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# BRITISH ANTARCTIC SURVEY

# INITIAL ENVIRONMENTAL EVALUATION FOR ROTHERA RUNWAY RESURFACING AND LIGHTING, SITE INVESTIGATION AND CONDITION SURVEY WORKS

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# CONTENTS

# TABLE OF FIGURES

## TABLE OF TABLES



## APPENDICES

**Appendix 6**

TERRESTRIAL NOISE ASSESSMENT

# NON-TECHNICAL SUMMARY

## Introduction

The Antarctic Infrastructure Modernisation Project (AIMP) is a long-term infrastructure upgrade of the British Antarctic Survey (BAS) facilities across the Antarctic and the South Atlantic. The project is part of a 10-year programme of works upgrading Rothera Research Station (hereafter referred to as 'Rothera'), BAS' largest facility supporting climate, biodiversity, and ocean research in the Antarctic region.

The Rothera Modernisation Project, which is part of AIMP, aims to provide a station that is fit for purpose for the next 25 years. In 2017, a Rothera Modernisation Master Plan Report was developed for Rothera, detailing the developments planned for the station over the next 25 years. In March 2021, the Master Plan Report was updated to reflect the progress and changes to Rothera since 2017 – this now represents the latest version of the Master Plan. The Master Plan sets out how the Rothera Modernisation Project will achieve ambitions for a research station that is resilient, flexible, and fit for the future. The AIMP for Rothera currently encompasses three phases.

Phase 1 included upgrading the Rothera Wharf (completed in 2020, assessed under the 2018 Rothera Wharf Reconstruction and Coastal Stabilisation Comprehensive Environmental Evaluation (CEE), and supporting Preliminary Environmental Appraisal (PEA)) and construction of the new Discovery Building alongside Site Wide Services Installation (assessed under the 2019 Rothera Modernisation Phase 1 Initial Environmental Evaluation (IEE)), the latter of which is currently being constructed, with anticipated completion in March 2026.

This IEE has been prepared by Ramboll UK Ltd (Ramboll) on behalf of BAS to assess the potential environmental impacts associated with selected activities of Phase 2 of the AIMP. Article 8 of the Protocol on Environmental Protection to the Antarctic Treaty 1991 (hereafter referred to as the Environmental Protocol), requires that any activities in the Antarctic Treaty shall be subject to an assessment, in accordance with the procedures set out in Annex I to the Environmental Protocol, Environmental Impact Assessment (EIA).

The information provided here aims to facilitate the approval of the works – as described below - by the Foreign, Commonwealth and Development Office (FCDO), the UK competent authority.

The future phases of the AIMP are yet to be detailed, however, at the current stage of planning, Phase 3 is anticipated to include replacement of selected buildings at Rothera, a new sewage treatment plant, improved communications infrastructure and continued renewable energy installations.

## Overview of Proposed Works

The proposed works have been referred to as the Rothera Runway Resurfacing and Lighting, Site Investigation and Condition Survey Works IEE, hereafter referred to as the IEE. The proposed works included in the scope of this assessment will play a pivotal role in realising the vision for Rothera and meeting the strategic aims of the AIMP. The proposed works included in the scope of this assessment have been divided into the following five projects:

- Runway Resurfacing and Lighting – construction, mechanical and electrical works to resurface the runway, install a turning circle at the southern end, and upgrade the existing lighting infrastructure to ensure continued operation of this important infrastructure to accommodate a new aircraft. Friction measurements will be undertaken on the runway to support work on performance and safety, and a trial of hydrogenated vegetable oil (HVO) as an alternative fuel;
- Runway Upgrade – a range of site investigation (SI) and survey works to inform any future design of the proposed runway upgrade. These include marine surveys to the north of the runway, investigation of the existing rock revetment, sea ice thickness, and a potential new access road to the Hangar, as well as geophysical marine surveys and the construction of two non-engineered slipways;
- Renewable Energy – condition surveys and environmental monitoring at various locations considered suitable for renewable energy generation (notably solar and wind) to inform future decision-making on renewable energy infrastructure installation;
- Hangar Redevelopment – a range of SI works and condition surveys to inform the future redevelopment of the existing Hangar to provide and maintain the infrastructure required to maintain effective air unit operations at Rothera. This includes intrusive SI works including trial pits and boreholes at selected locations at the Hangar and apron; and
- Fuel Farm Infrastructure Upgrades – construction of a new fuel farm hut and two large steel platforms so that the fuel in all three Marine Gas Oil bulk storage tanks can be circulated and filtered independently of the main fuel circulation line.

In addition to the four five key projects, support activities to enable the delivery of the proposed works are include as part of this assessment, including:

- Shipping cargo to Rothera;
- Transport of personnel to Rothera;
- Storage of cargo;
- Site set-up and presence of personnel;
- Vehicle, plant, and equipment operation;
- Fuel management and refuelling;
- Provision of accommodation, power, and domestic services; and
- Incineration of waste.

The proposed works are anticipated to be completed over two austral summer seasons commencing in November 2022 and ending in April 2024.

**Description of Site and Environment**

Rothera is located on the south easterly shore of Adelaide Island on the Antarctic Peninsula, which can be seen in Figure a, and has been used operationally on a continuous basis since 1975. The station was initially planned and constructed in phases which meant that infrastructure development was undertaken as operational requirements and demands changed.


**Figure a: Location of Adelaide Island in relation to the Antarctic Continent, Google Earth 2022**

Figure b is an environmental constraints map of Rothera. It identifies in detail, existing buildings, surface water features, vegetation, the ice ramp, and operational hazard zones in addition to skua nests, heritage assets and communications instruments.

