East Beach Hut, Rothera Point
Initial Environmental Evaluation

BAS Environment Office

December 2021

British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

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Contents

Non-Technical Summary 6
1 INTRODUCTION 10
1.1 Background to the IEE 10
1.2 Purpose and scope of document 10
2 APPROACH TO ENVIRONMENTAL IMPACT ASSESSMENT 11
2.1 Statutory requirements 11
2.2 EIA methodology 11
3 DESCRIPTION OF PROPOSED DEVELOPMENT 12
3.1 Purpose and need 12
3.2 Location 13
3.3 Scope of preferred option 14
3.4 Predicted lifespan 14
3.5 Hut design details 14
3.5.1 Hut location 14
3.5.2 Vehicle & Pedestrian Routes 16
3.5.3 Power Services 16
3.5.4 Anticipated Energy Efficiencies 16
3.6 Design details 17
3.6.1 Jackpad plinth system 17
3.6.2 Steel base frame 18
3.6.3 Hut structure 19
3.7 Alternatives considered 21
3.7.1 Do nothing option. 21
3.7.2 Alternative locations 21
3.7.3 Alternative Designs 21
3.8 Overview of works 21
3.9 Anticipated waste 22
3.10 Personnel 22
3.11 Plans for decommissioning proposed development 22
4 CONSTRUCTION METHODOLOGIES 23
4.1 Packaging 23
4.2 Construction 23
5 SUPPORT ACTIVITIES 25
5.1 Shipping & air freight 25

5.1.1 Cargo 25
5.1.2 Personnel 25
5.2 Accommodation 25
6 OPERATIONAL PROCEDURES 25
6.1 Fuel management & spill response 25
6.1.1 Fuel use 25
6.1.2 Fuel Storage 25
6.1.3 Rothera Oil Spill Contingency Plan (OSCP) 26
6.1.4 Chemical spill 26
6.2 Waste management 26
6.3 Biosecurity 27
6.4 Scientific activity post construction 27
7 DESCRIPTION OF ROTHERA POINT, INCLUDING THE CONSTRUCTION LOCATION SITE 28
7.1 Location 28
7.2 History of site 28
7.3 Use of Rothera Point 29
7.3.1 Domestic 29
7.3.2 Science 30
7.3.3 Air Operations 31
7.3.4 Vehicle Operations 31
7.3.5 Boating Operations 31
7.3.6 The construction site on East Beach 31
8 DESCRIPTION OF THE ENVIRONMENT AROUND ROTHERA POINT 31
8.1 Ecology 32
8.1.1 Terrestrial Flora 32
8.1.2 Terrestrial Fauna 35
8.1.3 Avifauna 35
8.1.4 Marine mammals 38
8.1.5 Non-native species 40
8.2 Physical Characteristics 40
8.2.1 Meteorological Conditions 40
8.2.2 Air Quality 41
8.2.3 Tides and Waves 42
8.2.4 Geomorphology 42
8.2.5 Soils 42
8.2.6 Surface Water 43

8.2.7 Geology 43
8.2.8 Glaciology 44
8.2.9 Permafrost 45
8.2.10 Flood Risk 46
8.2.11 Noise & vibration 46
8.3 Protected Areas 46
8.4 Cultural Heritage 48
8.5 Wilderness & Aesthetic Value 48
8.6 Climate Change Projections 49
8.7 Summary 50
9 ASSESSMENT OF THE ENVIRONMENTAL IMPACTS 51
9.1 Methodology 51
9.2 Proposed Activities 51
9.3 Environmental Aspects 51
9.4 Identification of Environmental Impacts and Mitigation Measures 55
9.4.1 Transport of the building materials to site 56
9.4.2 Impacts of construction activities 57
9.4.3 Impacts of support activities 61
9.5 Post construction/operation of new hut 63
9.6 Evaluation of the Environmental Impacts 65
9.6.1 Methodology 65
9.6.2 Risk Scoring 66
9.6.3 Risk Response 66
9.7 Impact Matrix 67
9.7.1 Transportation of construction material to East Beach 68
9.7.2 Construction activity Impacts 69
9.7.3 Support activity Impacts 72
9.7.4 Post construction operation of the building 73
9.8 Cumulative Impacts 75
10 MONITORING 75
11 GAPS IN KNOWLEDGE & UNCERTAINTIES 76
11.1 Site setup locations and logistics 76
11.2 Construction activities 76
11.3 Funding to facilitate on-going use of the hut 77
12 CONCLUSIONS 77
13 AUTHORS 78

14 ACKNOWLEDGEMENTS 78
15 REFERENCES 78
16 BIBLIOGRAPHY 81
17. APPENDICES 82

Non-Technical Summary

Introduction

This Initial Environmental Evaluation (IEE) has been prepared by the British Antarctic Survey (BAS) to assess the potential environmental impacts associated with the construction of a hut on East Beach, Rothera Point, for scientific purposes. The proposed activities are part of the Natural Environment Research Council's (NERC) plans to develop atmospheric research capability on Rothera Point.

The scope of this IEE includes

- Transportation of the hut to the site
- Construction of the facility.
- Support activities
- Post construction use of the facility for scientific research

Measurements taken over 3 years on Rothera East beach will improve the representation of aerosols and aerosol/cloud interactions within climate models and so improve predictions of climate change. The hut will contain a set of instruments measuring aerosol properties that will require automated atmospheric sampling and there will be a low-powered cloud lidar. It is planned that these instruments will run at this site for the 3 years of the funded project, but it is hoped that some of the observations may continue long term.

Scope of preferred option

The preferred option is the construction of a small pre-fabricated hut on East Beach, Rothera Point. The hut is 2.2 x 4.5 x 3.0 m (width x length x height) and would contain scientific equipment to facilitate atmospheric research at Rothera Point. Power would be limited to the provision of electricity via a cable that leads back to the existing electrical system at Rothera Research Station.

Structural design

The design life of the hut is intended to be 25 years.

Alternatives

The scientific need for an atmospheric research facility meant that the "Do Nothing" option is not viable. The lack of an appropriate location elsewhere in the vicinity of Rothera Research Station, due to the need for provision of electrical power, means that other possible sites located away from Rothera Point were not viable.

Several designs were considered for the hut that ranged in scale and complexity. However, mindful of factors including the size of the footprint, aesthetic and wilderness values, energy requirements and cost, it was decided that a building of the smallest size that still fulfilled the scientific requirements of the project would be constructed. Alternative methods of construction were also considered. In particular, efforts were made to find alternative methods for construction of the foundations, in an effort to move away from the use of a substantial concrete slab that could have caused a greater impact to wilderness and aesthetic values and would also have a high level of embedded carbon.

Description of the Environment

Rothera Research Station has been used operationally on a continuous basis since 1975. The station was initially planned and constructed in phases, after which other infrastructure was added as operational requirements changed. However, the works proposed in this IEE are outside the current operational footprint and previously developed areas on Rothera Point.

Levels of biodiversity at Rothera Point are comparable to other equivalent areas in Ryder Bay. Rothera Point contain some examples of Antarctic fellfield environment, which is reasonably rare in the wider area. This is typically a dry, cold terrestrial habitat prone to rapid freezing and thawing, that experiences seasonal snow cover and long hours of daylight in summer to which organisms have adapted in order to survive the extreme conditions. South polar skuas are the most abundant breeding birds at Rothera with occasional pairs of kelp gulls nesting and one Wilson's storm petrel nest has been found. Adélie penguins are regular visitors but do not breed at Rothera. Although no seals breed at Rothera, Weddell and leopard seals are present all year round. Crabeater, elephant and fur seals are also present during the summer months. Minke, humpback and killer whales are seen in Ryder Bay each summer.

Antarctic Specially Protected Area (ASPA) 129 is located on the northern end of Rothera Point, which was designated to protect scientific values, and to serve as a control site, against which the effects of human impact associated with the adjacent Rothera Research Station could be monitored in an Antarctic fellfield ecosystem. The area was designated as an Important Bird and Biodiversity Area (IBAs) by BirdLife in 2018 (AQ205). No non-native plants or invertebrates are known to be present at Rothera Point or in the adjacent marine environment.

The key environmental receptors which are most likely to be impacted by the construction and operation of the hut are as follows:

- Terrestrial flora – freshwater ponds and microbial mats to the northwest of the construction site.
- Terrestrial fauna – Nesting skuas on Rothera Point.

Description of Support Activities

Supporting activities include the shipping of the construction cargo to Rothera from the UK, the transportation of construction personnel via aircraft and/or ship to Rothera Research Station and the provision of accommodation and support services (e.g., power, food, water) to those personnel.

Impact Identification & Mitigation

A full assessment of the potential environmental impacts are included in this IEE. Most of the impacts can be managed within existing BAS procedures or with the addition of specific mitigation measures.

The most significant potential impacts predicted for the construction activities and associated supporting activities are:

- Atmospheric emissions associated with the transport of building material for the hut
- Potential introduction of non-native species
- Physical presence and disturbance to wildlife and vegetation
- Changes to the wilderness and aesthetic values of East Beach

The potential introduction of non-native species as a result of importing cargo or the deployment of personnel could have a significant impact in the longer term, but these impacts are less likely if standard operational procedures and enhanced mitigation measures are followed.

The likelihood of impacts occurring that are associated with the physical presence and physical disturbance created by the construction works is low and short-lived.

The most significant potential impacts predicted for the operation of the new building post construction are:

- Physical presence and use of space
- Visual and aesthetic change

The size of the new building has been rationalised against the existing estate in order to provide infrastructure which minimises energy use and maintenance requirements.

The hut will be constructed within as small a footprint as possible, commensurate with the scientific benefits derived from the facility. However, the wider context of near pristine Antarctic scenery of outstanding wilderness and aesthetic value surrounding Rothera should not be ignored. The impact from the scientific impact will be minimal, with the scientific equipment operating via an electrical cable from the station, resulting in no atmospheric emissions of greenhouse gasses from the hut itself (although emissions we occur associated with the electrical generators at Rothera Research Station. The lidar uses a relatively low power eye safe (ANSI Z136.1 2000, IEC 60825) laser and there should be no associated environmental impacts. Small volumes (< 1 litre) of butanol will be used, but should there be a spill this volatile alcohol will readily evaporate leaving no residue.

Monitoring Requirements

Monitoring activities to be undertaken during the project will include monitoring of skua breeding success on Rothera Point. The use of electrical energy at the hut will be monitored. Any environmental incident resulting from the construction or operation will be reported via the BAS Incident Reporting System (MAXIMO).

Gaps in Knowledge and Uncertainties

Further discussions will be undertaken with BAS Operations to finalise and agree the precise location and mechanism for supporting the hut, either involving Jackpads or small concrete plinths. However, it will be located within a radius of 20 metres of coordinates 67° 34' 09'' S, 68° 06' 53'' W. Given the nature of the beach site, the precise location is unlikely to have any bearing on the environmental impact of the hut. The selection of the final location will be determined taking into consideration the topography of the site (at the scale of metres or smaller), the position of any rocks or boulders that might interfere with hut supporting system, the effective absence of vegetation or standing water and the ease of accessibility from the coast for cargo transfer.

Conclusion

Having prepared this IEE along with rigorous mitigation measures to reduce the risk of the predicted impacts occurring, it is considered that the impact of the proposed activity will be **no more than minor or transitory**.

Authors of the IEE

This IEE has been prepared by Kevin A. Hughes and Nicola Couper-Marsh, with input from a number of expert contributors listed in the acknowledgements section.

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1 INTRODUCTION

1.1 Background to the IEE

This Initial Environmental Evaluation (IEE) has been prepared by the British Antarctic Survey (BAS) Environment Office to assess the potential environmental impacts associated with the proposed construction of a hut on East Beach, Rothera Point, for scientific purposes. The proposed activities are part of the Natural Environment Research Council's (NERC) plans to enhance BAS capability to perform atmospheric research at Rothera Point.

1.2 Purpose and scope of document

This IEE has been prepared in accordance with the requirements of Article 3 of Annex I to the Environmental Protocol and the Committee for Environmental Protection Environmental Impact Assessment Guidelines to provide sufficient information on the East Beach Hut project, for an informed judgement to be made on the possible environmental impact of these activities on the Antarctic environment and whether or not they should proceed. The document has been split into the following chapters:

- Chapter 1 provides an **introduction** to the proposed project
- Chapter 2 provides the **approach to the environmental impact assessment**
- Chapter 3 describe the **proposed development** including the need, scope, location, alternatives considered and design plans.
- Chapter 4 outlines the **construction methodologies**
- Chapter 5 describes the **support activities** required to facilitate the project
- Chapter 6 outlines the **standard operational procedures** that will be followed
- Chapter 7 provides a **description of the current site and existing operations**
- Chapter 8 outlines the current **baseline environmental conditions**
- Chapter 9 presents the **assessment of the environmental impacts** and proposed **mitigation**
- Chapter 10 presents the proposed **monitoring and audit programme**
- Chapter 11 provides information on any known **gaps in knowledge or uncertainties**
- Chapter 12 sets out the **conclusions** of the assessment
- Chapter 13 provides contact details for the **authors** of the document
- Chapter 14 **acknowledges the contributors** to the document
- Chapter 15 provides the **references**
- Chapter 16 provides the **bibliography**
- Chapter 17 provides the **appendices**

A non-technical summary has been included at the beginning of the document to provide an overview of the IEE in a clear, concise and non-technical manner as well as outlining the conclusions achieved.

2 APPROACH TO ENVIRONMENTAL IMPACT ASSESSMENT

2.1 Statutory requirements

To ensure the protection of the Antarctic environment, the Antarctic Treaty nations adopted the Protocol on Environmental Protection to the Antarctic Treaty in 1991 (hereafter referred to as the Environmental Protocol). The UK enforces the provisions of the Environmental Protocol through the 'Antarctic Act 1994 and Antarctic Act 2013' and 'Antarctic Regulations 1995/490 (as amended).

Article 8 to the Environmental Protocol requires that any activities in the Antarctica Treaty area shall be subject to an assessment, in accordance with the procedures set out in Annex I to the Environmental Protocol, Environmental Impact Assessment (EIA).

One of the guiding principles is that an EIA be carried out before any activity is allowed to proceed. Activities should be planned and conducted on the basis of *'information sufficient to allow prior assessments of, and informed judgements about, their possible impacts on the Antarctic environment'* (Article 3, Environmental Protocol).

Annex I to the Environmental Protocol sets out the detailed requirements for EIA in Antarctica, and establishes a three-stage procedure based on different levels of predicted impact.

The assessment levels are:

- Preliminary Stage;
- Initial Environmental Evaluation (IEE); and
- Comprehensive Environmental Evaluation (CEE).

If an activity is determined as having less than *a minor or transitory* impact, the activity may proceed. An IEE must be prepared if it is determined that an activity will have an impact equal to or no more than *minor or transitory*. A CEE is for activities that are likely to have more than a *minor or transitory* impact on the Antarctic environment.

Following the EIA process as outlined in Annex I and in agreement with the UK Foreign and Commonwealth Office, BAS concluded that an IEE is the appropriate level of assessment for the East Beach Hut construction project.

This IEE is publicly available on the BAS website and Antarctic Treaty Secretariat EIA database.

2.2 EIA methodology

The approach taken when compiling this EIA followed the Environmental Impact Assessment Guidelines (ATS, 2016) prepared by the Committee for Environmental Protection (CEP). The guidelines provide advice and recommendations on appropriate document structure as well as methodologies for identifying and evaluating impacts. These suggestions have been followed wherever possible.

Other previously published CEEs and IEEs have been used as sources of information on the potential environmental impacts of activities within Antarctica, including how these have been assessed and how mitigation measures have been identified.

The scope and nature of the activities and a description of the principal characteristics of the East Beach Hut project have been provided in an attempt to define the project (Chapters 3-5).

Baseline information on the current environmental state at Rothera has been included in order to evaluate the predicted impacts effectively. This information was largely sourced from scientific experts within BAS.

The environmental impact assessment process has followed a four-step process involving:

- Identifying the **proposed activities** of the project;
- identifying the **environmental aspects** – i.e., the way in which any of the proposed activities interact with the environment such as atmospheric emissions, noise, fuel spills, introduced non-native species etc.;
- identifying the **environmental impact** – i.e., the change in environmental value or resource as a result of the activity; and
- assessing the **significance of the identified impact**– i.e., considering the spatial extent, duration, probability of occurrence and severity of the potential impact on the environment with reference to the three levels of significance identified by Article 8(1) of the Protocol (i.e. less than, no more than or more than a minor or transitory impact.

A more detailed explanation of the methodology used is outlined in Chapter 9 - Assessment of the Environmental Impacts.

Chapter 9 presents the impacts that are identified and measures to mitigate or to prevent them from occurring. As suggested by the CEP's EIA guidelines, and successfully used in previous EIAs, a matrix format has been used to evaluate the significance of the identified impacts. Direct, indirect, cumulative and unavoidable impacts have been examined and are ranked according to their extent, duration, probability and significance. A risk rating has been applied to each impact before and after mitigation.

The impacts have been predicted on the basis of professional opinion and experience of individual BAS scientists and the BAS Environment Office.

An overarching conclusion of the EIA process has been presented in Chapter 12.

3 DESCRIPTION OF PROPOSED DEVELOPMENT

3.1 Purpose and need

Rothera Research Station was established in 1975 and has evolved in a relatively piecemeal manner over the intervening years. It comprises of some twenty-four principal buildings, which range in age from over 40 years to less than 10 years old. The nature and condition of the station's supporting infrastructure also varies significantly.

The science and operations functions for Rothera Station are currently undertaken from a number of disparate buildings spread across the site; however, none of the existing building are in a suitable location or contains the appropriate facilities for atmospheric research.

The proposal is to build a hut on East Beach, Rothera Point, as part of the NERC funded Southern Ocean Cloud (SOC) project. This project is investigating the role aerosols play in aerosol/cloud interactions at high latitudes. Atmospheric models have problems in representing clouds over the Southern Ocean and the Antarctic continent and errors in clouds within climate models are

responsible for large biases in the models over the Southern Ocean. The long-term measurements taken on Rothera East beach will enable BAS to improve the representation of aerosols and aerosol/cloud interactions within climate models and so improve predictions of climate change.

The hut is intended to contain a set of instruments measuring aerosol properties – size, ability to act as cloud nuclei, and chemical composition. Only atmospheric sampling is taking place. As well as the aerosol instruments there will be a low powered cloud lidar. The lidar uses a relatively low power eye safe (ANSI Z136.1 2000, IEC 60825) laser and there should be no associated environmental impacts on local wildlife or people in the vicinity. It is planned that these instruments will run in this hut for at least three years of the project and it is anticipated that observation will continue long term (funding dependant). If funding is not forthcoming, the hut will be removed entirely, including any foundation foots. Hut is likely to be staffed once or twice a week but at least weekly. Instruments will be monitored from the base so there will be no need for daily visits.

3.2 Location

Rothera Research Station is located on the south easterly shore of Adelaide Island on the Antarctic Peninsula Lat. 67°35'8"S, Long. 68°7'59"W. Adelaide Island is 140 km long, mountainous and heavily glaciated, with its highest peak at 2,565 metres.

The Station is mainly situated over an area of raised beaches which form a topographic “saddle” between Rothera Point, a large rock promontory to the East, and Reptile Ridge, a jagged outcrop of rock, to the West.

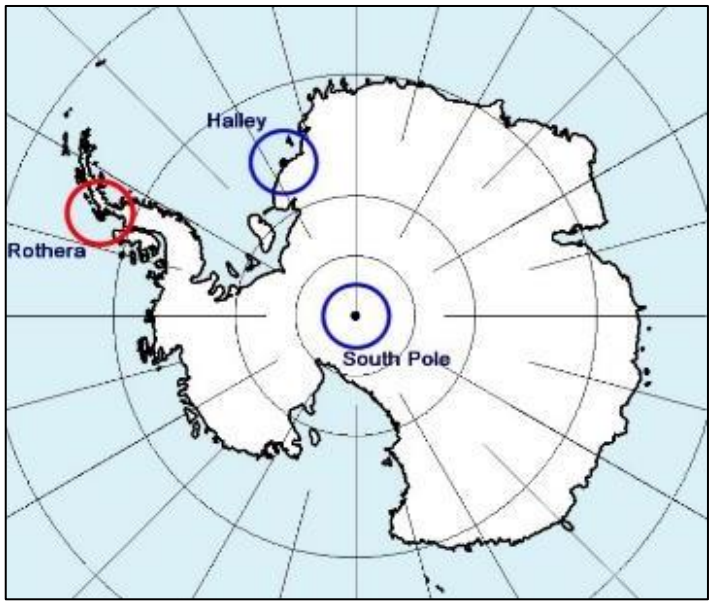

Figure 3-1 Location of Rothera in relation to the Antarctic continent

Figure 3-2 Aerial view of Rothera Research Station, showing East Beach to the right of the image

3.3 Scope of preferred option

The hut components will be sited to the east of Rothera Point on East Beach and delivered in shipping crates via the *RRS Sir David Attenborough* single tender vessel, offloaded by hand (without the use of overland vehicles) and stored at the location of the build for 2-4 weeks prior to the commencement of construction. The hut will comprise prefabricated units that will be constructed rapidly on site. An electrical cable will run from Rothera Research Station to the hut to supply electrical power.

3.4 Predicted lifespan

Although funding for the scientific activity is currently only available for 3 years, it is anticipated that further funding will be forthcoming for on-ging use of the hut. Therefore, the design life of the hut is intended to be at least 25 years.

3.5 Hut design details

3.5.1 Hut location

The hut needs to be located away from potential atmospheric impacts from Rothera Research Station (generator exhaust, aircraft exhaust, etc.).

The three options considered for the hut location were (i) the Rothera ice ski way, located on Wormald Ice Piedmont, (ii) Lagoon Island, Ryder Bay, and (iii) East Beach, Rothera Point. Of the three options, East Beach is the only site that is isolated from the Rothera Research Station but close enough to the station for a power cable to be laid to supply the energy needs of the scientific instruments. From an environmental perspective, it is also a site that has relative few environmental receptors compared to other locations on Rothera Point.

