order to promote its investigations in the area. The first phase of the station facilities will be implemented in 2014-2018. The station will be designed under the modular principle, thus minimising the construction costs, speeding up and simplifying the framework. The station is planned to start as a seasonal facility, with subsequent enhancement to wintering (year-round) operation. Limited staff, efficient power, heat, water supply, sewerage and waste management systems will contribute to minimum impact on the environment.

Earlier, in accordance with the requirements of the Protocol on Environmental Protection to the Antarctic Treaty and based on the Action Plan (2012), an Initial Environmental Evaluation (IEE) was prepared in connection with the Belarusian Antarctic station construction. The assessment included all the basic elements required by the *Guidelines for Environmental Impact Assessment in Antarctica (1999)*. The exposure caused by the station construction of stations was characterised as having “a minor or transitory impact”.

In this connection, the stated activities could be implemented without a Comprehensive Environmental Evaluation (CEE) to be prepared. However, according to the ATCM Recommendation XV-17, when considering the issue of opening a new station or supply facility, the Contracting Parties should prepare a Comprehensive Environmental Evaluation prior to such station or supply facility deployment. In connection with this project, a draft Comprehensive Environmental Evaluation for the proposed Belarusian Antarctic station deployment site was prepared to be further presented to the Antarctic Treaty Parties, Committee for Environmental Protection (CEP) and Antarctic Treaty Consultative Meeting (ATCM) in accordance with the established terms and procedures.

The impact assessment performed in accordance with the requirements of the Protocol on Environmental Protection demonstrated that the construction and the continued operation of BAS will be accompanied by emissions, discharges, waste accumulation, mechanical action on the ground, ice, as well as noise, electromagnetic radiation and possible introduction of alien microorganisms. However, the consequences of such impacts on the environmental components are assessed as minor, mainly due to the seasonality of the station operation, small number of staff, minimum scope of construction works involved in the transformation of the landscape, small amounts of fuel combustion.

Proposals for remediation of the environmental impacts have been developed. They include measures to reduce emissions, discharges, waste generation, waste management plans, routes planning, leak-preventing actions.

Proposals have been also prepared on monitoring programs focused on confirming the accuracy of predictions made regarding the environmental impacts and on detecting unforeseen impacts and exposures of greater impact than expected. They include selection of reference points and bookmark sites of systematic observations, control of the major natural components and sites (lakes, phytocenoses, bird colonies), industrial environmental monitoring and actions in case of accidents. The evaluation of the gaps in knowledge and uncertainties has been made.

In general, the impact due to the station (base) construction and operation can be identified as “minor or transitory”. The construction of a permanent research station is demonstrated to expand the research capacity in the area and benefit to fruitful international cooperation in Antarctica.

8. List of references

Abakumov E.V., Krylenkov V.A. Soils of Antarctica//Nature Journal, 2011. No. 3. P. 58-62.

Abakumov E.V., Lupachev A.V. Soil diversity of Antarctica terrestrial ecosystems (at the Russian Antarctic station locations)//Ukrainian Antarctic magazine. No. 10-11, 2011/2012. P. 222-228.

Annex 16 to the Convention on International Civil Aviation Volume I Aircraft Noise 3rd edition — July 1993.

ATCM XV. Final report of the fifteenth Antarctic treaty consultative meeting. Recommendation 17. Facilitation of scientific research: Siting of Stations. Paris, 9-20 October 1989. – http://www.ats.aq/devAS/ info_finalrep.aspx?lang=e&menu=5.

ATCM XXII/IP 66 Application of the «minor of transitory impact» criterion for EIA in different regions of Antarctica, Russian Federation. – http://www.ats.aq/devAS/ ats_meetings_doc_database.aspx?lang=e&menu=5.

ATCM XXII /WP 19 Environmental Impact Assessment - The Role of EIA Guidelines in Understanding "Minor" and "Transitory", Australia. – www.ats.aq/documents/ATCM22/wp/ ATCM22_wp019_e.pdf.

Calculation Methodology of pollutant emissions by civil aircraft engines, approved by the Russian Ministry of Transport on 27/10/2008.

Calculation Methodology of air pollutant emissions by permanent diesel power plants. St-Petersburg. 2001. Approved by the Russian Ministry for Natural Resources on 14/02/2011.

Committee for Environmental Protection (CEP). Guidelines for Environmental Impact Assessment in Antarctica. Resolution 4 (2005). – www.ats.aq/documents/cep/ Guidelines_EIA_e.pdf.

Committee for Environmental Protection (CEP). Practical Guidelines for Developing and Designing Environmental Monitoring Programmes in Antarctica. Resolution 2 (2005). – www.ats.aq/documents/cep/ Guidelines_monitoring_e.pdf.

COMNAP-SCAR Antarctic Environmental Monitoring Handbook (June 2000). – www.comnap.aq.

Comparative analysis of criteria, used for choosing the Belarusian Antarctic station location at the East Antarctic coastal area. Analytical memo. Ministry for Natural Resources and Environmental Protection. Minsk, 2007.

Decree of the President of the Republic of Belarus No. 200 on accession of the Republic of Belarus to the Protocol on Environmental Protection to the Antarctic Treaty of April 10, 2008 (effective for Belarus since August 15, 2008).

EASA Type Certificate Data Sheet for Noise Kamov Ka-32A11BC Type Certificate Holder: Kamov Company Moscow Russian Federation Issue 1, 28 September 2009

Electronic Directory on the Antarctic natural environment (http://www.aari.aq/gis/web/kosm/opisanie.html).

EMEP/EEA Atmospheric Air Pollutant Emission Inventory Guidebook. 2009. Technical guidance to prepare national emission inventories No 9/2009

EPA, 2000. Meteorological Monitoring Guidance for Regulatory Modeling Applications. EPA-454/R-99-005. Office of Air Quality Planning & Standards, Research Triangle Park, NC. (PB 2001-103606)

EPA, 2003: AERMOD Deposition Algorithms - Science Document (Revised Draft). U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

EPA, 2004a: Users Guide for the AMS/EPA Regulatory Model - AERMOD. EPA-454/B-03-001. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

EPA, 2008: AERSURFACE User's Guide. EPA-454/B-08-001. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina 27711.

GN 2.1.5.10-20-2003 – Tentative allowable concentrations (TAC) of chemicals at domestic and potable water bodies.

GN 2.1.5.10-21-2003 – Maximum permissible concentrations (MPC) of chemicals at domestic and potable water bodies.

GN 2.1.5.10-29-2003 – Maximum permissible concentrations (MPC) and tentative safe exposure levels (TSL) of chemicals at domestic and potable water bodies

Guidelines on quantitative and qualitative calculation of wastewaters and polluting substances entering the sewage systems of settlements. Moscow, 2001.

Helicopter Ka-32 Flight Manual.

INM 7.0 Technical Manual. U.S. Office of Environment and Energy Federal Aviation Administration. 2008.

INM 7.0 User's Guide U.S. Office of Environment and Energy Federal Aviation Administration. 2007.

ISO 1996-1:2003 Description, measurement and assessment of environmental noise. Part 1. Basic quantities and assessment procedures.

ISO 9613-2:1996 Noise. Attenuation of sound during propagation outdoors. Part 2. General method of calculation.

ISO 5667-12:1995 Water quality – Sampling – Part 12: Guidance on sampling of bottom sediments.

ISO 10381-4:2003 Soil quality – Sampling – Part 4: Guidance on the procedure for investigation of natural, near-natural and cultivated sites.

Kotlyakov V. M. Glaciology of Antarctica. Selective Works. Vol. 1, 2000.

Kupriyanov V. N. Acoustic protection design. Kazan, 2010.

Law of the Republic of Belarus No. 157-3 on accession of the Republic of Belarus to the Antarctic Treaty of July 19, 2006 (Belarusian National Register for Legal Acts, 2006, No. 122, 2/1254).

Lupachev A. V., Vetrova A. A., Ovchinnikova A. A., Kalinin P. I.. Effects of man-caused impact on Antarctic soils at the Russian research station locations//Materials of the 6th V.V.

Dokuchayev Soil Scientists Congress. All-Russian International Scientific Conference – Soils of Russia: current condition, prospects of study and usage. Volume 1. Petrozavodsk-Moscow, August 13-18, 2012. Petrozavodsk, Karelia Scientific Centre, 2012. Vol. 1.

Molodyozhnaya Station // Scientific & engineering description of the natural environment and facilities of the Russian Antarctic expedition stations, including evaluation of their environmental impact. Arctic and Antarctic Scientific Research Institute. RAE, Saint Petersburg, 1994

National Program on Monitoring of the Earth's polar areas and promotion of the Arctic and Antarctic expeditions for the period 2011-2015, as approved by Enactment No. 587 of the Belarusian Council of Ministers on May 10, 2011.