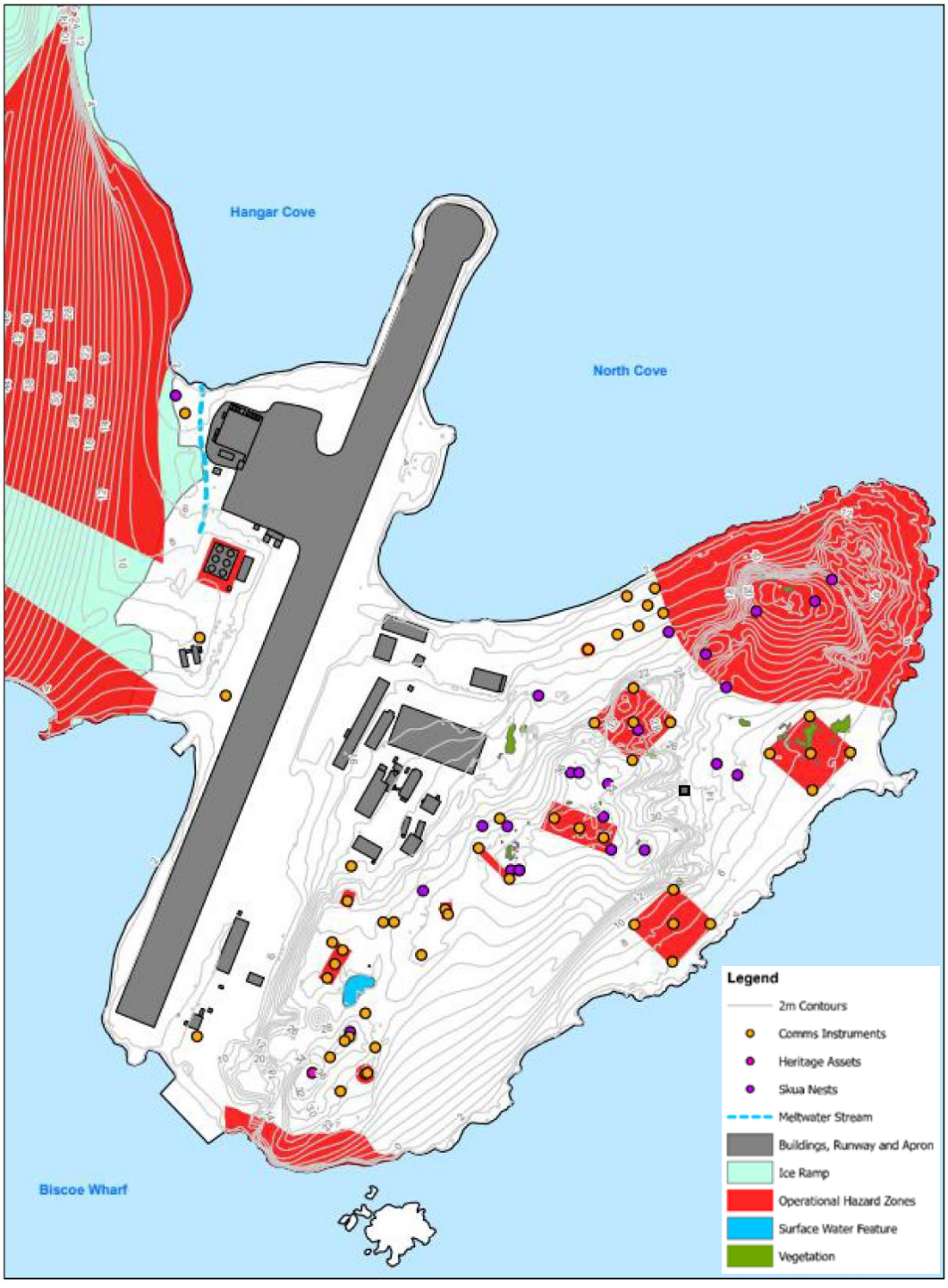


**Figure b: Rothera Environmental Constraints Map**

Rothera Point, the area of land to the east of the Wormald Ice Piedmont (as shown in Figure b above), is largely ice free and within which the Rothera Research station is situated. It contains no large areas of green vegetation and levels of biodiversity are lower than other equivalent

areas. However, Rothera Point does contain some examples of Antarctic fellfield environments, which are reasonably rare in the wider area. There is a patch of continuous moss to the north-east of the Discovery Building. As such, the vegetation on Rothera Point is of outstanding value. As far as is known, the terrestrial invertebrate fauna on Rothera Point is impoverished. South polar skuas (*Stercorarius maccormicki*) are the most abundant breeding bird on Rothera Point and their populations have been monitored annually since 1988. Other species such as seals and whales are only occasionally observed in the area. No non-native plants or invertebrates are known to be present on Rothera Point or in the adjacent marine environment. However, the nearshore marine environment is much more species rich and diverse.

Rothera Point is designated as an Antarctic Specially Protected Area (ASPA) to protect scientific values and serve as a control area against which the effects of human impacts can be monitored. This designation is unique as it is the only protected area currently designated solely for its value in monitoring human impacts. Figure c shows the location of Rothera Research Station relative to the ASPA.