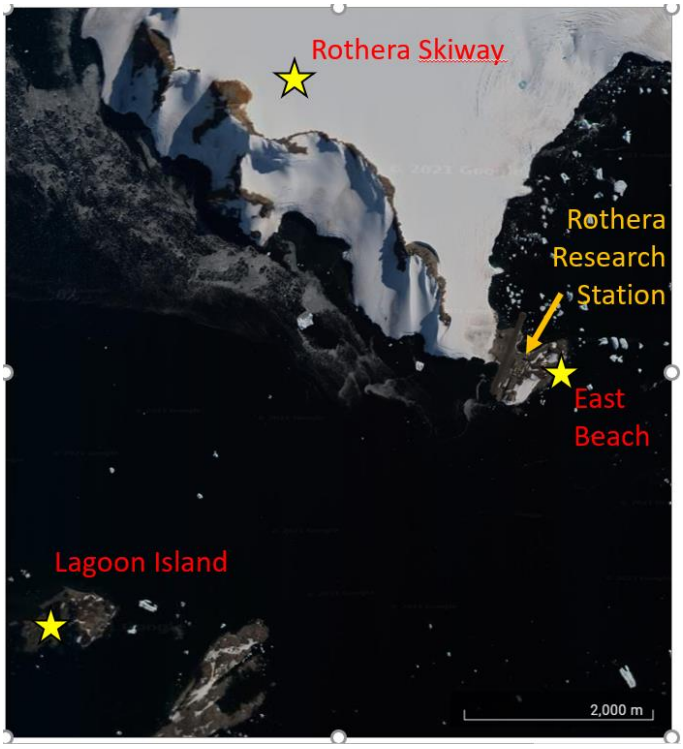

Figure 3-3 Satellite image of the vicinity of Rothera Point showing the proposed alternative locations of the Hut.

From a construction point of view, the location needs to have reasonably firm level ground. The location at 67° 34' 09'' S, 68° 06' 53'' W is close to the coast, on a raised beach above the highwater mark. The ground consists of large cobbles (c. 10 cm across) frequently embedded in consolidated sand. The hut will be positioned within 20 metres of coordinates 67° 34' 09'' S, 68° 06' 53'' W.

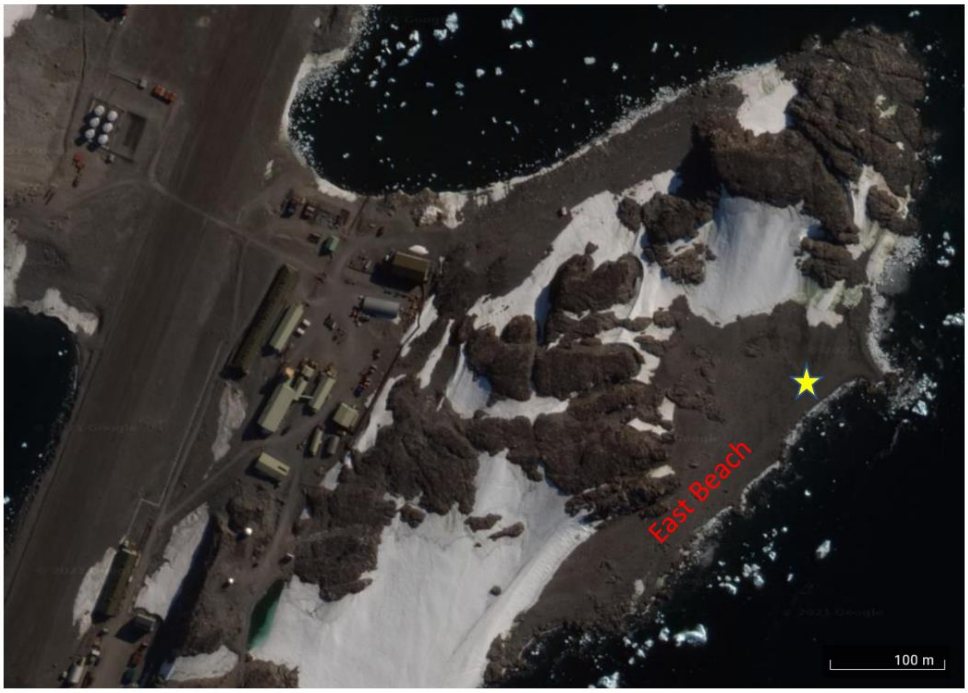

Figure 3-4 Satellite image of Rothera Point showing the proposed location of the Hut (yellow star) on East Beach. On the map, the yellow star has a radius equivalent to 20 metres, with the area covered representing the area in which the hut will be located (i.e. within 20 metres of coordinates 67° 34' 09'' S, 68° 06' 53'' W).

3.5.2 Vehicle & Pedestrian Routes

Access to the hut would be via the standard pedestrian route that follows the coast to the north of Rothera Point, leading eventually to East Beach, or via other established walking routes. There will be no access to the hut by overland vehicle. Similarly, no overland vehicles will be used in the delivery of material for construction of the hut, and construction cargo will be moved by hand.

3.5.3 Power Services

The total power required by the scientific instruments within the hut is around 2.5 kW. Electrical energy will be supplied by a reinforced cable from Rothera Research Station.

Figure 3-5. Proposed route of the armoured cable between East Beach and Rothera Research Station.

3.5.4 Anticipated Energy Efficiencies

The hut will be well insulated, with up to 120 mm of polyisocyanurate (PIR) insulation board. The board will not be directly exposed to the environment and will not be subject to abrasion or released into the environment. Off gassing, which is the release of the gas used to create the foam board in the first place does not occur once the board has been cured during manufacture. Non-halogenated hydrocarbons such as methyl formate and pentanes have largely replaced the use of chlorofluorocarbons in the manufacture of foam insulation boards. In this case, the blowing agent is CFC/HCFC free, has zero ozone depletion potential (ODP), and has low global warming potential (GWP). The residual heat given off by the instruments should be sufficient to heat the hut to a temperature that allows operation of the instruments.

3.6 Design details

For construction, the hut consists of five main elements:

1. Galvanised steel base frame, supported with Jackpad plinth system or concrete plinths (see later)
2. Structural pre-fabricated plywood floor deck panels
3. Structural pre-fabricated plywood wall panels, cladded with profiled steel sheet
4. Structural pre-fabricated plywood roof panels, pre-cladded with GRP coating
5. Gabion baskets (x4) and steel guywire to secure steel base.

With the majority of the components of the hut being prefabricated off site. it means that only basic, battery operated, power tools will be required.

In an effort to minimise environmental impact, including impact on aesthetic and wilderness values, materials and cost, the overall size of the hut's footprint has been kept as small as possible at 2.2 x 4.5 m.

Rock for filling the gabion baskets will be sourced from the station stock and will not be taken from the beach in the vicinity of the hut. This has been clearly communicated to the construction team.

3.6.1 Jackpad plinth system

The Jackpad plinth system (mentioned above) was selected to avoid the need to transport and cast large quantities of concrete on site. This would remove the risk of local pollution from cement dust.

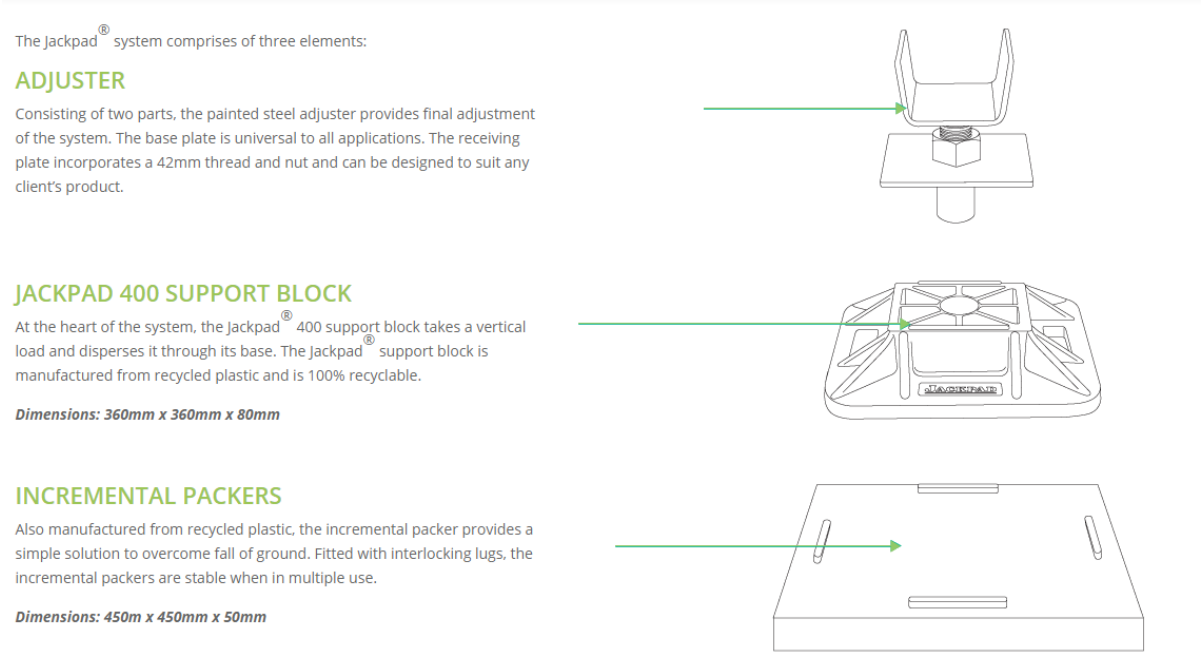

Figure 3-6 Description of the Jackpad system that will support the hut

If the ground bearing capacity at the site is not sufficient for the Jackpad system to work, it may be necessary to construct six plinths for the Jackpads to rest upon. The smallest size of plinth suitable for the purpose would be constructed (450 x 450 x 100 mm) which would require a small amount of pre-mixed bagged concrete to be prepared on site (approximately equating to 6 x 25 kg bags of pre-mixed postcrete). A small shuttering would be prepared for each plinth. A dry mixture of postcrete would be poured into the shuttering, with a small amount of fresh water added by hand. To minimise dispersal of cement dust, care shall be taken when dispensing the cement and the activity will only be undertaken on a calm day (thereby reducing the risk of wind dispersal). Due to the minimal amount of water needed, the water can be hand carried from the main base water supply by means of a liquid container. No tools will be required, therefore no tool cleaning will be required. When the hut is disassembled the small precast concrete plinths will be taken up by hand and removed from the site.

3.6.2 Steel base frame

The steel frame is a simple rectangle measuring 2166 x 4456 mm, with additional cross supports to facilitate the construction of the hut on top (see Figure 3.7). The Jackpads will connect to brackets offset from the corners and the mid-point of the longest two steel beams. Plates will be added to the four corners to allow the hut to be anchored to the ground using steel wires and Gabion baskets.

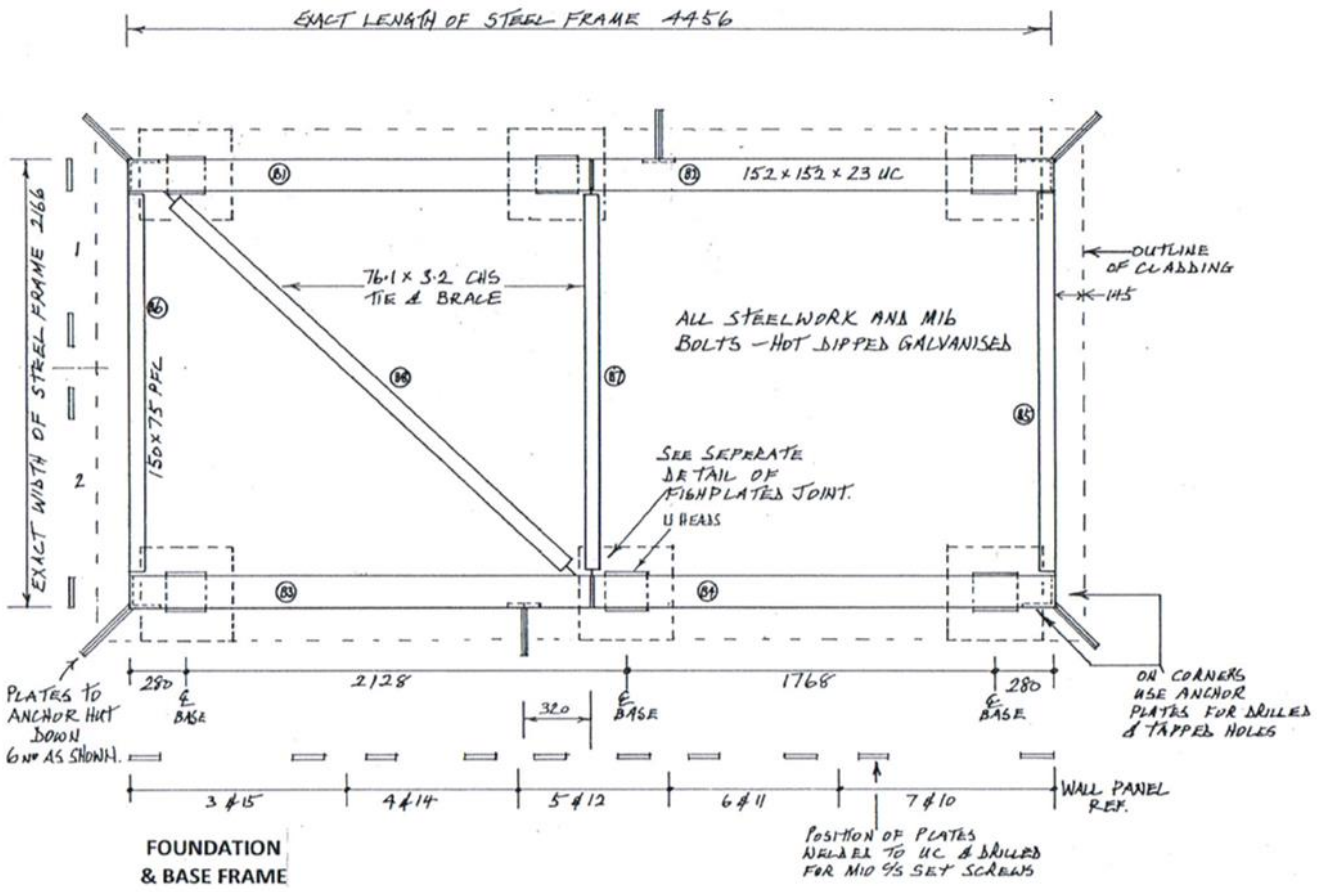

Figure 3-7. Steel base frame for the hut.

3.6.3 Hut structure

The hut is made predominantly of plywood with PIR insulation board. To withstand the elements, the external surface is covered with a thin layer metal. Two small windows have been included to provide natural light, but minimise heat loss from the hut. Ports are included in the roof to allow the fitting of air sampling equipment and other scientific devices.

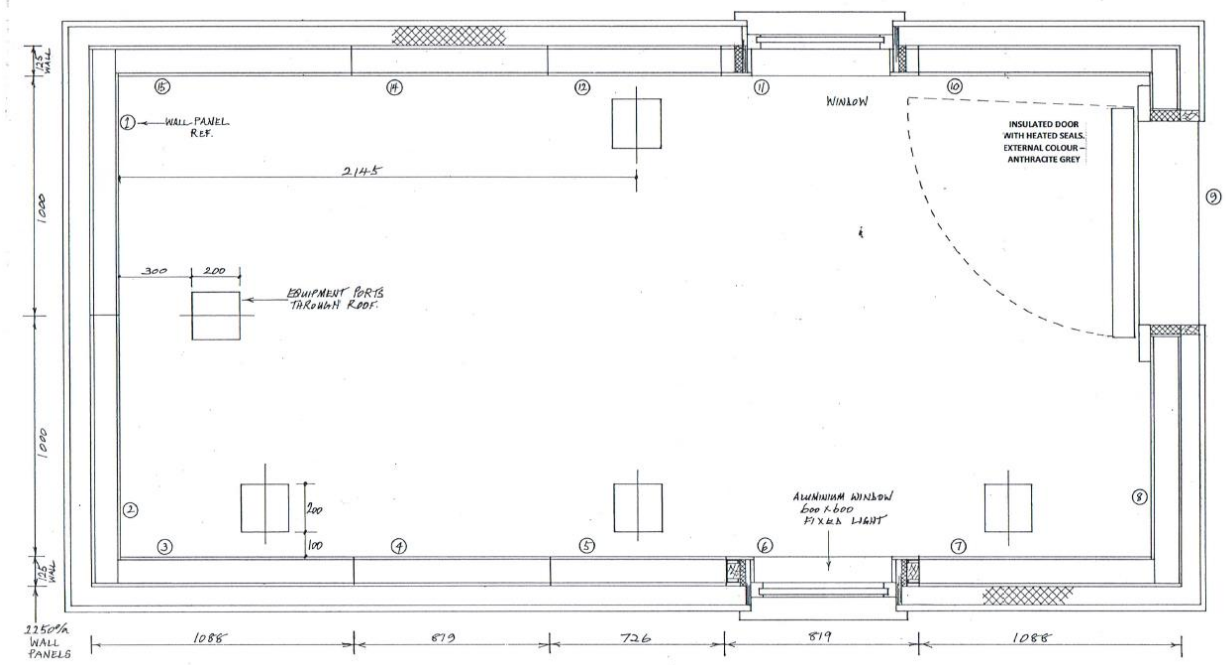

Figure 3-8. Horizontal cross section of the hut.

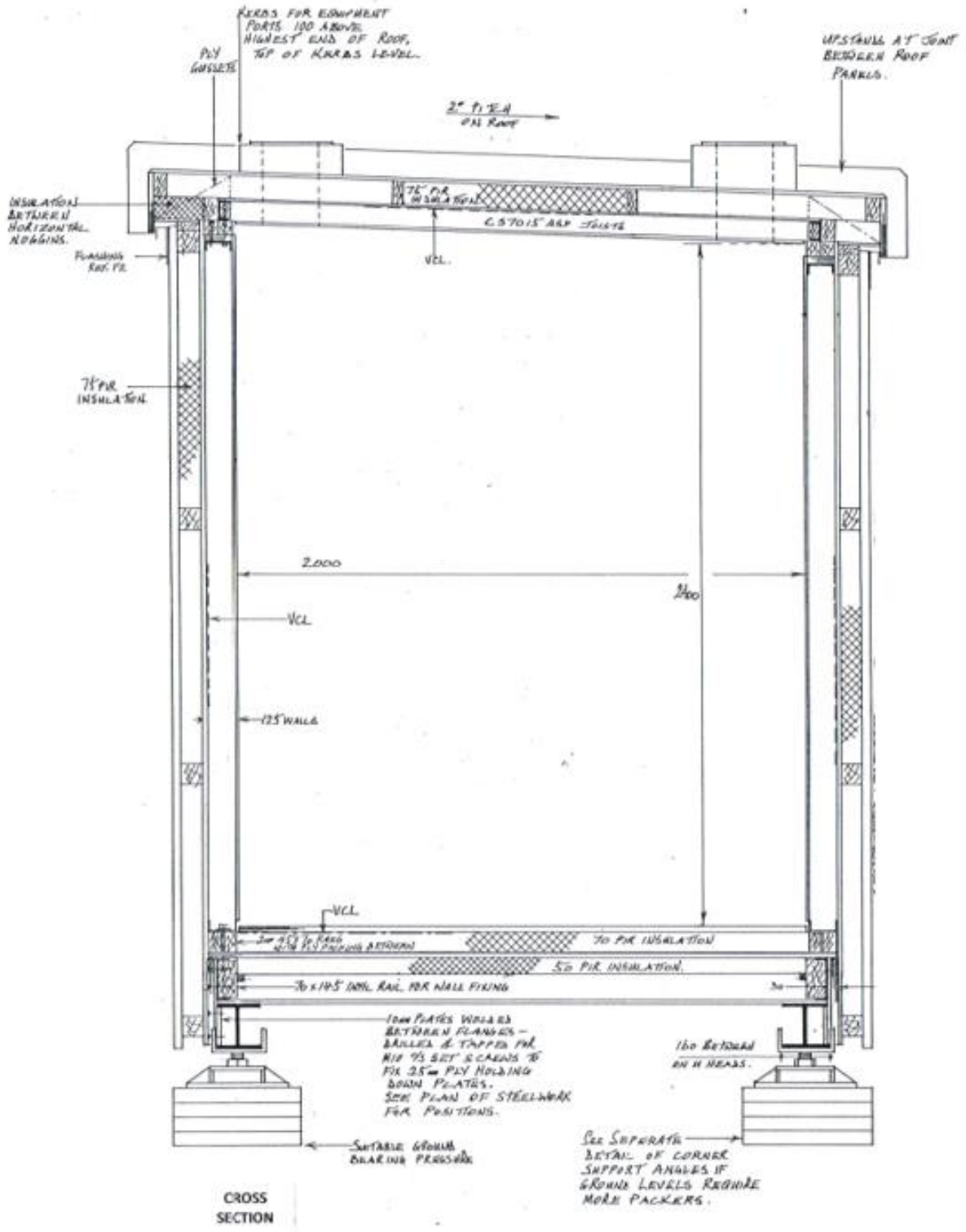

Figure 3.9. Vertical cross section of the hut

3.7 Alternatives considered

3.7.1 Do nothing option.

Enacting the 'do nothing' option would preclude the commencement of important atmospheric science at Rothera Point, and is therefore not considered further.

3.7.2 Alternative locations

As described earlier, the hut needs to be located away from potential atmospheric impacts from Rothera Research Station. The three options considered for the hut location were (i) the Rothera ice ski way, located on Wormald Ice Piedmont, (ii) Lagoon Island, Ryder Bay, and (iii) East Beach, Rothera Point. Of the three options, East Beach is the only site that is isolated from the Rothera Research Station but close enough to the station for a power cable to be laid to supply the energy needs of the scientific instruments.