National Program on Monitoring of the Earth's polar areas and promotion of the Arctic and Antarctic expeditions in 2007-2010 and for the period up to 2015, as approved by Enactment No. 1104 of the Belarusian Council of Ministers of 31/08/2006 (with amendments No. 1405 of 27/10/2009 (Belarusian National Register for Legal Acts, 2009, No. 264, 5/30673).

Noise Model Simulation (NMSim) User's Manual. Wyle Report WR 03-09 (J/N 45762.03) June/2005.

Practical Guidelines for Developing and Designing Environmental Monitoring Programs in Antarctica. Final Report of the 28th ATCM. 2005.

Protocol on Environmental Protection to the Antarctic Treaty: www.ats.aq/documents/recatt/Att006_e.pdf.

RD 52.04.186-89 - Guidelines for air pollution monitoring - M.: USSR State Hydrometeorology Committee, 1991 – Part I and II.

Reconstruction of the passenger berth at PETERGOF Protected Area's Nizhniy park. Section 8. List of measures on environmental protection.

Rotorcraft Noise Model Technical Reference and User Manual (Version 7.1) Wyle Report WR 08-04 February 2008

SanPiN 2.1.5.12-43-2005 - Sanitary regulations for drainage systems of settlements. Enactment No. 227 of the Belarusian State Doctor-in-Chief of 16/12/2005.

SanPiN No. 105 of 02/08/2010 - Sanitary requirements to potable water individual supply sources.

SanPiN No. 48 of 15/05/2012 - Requirements to drainage systems of settlements.

SanPiN 2.1.2.12-33-2005 - Sanitary requirements to surface water protection from pollution.

SanPiN 2.04.01-85 - Internal water supply and sewage system of buildings.

SanPiN 2.04.03-85 - Sewage system. External networks and constructions.

Short information on activity of the Republic of Belarus in Polar regions / XXX ATCM Item: ATCM 13. IP 130. 2007.

Smagin V. M. Chemical composition of precipitations at Mirny observatory area // Problems of Arctic and Antarctica. No. 76, 2007. P. 154-159.

SN 2.2.4/2.1.8.562-96 – Noise at workplaces, residential and public buildings and individual houses.

Spectral classes for FAA's Integrated Noise Model version 6.0. U.S. Department of Transportation Federal Aviation Administration. 1999.

Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases. UNEP Chemicals, Geneva 2005

State standard (STB) 17.1.3.05-2006. Environment Protection. Hydrosphere. Protection of surface and ground water from pollution at storage of oil and oil products. Common requirements WHO Air Quality Guidelines, Geneva, 2000.

Summary report on scientific research and logistic activities, performed by the Belarusian seasonal Antarctic expedition in 2010-2011 as part of the 56th Russian Antarctic Expedition / Belarusian Ministry for Natural Resources and Environmental Protection, National Centre for Polar Investigations. Minsk, 2011.

Technical Code of established practice (TCP) 17.11-02-2009 (02120/02030). Environmental protection and nature use. Waste Municipal waste management. Objects for solid municipal waste disposal. Rules for designing and operation.

Technical Code of established practice (TCP) 17.XXX. Environmental Protection and Nature Use. Wastes. Rules of Municipal Wastes Management.

Technical Code of established practice (TCP) 45-2.04-154-2009 (02250). Sound protection. Design Rules.

The World Atlas of Snow & Ice Resources in 2 Vol. – M., 1997.

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Annex 1

BAS modules description and major specifications

1. Laboratory & residential module, single-storey

Figure 1 - Left section of the module. Right-side view

Figure 2 – Middle section of the module. Right-side view

Function:

The laboratory & residential module is designed for:

- observations and laboratory tests to be performed;
- sanitary & hygienic purposes, rest (sleep) and catering of max. 3 people;
- laboratory equipment installation (oven, autoclave, microscope, binocular microscope, laboratory tables, shelves, etc.);

- hydro-biological instrument storage (water bottles, sediment samplers, plankton nets, sweep nets, fishing rods, sleds, motor-drill, etc.);

- biological samples container-packed storage, storage of dry samples, storage of chemicals, storage of diving equipment, food emergency packs, safety and firefighting equipment, spare parts, tools and accessories (single set) (STA-1) and outdoor equipment.

The module comprises of:

- 2-section prefabricated platform-basement (positioned on outrigger jacks and additional telescopic adjustable legs) to set the wagon container-type sections, equipped with easy-removable ladders and enclosures;

- one lab & household 'butterfly-type' (one-sided) wagon section with a set of furniture (cabinets, shelves, safe), life-supporting and power supply systems comprising of: refrigerator-freezer, shower, self-contained water supply system (a water pumping system without a water tower installed, horizontal water heater of 50-70 l capacity, water tank of 400-500 l capacity), as well as domestic wastewater collection and discharge system (400 l storage tank with internal heating, water pump for jet discharge of domestic wastewaters to a central sewer or drain in a mobile tank);

- one container-type service & residential wagon section with life-support and power supply systems comprising of: a mini-kitchen unit (microwave, teakettle, toaster, sink, kitchen cabinet with pull-out cutting board, double wall cupboard, 20 l water accumulation heater), electric toilet (Insinolet).

The major engineering specifications are given in Table 1 below.

Table 1 – Major engineering specifications of the laboratory & residential single-storey module

Engineering specifications	Value	
1. Dimensions, max., mm - length - width - height	 6058 7314 2438	
2. Module's gross weight, kg	8900	
3. Dimensions of the laboratory & utility wagon section, max., mm	external	internal
- length - width - height	4 558 2 438 2 438	4 408 2 238 2 218
4. Dimensions of the service & residential wagon section, max., mm	external	internal
- length	4558	4408
- width	2438	2238
- height	2438	2218
5. Laboratory & utility wagon section gross weight, kg	3900	
6. Weight of one basement section	500	
7. Platform-basement's gross weight	1500	
8. Service & residential wagon section gross weight, kg	3500	

2. Service & residential module, single-storey

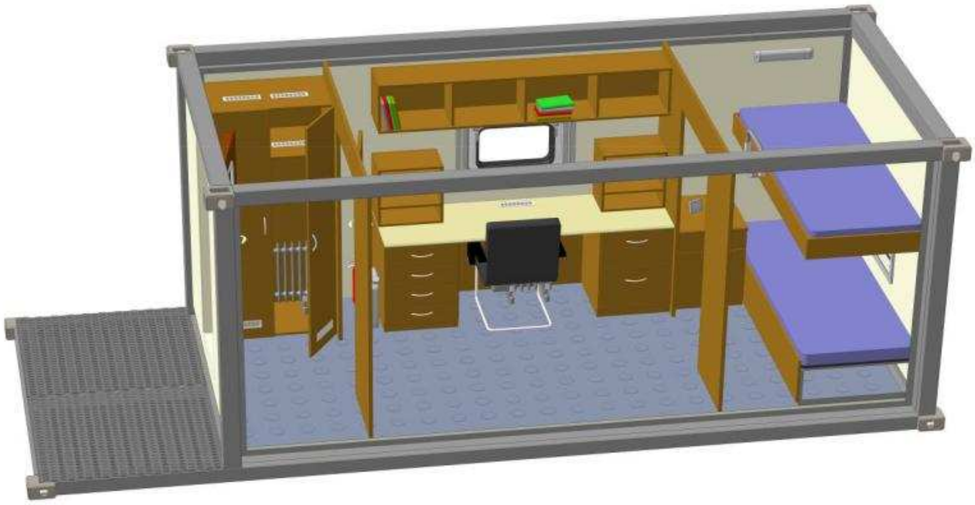

Figure 3 - Left section of the module. Right-side view

From the entrance: a lobby, wardrobe with heating elements, lab workplace, compartment for recreation.

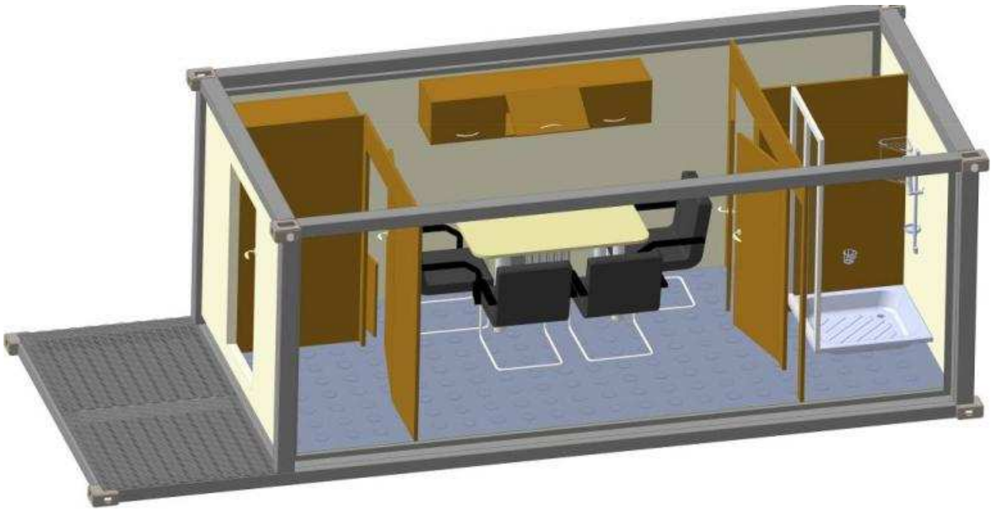

Figure 4 - Middle section of the module. Right-side view

From the entrance: a lobby, wardrobe, catering zone, mini-kitchen, toilet, shower, water treatment, heating and storage area.