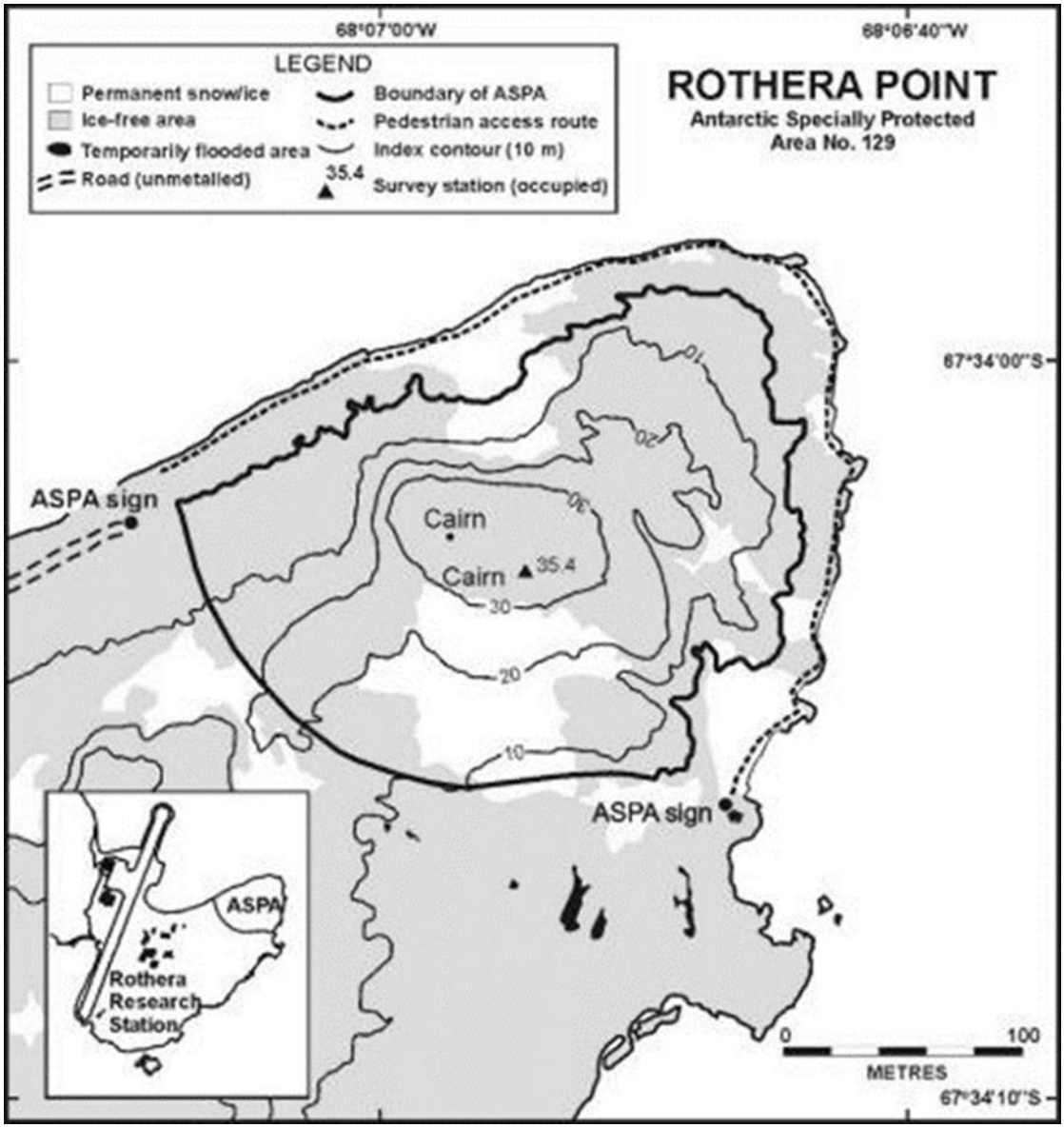


**Figure c: Map of ASPA No. 129 Rothera Point, Adelaide Island, BAS 2019**

The proposed works are within the footprint of existing infrastructure at Rothera and are largely on previously disturbed ground. The key environmental receptors which are most likely to be potentially impacted by the proposed works are terrestrial flora and fauna and local glaciology (particularly the ice ramp).

**Assessment of the Environmental Impacts**

The approach taken when compiling this EIA followed the Antarctic Treaty Secretariat (ATS) EIA Guidelines prepared by the Committee for Environmental Protection (CEP) alongside existing BAS IEE methodologies. The guidelines provide advice and recommendations on appropriate document structure as well as methodologies for identifying and evaluating impacts.

The EIA has followed a four-step process involving:

- Identifying the proposed activities of the project;
- Identifying the environmental aspects – the way in which any of the proposed activities interact with the environment such as atmospheric emissions, dust, noise, fuel spills, waste introduced, risk of non-native species etc.;
- Identifying the environmental impact – the change in environmental value or resource as a result of the activity; and
- Assessing the significance of the identified impact – 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 Environmental Protocol i.e., less than, no more than or more than a minor or transitory impact.

A full assessment of the potential environmental impacts, including any cumulative impacts with other activities at Rothera, are included in this IEE. For the purposes of the assessment of potential impacts, the activities of the proposed works have been divided into categories based on the nature of the works. The impact assessment categories are summarised here:

- Construction Activities;
- SI Works and Condition Surveys (intrusive and non-intrusive);
- Monitoring Activities; and
- Support Activities.

Potential impacts of the identified activities have been presented for each environmental aspect, where relevant, and key mitigation and/or monitoring requirements described.

**Atmospheric emissions** associated with all four of the impact assessment categories have the potential to contribute to global atmospheric pollution, as well as heavy metal and particulate fallout locally. Mitigation measures are in place to ensure that all operations are as efficient as possible to reduce excess fuel use.

**Noise emissions and vibration** associated with all four of the impact assessment categories have the potential to impact local fauna, potentially resulting in avoidance or stress behaviour and/or nest abandonment. A soft-start procedure will be implemented for all noisy construction and survey equipment, and for works at the Hangar and apron only, an acoustic screen will be implemented to effectively screen the adjacent skua nest from any noisy works. If agreed noise or vibration levels are exceeded, works in that area will cease until additional mitigation measures can be implemented.

**Dust emissions** associated with construction activities, SI and condition surveys, and support activities have the potential to effect local flora and fauna through smothering due to dust deposition. Dust deposition on areas of adjacent ice will decrease albedo and increase rates of ice melt at these locations. A weather forecast will be reviewed every morning to inform the decision of which activities can proceed that day and if any activities need to be suspended or additional mitigation measures put in place. If agreed dust levels are exceeded, works in that area will cease until additional mitigation measures can be implemented.