3.7.3 Alternative Designs

Several designs were considered for the hut that ranged in scale and complexity. However, mindful of factors including the size of the footprint, aesthetic and wilderness values, energy requirements and cost, it was decided that a building of the smallest size that still fulfilled the scientific requirements of the project would be constructed. However, should further scientific equipment need to be installed in the future, the hut is designed to allow further extensions to one end, thereby providing additional space.

Alternative methods for construction of the foundations were investigated, in an effort to move away from the use of a substantial concrete slab which would have caused a greater impact to wilderness and aesthetic values and would also have a high level of embedded carbon.

3.8 Overview of works

The East Beach Hut will be constructed within 20 metres of coordinates 67° 34' 09'' S, 68° 06' 53'' W. The precise location will be determined based upon the small-scale topography of the ground surface (i.e. the selection of a predominantly level location, free of large cobbles), the general lack of biological receptors and level of accessibility from the coast. The project is proposed to be completed over the Antarctic summer season 2021/22 commencing in January 2022 with completion anticipated to be in February 2022. A summary of the scope of works of the project consists of the following:

- Transportation of the building materials to site;
- Construction of the hut;

Construction equipment and materials will be demobilised from Rothera by the end of austral summer in 2022 by ship.

3.9 Anticipated waste

Generation of waste material will be minimised at every stage of the project (design, procurement and construction). Due to most elements of the hut being prefabricated, only minimal waste will be produced from the build of the hut (i.e., not drilling or cutting on site to produce saw dust, etc.). Waste will consist of plastic packing, small cardboard boxes from screws/fixings, used plastic silicon sealant containers and possibly used bags that held cement. A small amount of timber waste may also be produced. All construction waste will be managed onsite by the BAS construction team and then handled by the BAS waste management system.

The construction site will be kept clean and tidy throughout the construction period with wastes being segregated and temporarily stored in the shipping crates until they can be removed to the nearby station Interim Waste Handling Facility for final segregation and packaging as per the procedures set out in the BAS Waste Management Handbook (WMH). The crates are considered weather tight and secure and will prevent waste being windblown and lost to the environment. The construction team will take care to minimise windblow of any wastes. Following the completion of the project a search of the vicinity of the hut will be undertaken and any detected waste removed.

3.10 Personnel

Construction personnel will be on site at Rothera from November to April/May 2022, during which time other tasks on station will also be performed. It is anticipated that the maximum numbers of construction personnel on site for this project at any one time will be 6 pax. The personnel employed will be at the research station to complete a range of tasks, with the hut construction comprising only a small element of their workload. Consequently, no personnel are specifically travelling to Antarctica solely to construct the hut, and therefore greenhouse gas emissions from personnel travel will be minimised.

3.11 Plans for decommissioning proposed development

At the end of the hut's lifetime there is an obligation to remove the structure whilst mitigating the effect of the surrounding environment. It is envisioned the following will be taken into consideration:

- Reuse the majority of the equipment and furniture in the building either on station or returned to the UK.
- Deconstruct rather than demolish the building, so that it can be deployed in an alternative location.
- Planning in advance of the deconstruction to demonstrate opportunities of reuse or recycling.

The following general sequence for deconstruction may be used:

- Disconnect existing services.
- Remove the external attachments (scientific equipment)
- Remove any hazardous materials
- Remove prefabricated units
- Remove the Jackpads/concrete plinths and ground anchors

The ground profile under the hut should be largely unimpacted by the hut's construction. However, if necessary, the landscape could be blended in with the surrounding environment, making sure not

to disturb any vegetation that may have colonised the site during the period of its existence at the site.

4 CONSTRUCTION METHODOLOGIES

4.1 Packaging

The hut components will be delivered in shipping crate form to East Beach via the *RRS Sir David Attenborough* single tender vessel and stored at the location of the build for 2-4 weeks prior to the commencement of construction. Each crate is numbered in sequence so that only one crate will need to be opened at a time in order to build the hut. The crates can then be securely re-sealed at any point and be used to house any waste, though due to most elements of the hut being prefabricated only minimal waste will be created.

A schedule of components is provided in Appendix 1

4.2 Construction

The hut is designed in a way that construction can be undertaken by small number of construction personnel without access to any heavy plant or vehicles. Images from a test construction of the hut pre-fabicated units are shown in Figures 4-1 and 4-2. It is anticipated that four to six staff will be required for a total of three weeks at the location (January/February 2022). Rothera Point experience 24h daylight for almost all of this period, and therefore no lighting rigs will be needs and there should be no additional risk of bird strike.

The hut can also be easily removed from its location when it comes to the end of its life span. In essence, the process of construction the hut will need to be reversed.

Figure 4-1. End view of the partially assembled hut. Note the anchor plates at the bottom corners.

Figure 4-2. Oblique view of the partial constructed hut. One of the roof panels, with covered ports for scientific equipment, is visible in the foreground.

5 SUPPORT ACTIVITIES

5.1 Shipping & air freight

5.1.1 Cargo

Transport of all construction equipment from the supply hubs in the UK to the project site at Rothera will be undertaken by a ship (Sir David Attenborough).

Prior to and during loading, biosecurity measures outlined in the BAS Biosecurity Regulations will be undertaken. Visits to suppliers have been carried out to ensure that premises used for manufacture, storage and packing address biosecurity issues. Biosecurity inspections and fumigation will be carried out where materials are consolidated into containers. All cargo will be inspected before loading onto the vessel.

Upon arrival at Rothera, all cargo will be re-inspected either on board the vessel or after being unloaded. All inspections will be recorded and any incursions reported to BAS Environment Office.

5.1.2 Personnel

Personnel will be transported to Rothera either by sea or by air. Personnel will fly from the UK to South Atlantic gateways using established scheduled flights. The majority of personnel will then fly to Rothera on the BAS Dash 7 aircraft. In some instances, personnel may be transported by BAS ships to or from Rothera. All cargo and personnel will adhere to the BAS biosecurity procedures and the requirements set out in the BAS Biosecurity Regulations.

5.2 Accommodation

All personnel will be housed in either the existing permanent accommodation at Rothera (Admirals or Giants) or within Viking's House.

6 OPERATIONAL PROCEDURES

6.1 Fuel management & spill response

6.1.1 Fuel use

It has been estimated that the construction works will use very little, if any, fuel on site (no more than 20 litres on site at any one time). The only reason to have fuel on site would be to power a portable generator to recharge power tool batteries, if it becomes impractical to charge these at Rothera Research Station each day.

6.1.2 Fuel Storage

All fuel will be stored in a 20 l jerry can on site. Fuel spill equipment will be kept on site in case of a spill. Fuel will not be depoted at the build site or on East Beach prior to construction.

6.1.3 Rothera Oil Spill Contingency Plan (OSCP)

All refuelling will be carried out in accordance with the Rothera refuelling procedures. Any refueling will be undertaken using drip trays and should generators need to be used a plant nappy will be employed. All spills are to be reported to the Rothera Station Leader and to the BAS Environment Office. Reports shall be submitted on the BAS Incident Reporting System (MAXIMO).

All operatives will be briefed on the Rothera Oil Spill Contingency Plan by the project manager prior to works commencing. All spills are to be reported to the station leader and the BAS Environment Office at the time of occurrence.

All equipment will be inspected daily paying particular attention to possible leaks.

6.1.4 Chemical spill

Butanol will be used during the on-going operation of the scientific equipment post construction. The butanol will be stored in the chemical store in the Bonner Lab and only the amount needed for immediate use will be transported to the hut (< 1 litre). Should a spill occur, an appropriate chemical spill kit will be used (vermiculite to absorb the spill), although the volatile nature of this low molecular weight alcohol means and spill will quickly evaporate leaving no residue.

6.2 Waste management

It is anticipated that only a small amount of waste will be generated, i.e., c. 100 kg, which will comprise cardboard, plastic packaging material and empty concrete sacks. Waste will be stored to minimise the risk of dispersal by wind. The waste will be segregated before being transported to the Rothera Interim Waste Handling Facility, where it will be packaged, and disposed of in accordance with the BAS Waste Management Handbook. Human waste shall not be disposed of at the site. Toilets are available at Rothera Research Station. In emergencies, members of the construction team shall use a 'pee bottle' and dispose of the urine in the station toilets. The project manager will be responsible for managing all construction waste on site at Rothera.

All construction waste will be removed from the Antarctic Treaty area and returned to the UK for appropriate disposal in accordance with the Protocol on Environmental Protection to the Antarctic Treaty. The waste hierarchy will be applied.

Waste will be consigned to the BAS vessel for return to the UK. All wastes will be packaged and consigned in accordance with BAS's standard waste management procedures set out in the BAS Waste Management Handbook. Waste will be disposed of in the UK by licenced waste contractors meeting the requirements of the Waste (England and Wales) (Amendment) Regulations, 2014, the Duty of Care Regulations, 1991, and the Hazardous Waste Regulations, 2005.

Once the hut is operational and scientific activity commences, waste butanol (c. 1 litre) will be moved to the station in a polyethene (unbreakable) container every week for disposal through established waste streams in accordance with the BAS Waste Management Handbook. Human waste shall not be

disposed of at the site, but the researchers shall use the toilets available at Rothera Research Station. In emergencies, the hut occupant shall use a 'pee bottle' and dispose of the urine in the station toilets.

6.3 Biosecurity

The project will involve an increased input of cargo to Rothera. This activity has the potential to increase the risk of non-native species introductions into the local environment.

It is essential that all necessary precautions are taken to prevent the introduction of non-native species to Rothera from other locations. All activities shall be undertaken with reference to the BAS Biosecurity Regulations (2021) and the CEP Non-native Species Manual (2019). All personnel will be briefed on the need for appropriate biosecurity prior to deployment.

The measures include:

1. pre-departure checks of personal items and clothing for soil and propagules;
2. pre-departure checks of cargo and building material for soil or propagules;
3. checks of personal items and clothing prior to boarding the aircraft or while on the ship taking the individual to Rothera;
4. checks of cargo for soil or propagules prior to off-loading from the SDA; and
5. reporting of any incursions to the BAS Environment Office within 48 h and submission of a report on the incident reporting system (Maximo).

6.4 Scientific activity post construction

The hut will contain a set of instruments measuring aerosol properties that will require automated atmospheric sampling and there will be a low-powered cloud lidar. It is planned that these instruments will run at this site for the 3 years of the funded project, but it is hoped that some of the observations may continue long term. Impact from the science activity will be minimal other than emissions associated with the generation of electrical power (with occurs at the main station site, c. 400 m away), potential temporary pollution cause by a small spill (< 1litre) of butanol (which is a volatile chemical and will readily evaporate) and on-going impacts up on aesthetic and wilderness values associated with the present of the hut. The lidar operates under very low power and presents a negligible risk to wildlife.

7 DESCRIPTION OF ROTHERA POINT, INCLUDING THE CONSTRUCTION LOCATION SITE

7.1 Location

Built on a rock promontory at the southern tip of the Wormald Ice Piedmont, Rothera Research Station is situated on Adelaide Island to the west of the Antarctic Peninsula Lat. 67°35'8"S, Long. 68°07'59"W. East Beech Hut will be constructed on East Beach, separated from the rest of the station by high ground (up to c. 40 m above sea level).

7.2 History of site

Rothera Research Station has been used operationally, on a continuous basis since 25 Oct 1975. The station was initially planned and constructed in phases, after which other infrastructure was added as operational requirements changed. The eastern side of Rothera Point is largely free of buildings; however, several antennae have been erected (see Figure 7-2).

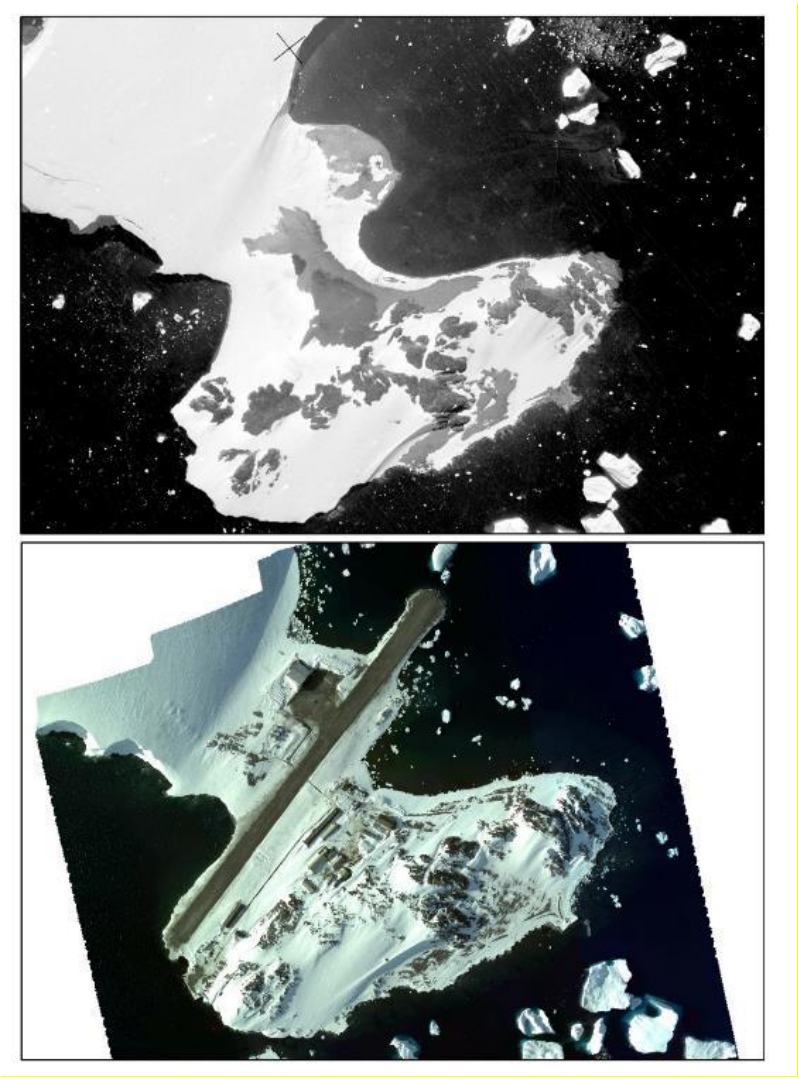

Figure 7-1 Aerial photographs of Rothera Point The photos shown in Figure 1 taken in 1957 (top) and 2013 (bottom) show the extent of human modification of the landscape in the intervening 57 years. Note that the northern and eastern area of Rothera Point (to the right and bottom of the images) has remained largely unaltered.

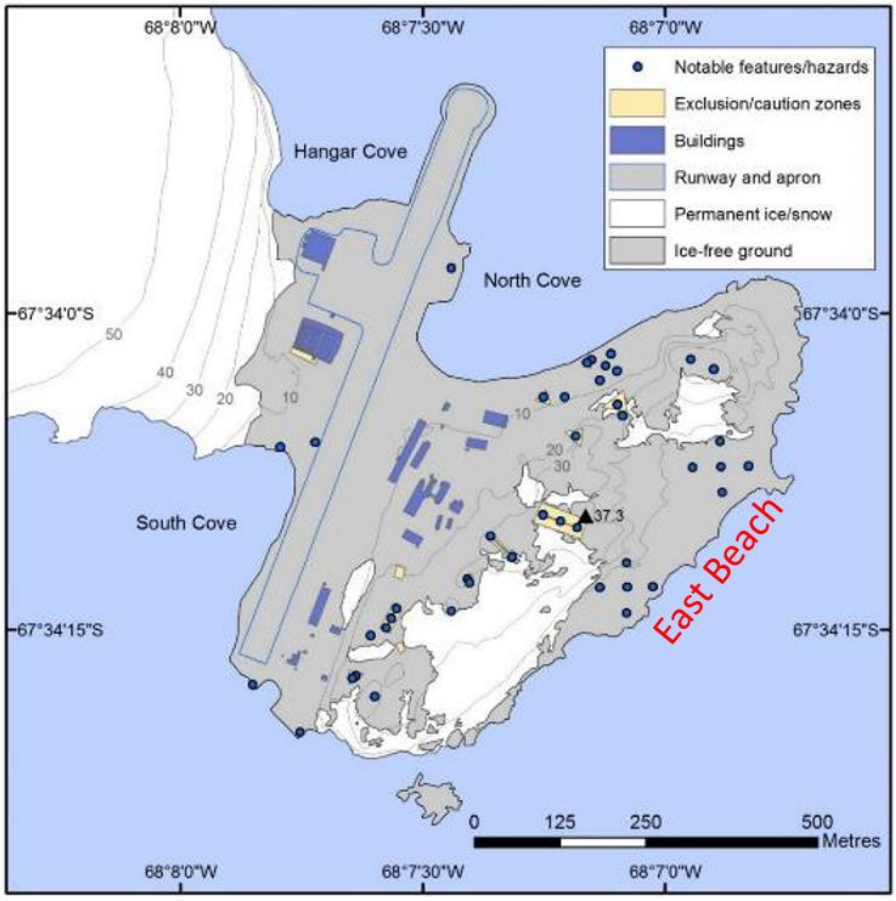

Figure 7-2 Buildings and other minor infrastructure (aerials, masts, radars, cairns, etc.) located on Rothera Point 2016.

7.3 Use of Rothera Point

7.3.1 Domestic

Rothera Station can currently support a maximum of 168 bed spaces (which includes the 32 beds in the temporary accommodation installed for the construction teams) during the austral summer which comprises both science and operational support personnel.

During the 2017-2018 season the maximum number of people on station reached 160 people with an average of 120 people on station at any one time. During the austral winter there are usually 20 people on station.

7.3.2 Science

Rothera supports a wide range of BAS, UK University and international collaborative science programmes including the Dirck Gerritsz laboratory that is staffed by scientists from the Netherlands polar research programme.

The scientific research conducted at Rothera spans a wide range of disciplines, including space weather, terrestrial biology, marine biology, oceanography, meteorology, atmospheric chemistry and ozone monitoring. The research at Rothera is led by three main BAS teams:

- Atmosphere, Ice and Climate (AIC)
- Space Weather and Atmosphere (SWA); and
- Biodiversity, Evolution and Adaptation (BEA)

7.3.2.1 Atmosphere, Ice and Climate

Meteorological data have been collected at Rothera since 1976, providing 41 years of continuous climatological data. These continuous data sets have provided the backbone of the important climate statistics from the Antarctic Peninsula, over the last four decades. Weather balloons are launched at over 400 locations around the world, at the same time each day. These data points are used in real-time by weather forecasters to get a global snapshot of the atmosphere. Climate scientists are also interested in the long-term records of temperatures at different heights in the atmosphere. At Rothera weather balloons are launched five times a week. There are only 18 launch sites in Antarctica so each site is crucial.

It is surprisingly hard to accurately measure precipitation quantities, particularly in windy and snowy conditions. At Rothera there is an array of precipitation sensors which, working side-by-side, gives us an idea of how much precipitation Rothera receives, and which sensors work best in which conditions.

There is a tide gauge installed at the wharf, which is calibrated once a week by conducting a tide dipping. This tide gauge forms part of the Global Sea Level Observing System.

It is vital that scientists continue to monitor the levels of ozone in the atmosphere so that they can understand the current state of the Antarctic ozone hole. At Rothera this is achieved using a SAOZ instrument (Systeme Automatique d'Observation Zenithal). SAOZ measures scattered sunlight in a way which allows scientists to determine how much ozone the light has passed through.

7.3.2.2 Space Weather and Atmosphere

Physical scientists use medium frequency radar and meteor radar to study wind and temperature in the upper atmosphere above Antarctica, and a low-power magnetometer at Rothera – one of a chain of instruments that BAS has installed across Antarctica – records variations in the Earth's magnetic field. Some of this equipment is located on East Beach, within 50 m of the proposed hut location.

7.3.2.3 Bonner laboratory & Biodiversity, Evolution and Adaptation

The Bonner Laboratory supports station focused science projects predominantly in the areas of marine biology, oceanography and terrestrial biology. The BEA team aims to understand how past, present and future environmental change has and will affect polar biodiversity both on land and in the ocean, and how life adapts to extreme polar conditions. Their research outcomes will provide deep insight into the impact of environmental change on the natural world, make a strong contribution to future

conservation measures, and generate new and innovative areas of research that have potential societal benefits.

7.3.3 Air Operations

To support science and logistics in Antarctica, BAS operate a fleet of five aircraft, specially adapted for flying in extreme Antarctic climate. The BAS aircraft consist of four De Havilland Canada Twin Otters and one De Havilland Canada Dash-7 equipped with modifications to allow them to carry out airborne science surveys. Between them they undertake a wide variety of transport and science missions.

Due to the 900 m gravel runway at Rothera the Dash-7 is able to undertake regular shuttle-flights to and from South Atlantic gateways and is able to carry fuel and provisions to the deep field site at Sky Blu which supports a blue ice runway. The Twin Otter aircraft whilst carry much smaller payloads are more versatile, being able to land on wheels or skis and regularly transport scientists to remote deep field study sites within Antarctica. Both aircraft types are sources of atmospheric emissions, and could therefore impact atmospheric research activities, hence the need to position the hut as far as possible from the Rothera runway (itself a source of dust).

7.3.4 Vehicle Operations

Vehicles at Rothera play a key role in moving people and equipment around the station. Maintenance of vehicles is undertaken by a team of vehicle mechanics and plant operators. The day-to-day coordination of vehicle use is arranged between the Facilities Engineer and the station management team. The current vehicle fleet at Rothera includes skidoos, tractors, trailers, forklift and bucket loaders, Snocat, Dozers, Cranes, Gators, ATV, snowblower, fire truck, digger, tankers and excavator,

7.3.5 Boating Operations

Boating operations are a vital part of science and operations activities at Rothera. There are currently five boats within the Rothera fleet. Sea Rover and Terra Nova are primarily used as science platforms, in particular for the deployment of CTDs. The three Humber Destroyers are used for diving and SAR cover for air operations as required. The SDA has a tender which can be deployed for movement or larger cargo items to locations around Rothera Point.

7.3.6 The construction site on East Beach

While much of Rothera Point has been subject to considerable human presence and impact since the mid-1970s, East Beach has remained largely free of infrastructure, albeit the area is visited on an almost daily basis by station personnel undertaking recreational walks. As a result, it has relatively high wilderness and aesthetic value compared with other areas on Rothera Point.