Figure 5 - Right section of the module. Right-side view

The service & residential module is designed for:

- observations and laboratory tests to be performed;
- sanitary & hygienic purposes, rest (sleep) and catering of max. 4 people;
- laboratory equipment installation (lidar, radiometer, ozonometer, other equipment for atmosphere investigation);
- storage of i tools and accessories for scientific equipment repair;
- storage of additional equipment, food emergency packs, safety and firefighting equipment, spare parts, tools and accessories (single set) and outdoor equipment.

The module comprises of:

- 3-section prefabricated platform-basement (positioned on outrigger jacks and additional telescopic adjustable legs) to set the wagon container-type sections, equipped with easy-removable ladders and enclosures;
- two container-type service & residential wagons section with a set of furniture as well as life-support and power supply systems;
- one container-type household wagon with a set of furniture (cabinets, shelves, safe), life-supporting and power supply systems comprising of: refrigerator-freezer, shower, self-contained water supply system (a water pumping system without a water tower installed, horizontal water heater of 50-70 l capacity, water tank of 400-500 l capacity), as well as domestic wastewater collection and discharge system (400 l storage tank with internal heating, water pump for jet discharge of wastewaters to a central sewer or drain in a mobile tank).

The major engineering specifications are given in Tables 2-3 below.

Table 2 – Major engineering specifications of the service & residential single-storey module

Engineering specifications	Value	
1. Dimensions, max., mm - length - width - height	 6 058 7314 2 438	
2. Module's gross weight, kg	10250	
3. Dimensions of the laboratory & utility wagon section, max., mm	external	internal
- length - width - height	4 558 2 438 2 438	4 408 2 238 2 218
4. Dimensions of the service & residential wagon section, max., mm	external	internal
- length	4558	4 408
- width	2 438	2 238
- height	2 438	2 218
5. Laboratory & utility wagon section gross weight, kg	3900	
6. Weight of one basement section	500	
7. Platform-basement's gross weight	1500	
8. Service & residential wagon section's gross weight, kg	3550	

Table 3. Package set of the laboratory & residential single-storey module

Component name	Number	Special note
Basement positioned on outrigger jacks with external easy-removable enclosure and corner elements (fixing brackets) for wagon section positioning	3	3 separate sections of the platform are transported in a bundle and installed on-site by helicopter separately, and then mounted (connected) to each other in a single (joint) platform-basement
Replaceable adjustable legs (the outriggers are set manually with fastening anchors to the surface)	8	Transported together (in one package) with the basement sections. Mounted under the basement following its installation on-site on the jacks
Container-type wagon section	3	Including one section without front and rear walls. Transported separately. Assembled by helicopter onto the basement following its installation on-site.
Vertical service ladder	1	Mounted on the front side wall of the module
Entry platform ladders	2	Transported together (in one package) with the basement sections. Mounted to the entry (side) platforms of the basement after its final installation on-site.
Collector tank for domestic wastewaters of 400 l capacity, double wall and heated.	1	Transported separately. Mounted underneath the laboratory & household wagon section following its installation onto the basement.

3. Laboratory & residential block module, two-storey

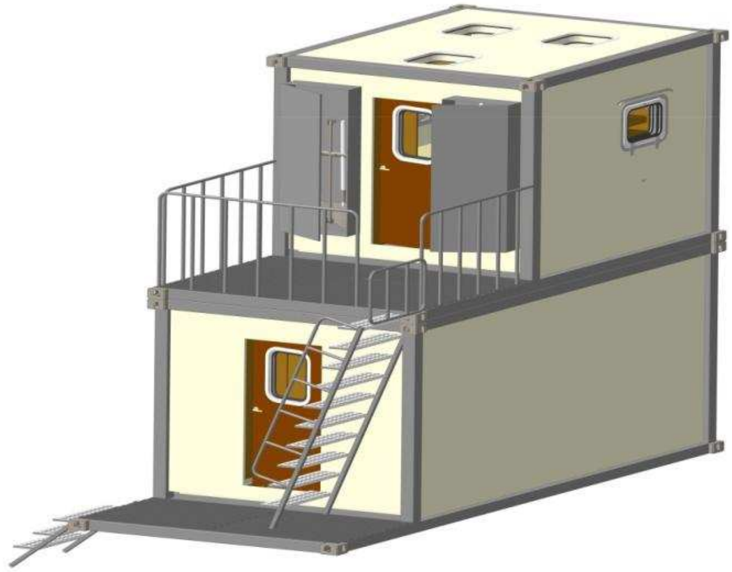

Figure 6 – General view of the laboratory & residential two-storey block module

Function:

The laboratory & residential two-storey block module is designed for:

- rest (sleep) and catering of max. 2 people;
- sanitary & hygienic purposes;
- installation of communication, navigation and monitoring equipment for the major meteorological parameters (satellite station, VHF and HF communication, satellite data receiving and processing equipment, recording blocks of automatic weather stations and similar equipment and instrumentation);
- storage of spare parts, tools and accessories for repair and adjustment of communication and navigation equipment (STA-CN) and outdoor equipment;
- storage of spare parts, tools and accessories (single set) (STA-1) and outdoor equipment;
- storage of food emergency packs, safety and firefighting equipment.

The module comprises of:

- one container-type service & residential wagon section, positioned on outrigger jacks and additional telescopic (replaceable) adjustable legs, equipped with easy-removable three-stairway ladder platform with easy-removable rails (entry enclosure), which include: set of furniture, life-supporting and power supply systems with 2.5-3.5 kW emergency backup, mini-kitchen unit (microwave, teakettle, toaster, sink with hinged dryer, single floor kitchen cabinet with pull-out cutting board, single wall-mounted kitchen cupboard, double wall cupboard, 20 l water accumulation heater, shower, electric toilet (Insinolet), self-sustained water supply system (water pumping system without a water tower installed, horizontal water heater of 50-70 l capacity, water tank of 200 l capacity), as well as domestic wastewater collection and discharge system (200-250 l storage tank with internal heating, water pump for jet discharge of domestic wastewaters to a central sewer or drain in a mobile tank);

- one block (wagon section) for communications, navigation and routine weather monitoring, including: life-supporting and power supply systems with 1.0-1.5 kW emergency backup, outdoor platform with easy-removable rails sized 2,500 x 2,400 mm, metal frames with adjustable angle for installation of solar panels, set of furniture: wardrobe (coupé) with shelves for STA, wardrobe (coupé) for multifunctional Modulus UPS installation, central operator desk with angular desktop shelves for communication and navigation equipment, fitter's table with drawers, side operator desk with drawers and a niche for computer, open wall-mounted shelves for equipment .

The major engineering specifications and package set details are given in Tables 4-5 below.

Table 4 – Major engineering specifications of the laboratory & residential two-storey module

Engineering specifications	Value	
1. Dimensions, max., mm - length - width - height	 6 058 2 438 4 876	
2. Module's gross weight, kg	6300	
3. Dimensions of the service & residential wagon section, max, mm	external	internal
- length - width - height	4 558 2438 2 438	4 408 2 238 2 218
4. Service & residential wagon section's gross weight, kg	3900	
5. Dimensions of the communication, navigation & monitoring section, max, mm	external	internal
- length	3 029	2 879
- width	2 438	2 238
- height	2 438	2 218
6. Communication, navigation & monitoring section's gross weight, kg	2 000	

Table 5. Package set of the laboratory & residential two-storey block module

Component name	Number	Special note
Telescopic (replaceable) adjustable legs	4	Transported separately. Mounted under the service & residential section following its installation on-site on the jacks.
Container-type wagon section	2	Transported separately. Mounted by Ka-32 helicopter in a two-storey structure (one section onto another).
Vertical service ladder, two-section	2	Mounted on the front side wall of each container-type wagon section
Three-stairway ladder platform with easy-removable rails (entry enclosure)	1	Transported by a separate package. Mounted from the entry side of the sections following their final installation on-site.
Outdoor platform with easy-removable rails sized 2,500 x 2,400 mm	1	Transported together with the service & residential wagon section. Mounted on the roof of the service & residential wagon section following its final installation on-site.
Collector tank for domestic wastewaters of 200-250 litres capacity, double wall and heated.	1	Transported separately. Mounted underneath the service & residential wagon section following its final installation on-site.