**Waste generation** associated with construction activities, SI and condition surveys, and support activities have the potential to impact on international and UK landfill capacity, and also an increased risk of waste being released into the local environment. The Site Waste Management Plan will be followed for all construction waste, and BAM aims of achieving an 80% diversion of construction waste from landfill and a 90% diversion of all waste from landfill.

**Light emissions** associated with construction activities, SI and condition surveys, and support activities have the potential to increase the risk of disturbance to local fauna and could potentially lead to increased bird strikes, injuries, and fatalities. Works will be undertaken during daylight hours as far as reasonably possible, and any bird strikes will be recorded on the BAS Incident Reporting System (Maximo) for monitoring and management purposes.

**Physical presence and use of space** associated with all four of the impact assessment categories has the potential to impact all ongoing operations at Rothera, disrupt science activities, day-to-day station operations and hamper good housekeeping. Construction, survey, and sampling locations will be confined to agreed areas, and a Rothera Station Integration Plan will be prepared to demonstrate adequate space use on site for the proposed activities.

**Physical or mechanical disturbance on land** associated with all four of the impact assessment categories has the potential to contribute to ground disturbance as a result of intrusive works, as well as the deterioration of existing roads used at Rothera. This is mitigated by minimising the footprint of works and locating intrusive SI away from sensitive environmental receptors through careful design.

**Fuel or hazardous substance release** associated with all four of the impact assessment categories has the potential to impact the local environment (marine and terrestrial). Pollution incidents could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. The Oil Spill Contingency Plan (OSCP) will be followed for all spills, and there will be pre-deployment and on-site training for staff.

**Non-native species introduction** is associated with support activities only. Introduced species may become established with negative impacts upon local ecosystem structure and function, endemic species and associated scientific research. All activities will be undertaken in accordance with the BAS Biosecurity Regulations, the CEP Non-Native Species Manual and the Runway Resurfacing and Lighting Project-Specific Biosecurity Plan.

**Disturbance to native flora and fauna** associated with all four of the impact assessment categories has the potential to effect local flora and fauna through disturbance, injury or fatality to marine mammals, marine benthic communities, and birds, which could result in avoidance or stress behaviour, nest abandonment or hearing damage. The BAS Wildlife Handling Manual will be referred to for any contact with wildlife, and specific mitigation measures will be introduced where required. Skua monitoring will continue and the demarcation of no-go-zone around the moss patch will be maintained.

**Visual** impacts associated with all four of the impact assessment categories has the potential to impact the built and natural landscape at Rothera by changing the visual and local aesthetic values of the surrounding landscape. All activities will be confined to agreed areas on site and any changes to these locations will be discussed and agreed with the Rothera Station management team, and where appropriate the BAS Environment Office and FCDO.

There are no potential **heritage** impacts identified associated with any of the impact assessment categories.

**Climate Change Resilience** has been considered as part of this IEE. The construction of the runway resurfacing, and lighting upgrades are not considered to be significantly susceptible or vulnerable to the effects of climate change in the short term and no significant effects are expected. The operation of the runway once resurfaced is not considered to be significantly susceptible or vulnerable to the effects of climate change in the medium term and no significant effects are expected. Therefore, the construction and operation of the runway resurfacing, and lighting upgrades are considered to be climate resilient.

Cumulative impacts have been assessed as part of this IEE. This assessment has considered interaction with present and previous activities, particularly the use of material quarried as part of the Rothera Wharf Reconstruction and Coastal Stabilisation CEE, the removal of the temporary jetty, and the overlap with the Discovery Building construction programme. The combined activities have the potential to increase noise disturbance, dust deposition, waste, light pollution, physical presence and use of space impacts, risks of fuel releases, disturbance to native flora and fauna, and temporary visual impacts to Rothera. The mitigation and monitoring proposals outlined in the IEE are considered to be sufficient to manage the environmental impacts associated with the potential cumulative effects listed above.

**Monitoring and Audit Requirements**

Monitoring activities will be undertaken during the proposed works, and will include monitoring of wildlife displacement, moss patch condition, neutralisation of cement contaminated waters, as well as monitoring of noise, vibration and dust at selected locations. Monitors will be hardwired to the station local area network to provide real time data. Real time data collection will allow BAS and BAM to fully understand the cause of any exceedance, which can then be actioned to mitigate the potential environmental impact within a suitable time frame. Monitoring of skua breeding success is a long-term monitoring activity and will continue.

An audit programme will be undertaken during the construction works by the site supervisor to ensure that the actions and mitigation measures committed to in this document are being adhered to. This will follow a BAS Environment Office approved checklist.

**Gaps in Knowledge and Uncertainties**

Exact timings of the works are not available for all activities, and where these are not available, an assumption has been made that these activities will take place within the 2022-2023 season. Any deviations to the information presented within this IEE will be accounted for within a Register of Project Variations; a live document that is actively managed and owned by BAS in close collaboration with BAM personnel in Rothera. Any variations will be reported in the Post Season Compliance Report, along with a full complement of the monitoring data collected in support of the works that season.

Monitoring equipment cannot be set-up until 3.5 weeks into the construction programme. The activities that will be undertaken during this period will be site set-up and snow clearance activities. Although the absence of monitoring equipment is acknowledged as a minor risk, this delay is considered acceptable given the challenges of delivering equipment and working in Antarctica. Another area of uncertainty is the slipway design and potential impacts to marine benthic ecology. Although the absence of further information is acknowledged as a minor risk, this is considered acceptable given the nature and duration of the works.

The funding and full scope of future phases of the AIMP has not yet been confirmed and will be considered in future EIAs.

**Conclusions**

The most significant potential impacts predicted for all four of the impact assessment categories are:

- Introduction of non-native species;
- Cumulative noise impacts due to overlapping construction periods with the Discovery Building;
- Dust deposition on the ice ramp and impacts to local flora and fauna through smothering;
- Physical presence, use of space and disturbance to science activities and day-to-day operations;
- Physical and/or mechanical disturbance to land as a result of intrusive SI works; and
- Terrestrial (and potentially marine) pollution from fuel spills.