8 DESCRIPTION OF THE ENVIRONMENT AROUND ROTHERA POINT

Reference is made in this section to Rothera Point. This is the area of land to the east of the Wormald Ice Piedmont, which is largely ice free and within which the Rothera Research station is situated. Rothera Point is located within Antarctic Conservation Biogeographic Region (ACBR) No. 3 Northwest

Antarctic Peninsula. Recent estimates suggest that ice-free ground may comprise as little as 0.18% of Antarctica (Burton-Johnson et al., 2016). Of the c. 25,000 km^2 of ice-free ground, only a small proportion is located close to the coast where climatic conditions are suitable for the development of substantial vegetation communities and where wildlife colonies and haul out sites are found (Fretwell et al., 2011). However, coastal sites are also often favoured as sites for logistic facilities by national operators and as visitation sites used by the tourism industry (Pertierra et al., 2017).

8.1 Ecology

Levels of biodiversity at Rothera Point are not high compared to other equivalent areas. For example, the nearby islands in Ryder Bay have much higher levels of biodiversity. However, Rothera Point does contain some examples of Antarctic fellfield environments, which are reasonably rare in the wider area (Convey and Smith, 1997). In contrast the near shore marine environment is considerably more species diverse and the subject of most biological research in the area (Barnes, 2007).

8.1.1 Terrestrial Flora

Rothera Point contains no large areas of green vegetation, with substantial continuous moss and liverwort patches limited to a single area of c. 100 m2 adjacent to a transient melt stream in a gully 100 m east of the Miracle Span marked as Area A in Figure 8-1. Confirming this, analysis of remote sensing imagery (using Normalised Difference Vegetative Index (NDVI) methodology) revealed that areas of significant green vegetation are spatially limited (Hughes et al., 2016). Areas of high NDVI value on East Beach relate to algae and cyanobacteria in ephemeral pools fed seasonally by melting snow and ice (Figure 8-1, area B).

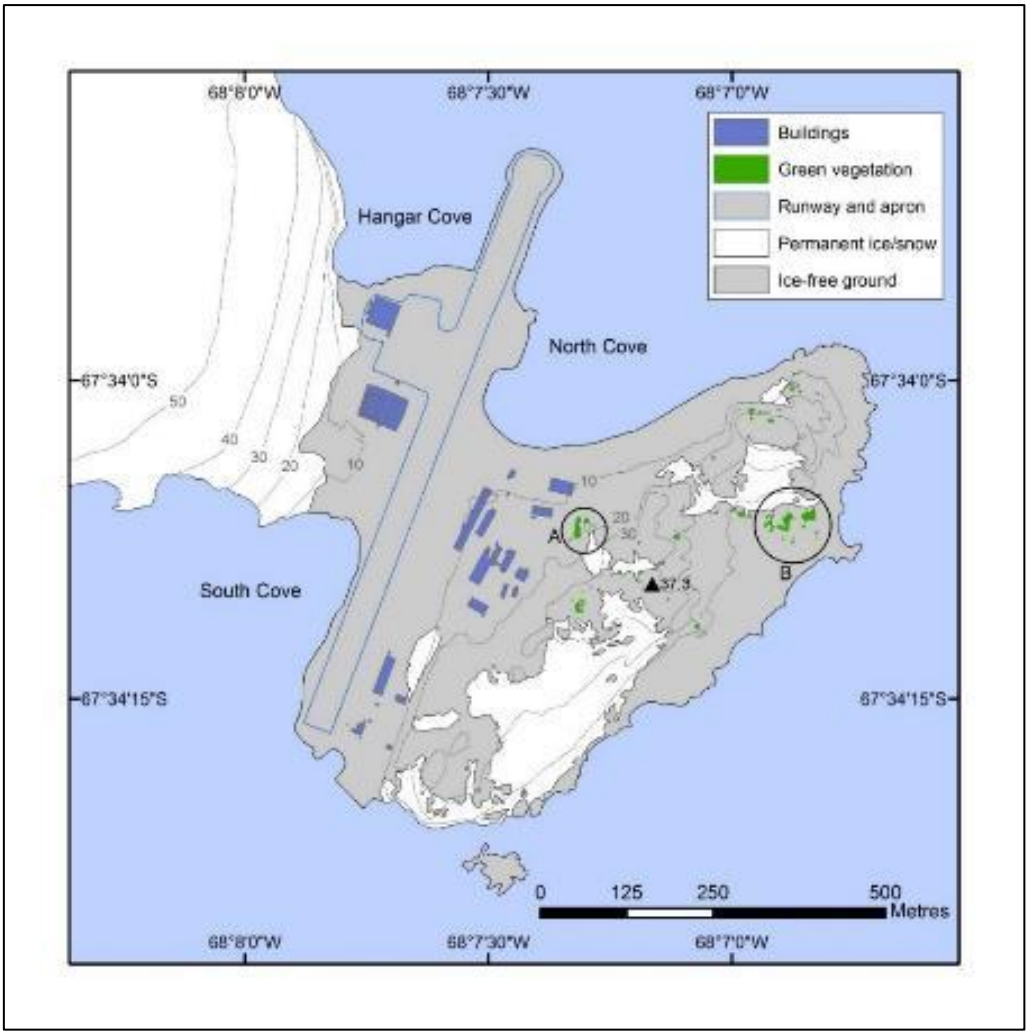

Figure 8-1 Areas of green vegetation detected on Rothera Point using NDVI methodology.

Circled areas A and B denote the location of particularly rich areas of moss/liverwort and algal vegetation, respectively. The algal vegetation labelled B in Figure 8-1 is close (c. 50 m) to the area where the building activity is proposed.

Cryptogams (mosses, liverworts, lichens, algae)

The terrestrial biological interest within the Rothera Point is predominantly on the rock bluffs where there is a locally abundant growth of lichens. Rorthera Point contains a unique diversity of plant species compared with other vegetated areas in the region (Cannone et al., 2018). The vegetation is representative of the southern "maritime" Antarctic fellfield ecosystem and is dominated by the fruticose lichens *Usnea antarctica, Usnea sphacelala*, and *Pseudephebe minuscula*, and the foliose lichen *Umbilicaria decussata* (Øvstedal and Smith 2001; Cannone et al., 2018). Lichen vegetation is reasonably well developed and diverse, dominated by crustose and foliose species, and is typical of the southern maritime Antarctic, as previously described. Bryophytes are generally sparse (mainly *Andreaea spp*). Bryophytes are limited to two main habitats, these being around the relatively small areas of soil and sorted ground, and in rock crevice and epilithic habitats (Ochyra et al., 2008). In the former habitat, although sparse on the higher ice-free area, there are some well-developed stands of *Andreaea* spp. especially below the western and south-western edges of the Antarctic Specially Protected Area (ASPA 129) (see Section 10.9 Protected Areas), and *Sanionia* sp. especially below the eastern and south-eastern edges. These are intermixed with a small amount of what appears to be

Bryum sp. and possibly also *Ceratodon* and *Cephaloziella*. Examples of crevice and epilithic species include *Bartramia* (some with sporophytes) and *Schistidium/Grimmia.*

Extensive areas of microbial mats are located on East Beach within freshwater ponds that vary in size depending on the season and amount of melt from snow slopes to the south of the ASPA. The level of biodiversity has been little studies but may contain cyanobacteria, including *Phormidium* spp., and unicellular and filamentous eukaryotic algae. The common salt tolerant alga *Prasiola crispa* is rare at this site.

The vegetation composition does appear to have remained constant since the mid-1990s. The total area of moss cushions or carpets, while remaining small, may have expanded slightly, including habitats along the spine of Rothera Point, and in pond areas of East Beach (P. Convey, pers comm.).

Vascular plants

A single very small population of Antarctic pearlwort (*Colobanthus quitensis*) has been observed below the northern cliff of the Point (Figure 8-2 and 8-3). A small population of Antarctic pearlwort (*Colobanthus quitensis*) may continue to persist in a small gully at the base of crags under the Point's north-west cliffs. Sixteen separate plants or clumps of varying sizes were noted previously, at least two of which included mature and open seedheads; however, these plants are vulnerable to long-term burial by snow and their persistence is uncertain. A single plant of Antarctic hairgrass (*Deschampsia antarctica*) was located in a small depression at the northern edge of the summit plateau of the Point (Figure 8-4 and 8-5). This plant also possessed a single mature seedhead. However, its on-going persistence at the site is in doubt.

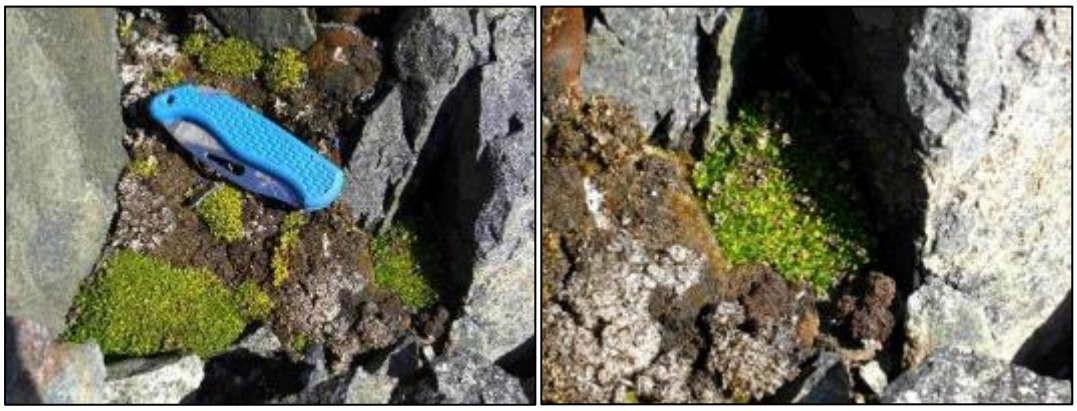

Figure 8-2. Small population of Antarctic Pearlwort C. quitensis*. Figure 8-3 Plant with previous year's seed heads*

Figure 8-4 Location of Antarctic Hairgrass Deschampsia antarctica. Figure 8-5 Inflorescence

8.1.2 Terrestrial Fauna

The terrestrial invertebrate fauna is impoverished and consists only of a few species of mites and springtails, of which *Halozetes belgicae* and *Cryptopygus antarcticus* are the most common. Nematodes and rotifers have also been recorded in freshwater pools. There are no special or rare terrestrial fauna on Rothera Point (Convey and Smith, 1997).

8.1.3 Avifauna

Common Breeding Species at Rothera

For a comprehensive review of birdlife at Rothera Point, including reference to relevant literature, see Milius, 2000. Of the bird species observed in the vicinity of Rothera Point, only some are known to breed locally: snow petrel (*Pagodroma nivea*), Wilson's storm petrel (*Oceanites oceanicus*), imperial/Antarctic shag or cormorant (*Phalocrocorax [atriceps] bransfieldensis*), south polar skua (*Catharacta maccormicki*), and kelp/Dominican gull (*Larus dominicanus*) and Antarctic tern (*Sterna vittatta*). On Rothera Point itself, south polar skuas are the most abundant breeding birds with occasional pairs of kelp gulls nesting and one Wilson's storm petrel nest has been found (Phillips et al., 2019).

Snow Petrel (*Pagodroma nivea)*

Snow petrels may breed in small numbers and are recorded throughout the year around Rothera Point, though less often in early and mid-summer. It is possible that they breed on some of the rock outcrops in the Rothera area.

Wilson's storm petrel (*Oceanites oceanicus*)

This species may breed in small numbers on Rothera Point, probably <15 pairs, although it also breeds on many (maybe all) of the other local islands in Ryder Bay, e.g., Lagoon Island. Birds return in late November or early December and although records are few, their departure is likely to be during April.

Antarctic shag (*Phalacrocorax [atriceps] bransfieldensis*)

Up to 74 pairs of the Antarctic shag breed on Killingbeck Island (1.6 km east of Rothera Point) and the small rock just north of the island. Up to 251 pairs breed on Mucklescarf Island, close to Lagoon Island, although the exact numbers may vary considerably between years. A further colony located on Skart Island (Mikkelsen Islands) was discovered in Jan 2018 and contained 80 pairs (Phillips et al., 2019). Antarctic shags can be seen at all times of the year, although their presence in winter is likely to be dependent on sea-ice conditions. Between late March and late June 1996, large flocks containing 300–400 adult and juvenile birds were seen with over 1000 recorded on 22 June, indicating that more than just the local breeding population was present.

South polar skua (*Stercorarius maccormicki*)

South polar skuas breed at Rothera Point and the population has been monitored annually since the 1988/89 season. The location of recorded nest sites are shown in **Error! Reference source not found.**) (UK Polar Data Centre, Rothera Point and Anchorage Skua data, 2017). Nest sites are often reused but may be inactive for a number of consecutive years. Rock removal undertaken during the 2018/19 season means the most southerly nesting site may no longer remain viable. Long-term data indicated that the population size at Rothera Point varied considerably between years, increasing overall by 1.9% per annum from 11 breeding pairs in 1975/76 to 24 breeding pairs in 2017/18 (see Figure 8-7)

Additionally, up to almost 1000 birds breed on many of the other islands in Ryder Bay (Lagoon, Leonie, Killingbeck, Donnelly and Anchorage) (See Figure 8-7 and Figure 8-8; Phillips, 2019) and at least one incubating pair has been observed on Reptile Ridge. The spring return to Rothera usually falls between 15 and 25 October with departure in late April/early May, with the latest birds likely to be migrants from farther south. At Rothera Point, large numbers of non-breeding skuas (up to 200) congregate in communal areas, often near shallow melt pools, particularly beside the melt pools on East Beach and at either end of the runway.

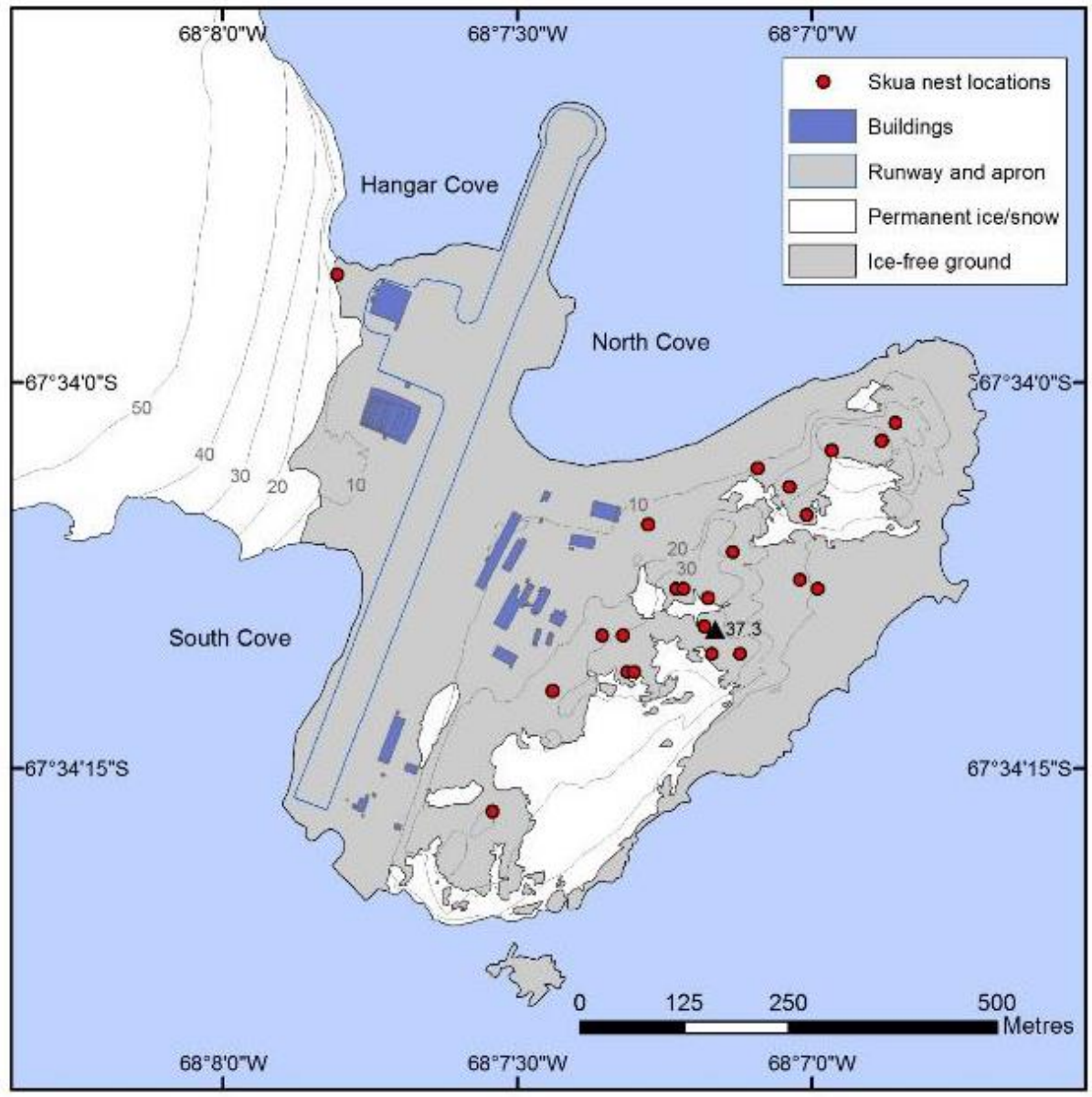

Figure 8-6 Distribution of skua nesting sites on Rothera Point, Adelaide Island between 2005 and 2016.

Note, the red circles mark the general areas in which nests are located as the precise location may vary by a few metres year on year.

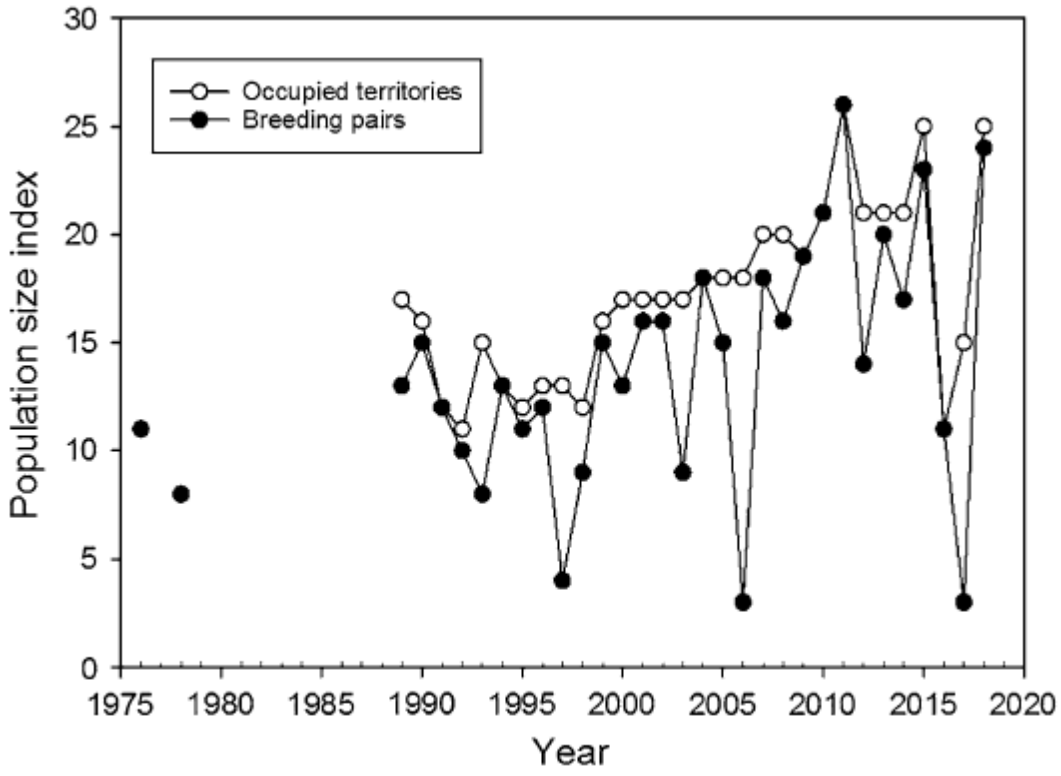

Figure 8-7 Changes in population sizes of south polar skuas at Rothera Point, Ryder Bay (Antarctic Peninsula) from 1976 to 2018. Years refer to the time of chick fledging (i.e. 1976 represents the 1975/76 austral summer)

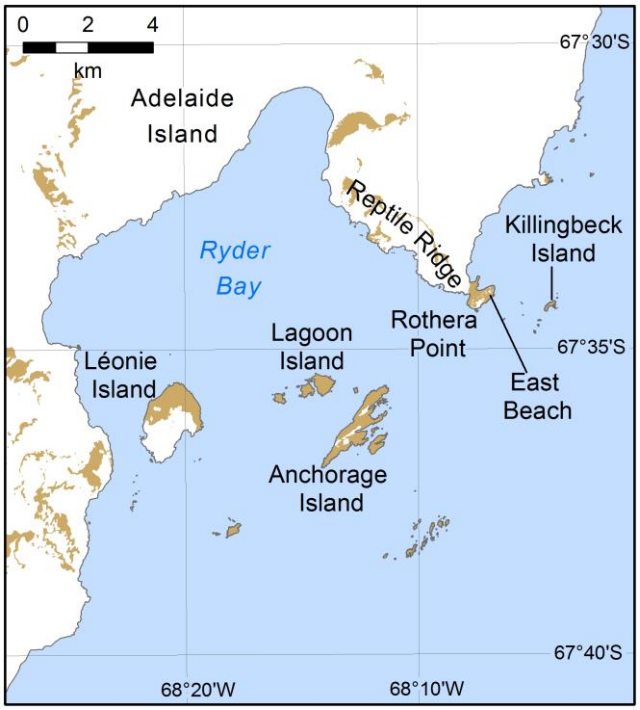

Figure 8-8 Location map of Ryder Bay and surrounding area

Kelp gull (*Larus dominicanus*)

The Rothera Point breeding population varies from c. zero to four pairs. This species also breeds on the other local islands (Killingbeck, Lagoon, Anchorage and in larger numbers on Leonie). In winter, kelp gulls are one of the most regularly recorded species at Rothera.