4. Production & residential module, two-storey

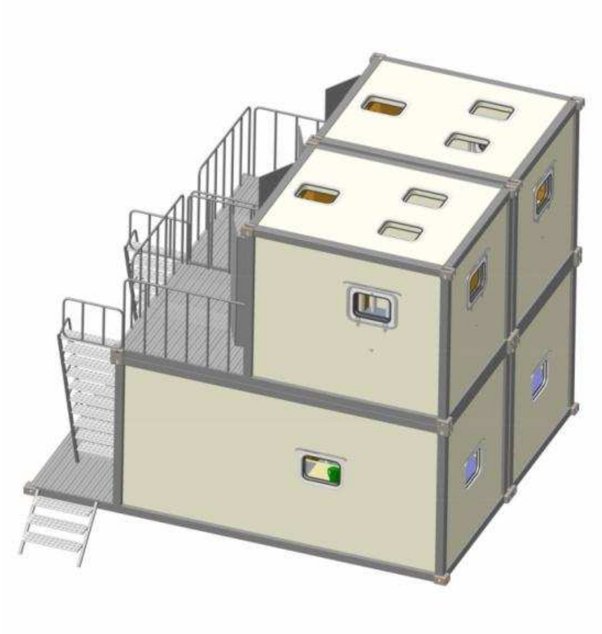

Figure 7 – General view of the production & residential two-storey module

Function:

The production & residential two-storey module is designed for:

- rest (sleep) and catering of max. 2 people;

- repair works;
- sanitary & hygienic purposes;
- storage of mechanic and woodwork tools;
- storage of equipment;
- storage of food emergency packs, safety and firefighting equipment;
- storage of spare parts, tools and accessories (STA) and outdoor equipment.

The module comprises of:

- simplex prefabricated platform-basement (positioned on outrigger jacks and additional telescopic adjustable legs) to set the wagon container-type sections, equipped with easy-removable ladders and enclosures;
- container-type residential wagon section (lower block) with life-supporting and power supply systems comprising of: 20 l water accumulation heater, electric toilet (Insinolet), sink, shower, twin residential compartment, wardrobe, self-contained water supply system (a water pumping system without a water tower installed, horizontal water heater of 50-70 l capacity, water tank of 200 l capacity), as well as domestic wastewater collection and discharge system (400 l storage tank with internal heating, water pump for jet discharge of domestic wastewaters to a central sewer or drain in a mobile tank);
- container-type production wagon section (upper block) for two workplaces (mechanics & woodwork), life-supporting system (bio-toilet and washbasin unit), wardrobe for work outerwear, wardrobe for tools and accessories, desk, workbench and vise, grinding machine, drilling machine, portable cutting machine with a holder for the cutting machine.

The major engineering specifications and package set details are given in Tables 6-7 below.

Table 7 – Major engineering specifications of the production & residential two-storey module

Engineering specifications	Value	
1. Dimensions, max., mm		
- length	6 058	
- width	6 058	
- height	4 876	
2. Module's gross weight, kg	9 300	
3. Dimensions of the residential wagon section, max., mm	external	internal
- length	6058	5 908
- width	2438	2238
- height	2438	2218
4. Dimensions of the repair wagon section, max., mm	external	internal
- length	6058	5908
- width	2438	2238
- height	2438	2218
5. Production & residential wagon section's gross weight, kg	4400	
6. Weight of one basement section	500	
7. Platform-basement's gross weight	500	
8. Service & residential wagon section's weight, kg	4400	

Table 8. Package set of the production & residential two-storey module

Component name	Number	Special note
Basement positioned on outrigger jacks with external easy-removable enclosure and corner elements (fixing brackets) for wagon section positioning	1	1 section of the platform is transported in a bundle and installed on-site by helicopter, and then mounted (connected) to each other in a single (joint) platform-basement
Replaceable adjustable legs	4	Transported together (in one package) with the basement sections. Mounted under the basement following its installation on-site on the jacks
Container-type wagon section	2	Transported separately. Assembled by helicopter onto the basement following its installation on-site.
Vertical ladder for climbing to the 2nd level	1	Mounted on the front wall of the wagon section
Entry platform ladder with easy-removable rails	2	Transported together (in one package) with the basement sections. Mounted to the entry (side) platforms of the basement after its final installation on-site.
Collector tank for domestic wastewaters of 400 l capacity, double wall and heated.	1	Transported separately. Mounted underneath the laboratory & household wagon section following its installation onto the basement.

Maps of air pollutants dispersion from stationary sources at BAS operation. Scenario 2

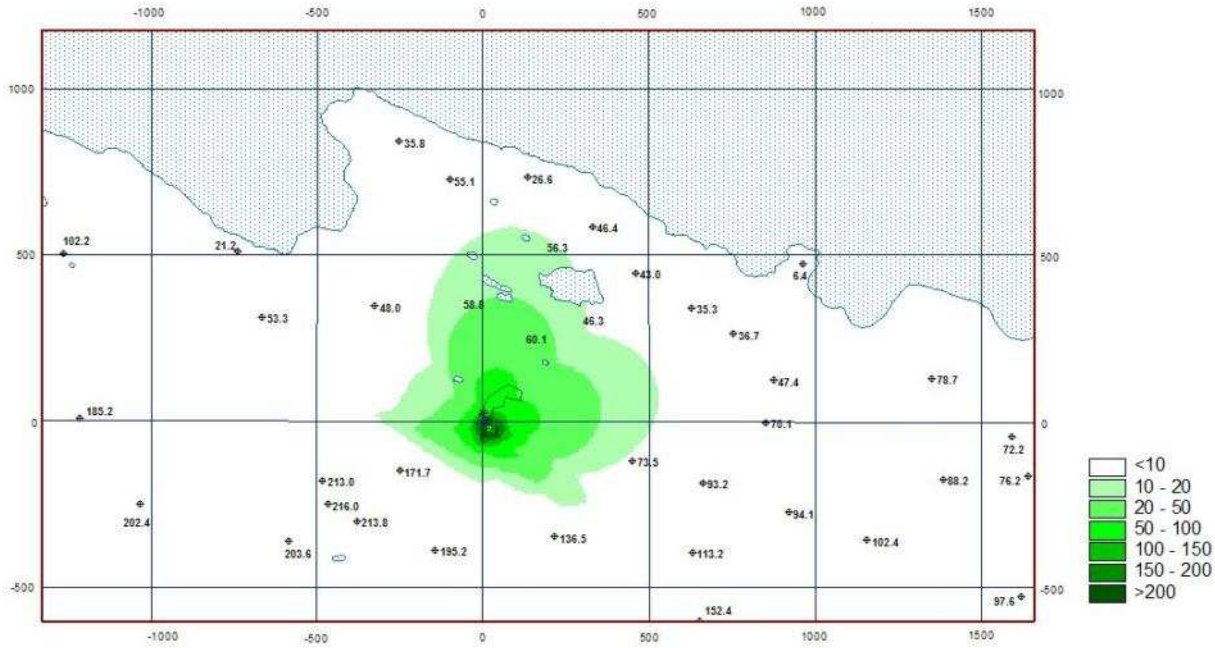

Figure 1 – Distribution of maximum 1-hour carbon oxide concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

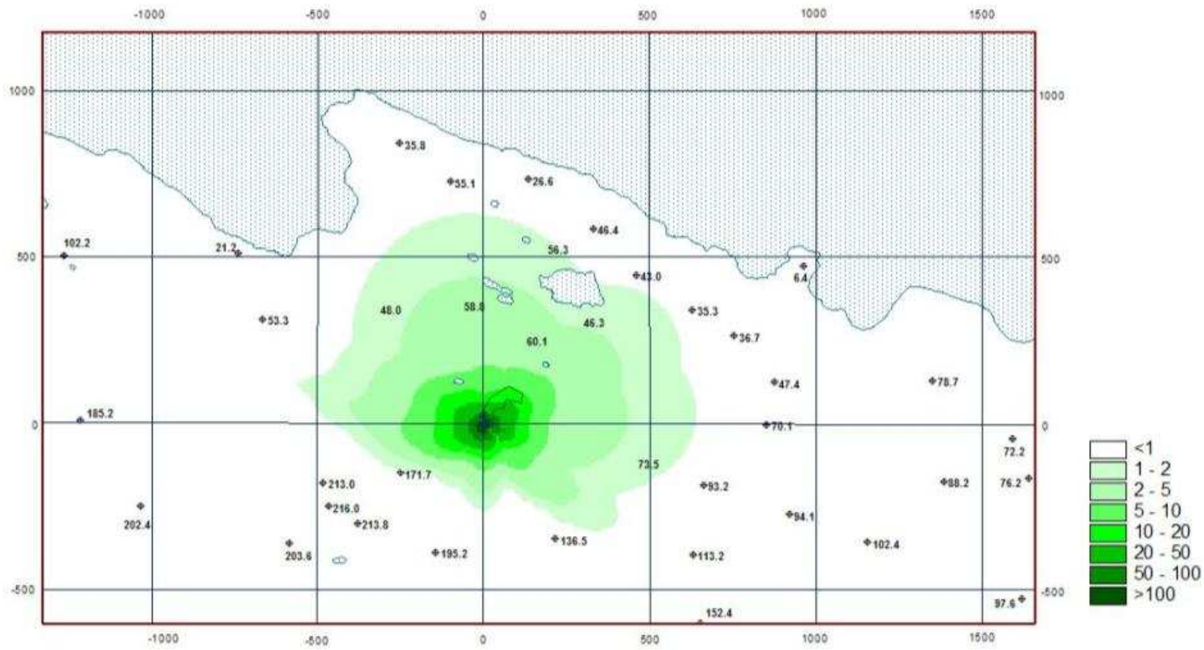

Figure 2 – Distribution of maximum 24-hour carbon oxide concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