Having prepared this IEE along with rigorous and specific mitigation measures to reduce the risk of the potential impacts occurring, alongside a thorough monitoring and auditing proposal, it is considered that the proposed works will have no more than a minor or transitory impact.

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# TABLE OF ABBREVIATIONS

| Term | Abbreviation |
|---|---|
| Three dimensional | 3D |
| Above Sea Level | ASL |
| Air Traffic Control | ATC |
| (Abbreviated) Precision Approach Path Indicator | (A)PAPI |
| Antarctic Conservation Biogeographic Region | ACBR |
| Antarctic Infrastructure Modernisation Project | AIMP |
| Antarctic Specially Protected Area | ASPA |
| Antarctic Treaty Secretariat | ATS |
| Atmosphere, Ice and Climate | AIC |
| Aviation Fuel | AVTUR |
| British Antarctic Survey | BAS |
| BAM Nuttall | BAM |
| Biodiversity, Evolution and Adaptation | BEA |
| Building Management System | BMS |
| Building Research Establishment | BRE |
| Building Research Establishment Environmental Assessment Method | BREEAM |
| British Standard | BS |
| California Bearing Ratio | CBR |
| Civil Engineering Environmental Quality | CEEQUAL |
| Committee for Environmental Protection | CEP |
| Comprehensive Environmental Evaluation | CEE |
| Conductivity, Temperature and Depth | CTD |
| Decibels | dB |
| A-weighted Decibels | dBA |
| Oil Spill Contingency Plan | OSCP |
| Energy Simulation Workflow | ESW |
| Environmental Impact Assessment | EIA |
| Foreign, Commonwealth and Development Office | FCDO |
| General Packet Radio Service | GPRS |
| Global Positioning System | GPS |
| Global Sea Level Observing System | GSLOS |
| Greenhouse Gas | GHG |
| Ground Investigation | GI |
| Ground Penetrating Radar | GPR |
| Hydrogenated Vegetable Oil | HVO |
| Important Bird and Biodiversity Area | IBA |
| Initial Environmental Evaluation | IEE |
| International Organisation for Standardisation | ISO |
| Key Performance Indicators | KPI |
| Light-emitting Diode | LED |

| | |
|---|---|
| Light Weight Deflectometer | LWD |
| Marine Gas Oil | MGO |
| Mean Higher High Water | MHHW |
| Mean Lower Low Water | MLLW |
| Mean Sea Level | MSL |
| Mechanical and Electrical | M&E |
| Marine Mammal Observer | MMO |
| Mobile Elevating Work Platform | MEWP |
| Natural Environment Research Council | NERC |
| Netherlands Organisation for Scientific Research | NWO |
| New Bransfield House | NBH |
| Non-Native Species | NNS |
| Normalised Difference Vegetative Index | NDVI |
| Old Bransfield House | OBH |
| Peak Particle Velocity | PPV |
| Photovoltaic | PV |
| Preliminary Environmental Appraisal | PEA |
| Publicly Available Specification | PAS |
| Remotely Operated Vehicle | ROV |
| Reverse Osmosis | RO |
| Royal Research Ship Sir David Attenborough | RRS SDA |
| Runway End Identifier Lighting | REIL |
| Runway Entrance Lights | REL |
| Search and Rescue | SAR |
| Sewage Treatment Plant | STP |
| Sir David Attenborough | SDA |
| Site Investigation | SI |
| Site Waste Management Plan | SWMP |
| Sound Detection and Ranging | SoDAR |
| South American Atlantic Service | SAAS |
| Space Weather and Atmosphere | SWA |
| Station Lead | SL |
| Sustainability Assurance Group | SAG |
| Sustainability Management Plan | SMP |
| Sustainable Development Goals | SDG |
| Systeme d’Analyse par Observations Zénithales | SAOZ |
| Total Suspended Particulate | TSP |
| Ultraviolet | UV |
| United Kingdom Antarctic Heritage Trust | UKAHT |
| United Kingdom Research and Innovation | UKRI |
| United Nations | UN |
| Vibration Dose Values | VDV |
| Weather Research and Forecasting | WRF |

| | |
|---|---|
| Work Stage | WS |

# 1. INTRODUCTION

## 1.1 Background to AIMP

The Antarctic Infrastructure Modernisation Project (AIMP) is a long-term infrastructure upgrade of the British Antarctic Survey (BAS) facilities across the Antarctic and the South Atlantic. Over the next 5-10 years the AIMP represents the largest UK Government investment in polar science since the 1980s and will enable BAS to continue to deliver world leading science capability in the Polar Regions. BAS have appointed the engineering consultancy Ramboll as the Technical Advisors for the project and BAM Nuttall (BAM) have been contracted as the Construction Partner, who in turn are partnered with design consultants Sweco UK.

This project is part of a 10-year programme of works upgrading Rothera Research Station (hereafter referred to as 'Rothera'), see Figure 1-1, BAS' largest facility supporting climate, biodiversity, and ocean research in the Antarctic region. The Rothera Modernisation Project, which is part of AIMP, aims to provide a station that is fit for purpose for the next 25 years. In 2017, a Rothera Modernisation Master Plan Report was developed for Rothera, detailing the developments planned for the station over the next 25 years. In March 2021, the Master Plan Report[1] was updated to reflect the progress and changes to Rothera since 2017 – this now represents the latest version of the Master Plan. The Master Plan sets out how the Rothera Modernisation Project will achieve ambitions for a research station that is resilient, flexible, and fit for the future. The AIMP for Rothera currently encompasses the following phases as outlined below.