Antarctic tern (*Sterna vittata*)

Breeds locally, on Killingbeck Island, Reptile Ridge (c. 100 pairs) and on Lagoon Island and possibly Anchorage Island. About 60 terns, some of which were on nests, were noted on Rothera Point in February 1962 and a nesting colony of 100+ birds was reported at Rothera Point on 16 January 1969. However, the colony disappeared after the establishment of the station in 1976. Birds are seen commonly around Rothera Point between late September/early October and March and far more rarely in winter.

Common Non-breeding Species at Rothera

Emperor penguin (*Aptenodytes forsteri*)

Emperor penguins are rare, although almost annual, visitors, with seldom more than single birds seen although a group of 19 was recorded on 7 November 1977. Nearly all records fall between August and November.

Adélie penguin (*Pygoscelis adeliae*)

Seen almost daily during the summer months (late October to March) and less frequently, but still regularly, throughout the remainder of the year. In summer, counts vary greatly with up to 120 birds observed on East Beach on a single day. Winter occurrence is probably largely dependent on sea ice coverage; available records suggest that they become quite scarce when the sea ice is at its most extensive. During February and March, many of the birds present come ashore to moult. From late February to April, a small number of first-year birds are regularly recorded, although during the winter almost all birds are adults. Fragments of bone and egg shell in soil provide evidence of ancient penguin (mid to late Holocene), probably Adélie penguin, colonies on Rothera Point (Emslie and McDaniel, 2002).

Chinstrap penguin (*Pygoscelis antarctica*)

Rare summer visitors with records usually involving single birds between January and March.

8.1.4 Marine mammals

Seals

No seals use Rothera Point as a breeding site. Weddell seals (*Leptonychotes weddelli*) are the most obvious mammal and are present all year round in the area around Rothera Point (See Figure 8-9) (BAS, 2017). In late September, pups are born out on the sea ice. Crabeater seals (*Lobodon carcinophagus*) and elephant seals (*Mirounga leonina*) are also present, and fur seals (*Arctocephalus gazelle*) arrive in varying numbers at the end of each summer. Increasing numbers of both elephant and fur seals have been experienced in the last few seasons at Rothera and whilst no scientific surveys have been undertaken to establish the actual numbers of individuals, operational tasks have been impacted by the presence of seals on roadways and the runway. The leopard seal (*Hydrurga leptonyx*) is present all year round and, in 2003, an attack resulted in the death of a marine biologist at Rothera Point (Muir et al., 2006).

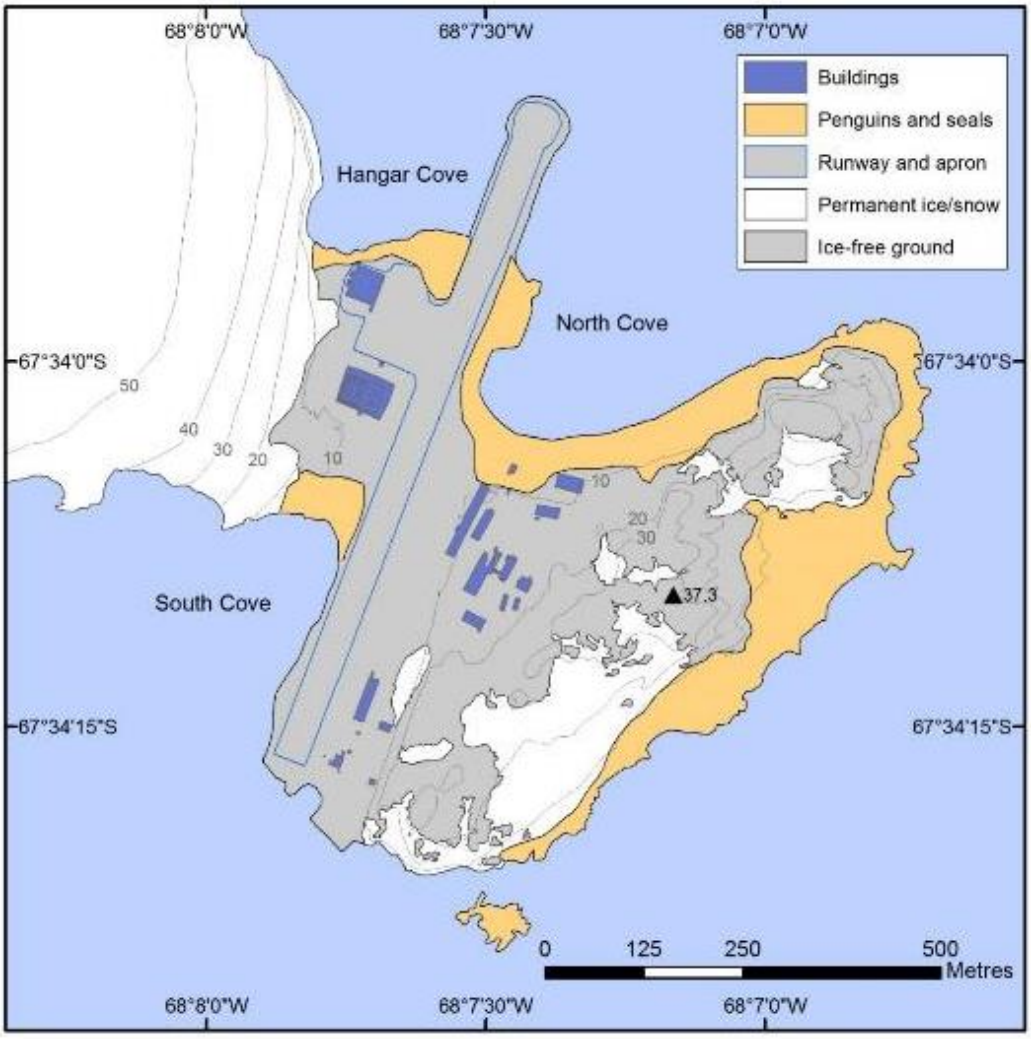

Figure 8-9 Low lying area of Rothera Point where low densities of seals & penguins may be found commonly

Whales

Minke whales (*Balaenoptera bonaerensis*) and humpback whales (*Megaptera novaeangliae*) are seen in Ryder Bay each summer. During some years minke whales can be observed frequently and may be year-round residents, including within the ice pack if present. There is little evidence for substantial blue or fin whale activity in Marguerite Bay (Sirovic and Hildebrand, 2011). Killer whales (*Orcinus orca*) inhabit the larger Marguerite Bay area and are usually seen from the station several times each summer. Humpback whales are seasonal residents, migrating between tropical breeding and calving grounds to feed along the Western Antarctic Peninsula in austral summer and autumn months. There are areas within Marguerite Bay with high krill predator occurrence rates including the area around Rothera Point and the northern extent of Marguerite Bay near the south eastern end of Adelaide Island (Friedlaender et al., 2011).

8.1.5 Non-native species

No non-native plants or invertebrates are known from Rothera Point or the adjacent marine environment. However, there was a report, dating from the mid-1990s, of the non-native collembolan (springtail) *Hypogastrura viatica* at Leonie Island, Marguerite Bay (Hughes et al., 2015; 2017). This is the most southerly record of the presence of a non-native species in the natural environment on the Antarctic Peninsula (see **Error! Reference source not found.**).

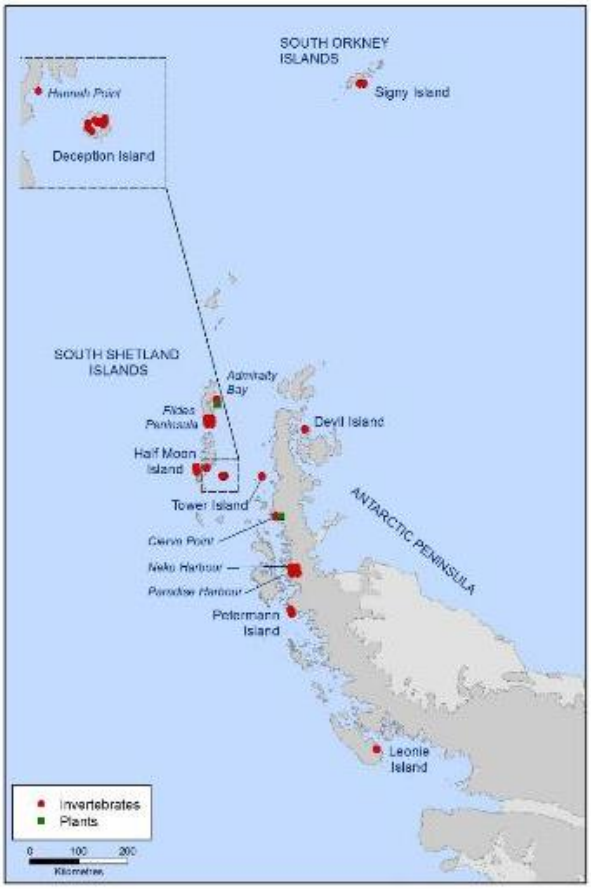

Figure 8-10 Map of the Antarctic Peninsula region showing the distribution of known non-native species

8.2 Physical Characteristics

8.2.1 Meteorological Conditions

The climate is cold and dry and represents a transition from that typical of the more oceanically-influenced 'maritime' Antarctic to the north and the more extreme climate of 'continental' Antarctica to the south. A programme of surface synoptic meteorological measurements commenced at Rothera Research Station in 1977 (Turner et al., 2004). Mean monthly air temperatures range between c. -10.5 and +1.4 ^{o}C (see Figure 8-12**Error! Reference source not found.**), with the prevailing wind from the north-north-east and averaging at 12.1 m s^{-1} (see Figure 8-13).

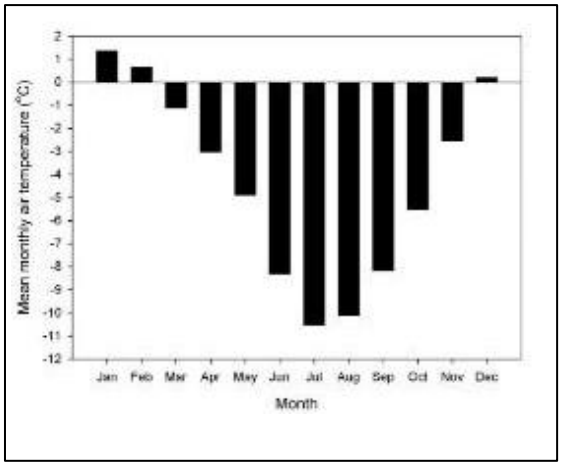

Figure 8-11 Mean monthly air temperature at Rothera Point, Adelaide Island (1977-2015)

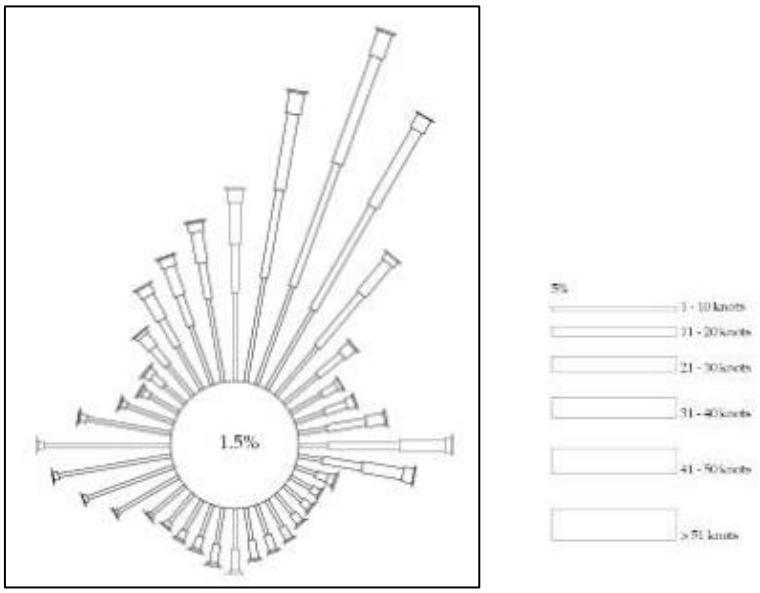

Figure 8-12 Wind rose for Rothera Point, Adelaide Island

8.2.2 Air Quality

No air quality data exist for Rothera Point, but it is hoped that the installation of the hut on East Beach will resolve this issue. Significant volumes of hydrocarbons are combusted in the vicinity of the station to power station generators and the engines of vehicles, ships, small boats and aircraft. Monitoring of heavy metals in lichens on Rothera Point undertaken between 1976 and 1989 showed pollution close to the station, particularly those areas affected by diesel generators and within c. 200 m to the northwest, north and northeast of the station, corresponding with the prevailing wind directions (Bonner et al., 1989). Beyond this area the concentrations progressively declined with increasing distance from the station. Nevertheless, the frequently high to moderate wind speeds in the area may rapidly disperse any pollutants, so minimising any impacts beyond the immediate vicinity of the pollution sources.

8.2.3 Tides and Waves

The tides at Rothera are diurnal (i.e., one high tide and one low tide each day). On some neap tides the difference between high and low water can be very small (see Figure 8-14).

Figure 8-13 Tide Table

Astronomical tides for Rothera Point are given on Admiralty chart 3462 as follows (CD: chart datum):

State of the Tide	Abbrev.	Level
Mean High High Water	MHHW	+1.3 m CD
Mean Low Low Water	MLLW	+0.4 m CD
Mean Sea Level (taken as the mean of MHHW & MLLW)	MSL	+0.85 m CD

8.2.4 Geomorphology

Rothera Point is a small peninsula situated on the southeast of Adelaide Island (Bonner et al., 1989). It is a low rocky headland of about 0.4 km^2 comprising a north-east to south-west trending, with a dissecting ridge rising to 39 m altitude. There is an area of raised beach composed of rounded boulders on the south-eastern side and similar but more extensive terrain (though composed of smaller stones and pebbles) on the north-west side. The latter forms an isthmus between North and South Cove and connects Rothera Point itself to Adelaide Island. The isthmus was extensively altered and widened during the construction of the gravel runway in the early 1990s. The sloping ice-ramp with a gradient of about 1:5 leads from the isthmus to the Wormald Ice Piedmont.

The rocks of Rothera Point have been subject to extensive frost shatter although some areas have been made smooth by the action of ice that has since retreated. A large ice-dammed melt pool that used to exist where Rothera Station now stands had disappeared by the early 1970s; its former shore lines were distinguished by more than 20 narrow terraces, but these are now largely indistinguishable due to station construction activities (Shears, 1995). Several poor quality raised beach terraces are present on East Beach, representing previous higher sea level episodes, and the process of isostatic rebound is thought to be on-going in the area. Raised beaches are also evident on the neighbouring Anchorage and Leonie islands and occur at 6, 18 and 23 m. Other areas of ice-free topography are widespread elsewhere in Laubeuf Fjord and northern Marguerite Bay, but few possess extensive level ground.

During the 2018/19 season rock was removed from the rock cliffs north-east of Biscoe Wharf to provide material for construction of the replacement wharf.

8.2.5 Soils

Soil is restricted to small pockets of glacial till and sand intermixed with relictual penguin guano in depressions and amongst the rocks (ATS, 2017). Deeper deposits have permafrost and occur as scattered small circles and polygons of sorted material. There are no extensive areas of patterned ground and periglacial features are poorly represented. There are frequent accumulations of decaying

limpet (*Nacella concinna*) shells deposited by gulls (*Lars dominicanus*), forming patches of calcareous 'soil'. The disappearance of snow and ice patches during the past 30 years has revealed deposits of organic mud, feathers and bones derived from an ancient Adelie penguin rookery (Emslie and McDaniel, 2002). Otherwise, there are no accumulations of organic matter, except for a very shallow layer of decaying moss peat beneath patches of moss.

8.2.6 Surface Water

No large areas of freshwater exists on Rothera Point, with the exception of a c. 50 metre long transient pool located at the west fringe of the large area of permanent ice to the south of Rothera Point. Seasonal meltwater from the permanent ice feeds into this water body, which consequently fluctuates in level. During winter, and sometimes extending into the summer months, the surface of the water is not visible due to ice and snow cover. The pool was partially infilled during the 2018/19 season. Transient streams may form at other locations around the Point, with flow rate depending upon the season and level of melt of the associated snow and ice bodies. The large relatively flat area of ground at East Beach may contain transient pools that may support algal and cyanobacterial communities. The flat area to the west of the Hangar may contain small transient meltwater pools.

8.2.7 Geology

The stratified rocks of central Adelaide Island are probably of Late Jurassic age, based on similarities to rocks from elsewhere on the west coast of the Antarctic Peninsula (Riley et al., 2012). The lithological unit that is directly relevant to Rothera Point and the surrounding area is the 'Adelaide Island intrusive suite' which is a series of isolated and composite granitoid plutons. A large part of the exposed geology on Adelaide Island consists of these plutonic rocks. Many of the plutons on Adelaide Island are heterogeneous and are characterised by concentrations of well-rounded xenoliths, which are typically more mafic than the host rock. The plutons can be seen to intrude the volcano-sedimentary sequences at several localities, including Reptile Ridge which lies at the top of the Rothera ice ramp.

The geology around Rothera Point is dominated by granodiorite, with minor amounts of quartz diorite and diorite. The geology of Rothera Point is interpreted to be consistent with the rest of the Adelaide Island intrusive suite and is therefore thought to be approximately 48 Ma (Eocene age). The mineralogy of the Rothera Point granodiorite consists of plagioclase, quartz, amphibole, biotite and variable amounts of chlorite and epidote, which has formed along cracks and joints in the rock, as a result of hydrothermal alteration. Malachite (copper) mineralisation is also a characteristic of the granodiorites of the Wright Peninsula and Rothera Point.

Close to the Memorial on Rothera Point, the primary lithology is granodiorite, although it is frequently characterised by abundant rounded mafic patches within the granodiorite host (Figure 8-14). The mafic 'blebs' are gabbroic in composition and are distinct to the xenolith-hosted granodiorite. The formation of this feature would have meant that the mafic blebs (gabbro) were relatively hot and less viscous compared to the 'colder' and more viscous granodiorite magma, therefore the gabbro would have 'frozen' when intruded into the granodiorite magma. This process where the gabbro and granodiorite magmas remain as distinct, recognizable rock types rather than becoming completely mixed is called 'magma-mingling'. With magma mingling there are some chemical interactions between the two magmas by slow and complex diffusional processes, but thermal equilibrium is reached long before chemical equilibrium, so the effects on the granodiorite composition are relatively minor.

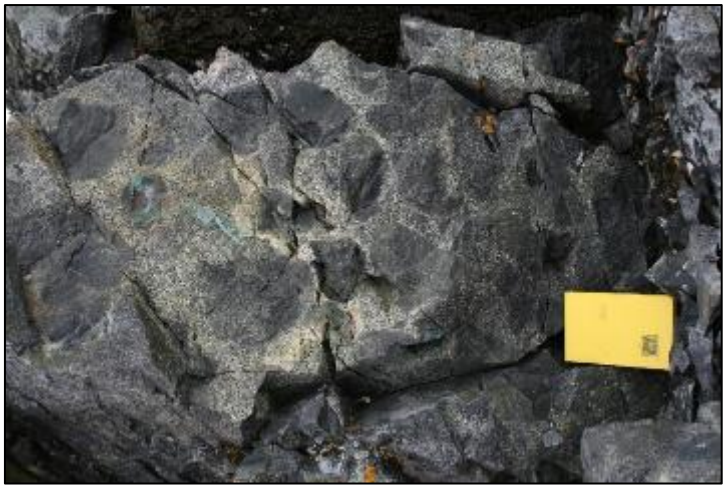

Figure 8-14 Magma mingling on Rothera Point.

8.2.8 Glaciology

Access from Adelaide Island to Rothera Point is via an ice ramp forming the southern limit of the Wormald Ice Piedmont (**Error! Reference source not found.**See Figure 8-16).

Figure 8-15 The ice ramp that connects Rothera Point to the Wormald Ice Piedmont.

The surface elevation of the ramp rises from 10 to 110 m asl, over a horizontal distance of around 600 m. Following the establishment of the scientific station in 1975, the ramp saw considerable year-round vehicle traffic, largely in support of aircraft operations from a skiway on the piedmont. This

traffic increased steadily over the years. In early 1990, construction of a gravel runway between the station and ramp began and by 1992 all aircraft operations had been transferred to this runway. Subsequent traffic on the ramp has been light. A survey programme was initiated in February 1989 to monitor the ice ramp's mass balance and to detect any changes (Smith et al., 1998). The uppermost part of the ramp shows no clear decline in mass balance; however, lower sections of the ramp surface have lowered, in common with other sites on the Antarctic Peninsula (**Error! Reference source not found.**See Figure 8-17). The deposition of dust on the ramp originating from the runway may also be contributing to surface lowering, and mitigation measures are employed to reduce dust dispersal from the runway. Studies suggest that the ramp has been subject to episodes of advance and retreat over longer timescales.

