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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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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 4^{th} and 5^{th} 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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