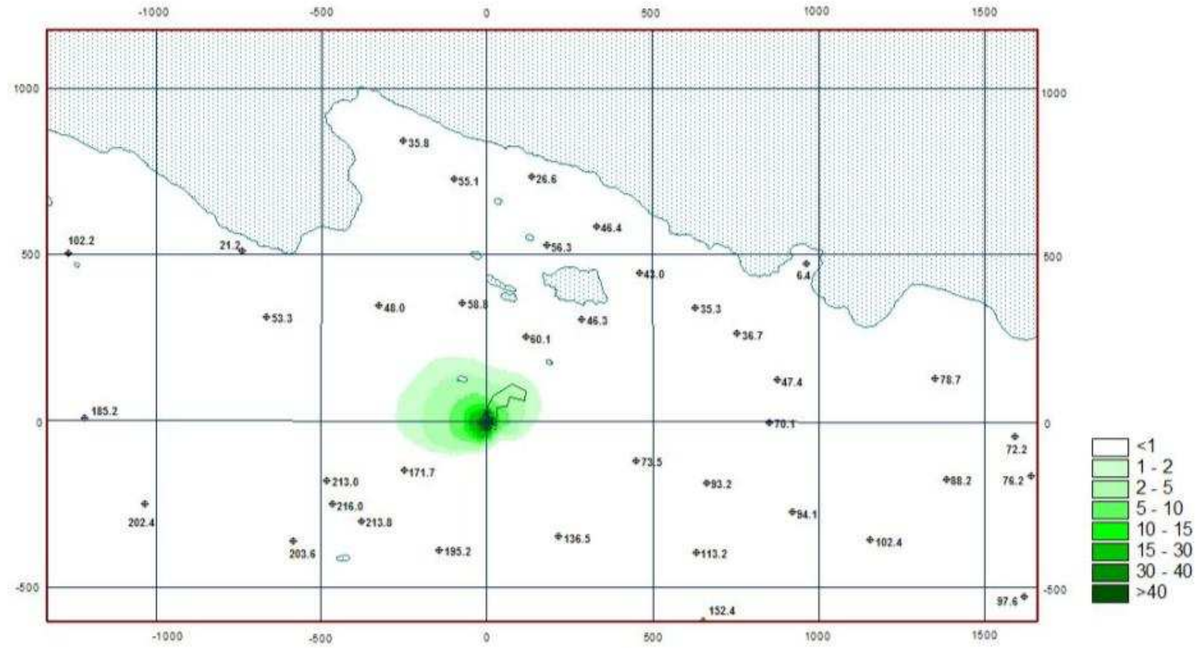

Figure 3 – Distribution of monthly average carbon oxide concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

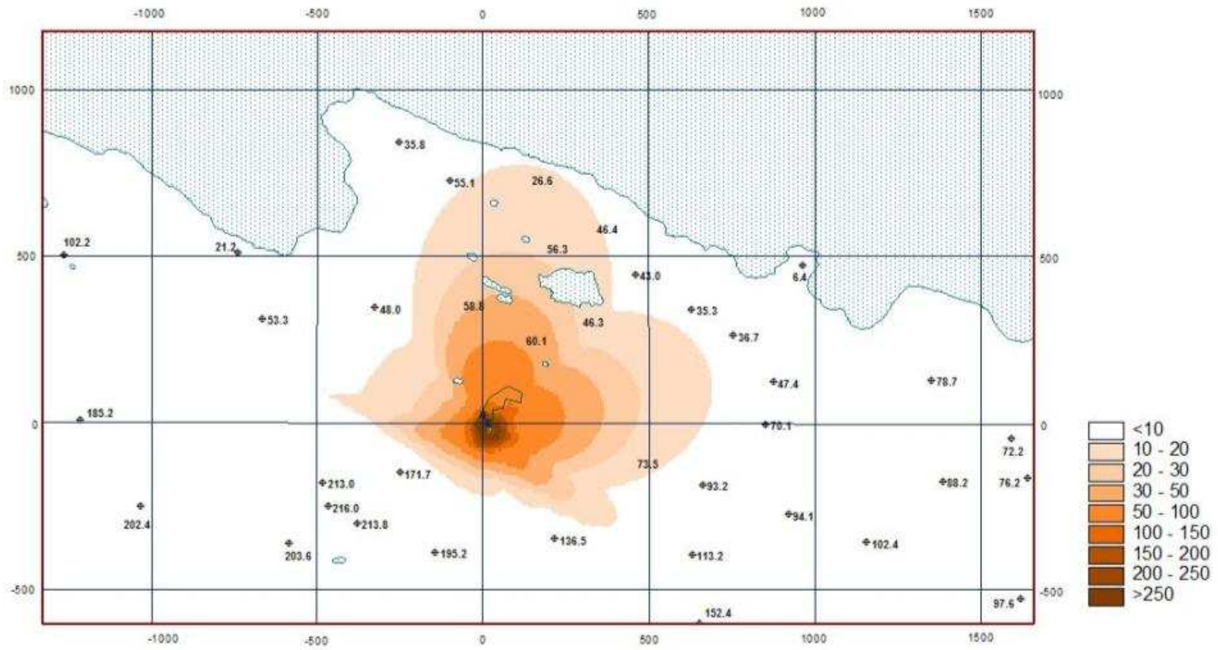

Figure 4 – Distribution of maximum 1-hour nitrogen dioxide oxide concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

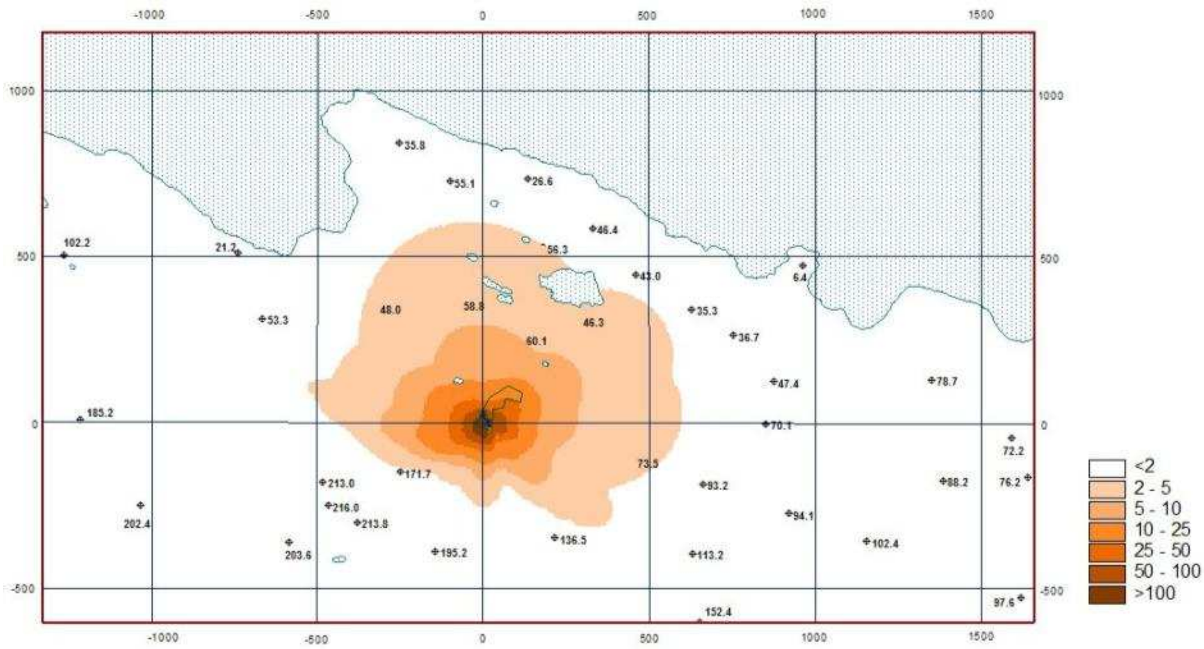

Figure 5 – Distribution of maximum 24-hour nitrogen dioxide concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 2