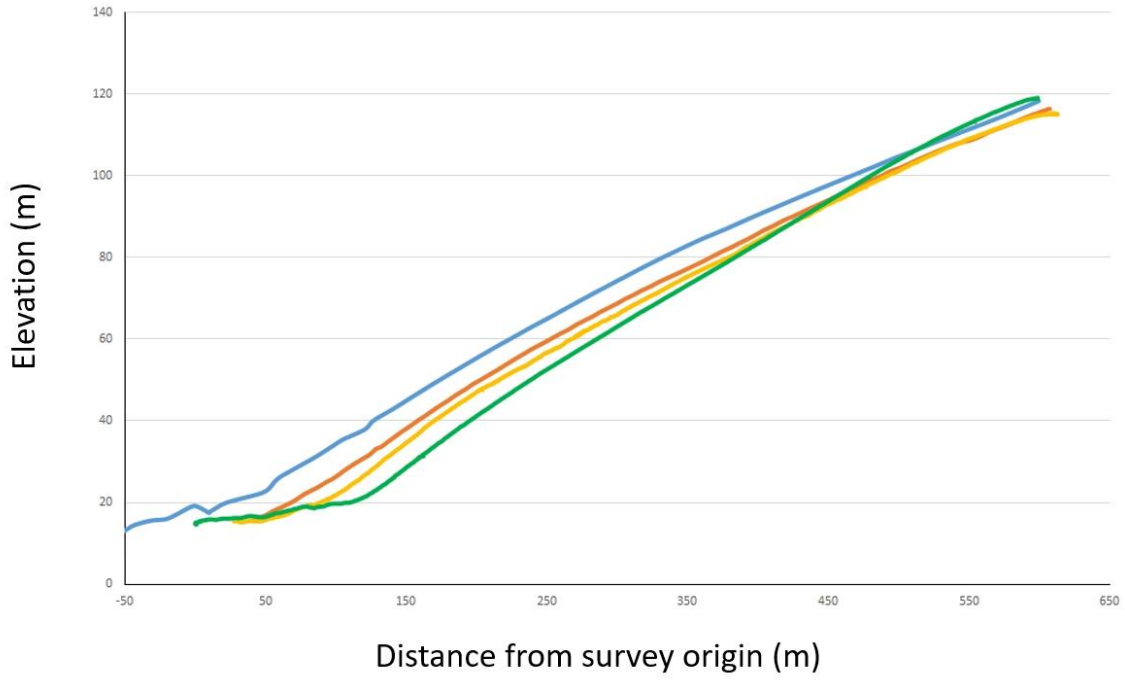

Figure 8-16 Elevation of the Rothera ice ramp between 1989 and 2021. Line colours correspond to ramp profiles surveyed during different years: blue (1989), orange (1998), yellow (2008), green (2021).

Several other areas of permanent ice exist on Rothera Point, notably to the south where ice cliffs have formed above the sea (to the east of the wharf) but also crossing the southern boundary of Antarctic Specially Protected Area No. 129 shown on Figure 8-18.

8.2.9 Permafrost

In February 2009 a new 30 m permafrost borehole was installed close to the British Antarctic Survey Station at Rothera Point, Adelaide Island (67.57195°S 68.12068°W) (Guglielmin et al., 2014). The borehole is situated at 31 m asl on a granodiorite knob with scattered lichen cover. Snow persistence is variable both spatially and temporally with snow free days per year ranging from 13 to more than 300, and maximum snow depths varying between 0.03 and 1.42 m. This variability is the main cause of high variability in ground surface temperatures, that ranged between − 3.7 and − 1.5 °C. The net effect of the snow cover is a cooling of the surface. The active layer thickness ranged between 0.76 and 1.40 m. Active layer thickness temporal variability was greater than reported at other sites at

similar latitude in the Northern Hemisphere, or those with similar mean annual air temperature to the Maritime Antarctica, because vegetation and a soil organic horizon are absent at the study site. No change in temperatures during the year was observed at about 16 m depth, where the mean annual temperature was − 3 °C. Permafrost thickness was calculated to range between 112 and 157 m, depending on the heat flow values adopted. The presence of sub-sea permafrost cannot be excluded considering the depth of the shelf around Rothera Point and its glacial history.

8.2.10 Flood Risk

Tsunami risk is difficult to predict or mitigate against; however, the region lies within the influence of tectonic events around the Scotia Arc and may be subject to tsunami incidents at some points in the future. Nevertheless, the location of Rothera Point within Marguerite Bay on the east side of Adelaide Island, with the Antarctic Peninsula on the other side of Laubeuf Fjord, may afford some protection against the most severe impact of a tsunami with a more distant source.

Sea level rise is not expected to be sufficient over the anticipated lifespan of the wharf to present a significant threat and will be largely compensated for by on-going isostatic rebound in the region. Some local flood risk may be presented by the drainage of the freshwater pool located to the south of Rothera Point, should any alterations be made to the local topography during possible future construction work.

8.2.11 Noise & vibration

Rothera Point is already an area subject to substantial levels of noise originating from aircraft using the gravel runway, large vehicles for cargo transfer, construction purposes and snow movement, and occasional use of sirens to signal aircraft landings or a station emergency. Many of the marine mammals hauled out around the station and the non-breeding skuas that congregate, particularly at the north end of the runway, appear to be habituated to these noises and show little or no observable sign of disturbance. Penguins and seals that may congregate on East Beach are subject to less noise originating from the station and runway.

8.3 Protected Areas

The construction site for the East Beach hut is located approximately 100 m south of the southern boundary of Antarctic Specially Protected Areas (ASPA) 129 Rothera Point, Adelaide Island (Lat. 68°07'S, Long. 67°34'W). The primary reason for the designation of ASPA No. 129 as an Antarctic Specially Protected Area is to protect scientific values, and primarily that the ASPA would serve as a control area. The intention was that the effects of human impact associated with the adjacent Rothera Research Station (UK) could be monitored in an Antarctic fellfield ecosystem (**Error! Reference source not found.**see Figure 8-18) (ATS, 2017). Rothera Point was originally designated in Recommendation XIII-8 (1985, SSSI No. 9) after a proposal by the United Kingdom. Subsequent research has shown that the area has significant nature conservation value (Cannone et al., 2018).

The ASPA is unique in Antarctica as it is the only protected area currently designated solely for its value in the monitoring of human impact. The objective is to use the ASPA as a control area that has been relatively unaffected by direct human impact, in assessing the impact of activities undertaken at Rothera Research Station on the Antarctic environment. Monitoring studies undertaken by the British Antarctic Survey (BAS) began at Rothera Point in 1976. On-going environmental monitoring activities within the Area and Rothera Point include: (i) assessment of heavy metal concentrations in lichens; (ii)

measurement of hydrocarbon and metal concentrations in gravel and soils and (iii) survey of the breeding bird populations.

Entry into the ASPA is strictly prohibited unless in accordance with a permit issued by an appropriate national authority (e.g., the FCDO Polar Regions Department).

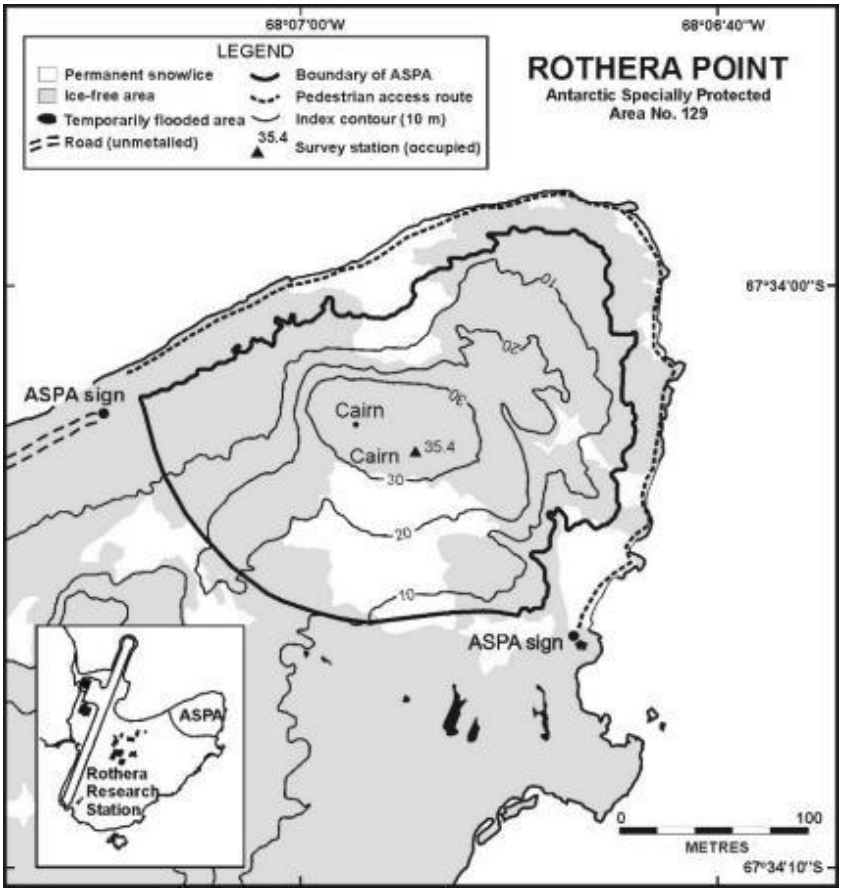

Figure 8-17 Map of ASPA No. 129 Rothera Point, Adelaide Island

Figure 8-18 Map of the multi-site ASPA within the Léonie Islands, Ryder Bay, Antarctic Peninsula: Anchorage Island; Donnelly Island; East Lagoon Island; western Léonie Island; Mucklescarf Island and south-east Adelaide Island.

Although not formally recognised under the Antarctic Treaty System, BirdLife designated the areas around Ryder Bay an Important Bird and Biodiversity Area (IBA) in 2018 (AQ205). The IBA includes part of Rothera Point that includes East Beach (see Figure 8-20).

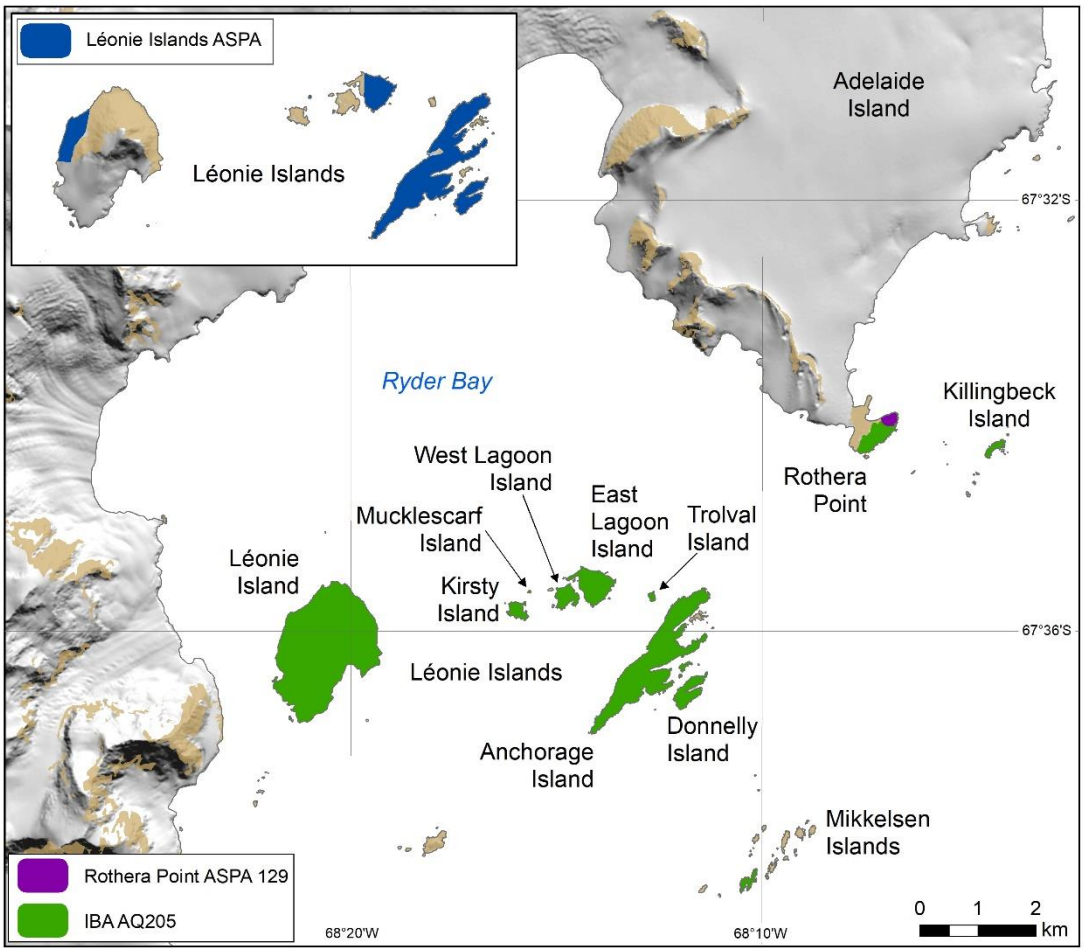

Figure 8-20. Map of the Ryder Bay area showing the extent of ASPA 129 Rothera Point (purple), ASPA 177 Leonie Islands and south-east Adelaide Island (blue) and Important Bird and Biodiversity Areas (IBA) AQ205 (green). Note East Beach is included within IBA AQ205.

8.4 Cultural Heritage

BAS has operated from Rothera since 1975. Whilst there are no formally designated Historic Sites and Monuments (HSMs) at Rothera, that station does have a rich cultural heritage which has developed over the years. There are no sites of cultural heritage value on East Beach with the memorial to the south of Rothera Point the nearest site of cultural value.

8.5 Wilderness & Aesthetic Value

Whilst there is not an internationally agreed definition of aesthetic value in Antarctica, it is generally characterised by the lack of visible evidence of human activity including permanent infrastructure. In addition, the wilderness value of a location in Antarctica is often related to a feeling of remoteness (Tin and Summerson, 2013).

Rothera Research Station has been the main BAS research and operational hub within Antarctica for more than 40 years concentrating its infrastructure development largely within the confines of the 0.4 km^2 area of Rothera Point. This concentration of activity within a small area means that there has not been an on-going expansion of the station footprint (as observed at other Antarctic stations), not least because space for construction is limited.

A result of this constraint is that evidence of human presence is visible from most areas of Rothera Point; however, the great majority of infrastructure has been construction on the northwest side of the central rocky north-east to south-west trending ridge that dissects Rothera Point. Consequently, it is possible to experience a genuine wilderness experience when on East Beach and on the northern fringes of Antarctic Specially Protected Area No. 129. Indeed, it is common for station personnel wanting to get away from busy station life to go for a 'walk round the Point', which involves walking around the northern fringes of the ASPA to East Beach and then up to the memorial cross before returning to station. With most of the infrastructure confined to the Point itself, views in almost every direction away from the Point show near pristine Antarctic scenery of outstanding wilderness and aesthetic value (Figure 8-1). The proposed works for the East Beach hut are well within the more 'pristine' and least disturbed area of Rothera Point.

Figure 8-21 View from Rothera Point across Marguerite Bay to Leonie Island, and the Princess Royal Range beyond

8.6 Climate Change Projections

Rothera Point has been subject to human activity for over 40 years and in that time some parts have been dramatically modified from their original state, while others remain relatively free of impacts. Coupled with this, climate variability has resulted in changes in marine, terrestrial and ice characteristics around Rothera Point with consequent impacts upon local marine and terrestrial ecosystems. On-going development of BAS' logistical capacity at Rothera will likely result in further

modifications of the environment, with impacts likely to be minimised if constrained to areas of existing human activity and impact.

Climate change impacts may be more difficult or impossible to mitigate, which may have substantial impacts on elements of the logistical capacity at the station. With the current scientific data available it is impossible to accurately predict the impacts of climate change on environments in the vicinity of Rothera Research Station. However, should climate warming occur then impacts upon the Rothera Research Station and Rothera Point may include:

- melting and steepening of the ice ramp that joins Rothera Point to the rest of Adelaide Island;
- increase in ice-free ground on Rothera Point, associated with the melting and shrinking of areas of permanent ice;
- changes in bird population numbers linked to climate change effects on food sources and weather conditions during the breeding season;
- seasonal changes in water availability for terrestrial communities leading to alterations in community structure and species distribution across Rothera Point;
- changes in permafrost depth;
- further changes in the intensity of iceberg scour of marine environments around Rothera Point, linked to changes in sea ice conditions that are, in turn, associated with changes in winds over the Peninsula;
- changes in the presence of sea ice-dependant species around Rothera, as sea-ice become less reliable; and
- increased likelihood of establishment of any non-native species introduced to Rothera Point.

While the potential changes described here are significant, it is anticipated that the location selected for the hut construction will not be subject to substantial negative impacts resulting from climate change over its planned life span of 25 years.

8.7 Summary

The key environmental receptors which are most likely to be impacted by the East Beach Hut Project are as follows:

- Terrestrial fauna – nesting skuas on Rothera point (with the nearest nests located, c. 75 m from the hut).
- Native terrestrial and freshwater fauna and flora – which may be impacted by disturbance, potential fuel/chemical spills or biosecurity incursions (with the nearest transient ponds c. 30 m from the hut and the ASPA boundary c. 75 m from the hut).
- Wilderness and aesthetic values – the hut would be the only building on East Beach, which currently is the area of Rothera Point with the highest wilderness value that is accessible to station personnel.

Other impacts will be associated with the emission of greenhouse gasses. These include carbon dioxide emitted as a result of the transportation of people and building materials to the site.

9 ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

9.1 Methodology

This chapter identifies the actual or potential impacts that could or will occur as a result of the proposed project activities.

The environmental impact assessment process has followed a four-step process involving:

- Identifying the **proposed activities** of the project;
- identifying the **environmental aspects** – i.e., the way in which any of the proposed activities interact with the environment such as atmospheric emissions, dust, noise, fuel spills, introduced non-native species, etc.;
- identifying the **environmental impact** – i.e., the change in environmental value or resource as a result of the activity; and
- assessing the **significance of the identified impact** – i.e., considering the spatial extent, duration, probability of occurrence and severity of the potential impact on the environment with reference to the three levels of significance identified by Article 8(1) of the Protocol (i.e., less than, no more than or more than a minor or transitory impact.

9.2 Proposed Activities

The nature and scale of the proposed activities associated with the Rothera Modernisation project have been described in this document. These activities have been summarised and divided into the following categories for the purposes of impact assessment:

- Transportation of the building material to site
- Construction of the hut
- Support activities
- Post construction operation of the building

9.3 Environmental Aspects

"*An environmental aspect may involve an output or addition to the environment (e.g., emission of pollutants/noise/light, human presence, transfer of native or non-native species, direct contact with wildlife/vegetation, leak or spill of hazardous substances etc.) or a removal from the environment (e.g., use of lake water, collection of moss samples, removal of rocks).*" (ATCM, EIA Guidelines, 2016)

The environmental aspects associated with the activities listed in Section 9.2 have been summarised in Figure 9-1 below. The reliance on the SDA cargo tender also presents the risk of fuel spills for cargo delivery. Due to nature of the project it has been identified that the construction activities will increase the current footprint of the operational site to East Beach and has the potential to cause physical disturbance on land and to flora and fauna. The potential to introduce non-native species as a result of input of cargo and personnel to Rothera is also identified.

Figure 9-1 Tqble of Environmental Aspects

No.	ACTIVITIES	ENVIRONMENTAL ASPECTS											
		Atmospheric emissions (burning fossil fuels)	**Noise emissions**	**Dust emissions**	**Waste**	**Light (external)**	**Physical presence and use of space**	**Physical/ mechanical disturbance on land**	**Fuel or hazardous substance release**	**Non-native species introduction**	**Disturbance to native flora/fauna**	**Visual**	**Heritage**
Transportation of construction material to East Beach													
1.	Ship tender operation	✓	✓					✓	✓	✓	✓		
2.	Manual off loading of cargo from tender		✓					✓			✓		
3.	Storage of cargo on East Beach						✓	✓		✓		✓	
Construction activities													
4.	Site set up & presence of construction personnel	(✓)	✓		✓		✓	✓			✓	✓	
5.	Operation of portable generator to recharge battery operated hand tools	✓	✓						✓		✓		
6.	Fuel management & refuelling	(✓)			✓				✓				
7.	Jackpad use & concrete plinths (if required)	(✓)		✓	✓		✓	✓					
8.	Erection of hut base frame steelworks		✓		✓		✓					✓	
9.	Installation of cladding & roof panels				✓		✓					✓	
10.	Provision of electrical services (cable from station)	(✓)			✓		✓	✓			✓	✓	
Support activities													
11.	Shipping cargo to Rothera	✓								✓			
12.	Transport of personnel to Rothera (flights & shipping)	✓	✓							✓			
13.	Provision of accommodation & support services (e.g. power, food, water) for personnel	✓			✓				✓				
Post construction/ operation of new hut													
14.	Day to day operation of the hut (science)	✓			✓	✓	✓		✓			✓	

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9.4 Identification of Environmental Impacts and Mitigation Measures

This section identifies the potential environmental impacts of the project. The impacts are considered to be any changes in environmental value or resource that will or may occur as a result of the identified outputs/aspects, from the proposed activities. The worst case impacts have been considered here and the actual or potential impacts are summarised in Table 9.7 impact Matrix.

The impacts have been divided as per the four core activities of the project listed in Section 9.2 and below.

- Transportation of the building materials to site
- Construction of the hut
- Support activities
- Post construction operation of the building for scientific purposes

To avoid repetition where the same impact has been predicted to occur across a number of activities, the environmental impact and mitigation measures have been presented together.

Each impact has been identified as either direct, indirect, cumulative or unavoidable defined as follows:

- A **direct impact** is a change in environmental value or resource that results from direct cause-effect consequences of interactions between the exposed environment and the activity (e.g., decrease of a limpet population due to an oil spill, or a decrease of a freshwater invertebrate population due to lake water removal) (ATCM, EIA Guidelines, 2016).

- **An indirect impact** is a change in environmental value or resource that results from interactions between the environment and other impacts - direct or indirect (e.g., alteration in seagull population due to a decrease in limpet population which in turn was caused by an oil spill) (ATCM, EIA Guidelines, 2016).

- A **cumulative impact** is the combined impact of past, present, and reasonably foreseeable activities. These activities may occur over time and space and can be additive or interactive/synergistic. (e.g., decrease of limpet population due to the combined effect of oil discharges by base and ship operations).

- An **unavoidable impact** is an impact for which no further mitigation is possible. For example, it may be possible to reduce the area from which the proposed new infrastructure will be visible, but it is unavoidable that the infrastructure will be visible over some area.