[1] Ramboll, 2021. Rothera Modernisation. Master Plan Report 2021. ROMAST-RAM-ZZ-RO-RP-PM-0001, C01


**Figure 1-1: Location of Rothera, Adelaide Island, Antarctica. Google Earth, 2022**

### Phase 1

- Upgrading the Rothera Wharf to be suitable for the mooring of the Royal Research Ship Sir David Attenborough (RRS SDA) (assessed under the 2018 Rothera Wharf Reconstruction and Coastal Stabilisation Comprehensive Environmental Evaluation (CEE), and supporting Preliminary Environmental Appraisal (PEA)), completed in 2020; and
- Construction of the new Discovery Building (previously referred to as the Operations Building in the 2019 Rothera Modernisation - Phase 1 Initial Environmental Evaluation (IEE) which will provide upgraded office, storage, and maintenance facilities, alongside Site Wide Services Installation (currently being constructed with anticipated completion in March 2026).

### Phase 2

- Rothera runway resurfacing and upgrades, including an extension to accommodate a new aircraft;
- Refurbishment of the existing Hangar, or construction of a new Hangar to facilitate the new aircraft;
- Renewable energy infrastructure to contribute to the Rothera 2030 zero carbon strategy;
- Construction of a new accommodation block; and
- Construction of a new Waste Facility.

**Phase 3**

The future phases of the AIMP are yet to be detailed, however, at the current stage of planning, Phase 3 is anticipated to include:

- A new building to replace the Bonner Laboratory;
- A new building to replace New Bransfield House;
- A new building to replace Admirals House;
- A new sewage treatment plant;
- Improved communications infrastructure; and
- Continued renewable energy installations.

The funding and full scope of these future phases has not yet been confirmed and will be considered in future environmental impact assessments (EIA).

This IEE has been prepared by Ramboll UK Ltd (Ramboll) on behalf of BAS to assess the potential environmental impacts associated with selected activities of Phase 2 of the AIMP. The information provided here aims to facilitate the approval of the works – as described below - by the Foreign, Commonwealth and Development Office (FCDO), the UK competent authority.

## 1.2 Overview of Proposed Works

The proposed works has been referred to as the Rothera Runway Resurfacing and Lighting, Site Investigation and Condition Survey Works IEE, hereafter referred to as the IEE. This IEE assesses the potential impacts of the supporting site investigation (SI), and condition survey works proposed to inform a number of the redevelopment and modernisation aspirations listed above. With the exception of the runway resurfacing and lighting works, the items listed below are centred on SI, condition surveys[2] and environmental monitoring as opposed to the construction of new development.

The scope of this IEE includes selected activities of the AIMP Phase 2 as listed within Section 1.1. The proposed works have been divided into the following five projects:

- Runway Resurfacing and Lighting;
- Runway Upgrade;
- Renewable Energy;
- Hangar Redevelopment; and
- Fuel Farm Infrastructure Upgrades.

A detailed scope of works is provided in Section 3.2.

Further works required to support AIMP Phase 2 will be captured and assessed in future EIAs when preferred design options become clearer following the completion of the proposed supporting SI, condition surveys and environmental monitoring activities that are included within the scope of this assessment.

[2] The term condition surveys has been used throughout this IEE to provide a distinction between survey activities undertaken to assess the condition of structure and/or features to support future phases of development and general environmental surveys and monitoring. Where relevant it is indicated whether these condition surveys are intrusive or non-intrusive.

## 1.3 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 to provide sufficient information on the scope of works, 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 scope of this document covers the works associated with the AIMP Phase 2 Rothera runway resurfacing and lighting, SI and condition survey works only. Other development works which may be undertaken at Rothera in the future but have yet to be fully scoped, designed or funded are not included in this assessment. Such future initiatives have however been outlined in Chapter 12: Gaps in Knowledge and Uncertainties.

This document comprises the following chapters:

- Chapter 1 introduces the proposed project;
- Chapter 2 provides the approach to the EIA;
- Chapter 3 describes the proposed development including the need, location, scope, alternatives considered and design plans (where applicable);
- Chapter 4 outlines the construction, SI, condition survey and monitoring methodologies;
- Chapter 5 describes the support activities required to facilitate the projects;
- Chapter 6 outlines the operational procedures that will be followed;
- Chapter 7 outlines the programme of activities;
- Chapter 8 presents a description of the site including location, site history and current uses;
- Chapter 9 presents the current environmental baseline conditions at Rothera;
- Chapter 10 provides the assessment of environmental risks and potential impacts associated with the proposed activities and any cumulative activities identified;
- Chapter 11 presents the monitoring and audit requirements;
- Chapter 12 provides the gaps in knowledge and uncertainties; and
- Chapter 13 provides the conclusions of the IEE.

## 1.4 Contact Details

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# 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[3] (hereafter referred to as the Environmental Protocol). The UK enforces the provisions of the Environmental Protocol through the 'Antarctic Act 1994[4]', the 'Antarctic Act 2013[5]', and the 'Antarctic Regulations 1995/490 (as amended)[6]'.

Article 8 of the Environmental Protocol requires that any activities in the Antarctic Treaty shall be subject to an assessment, in accordance with the procedures set out in Annex I to the Environmental Protocol, 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 three assessment levels based on different levels of predicted impact. The assessment levels are:

- Preliminary Stage;
- IEE; and
- CEE.

If an activity is determined, on the basis of a completed Preliminary Stage, 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 required 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 FCDO, it is concluded that an IEE is the appropriate level of assessment for the scope of works outlined in Section 3.2.