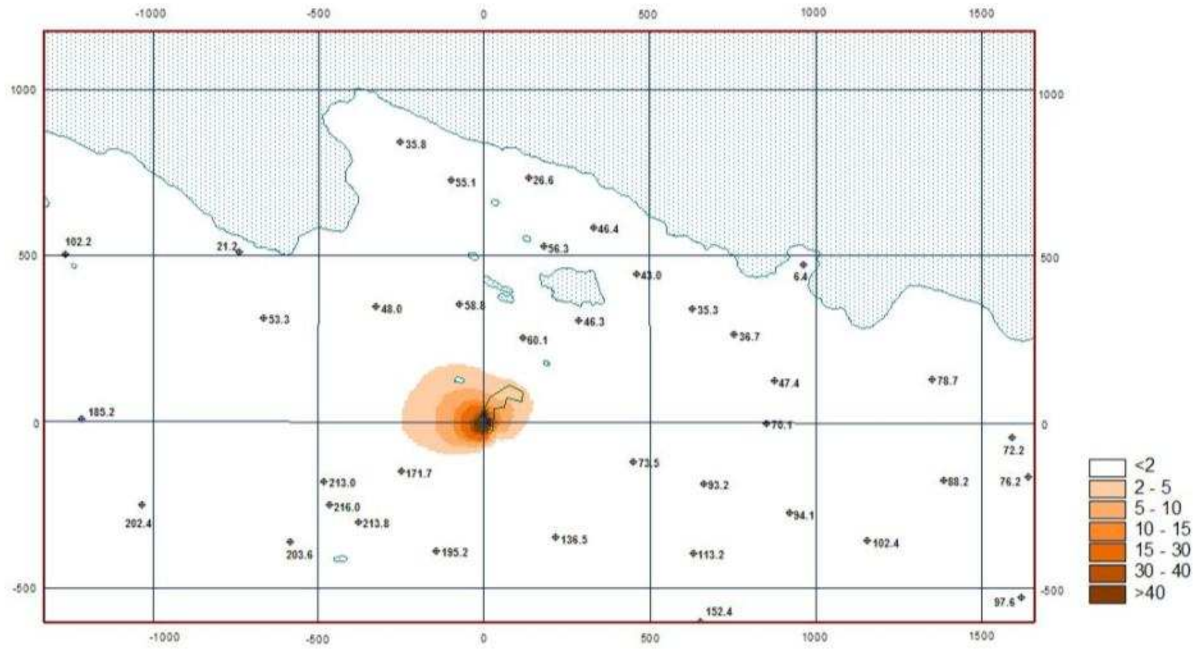

Figure 6 – Distribution of monthly average nitrogen dioxide concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 2

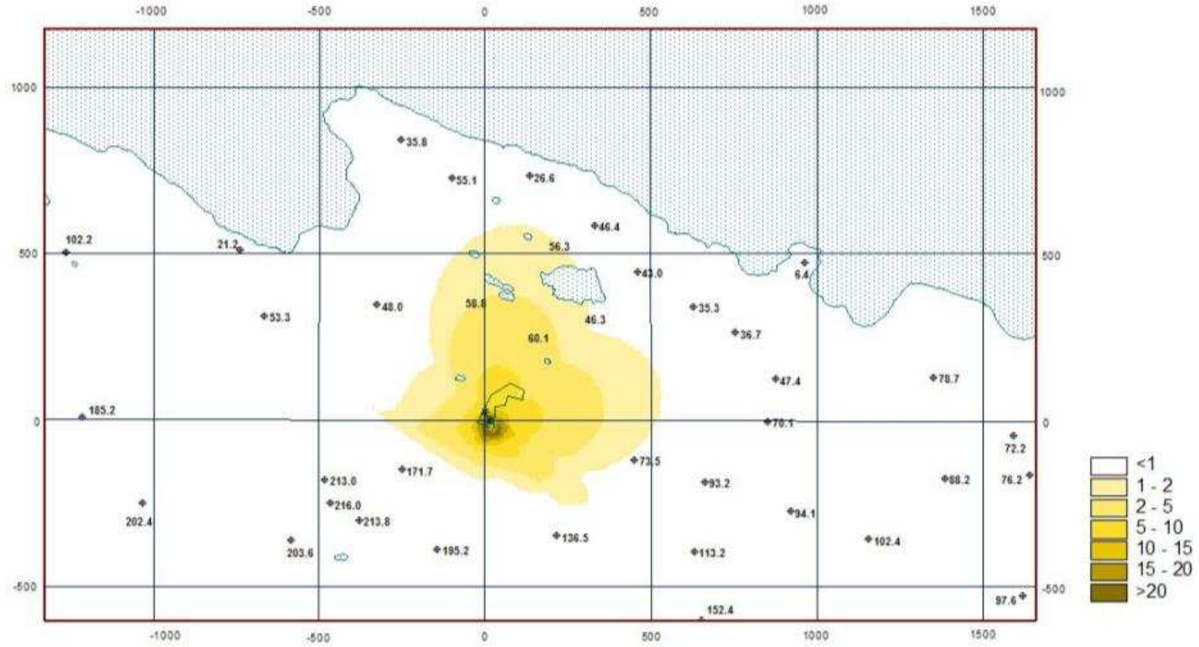

Figure 7 – Distribution of maximum 1-hour PM10 concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

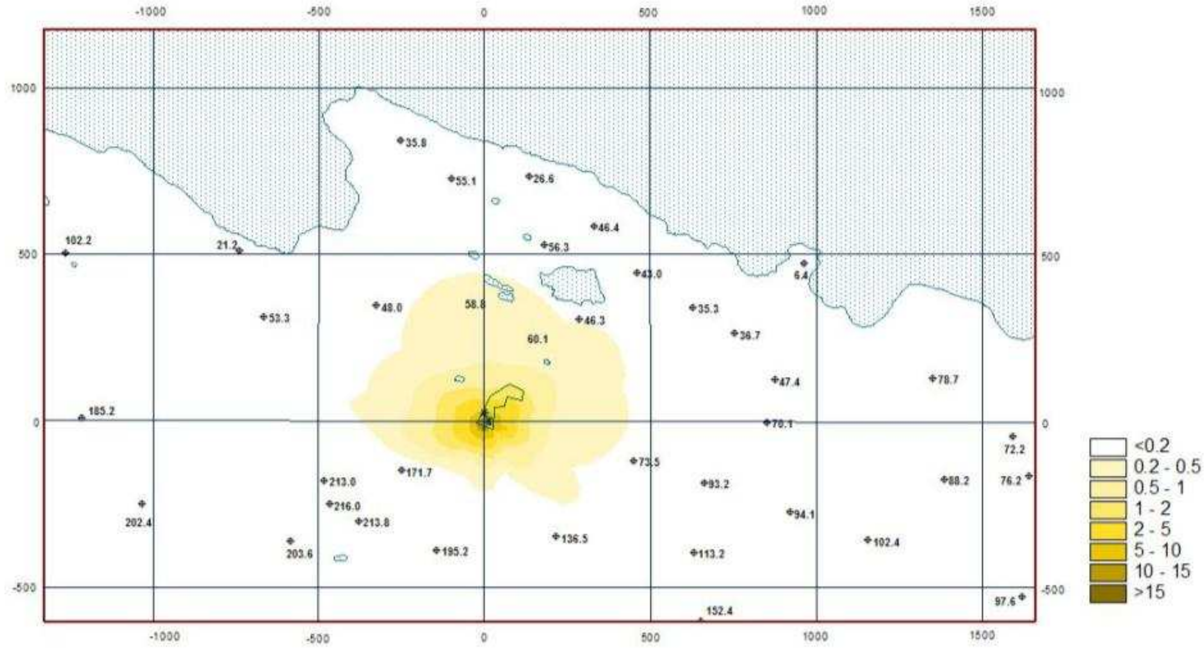

Figure 8 – Distribution of maximum 24-hour PM10 concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