9.4.1 Transport of the building materials to site

9.4.1.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Transportation of the construction material to Antarctica on the RRS Sir David Attenborough
- Ship tender operations

Mitigation:

- The ship and tender are new and has modern and efficient engines.
- Regular inspection and maintenance will be carried out to ensure tender engines operate efficiently.
- The cargo delivery will be undertaken a quickly as feasible and safe.

9.4.1.2 Noise pollution

Noise produced as a result of tender operation and cargo movement has the potential to disturb local wildlife potentially resulting in avoidance or stress behaviour, nest abandonment or hearing damage.

Associated Activities:

- Ship tender operations
- Manual off-loading of cargo from tender

Mitigation

- The cargo delivery will be undertaken a quickly as feasible and safe.
- Construction staff will try to keep noise to a minimum.

Monitoring

- The long-term monitoring of nesting skuas at Rothera will continue by BAS scientists throughout the season and will help to identify the longer-term impact of these activities on nesting success.

9.4.1.3 Fuel or hazardous substance release

There is potential for pollution to the local environment (marine and terrestrial) through the use of fuels and hazardous substances. This could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste will be generated if absorbents are used as a result of a spill.

Associated Activities:

- Ship tender operations

Mitigation:

- The tender will return to the SDA for refuelling, where it will occur in accordance with SDA marine standing instructions (MSI).
- All construction staff to receive spill response training.
- Rothera Oil Spill Contingency Plan to be followed for all spills.
- All spills shall be reported to the Rothera Station Leader, BAS Environment Office and reported on Maximo

9.4.1.4 Disturbance to native flora & fauna

Tender operation has the potential to cause disturbance, injury or fatality to local seals and birds resulting in avoidance/stress behaviour or a fatality should a boat strike occur. It may also be necessary (although unlikely) that seals may be occupying the construction site prior to cargo offload.

Associated Activities:

- Ship tender operation
- Manual off-loading of cargo from tender
- Storage of cargo on the beach

Mitigation:

- All construction staff to receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife.
- Only trained personnel will be involved in the displacement of seals which by their presence are stopping or delaying the progress of works. Training will be provided onsite by an appropriately trained member of BAS staff.
- Tender crew and workers on land to remain vigilant for birds and marine mammals in the water at all times, and slow or stop the tender as necessary.
- Tender crew and works on land to remain vigilant for freshwater ponds terrestrial vegetation and avoid trampling impacts.

Monitoring:

- Long term skua monitoring to continue throughout construction programme by BAS staff.

9.4.2 Impacts of construction activities

9.4.2.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Site set up and presence of construction personnel
- Jackpad use and concrete plinth casting (if required)
- Operation of portable generator to recharge battery operated hand tools
- Embedded carbon associated with the construction materials

Mitigation:

- Regular weekly inspection and maintenance will be carried out to ensure the generator operates efficiently.
- No mitigation has been provided for the emissions associated with the production of the concrete plinths.

9.4.2.2 Cement dust

Cement dust, produced as a result of casting the concrete plinths, may have a negative impact upon any local terrestrial environments and vegetation.

Associated Activities:

- Concrete plinth casting

Mitigation

- The smallest size of plinth suitable for the purpose would be constructed (450 x 450 x100 mm – six in total)
- To prevent dust release, pre-mixed bagged concrete to be used.
- If the hut is to be disassembled at a later date, the small precast concrete plinths can be taken up by hand and removed from the site.

9.4.2.3 Noise pollution (Direct/Cumulative)

Noise produced as a result of construction activities has the potential to disturb local wildlife potentially resulting in avoidance or stress behaviour and nest abandonment.

Associated Activities:

- Erection of steelworks and hut
- Installation of cladding & roof panels
- Operation of the portable generator

Mitigation

- Construction staff will try to keep construction noise to a minimum. Shouting will be kept to a minimum, as will use of handheld power tools and use of the portable generator.
- Where possible, power tool batteries will be charged overnight at Rothera Research Station. If required, portable generators will be operated for the minimum time possible.

Monitoring

- The long-term monitoring of nesting skuas at Rothera will continue by BAS scientists throughout the season and will help to identify the longer-term impact of these activities on nesting success.

9.4.2.4 Handling of waste (Direct)

The construction project will generate very small quantities of waste (c. 100 kg) that will need to be sent to landfill and other appropriate disposal. There is also an increased risk of waste being released into the local environment if suitable waste management procedures are not followed. Construction workers may need to urinate when working at the site.

Associated Activities:

- Site set up and presence of construction personnel
- Installation of cladding and roof panels

Mitigation:

- The BAS Waste Management Handbook will be followed for all waste.
- Pre-deployment training on waste management will be provided
- Daily checks will ensure waste is contained to avoid wind blow and no waste left on site at the end of the working day
- All construction waste will be returned to the UK and disposed of by licensed contractors.
- Packaging will be minimised where possible prior to consigning cargo south.
- Human waste shall not be disposed of at the site. Toilets are available at Rothera Research Station. In emergencies, the construction personnel shall use a 'pee bottle' and dispose of the urine at the station.

Monitoring:

- Disposal routes of waste will be recorded as and when waste is returned to the UK. The waste will be included in the overall waste statistics gather for the station.

9.4.2.5 Light pollution (Direct)

The use of artificial light in low light or during the hours of darkness could attract birds and lead to bird strikes, injury or fatalities.

Associated Activities:

- Site set up & presence of construction personnel

Mitigation:

- No construction work shall be undertaken after dark, so no lights will be used
- Rothera Station Leader and BAS Environment Office to be informed should there be any bird strikes

Monitoring:

- Any bird strikes will be recorded on the BAS Incident Reporting System, i.e., MAXIMO.

9.4.2.6 Physical disturbance on land (Direct & Cumulative)

There is the potential for disturbance of ground surfaces due to increased human activity in the vicinity of the construction site.

Associated Activities:

- Site set up & presence of construction personnel
- Jackpad use and concrete plinths (if required)
- Provision of electrical services (cable from station)

Mitigation:

- Construction team to limit their activities to the areas immediately around the hut
- No landscaping of ground surface prior to construction
- The electrical cable from the station to the hut shall not be buried and shall remain above ground.
- Surplus cable will be supplied to allow for re-routing should the skua nest positions have changed by the time the cable is to be installed. The laying of the cable shall only be undertaken following consultation with the Bonner Laboratory Manager (who undertakes the routine skua monitoring at Rothera Point) and a site visit to identify a route for the cable that will avoid skua next to the maximum extent practicable.

Monitoring:

- The long-term monitoring of nesting skuas at Rothera will continue by BAS scientists throughout the season and will help to identify the longer-term impact of these activities on nesting success.

9.4.2.7 Fuel or hazardous substance release (Direct, indirect & cumulative)

There is potential for pollution to the local environment (marine and terrestrial) through the use of fuels and hazardous substances during construction. This could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste will be generated if absorbents are used as a result of a spill.

Associated Activities:

- Fuel management & refuelling
- Operation of the portable generator

Mitigation:

- Refuelling will be carried out by trained personnel in line with station refuelling procedures (e.g., including the use of drip trays during refuelling, and plant nappies on generators).
- Spill kits will be provided
- All construction staff to receive spill response training.
- Rothera OSCP to be followed for all spills
- All spills shall be reported to the Rothera Station Leader and BAS Environment Office and reported using the BAS Incident Reporting System (MAXIMO).

9.4.2.8 Disturbance to native flora & fauna

Construction activities have the potential to cause disturbance, injury or fatality to local seals and birds resulting in avoidance/stress behaviour and nest abandonment.

Associated Activities:

- Site set up and presence of construction personnel
- Provision of electrical services (cable from station)

Mitigation:

- All construction staff to receive pre-deployment and on-station briefings regarding wildlife viewing, working close to wildlife and minimising trampling of vegetation.
- Only trained personnel will be involved in the displacement of seals which by their presence are stopping or delaying the progress of works. Training will be provided onsite by an appropriately trained member of BAS staff.

Monitoring:

- Long term skua monitoring to continue throughout construction programme by BAS staff.

9.4.2.9 Visual impacts (Direct)

The construction activities associated with the construction are anticipated to have a visual impact in the short term with the presence of construction personnel and equipment.

Associated Activities:

- Erection of steelworks
- Installation of cladding and roof panels

Mitigation:

- Construction activities will be confined to the site and undertaken a quickly as is feasible and safe.

9.4.3 Impacts of support activities

9.4.3.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Shipping cargo to Rothera
- Transport of personnel to Rothera
- Provision of accommodation, power and domestic services

Mitigation:

- Due to the limited number of available beds on station only staff essential to the construction of the hut will be sent to Rothera.
- Economic and operational constraints on shipping cargo will also be employed and a rationalisation of what equipment will be needed has been undertaken.

- All staff on station will be briefed on using energy efficiently whilst on station including short minute showers, minimising water usage and switching of power and lights when not needed.

Monitoring:

- Data will be collected concerning the contribution to atmospheric pollution from the deployment of personnel and cargo.

9.4.3.2 Non-native species introduction (Indirect)

Non-native species may be imported unintentionally to Rothera and the local vicinity in association with equipment and general cargo. Introduced species may become established in ice-free areas with negative impacts upon local ecosystem structure and function, endemic species and associated scientific research.

Associated Activities:

- Shipping cargo to Rothera
- Transport of personnel to Rothera

Mitigation:

- All personnel being deployed to Rothera will receive a pre-deployment briefing from a member of the BAS Environment Office, which will cover biosecurity, waste management, oil spill response and wildlife interactions.
- All activities will be undertaken in accordance with the BAS Biosecurity Regulations (compiled with reference to the CEP Non-native Species Manual).
- All equipment, materials and personal belongings will be checked prior to loading onto the vessel and on disembarkation/offloading at Rothera.
- The following requirements will be placed in all plant and equipment to be shipped to Rothera:
    - All re-usable containers will be thoroughly cleaned and lined with plastic sheeting.
    - No polystyrene or organic packaging material, including hay straw or wood shavings, will be used.
    - All wood packaging and wood products will be new and comply with ISPM 15[1].
    - Openings in structural members will be sealed.
    - Containers will be cleaned and fumigated.
- All equipment and materials required for the proposed activity will be thoroughly cleaned before dispatch to Antarctica.
- Should soil, seeds or propagules be imported unintentionally, they must be carefully collected and removed. Rodents and insects must be exterminated immediately. Disposal may include incineration at Rothera or removal from Antarctica.
- The Rothera Station Leader and the BAS Environment Office must be informed within 48 hours if a biosecurity incident occurs and it shall be reported on the BAS Incident Reporting System (MAXIMO).

[1] ISPM 15 is an International Phytosanitary Measure that directly addresses the need to treat wood materials of a thickness greater than 6mm. Its main purpose is to prevent the international transport and spread of disease and insects that could negatively affect plants or ecosystems.

9.5 Post construction/operation of new hut

9.5.1.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Day to day operation of the hut (science)

Mitigation:

- The power requirement has been reduced to the minimum possible while still delivering the science need.

9.5.1.2 Waste (Direct)

Those working within the hut will generate a small quantity of non-hazardous waste. Butanol is used in the scanning mobility particle sizer housed in the hut, and it expected that around 1L of hazardous butanol waste will be produced every week. Occupants of the hut may need to go to the toilet.

Associated Activities:

- Day to day operation of the hut (science)

Mitigation:

- Hazardous and non-hazardous waste will be disposed of through existing waste streams on station and in accordance with the BAS Waste Management Handbook.
- Waste butanol (c. 1 litre) will be moved to the station in a polyethene (unbreakable) container every week for disposal.
- Human waste shall not be disposed of at the site. Toilets are available at Rothera Research Station. In emergencies, the hut occupant shall use a 'pee bottle' and dispose of the urine at the station.

Monitoring:

- All quantities and final disposal routes for BAS generated waste will be captured in the annual waste statistics.

9.5.1.3 Light pollution (Direct)

The use of artificial light in low light or during the hours of darkness could attract birds and lead to bird strikes, injury or fatalities. The lidar uses a relatively low power eye safe (ANSI Z136.1 2000, IEC 60825) laser and there should be no associated environmental impacts on birdlife.

Associated Activities:

- Day to day operation of the hut (science)

Mitigation:

- Blinds shall be installed on the two hut windows for use at dusk and after dark
- Rothera Station Leader and BAS Environment Office to be informed should there be any bird strikes. Any incident shall be reported on the BAS Incident Reporting System (MAXIMO)

Monitoring:

- Any bird strikes will be recorded on the BAS incident reporting system and Bird Strike Log.

9.5.1.4 Physical presence and use of space (Direct)

The new hut will be 2.2m (width) x 4.5m (length) x 3.1m. It will be the only building on East Beach, albeit there are antennae masts in the area.

Associated Activities:

- Day to day operation of the hut (science)

Mitigation:

- The size of the building has been kept to the minimum required to deliver the science needs.

9.5.1.5 Visual (Direct)

The aesthetic values at East Beach will alter with the construction of the new hut.

Associated Activities:

- Day to day operation of the hut (science)

Mitigation:

- The size of the building has been kept to the minimum required to deliver the science needs.
- The building will be a soft green, in an attempt to blend into the environment, and as used in other buildings on Rothera Point.

9.6 Evaluation of the Environmental Impacts

9.6.1 Methodology

The potential environmental impacts associated with the Rothera Modernisation project have been identified. This section evaluates those impacts in order to identify both the significance and risk of the impact occurring.

In order to evaluate the overall significance, each potential impact has been assessed against the following criteria:

- extent of impact – area or volume where changes are likely to be detectable;
- duration of impact - time period during which changes are likely to occur;
- probability of the impact occurring; and
- severity of the impact if it were to occur - a measure of the amount of change on the environment which also considers the resilience of the environment and its ability to recover from the impact.

Each criterium for each impact is given a score from 1 – 5 to identify whether it is considered 'very low', 'low', 'medium', 'high' or 'very high'. Figure 9-3 provides an explanation and definition of the scale used.

Figure 9-2 Evaluation of impact significance

Impact Criteria	**Definition of Scoring Values**				
	Very Low (VL) 1	**Low (L) 2**	**Medium (M) 3**	**High (H) 4**	**Very High (VH) 5**
Extent of Impact	Site specific: Confined to the construction site, specific asset or laydown areas	Local: Confined to Rothera Point and local marine environment	Regional: Northwest Antarctic Peninsula (Biogeographic region)	Continental: Antarctica and Southern Ocean south of 60°S	Global: Earth and atmosphere
Duration of Impact	Minutes to days	Weeks to months	Several seasons to several years	Decades	Centuries to millennia
Probability of Impact	Very unlikely to occur under any circumstance	Unlikely to occur under normal operations & following standard BAS procedures	Possible if standard BAS or project specific procedures are not followed.	Probable. Likely to occur during the project.	Unavoidable. Certain to occur
Significance/Severity of Impact	No direct impact on the environment and local ecosystems. Recovery is definite.	Impacts may occur but are less than minor or transitory. Reversible in the short term.	Changes to the environment and local ecosystem are minor or transitory. Recovery is likely.	Changes to environment and local ecosystem are greater than minor or transitory. Recovery is slow and uncertain.	Major changes to the environment and local ecosystem which are irreversible, certain to occur and unavoidable. Recovery unlikely.

9.6.2 Risk Scoring

Once the significance criteria have been scored for each impact, this is then used to calculate the overall risk score by using the following calculation:

Risk Score = Extent x duration x probability x severity

By multiplying the value of each criterion, a risk score between 1 and 625 is produced. This is repeated after the mitigation measures have been implemented to allow for a comparison and to demonstrate whether the mitigation measures have resulted in a reduction of the risk score. The higher the number the greater the environmental risk of the impact. The risk score values have been split into categories of impact and colour coded for ease of identification. As presented in the table below, they are aligned to the three levels of impact significance identified in Article 8(1) of the Environmental Protocol.

Figure 9-3 Risk Score & Description

Description	Risk Score	Ref Article 8(1) of the Environmental Protocol
Impact acceptable and will be managed through normal operating procedures and outlined mitigation measures	1-60	Less than minor or transitory
Impact needs active management through mitigation measures and monitoring	61 -120	No more than minor or transitory
Impact significant. If no practical mitigation measures are possible then BAS senior management must decide whether to accept the risk.	121 – 625	More than minor or transitory

9.6.3 Risk Response

Aligned with the risk score, a risk response has been identified for each impact. Three different overarching responses are identified:

- Avoid – apply mitigation so that the impact does not occur
- Reduce – apply mitigation to reduce the risk of the impact occurring
- Accept – acceptance of the risk of the impact occurring with no further mitigation

Where 'avoid' or 'reduce' have been assigned to an impact, the response should involve applying the normal operating procedures and mitigation measures in order to eliminate or reduce the risk. The risk score is then recalculated. Where there are no practical mitigation measures for an impact the response can only be 'accept'. Therefore, if the activity is undertaken, the resulting impact must be accepted.

9.7 Impact Matrix

9.7.1 Transportation of construction material to East Beach																	
No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
	• Transportation of the construction material on the SDA • Ship tender operations	Atmospheric pollution	Minor but cumulative contribution to regional and global atmospheric pollution.	Direct/ Cumulative	5	2	5	2	100	Reduce	• The ship and tender are new and has modern and efficient engines. • Regular inspection and maintenance will be carried out to ensure tender engines operate efficiently. • The cargo delivery will be undertaken as quickly as feasible and safe.	5	2	4	2	80	No more than minor or transitory
	• Ship tender operations • Manual off-loading of cargo from tender	Noise	Disturbance, injury or fatality to local seals and birds resulting in in avoidance or stress behaviour, nest abandonment or hearing damage.	Direct	1	3	3	2	18	Reduce	• The cargo delivery will be undertaken as quickly as feasible and safe. • Construction staff will be instructed to keep noise to a minimum. Minimise shouting, use of powered hand tools and the portable generator.	1	2	3	2	12	Less than minor or transitory
	• Ship tender operations	Fuel or hazardous substance release	Pollution to local environment. Mortality to marine and terrestrial flora & fauna. Secondary contamination to birds if ingested.	Direct, indirect & cumulative	2	3	3	3	54	Reduce	• The tender will return to the SDA for refuelling, where it will occur in accordance with standard protocols. • All construction staff to receive spill response training. • Rothera station spill response plans to be followed for tier 1 spills • Rothera OSCP to be followed for tier 2 or 3 spills • All spills reported to Rothera Station Leader & BAS Environment Office	2	3	2	2	24	Less than minor or transitory

	• Ship tender operation • Manual off-loading of cargo from tender	Disturbance to native flora and fauna	Tender operation has the potential to cause disturbance, injury or fatality to local seals and birds resulting in avoidance/stress behaviour or a fatality should a boat strike occur. It may also be necessary (although unlikely) that seals may be occupying the construction site prior to cargo offload.	Direct/ Cumulative	2	1	4	2	16	Reduce	• All construction staff to receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife. • Only trained personnel will be involved in the displacement of seals which by their presence are stopping or delaying the progress of works. Training will be provided onsite by an appropriately trained member of BAS staff. • Tender crew and workers on land to remain vigilant for birds and marine mammals in the water at all times, and slow or stop the tender as necessary • Tender crew and works on land to remain vigilant for freshwater ponds terrestrial vegetation and avoid trampling impacts.	2	1	3	2	12	Less than minor or transitory

9.7.2 Construction activity Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
1.	• Site set up and presence of construction personnel • Concrete plinth casting • Operation of portable generator to recharge battery operated hand tools	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution.	Direct/ Cumulative	1	2	5	2	20	Reduce	• Generator will be selected which balance efficiency & reduced emissions. • Regular weekly inspection and maintenance will be carried out to ensure the generator operates efficiently. • No on-site mitigation has been provided for the emissions associated with the production of the concrete foundations, steel works or other construction materials. • Embedded carbon associated with the construction materials	1	2	4	2	16	Less than minor or transitory
2.	• concrete plinth casting	Pollution	Increased alkalinity of soils with negative impact upon vegetation	Direct/ Cumulative	1	3	3	3	27	Reduce	• The smallest size of plinth suitable for the purpose would be constructed (450 x 450 x100 mm) • To prevent dust release, pre-mixed bagged concrete to be used on. • If the hut is to be disassembled at a later date, the small precast concrete plinths can be taken up by hand and removed from the site.	1	2	2	2	8	Less than minor or transitory

9.7.2 Construction activity Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
3.	• Erection of steelwork and hut • Operation of the portable generator to recharge battery operated hand tools	Noise	Disturbance to local seals and birds resulting in avoidance behaviour, nest abandonment.	Direct/ Cumulative	2	2	3	2	24	Reduce	• Construction staff will try to keep construction noise to a minimum. Shouting will be kept to a minimum, as will use of handheld power tools and use of the portable generator. • To avoid use of generators, where possible, power tool batteries will be charged overnight at Rothera Research Station. If required, portable generator will be operated for the minimum time possible.	1	2	3	2	12	Less than minor or transitory
4.	• Site set up & presence of construction personnel • Installation of cladding & roof panels	Waste	Increased waste sent to landfill. Pollution of local environment.	Direct	2	2	3	3	36	Reduce	• The Project Manager will be present on site and advise which of the building's contents are either waste or materials to be retained. • The BAS Waste Management Handbook will be followed for all waste. • Pre-deployment training on waste management will be provided • Daily checks will ensure waste is contained to avoid wind blow and no waste will be left on site at the end of the working day. • Dedicated area for storing and segregating waste will be provided. • All construction waste will be returned to the UK and disposed of by licensed contractors. • Packaging will be minimised where possible prior to consigning cargo south. • Human waste shall not be disposed of at the site. Toilets are available at Rothera Research Station. In emergencies, the construction personnel shall use a 'pee bottle' and dispose of the urine at the station.	1	2	2	2	8	Less than minor or transitory
5.	• Site set up & presence of construction personnel	Light pollution	Bird strikes, injury or fatalities.	Direct	1	2	3	3	18	Reduce	• No construction work shall be undertaken after dark • Rothera Station Leader and BAS Environment Office to be informed should there be any bird strikes	1	1	1	2	2	Less than minor or transitory
6.	• Jackpad use and concrete plinths (if required) • Provision of electrical services (cable from station)	Physical presence & use of space	Disturbance of ground surfaces due to increased human activity in the vicinity of the construction site.	Direct, indirect & cumulative	2	2	5	3	60	Reduce	• Construction team to limit their activities to the areas immediately around the hut • No landscaping of ground surface prior to construction	2	2	5	2	40	Less than minor or transitory