It is acknowledged that EIA best practice is to take a holistic approach for multiple developments. However, the AIMP spans a number of infrastructure development projects which are intended to be funded and constructed over a period of at least 10 years and for which design details are not yet available. Without those design details and methodologies, the environmental impacts cannot be predicted with confidence. The latest of these was the construction of the new Discovery Building as part of the AIMP Phase 1, which commenced in 2020 and construction is anticipated

[3] ATS, 2022. Protocol on Environmental Protection to the Antarctic Treaty, 1991, online. Available at: https://documents.ats.aq/recatt/Att006_e.pdf [Accessed 24/03/2022]

[4] UK Legislation, 2022. Antarctic Act, 1994, online. Available at: https://www.legislation.gov.uk/ukpga/1994/15/contents [Accessed 24/03/2022]

[5] UK Legislation, 2022. Antarctic Act, 2013, online. Available at: https://www.legislation.gov.uk/ukpga/2013/15/contents/enacted [Accessed 24/03/2022]

[6] UK Legislation, 2022. The Antarctic Regulations, 1995 No. 490, online. Available at: https://www.legislation.gov.uk/uksi/1995/490/made [Accessed 24/03/2022]

until 2026. An IEE was produced and approved for that project. Cumulative impacts of the Discovery Building works coinciding with the proposed works set out in this document have been addressed where possible within this assessment. The activities in this assessment will also be assessed cumulatively in any future EIA submission for further works at Rothera.

This IEE is to be made publicly available on both the BAS website and the Antarctic Treaty Secretariat (ATS) EIA database.

## 2.2 EIA Methodology

The approach taken when compiling this EIA followed the EIA Guidelines (ATS, 2016[7]) 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.

The EIA has followed a four-step process involving:

- Identifying the proposed activities of the project;
- Identifying the environmental aspects – the way in which any of the proposed activities interact with the environment such as atmospheric emissions, dust, noise, fuel spills, waste, introduced non-native species etc;
- Identifying the environmental impact – the change in environmental value or resource as a result of the activity; and
- Assessing the significance of the identified impact – 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 Environmental Protocol i.e., less than, no more than or more than a minor or transitory impact.

Other previously published IEEs and CEEs have been used as sources of information on the potential environmental impacts of activities within Antarctica, including examples of approaches to assessment of activities and impacts, and appropriate mitigation measures to manage potential environmental impacts. This includes the most recent IEE produced by BAS[8] for the construction of the Discovery Building as part of AIMP Phase 1.

Baseline information on the current environmental state at Rothera has been included in order to evaluate the potential impacts effectively. This information was largely sourced from scientific experts within BAS and includes recent work by BAS scientists to update the environmental baseline[9].

The scope and nature of the activities and a description of the principal characteristics of the AIMP Phase 2 works have been provided in Chapters 3-7. Design and construction details have been provided by the Construction Partner BAM and the Technical Advisor, Ramboll.

A more detailed explanation of the assessment methodology used is outlined in Chapter 10 - Assessment of the Environmental Impacts.

[7] CEP, 2016. Guidelines for Environmental Impact Assessment in Antarctica, online. Available at: https://documents.ats.aq/recatt/Att605_e.pdf [Accessed 02/03/2022]

[8] BAS, 2019. Rothera Modernisation – Phase 1 Initial Environmental Evaluation - BAS AIMP

[9] Environmental Baseline Information for Rothera Point, Adelaide Island, Antarctica Version 2.0; BAS Environment Office (February 2022)

Chapter 10 also presents the possible impacts 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 potential impacts have been predicted on the basis of professional opinion and experience of the Ramboll EIA team, individual BAS scientists and the BAS Environment Office. Environmental monitoring is undertaken by BAM continuously at strategic locations at Rothera to monitor noise, vibration and dust levels associated with BAS operations. The outcomes of a review of environmental monitoring in 2021-2022 by BAS[10] has also been included as part of this IEE. Monitoring proposals for the next season have been provided in Chapter 11.

A monitoring and audit plan has been developed to ensure that early warning of unforeseen adverse effects can be identified quickly, and modifications of activities can be made should they be necessary.

## 2.3 Sustainability

The BAS Sustainability Strategy for the AIMP[11] has been developed to ensure that BAS infrastructure is designed, constructed, and operated in accordance with best international sustainability practice. The strategy objectives were amended in October 2020 following a review with members of the Sustainability Assurance Group (SAG). The SAG is responsible for setting sustainability targets and monitoring Key Performance Indicators (KPI), maintaining the strategy through regular updates, and benchmarking progress to ensure the AIMP remains at the forefront of sustainable development.

Presented as Table 2-1 overleaf, the tabular Sustainability Strategy outlines eight aims with associated objectives. Covering key sustainability themes, the strategy has been developed through consideration of international best practice as well as the sustainability ambitions and requirements of the AIMP.

In October 2020, the Technical Advisor completed a gap analysis review of the BAS AIMP Sustainability Strategy (2018), UKRI Environmental Sustainability Strategy (2020) and NERC Responsibility Framework (currently under review with sustainability targets and objectives pending approval). The outcome of this review is that all three strategies are closely aligned and cover similar priority areas.

The AIMP includes projects that have committed to schemes with sustainability requirements such as the Civil Engineering Environmental Quality assessment and award scheme (CEEQUAL), the Building Research Establishment Environmental Assessment Method (BREEAM) and the UK Government's Soft Landings Framework. As these schemes are largely evidence based, the Strategy has been developed to provide clear guidance for teams to demonstrate the sustainability of their projects. From an international perspective, the United Nation's (UN) Sustainable Development Goals (SDGs) are recognised as a transparent and global definition of sustainability and have been reflected in the formation of this strategy.

[10] BAS AIMP Partnership, 2022. British Antarctic Survey AIMP RMP Environmental Monitoring Review 2021-2022 Report

[11] BAS November 2020. AIMP Sustainability Strategy, SUST-RAM-XX-ZZ-SG-Z-0001

Project specific, Sustainability Management Plans (SMP) are developed for individual AIMP projects, and a sub-committee of the SAG review targets and objectives set for each SMP and provide an assurance function by co-ordinating regular reporting meetings to monitor and analyse the sustainability performance of these projects.

BAS has committed to achieving net zero carbon emissions by 2040 in line with the UK Research and Innovation (UKRI) Environmental Sustainability Strategy. To support this goal, the Rothera Decarbonisation Strategy[12] aims to have a permanently zero greenhouse gas (GHG) emissions at Rothera by 2030 through directly managed operations. There are six objectives within the Rothera Decarbonisation Strategy:

- Maximise the energy efficiency of the station's buildings;
- Develop a site energy infrastructure;
- Develop a smart grid;
- Electrify the station's fleet (vehicles, boats);
- Achieve extensive carbon neutrality in construction activities; and
- Increase positive impact by influencing supply chain.