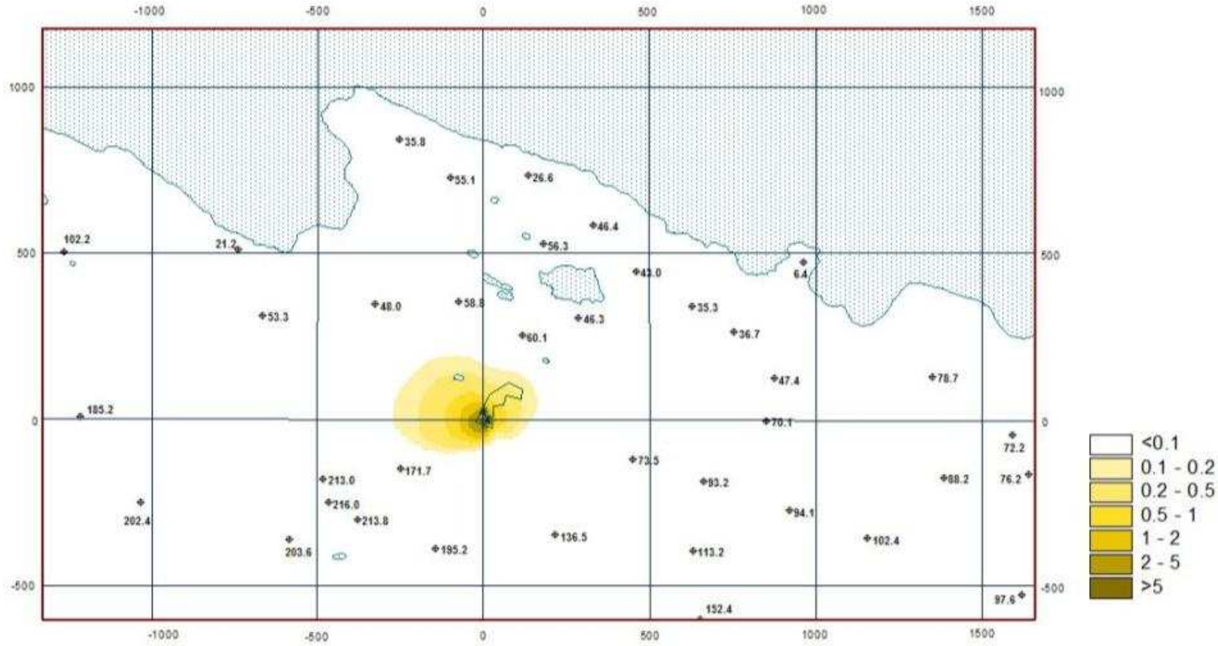

Figure 9 – Distribution of monthly average PM10 concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

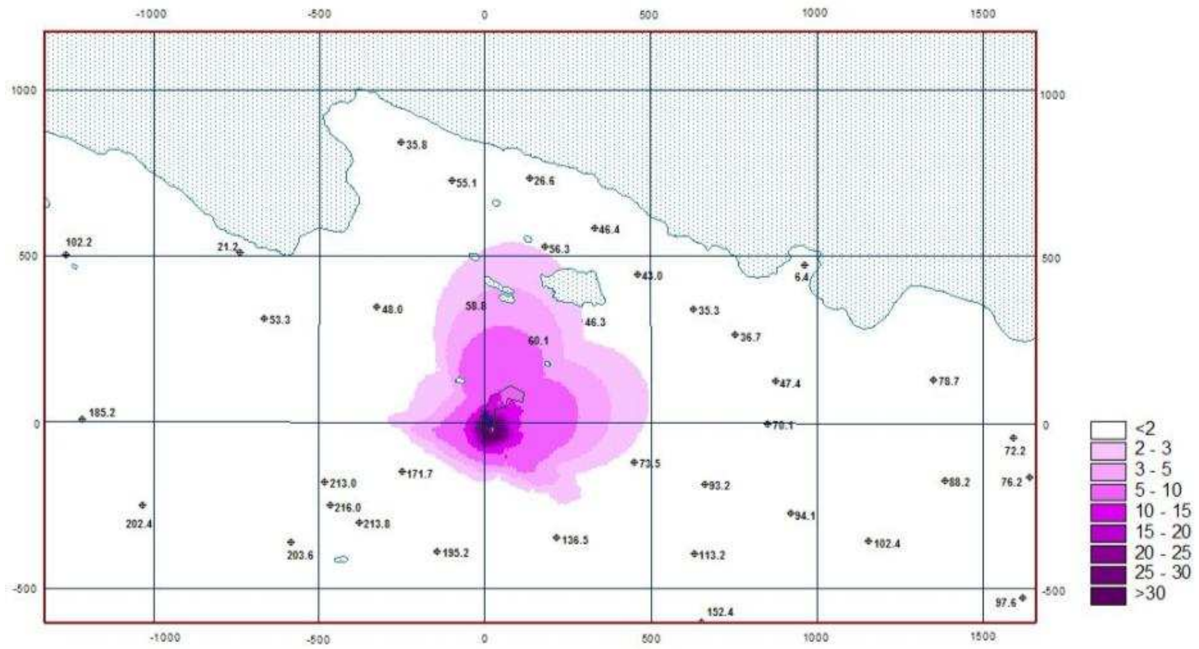

Figure 10 – Distribution of maximum 1-hour sulfur dioxide concentrations in atmospheric air from BAS stationary sources operation, µg/m^3. Scenario 2

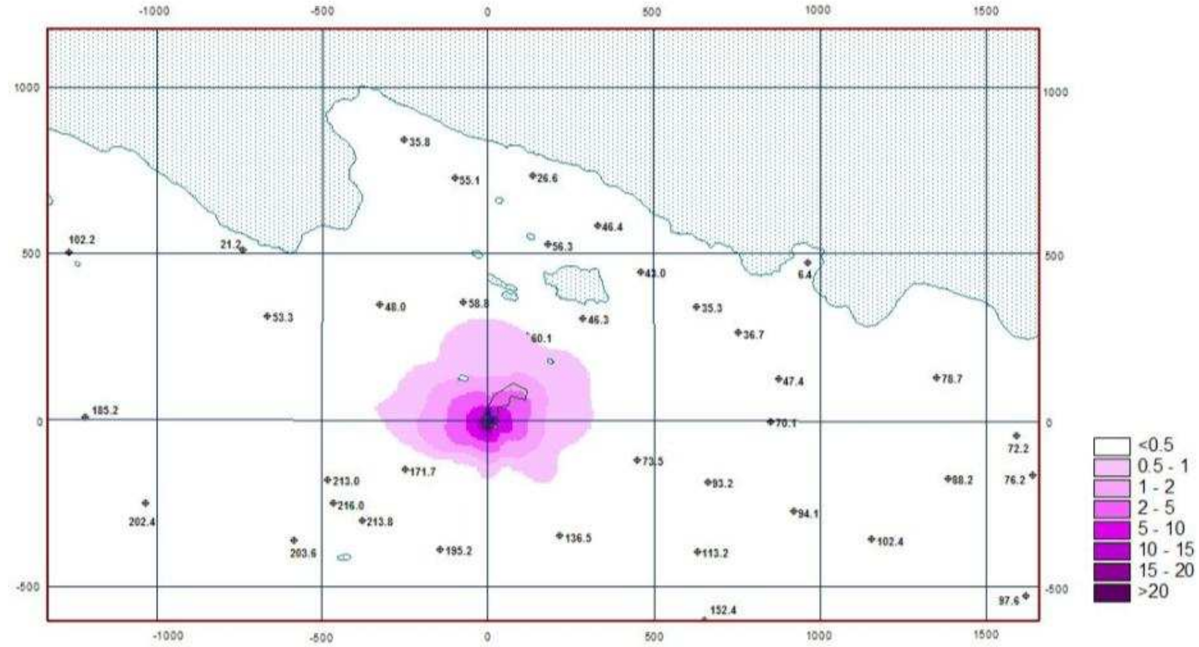

Figure 11 – Distribution of maximum 24-hour sulfur dioxide concentrations in atmospheric air from BAS stationary sources operation, $\mu g/m^3$. Scenario 2

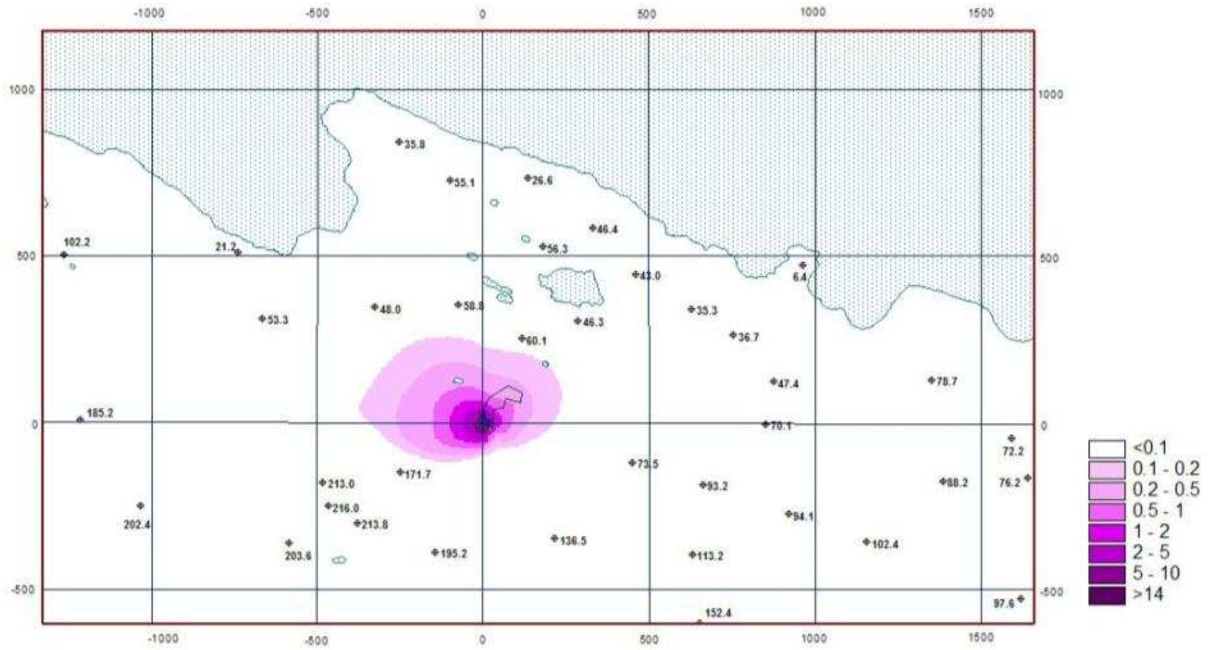

Figure 12 – Distribution of monthly average sulfur dioxide concentrations in atmospheric air from BAS stationary sources operation, $\mu g/m^3$. Scenario 2