9.7.2 Construction activity Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
											• The electrical cable from the station to the hut shall not be buried and shall remain above ground • Surplus cable will be supplied to allow for re-routing should the skua nest positions have changed by the time the cable is to be installed. • The laying of the cable shall only be undertaken following consultation with the Bonner Laboratory Manager (who undertakes the routine skua monitoring at Rothera Point) and a site visit to identify a route for the cable that will avoid skua next to the maximum extent practicable.						
7.	• Fuel management & refuelling • Operation of the portable generator	Fuel or hazardous substance release	Pollution to local environment. Mortality to flora & fauna. Secondary contamination to birds if ingested.	Direct, indirect & cumulative	1	3	3	3	27	Reduce	• Refuelling will be carried out by trained personnel in accordance with station refuelling procedures (e.g., including the use of drip trays during refuelling, and plant nappies on generators) • Spill kits will be provided • All construction staff to receive spill response training • Rothera Research Station oil spill response plans to be followed for tier 1 spill • All spills reported to Rothera Station Leader & BAS Environment Office and reported using the BAS Incident Reporting System (MAXIMO)	1	3	2	3	18	Less than minor or transitory
8.	• Site set up and presence of construction personnel • Provision of electrical services (cable from station)	Disturbance to native flora and fauna	Disturbance to local seals and birds resulting in avoidance behaviour, nest abandonment.	Direct	2	2	3	3	36	Reduce	• All construction staff to receive pre-deployment and on-station briefings regarding wildlife viewing, working close to wildlife and minimising trampling of vegetation • Only trained personnel will be involved in the displacement of seals which by their presence are stopping or delaying the progress of works. Training will be provided onsite by an appropriately trained member of BAS staff.	2	2	2	2	16	Less than minor or transitory
9.	• Erection of steelworks • Installation of cladding and roof panels	Visual	Visual change to the built and natural landscape altering aesthetic value of Rothera.	Direct/ Cumulative	1	2	5	3	30	Accept	• Construction activities will be confined to the site and undertake as quickly as is feasible and safe.	1	2	5	3	30	No more than minor or transitory

9.7.3 Support activity Impacts																	
No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
1.	• Shipping cargo to Rothera • Transport of personnel to Rothera • Provision of accommodation, power, & domestic services	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution. Heavy metal and particulate fallout	Direct/ Cumulative	3	2	5	2	60	Accept	• Only staff essential to the construction of the hut will be deployed to Rothera. • Rationalisation of equipment shipped to station to be undertaken. • All staff will be briefed on energy efficiency whilst on station.	3	2	5	2	60	Less than minor or transitory
3.	• Shipping cargo to Rothera • Transport of personnel to Rothera	Non-native species introduction	Non-native species introduced & established altering local ecosystem. Increased risk to endemic species. Impact on future science.	Indirect	2	4	3	4	96	Reduce	• All staff to attend biosecurity briefing at pre deployment training • All personnel to comply with BAS Biosecurity Regulations. • All cargo to be biosecurity checked prior to consignment and on arrival at Rothera • Personal items of clothing to be cleaned and checked before deployment • Should soil, seeds or propagules be imported unintentionally, they must be carefully collected and removed. Rodents and insects must be exterminated immediately. Disposal may include incineration at Rothera or removal from Antarctica. • The Rothera Station Leader and the BAS Environment Office must be informed within 48 hours if a biosecurity incident occurs and it shall be reported on the BAS Incident Reporting System (MAXIMO)	2	4	2	4	64	No more than minor or transitory

9.7.4 Post construction operation of the building																	
No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
1.	• Operational impacts of the new hut	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution.	Direct/ Cumulative	1	4	5	3	60	Reduce	• The power requirement has been reduced to the minimum possible while still delivering the science need.	1	4	5	2	40	Less than minor or transitory
2	• Operational impacts of the new hut	Waste	Increased waste sent to landfill. Pollution of local environment.	Direct	1	4	5	2	40	Reduce	• Hazardous and non-hazardous waste will be disposed of through existing waste streams and in accordance with the BAS Waste Management Handbook. • Waste butanol (c. 1 litre) will be moved to the station in a polyethene (‘unbreakable’) container every week. • Human waste shall not be disposed of at the site. Toilets are available at Rothera Research Station. In emergencies, the hut occupant could use a ‘pee bottle’, or equivalent, and dispose of the urine at the station.	1	4	5	1	20	Less than minor or transitory
3	• Operational impacts of the new hut	Light emissions	Disorientation of birds causes strikes resulting in injury or mortality	Direct	1	4	3	3	36	Reduce	• Blinds shall be installed on the two hut windows for use at dusk and after dark • Rothera Station Leader and BAS Environment Office to be informed should there be any bird strikes. Any incident shall be reported on the BAS Incident Reporting System (MAXIMO)	1	4	2	3	24	Less than minor or transitory
4	• Operational impacts of the new hut	Physical presence & use of space	The new building will be the only building on East Beech.	Direct	1	4	5	3	60	Accept	• The size of the building has been kept to the minimum required to deliver the science need.	1	4	5	3	60	Less than minor or transitory
5.	• Operational impacts of the new hut	Visual	Visual change to the landscape altering aesthetic value of Rothera Point	Direct/ cumulative	2	4	5	3	120	Accept	• The size of the building has been kept to the minimum required to deliver the science need. • The building will be a soft green, in an attempt to blend into the environment, and as used on other buildings on Rothera Point.	2	4	5	3	120	No more than minor or transitory

9.8 Cumulative Impacts

Cumulative impacts are the combined impacts of past, present and reasonably foreseeable activities which may occur over time and space and be interactive (ATS, 2016). When considered in this wider context of other actions, an activity may result in a potentially significant impact that may occur over a longer period of time, at a particular location and in conjunction with other events.

Rothera Point has been used operationally since 1975 and has been developed and expanded ever since. The proposed works will increase the overall footprint of the current station to a small degree.

Potential cumulative impacts resulting from the East Beach Hut construction project relate to the long term use of the hut for scientific activity, including, use of electrical energy and associated emissions, on-going minor disturbance of wildlife and tramping of the very limited terrestrial biodiversity present at the site. A potentially more significant impact related to the opening up of East Beach to the construction of building infrastructure, where none had existed previously. Other potential projects, of possibly a larger spatial scale, may also be targeted for the East Beach areas, including the construction of wind turbines, or the quarrying of rock for station modernisation projects. The potential cumulative impact upon the area's wilderness and aesthetic values could be substantial.

10 MONITORING

Article 5 of Annex I to the Environmental Protocol explicitly requires appropriate monitoring of key environmental indicators to be put in place to assess and verify the predicted impacts following completion of a CEE, although it is good practice to put in place monitoring associated with projects at IEE level. It states that monitoring needs to "*be designed to provide regular and verifiable records of the impacts of the activity*" (Article 5(2)) and to *"provide information useful for minimising or mitigating impacts, and, where appropriate, information on the need for suspension, cancellation or modification of the activity"* (Annex I, Article 5, (2) (b) Environmental Protocol, 1991). Provision should also be made for regular and effective monitoring to be in place to facilitate early detection of possible unforeseen effects of activities (Article 3 (2) (e) Environmental Protocol, 1991).

The main impacts identified in this assessment for which there are key environmental indicators include the contamination of the terrestrial environment and wildlife displacement.

The monitoring tasks are split into three types of activities;

1. Short term monitoring of activities which could result in an immediate impact on the environment and can be modified during the construction programme to avoid adverse effects. This will include monitoring incident of wildlife displacement

2. Monitoring of environmental parameters which may reflect impacts that can only be measured in the long term (i.e., over several Antarctic seasons) and subsequently are unlikely to be modified beyond the original mitigation identified in the EIA. This will include monitoring of Skua breeding success on Rothera Point

Any changes to activities proposed as a result of the monitoring data, will be made by the Project Manager in conjunction with the BAS Environment Office. All monitoring data will be communicated to the BAS Environment Office.

Figure 10-1 Environmental Management Activities

Environmental Management Activity	Reporting Output
Waste Management: segregation, packaging, storage and disposal of waste as per the BAS Waste Management Handbook	▪ Waste Data (which will be a composite of all Rothera waste data)
Biosecurity: Adherence to the BAS Biosecurity Regulations at all stages of cargo and personnel movement. Upon arrival at Rothera, all cargo will be re-inspected either on board the SDA. All inspections will be recorded and any incursions reported to BAS Environment Office.	▪ Biosecurity breaches reported
Fuel Management: daily refuelling as per refuelling procedure.	▪ Training records of staff ▪ Fuel spills reported ▪ Station wide fuel consumption for carbon accounting
Oil Spill response: The Project Manager will respond to all Tier 1 spills and follow the direction of Rothera Station Leader for all Tier 2 and Tier 3 spills.	▪ Fuel spills reported ▪ Spill kits used and disposed of appropriately
Emissions when hut in use: The energy consumption of the equipment within the hut is less than 2.5 kWh. Therefore, the annual energy consumption will be less than 21,900 kWh. This equates to 6.7 tonnes of CO_2, using a CO_2 emission factor of 0.309 kge / kWh.	▪ Meters shall be installed in the hut to record electrical energy consumption.

In addition, BAS will continue to monitor waste statistics and fuel use for carbon accounting, e.g., flights, ships, etc., which will be reported annually to the FCDO as the UK competent authority.

11 GAPS IN KNOWLEDGE & UNCERTAINTIES

11.1 Site setup locations and logistics

The precise location of the hut (within an area of c. 20 m radius of coordinates 67° 34’ 09’’ S, 68° 06’ 53’’ W) has been identified indicatively in Figures 3.4. Further discussions will be undertaken with BAS Operations to finalise and agree the location once the full site logistics are fully committed and developed prior to the start of the construction work.

11.2 Construction activities

It has yet to be determined whether or not the Jackpad system will be sufficient to support the hut alone, or whether six small concrete plinths will need to be constructed. Further discussions will be undertaken with BAS Operations to finalise and agree the best method once the precise location is determined.

11.3 Funding to facilitate on-going use of the hut

Funding for the science for which the hut is being constructed has only been secured for 3 years. However, it is anticipated that further funding will be forthcoming for on-ging use of the hut. The design life of the hut is intended to be at least 25 years, but if funding is not forthcoming, the hut will be completely removed.

12 CONCLUSIONS

The East Beach Hut construction project is an essential project for BAS to be able to undertake atmospheric research on Rothera Point.

The proposed plans largely avoid areas of ecological sensitivity.

A full assessment of the potential environmental impacts is included in this IEE. Most of the impacts can be managed within existing BAS procedures or with the addition of specific mitigation and monitoring.

The most significant potential impacts predicted for the activities are:

- Atmospheric emissions associated with the transportation of building materials to Rothera
- Introduction of non-native species
- Physical presence and disturbance impacting wildlife and vegetation
- Impacts on the longer-term wilderness and aesthetic values of East Beach

The introduction of non-native species as a result of importing cargo or the deployment of personnel could have a significant impact in the longer term, but these impacts are less likely if standard operational procedures and enhanced mitigation measures are followed.

The likelihood of impacts occurring that are associated with the physical presence and physical disturbance created by the construction works are low due to the small scale of the hut.

Impacts to wilderness and aesthetic values due to the construction process may be significant but short-lived. The scale of the project has been kept to a minimum to limit the impact upon aesthetic and wilderness values.

The most significant potential impacts predicted for the operation of the new building post construction are:

- Physical presence and use of space
- Visual and aesthetic change

The scale of the hut shall be kept to the minimum required to deliver an effective science programme. However, the hut will have an impact on wilderness and aesthetic values and potentially have a cumulative impact by opening up development on East Beach.

Having prepared this IEE along with rigorous mitigation measures to reduce the risk of the predicted impacts occurring, it is considered that the proposed activities will have **no more than a minor or transitory impact**.

13 AUTHORS

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14 ACKNOWLEDGEMENTS

Expert contributors to the Baseline Section include the following BAS personnel; Steve Colwell, Peter Convey, Rosey Grant, Laura Gerrish, Ieuan Hopkins, Louise Ireland, Anna Malaos, Teal Riley, Helen Peat, Richard Phillips, Andrew Smith and Iain Staniland. Detail on facilities management at Rothera was provided by Connor Grange and Alexander Coniff. Information on the science activities were supplied by Tom Lachlan-Cope.

This IEE has been reviewed internally at BAS by Rachel Clarke.

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17. APPENDICES

Appendix 1. Schedule of components for the British Antarctic Survey, East Beach hut, Rothera Research Station

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
JACKPAD FOUNDATION BASES					
	Support Blocks – Plastic	360 x 360 x 80	7.00	6	42.00
	Adjusters & U Heads Galvanised Steel	200 x 200 x 180	14.30	6	85.80
	Incremental Packing - Plastic	450 x 450 x 50	8.50	72	612.00
	Laser Cut Spanner	600 long	6.00	1	6.00
STEEL BASE FRAME - GALVANISED					
	Beam 152 x 152 UC with fabricated projecting brackets **B1 & B3**	2428 x 152 x 152	65.87	2	131.74
	Beam 152 x 152 UC with fabricated projecting brackets **B2 & B4**	2428 x 152 x 152	70.32	2	140.64
	150 x 75 PFC Channel with projecting end plates **B5 & B6**	1862 X 150 X 75	41.34	2	82.68
	76 dia. CHS Braces	1 @ 2500 x 76 dia. 1 @ 2000 x 76 dia.	Weight of 2 No. – 29.86	2	29.86
	Flat Fish Plates	400 x 110 x 12	2.24	4	8.96
	Brace for underside 50 x 50 angle	2680 x 50 x 50	10.57	1	10.57
				PAGE TOTAL:	**1150.25**

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
	Galvanised nuts, bolts, washers and set screws for Base Frame	-	-	2 Bags	9.00
	Galvanised Bow Shackles B.S. 3032 SWL 2.00T	¾" x 35mm x 86mm	3.18	6	19.08
	Temporary spreader for steel base frame assembly – timber and plywood	2160 x 95 x 54	4.27	1	4.27
		SUB TOTAL OF STEEL FRAME 436.80 kg			
GALVANISED L SHAPED BRACKETS					
	Mild Steel brackets 60 x 6 Section – Wall panel holding down.	280 x 100 L Shape	1.12	28	31.36
	Mild Steel brackets 120 x 4 Section – Roof Panel holding down.	250 x 120 L Shape	1.46	11	16.06
	Mild Steel brackets 90 x 4 Section – Roof Panel holding down.	250 x 90 L Shape	1.09	7	7.63
		SUB TOTAL OF GALVANISED BRACKETS 55.05kg			
				PAGE TOTAL:	**87.40**

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
LOWER FLOOR					

Panels 17 & 18	Floor Deck – Plywood with metal framing with sole plates fixed to top.	2226 x 1152 x 248	87.49	2	174.98
Panel 16	Floor Deck – Plywood with metal framing with sole plates fixed to top.	2226 x 1152 x 248	108.32	1	108.32
Panel 19	Floor Deck – Plywood with metal framing with sole plates fixed to top.	2226 x 1152 x 248	102.59	1	102.59
OVERLAY FLOOR DECKS					
Panels 20, 21, 22, 23	Floor deck – plywood and timber.	2161 x 1016 x 95	48.11	4	192.42
WALL PANELS					
Panels 1 & 2	Wall panel – plywood with metal and timber framing.	2611 x 1032 x 125	78.89	2	157.78
Panels 3 & 7	Wall panel – plywood with metal and timber framing.	2560 x 1110 x 125	94.47	2	188.94
Panel 4	Wall panel – plywood with metal and timber framing.	2560 x 864 x 125	69.71	1	69.71
Panel 5	Wall panel – plywood with metal and timber framing.	2560 x 771 x 125	47.35	1	47.35
Panel 6	Wall panel – plywood with metal and timber framing **WITH WINDOW**.	2560 x 864 x **235**	82.97	1	82.97
Panel 10 & 15	Wall panel – plywood with metal and timber framing.	2611 x 1110 x 125	97.93	2	195.86
Panel 11	Wall panel – plywood with metal and timber framing.	2611 x 864 x 125	71.00	1	71.00
				PAGE TOTAL:	**1391.92**

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
Panel 14	Wall panel – plywood with metal and timber framing **WITH WINDOW**.	2611 x 864 x **235**	83.47	1	83.47
Panel 12	Wall panel – plywood with metal and timber framing.	2611 x 771 x 125	48.04	1	48.04
Panel 8	Wall panel – plywood with metal and timber framing.	2611 x 838 x 125	68.53	1	68.53
Panel 9	Wall panel – plywood with metal and timber framing.	2611 x 1180 x 125	73.13	1	73.13
Cill Fabrication	Timber, plywood & S.S. Facing. Fits onto wall panel 9.	850 x 525 x 302	33.21	1	33.21
ROOF PANELS					
Panel 24	Roof panel in plywood, metal and timber framing and with GRP roof finish applied.	2746 x 1262 x 401	165.68	1	165.68
Panels 25 & 27	Roof panel in plywood, metal and timber framing and with GRP roof finish applied.	2746 x 819 x 326	101.41	2	202.82
Panel 26	Roof panel in plywood, metal and timber framing and with GRP roof finish applied.	2746 x 726 x 401	114.40	1	114.40
Panel 28	Roof panel in plywood, metal and timber framing and with GRP roof finish applied.	2746 x 1262 x 401	155.98	1	155.98

Doorset	Steel faced timber doorframe with steel faced insulated door – projecting ironmongery.	2300 x 1150 x 245 o/a	90	1	90.00
	Plywood box enclosing Heat Trace Transformer	280 x 230 x 230	10.00	1	10.00
Perimeter Base Covers	30mm thick Birch plywood pieces	2400 x 316 x 30	15.96	6	95.76
				PAGE TOTAL:	**1141.02**

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
Plywood make-ups at bottom of wall panels	12mm thick Birch plywood bundled together.	1053 x 245 x 168	26.88	1 Bundle	26.88
Internal wall and ceiling covers	9mm thick Birch plywood bundled together.	2440 x 115 x 162	31.82	1 Bundle	31.82
LOOSE TIMBERS					
Skirting & Wall ceiling cover.	PAR Redwood	2250 x 95 x 25	2.88	12	34.56
Cladding Battens	PAR Redwood	2500 x 77 x 70	8.07	23	185.61
Cladding Battens	PAR Redwood	1200 x 77 x 70	4.04	3	12.12
Cladding Battens	PAR Redwood	2500 x 77 x 32	3.55	10	35.50
External Insulation Layer	PIR Insulation board with aluminium foil faces	2400 x 805 x 75	4.73	2	9.46
	PIR Insulation board with aluminium foil faces.	2400 x 820 x 75	4.83	11	53.13
	PIR Insulation board with aluminium foil faces.	2400 x 883 x 75	5.19	4	20.76

Temporary Wall Braces	Redwood with metal BKT bolted to each end.	2046 x 95 x 82	6.13	4	24.52
Vapour Control Layer for overlay floor	Polythene & aluminium laminate	Roll size 2000 x 100 dia.	-	1 Roll	6.00
	SS Fabrication	1258 x 135 x 40	3.94	1	3.94
				PAGE TOTAL:	**444.30**

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
FIXINGS, TAPES AND SEALANTS					
	Bolts for panel joints and coach screws for door fixing	Box 350 x 350 x 350	-	1 Box	27.00
	Cladding screws, butyl tape, plastic washers and screws to fix insulation	Box 350 x 350 x 350		1 Box	20.00
	Fixing for cladding rails	Box 350 x 350 x 350		1 Box	34.00
	General Fixings	Box 350 x 350 x 350	30.00	2 Boxes	60.00
	Tapes and Sealants	Box 350 x 350 x 700	25.00	2 Boxes	50.00
CLADDING					
High Side Sheets	Plastisol coated profiled steel sheet.	2855 x 1102 x 26	19.60	11	215.60
Low Side Sheets	Plastosol coated profiled steel sheet.	2777 x 1102 x 26	19.06	5	95.30
Ref F1	Plastisol coated steel flashings – shaped as Schedule.	2855 x 430 Girth	6.75	4	27.00

Ref F2	Plastisol coated steel flashings – shaped as Schedule.	2600 x 217 Girth	3.11	6	18.66
Ref F3	Plastisol coated steel flashings – shaped as Schedule.	2600 x 420 Girth	6.01	2	12.02
Ref F4	Plastisol coated steel flashings – shaped as Schedule	1110 x 613 Girth	3.74	1	3.74
Ref F5	Plastisol coated steel flashings – shaped as Schedule	840 x 240 Girth	1.11	2	2.22
Ref F6	Plastisol coated steel flashings – shaped as Schedule	900 x 271 Girth	1.35	4	5.40
Ref F7	Plastisol coated steel flashings – shaped as Schedule	850 x 386 Girth	1.69	2	3.38
Ref F8	Plastisol coated steel flashings – shaped as Schedule	2600 x 230 Girth	3.29	2	6.58
				PAGE TOTAL:	**580.90**

ELEMENT	COMPONENT	APPROX. OVERALL SIZE	APPROX. WEIGHT OF EACH (Kg)	QUANTITY	TOTAL WEIGHT (Kg's)
Ref F9	Plastisol coated steel flashings – shaped as Schedule	600 x 732 Girth	2.42	2	4.84
Ref F10 and F11	These are trims which will be fixed to Roof Panels	-	-	-	12.17
External covers to roof panel joints	2mm Aluminium fabricated shaped covers as drg 5 with PPC finish.	2762 x 324 x 116	4.67	4	18.68

BUILDING MANUAL					
	Plywood box enclosing document file.	400 x 350 x 110	6.00	1	6.00
				PAGE TOTAL:	**41.69**

NOTE – THIS SCHEDULE WAS COMPILED PRIOR TO THE HUT MANUFACTURE AND TRIAL ERECTION – MINOR CHANGES WILL OCCUR