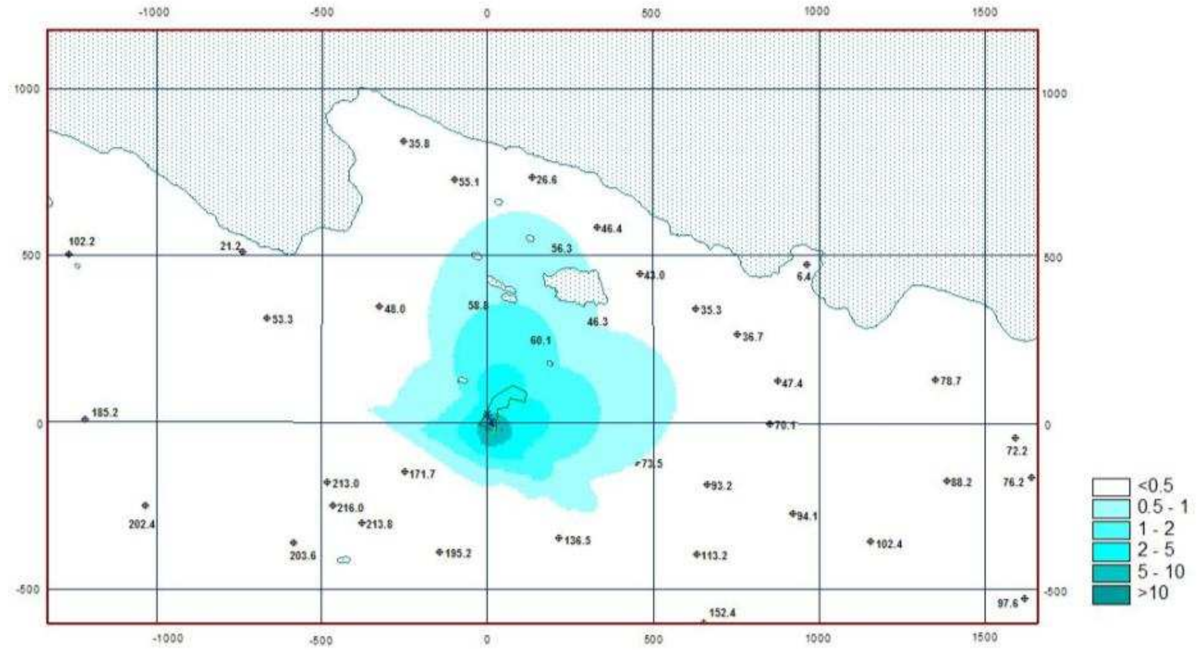

Figure 13 – Distribution of maximum 1-hour hydrocarbon concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 2

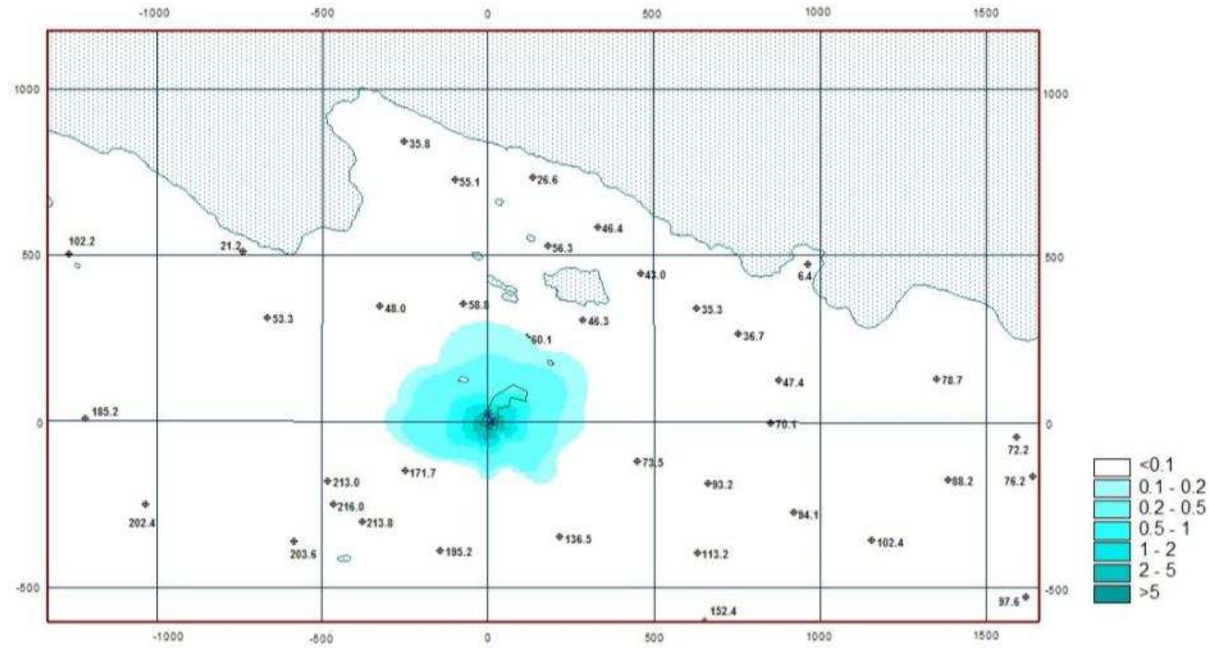

Figure 14 – Distribution of maximum 24-hour hydrocarbon concentrations in atmospheric air from BAS stationary sources operation, μg/m^3. Scenario 2

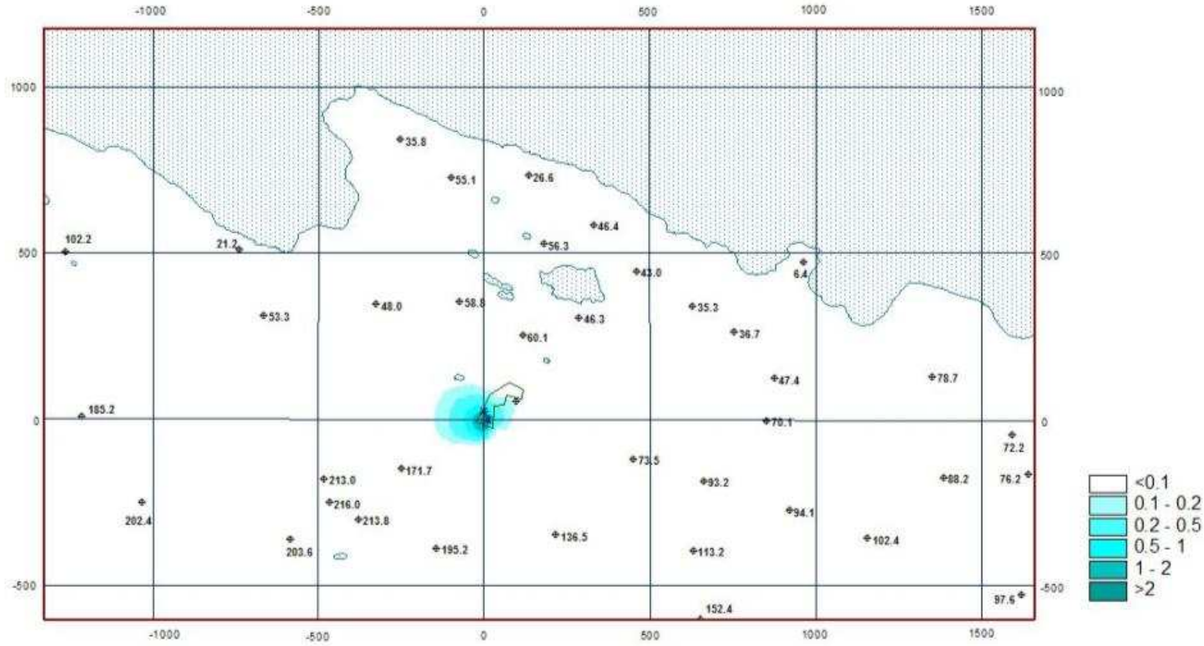

Figure 15 – Distribution of monthly average hydrocarbon concentrations in atmospheric air from BAS stationary sources operation, $\mu g/m^3$. Scenario 2