The Rothera Decarbonisation Strategy identifies a set of milestones and enabling works that will need to be delivered in order to achieve zero operation GHG emissions by 2030.

[12] Rothera Decarbonisation Strategy, BAS (March 2020)

**Table 2-1: AIMP Sustainability Strategy Aims and Objectives**

| Aims | | Objectives | | |
|---|---|---|---|---|
| | | **A** | **B** | **C** |
| **1** | **Create and maintain healthy working areas** | | | Review the BAS Health and Wellbeing Strategy and consider implications for construction and operation activities |
| **2** | **Maintain an efficient and sustainable water and wastewater regime** | Ensure water conservation and recycling principles are incorporated into design proposals | Review wastewater (treatment) regime and consider alternative, more sustainable solutions | All operations will be planned to minimise water consumption |
| **3** | **Create an efficient, reliable, and sustainable Antarctic energy network** | Minimise energy related carbon emissions through best practice design across all AIMP projects through reducing energy demand and using low-carbon sources of energy | Minimise energy-related carbon emissions during operational phase of AIMP projects through reducing energy demand | |
| **4** | **Ensure resilient facilities through sustainable and appropriately innovative design** | Encourage innovation throughout the design and procurement process | Challenge designs by targeting ambitious sustainability goals and ratings through following principles of BREEAM or CEEQUAL or equivalent as agreed by UKRI/NERC/BAS | All work to adhere to BAS Resilience Strategy |
| **5** | **Develop and maintain inclusive, safe, resilient and sustainable BAS Antarctic communities** | Maximise liveability and community-centric building design e.g., thermal comfort, air quality and natural daylight through best use of design standards | Maintain and regularly monitor the performance of project infrastructure to ensure that it continues to meet the needs of the Antarctic community | Embed health and safety considerations within each project (aligning with the BAS H&S Policy) |
| **6** | **Ensure responsible sourcing and efficient use of all resources through** | Ensure sustainable sourcing of all materials and services throughout the supply chain, to be recorded | Ensure sustainable use of materials and facilities through application of the Waste Hierarchy and the | |

| Aims | | Objectives | | |
|---|---|---|---|---|
| | | **A** | **B** | **C** |
| | **sustainable design and procurement** | within a Sustainable Procurement Statement for each project | integration of circular economy principles | |
| **7** | **Prioritise action to combat climate change and its impacts** | Establish whole life GHG emissions reduction targets for all projects, including the application of PAS 2080 (Carbon Management in Infrastructure) | Design and deliver facilities that are resilient and adaptable to the impacts of climate change | Establish low-carbon leadership at Board level (Note this applies at programme level only and is not included in project specific Sustainability Management Plans) |
| **8** | **Interact sustainably with the Antarctic environment** | Project designs shall demonstrate that construction & operation of facilities will have no lasting negative impact on life below water, life on land, or the natural environment | Projects should demonstrate ongoing monitoring of environmental impacts on sensitive receptors identified and agreed within the EIA | Uphold the highest standard of biosecurity for all personnel, cargo, plant and materials that enter or re-enters the Antarctic environment through project-specific Biosecurity Plans and provision of training for all site operatives |

# 3. DESCRIPTION OF PROPOSED WORKS

## 3.1 Purpose and Need

The Rothera Modernisation project encompasses significant investment to modernise and restore Rothera's infrastructure so that it remains at the forefront of climate, biodiversity, and ocean research, and is cost effective, safe and minimises demand for energy by improving energy efficiency. Many of the existing buildings have reached or are fast approaching the end of their economic life, driving up maintenance costs and reducing organisational resilience. The objective of the AIMP as a whole is to reduce operating costs at Rothera whilst maintaining current operations in Antarctic through:

- Replacing aged buildings with modern, more flexible spaces to minimise future maintenance and operating costs and significantly improve the energy efficiency to support BAS Sustainability targets;
- Consolidating and rationalising the existing estate to provide infrastructure which minimises energy use and reduces the costs of snow clearance and maintenance of services.

The vision for Rothera and the strategic aims of the AIMP are as follows.

- Centre of excellence for polar science for all UK scientists;
- Outstanding operational delivery;
- Integrated logistic hub that allows access to the rest of the continent;
- Network-enabled station for multi-disciplinary science;
- Station of choice for international collaboration;
- Showcase for UK science and technology; and
- A test bed for cutting-edge innovation for extreme environments.

The strategic aims of the AIMP include:

- Enable and support frontier science;
- Implement the UKRI environmental sustainability strategy; and
- Champion public engagement.

The proposed works included in the scope of this assessment will play a pivotal role in realising the vision for Rothera and meeting the strategic aims of the AIMP. The proposed scope of works is outlined in Section 3.2.

## 3.2 Scope of Proposed Works

The proposed works have been divided into four five key projects as highlighted in Section 1.2. A high-level scope and justification of the proposed works associated with each project is outlined below, with further details on methodology and a discussion of any alternative designs or methods presented in Section 4. A plan showing the location of these activities is presented in Figure 3-1.

### 3.2.1 Runway Resurfacing and Lighting

The works to resurface the runway and upgrade the existing lighting infrastructure are required to accommodate the new aircraft that BAS propose to introduce to their fleet. The proposed works include the complete resurfacing of the existing runway, which would require the processing of existing quarried material obtained from the temporary wharf quarry (assessed and approved in

the Rothera Wharf Reconstruction and Coastal Stabilisation CEE[13]) to provide construction materials, as well as an increase in the usable runway length through the provision of an extension to the gravel surface at 0 m to -17 m chainage at the southern end of the runway. These works will remain within the existing footprint of the runway and not extend into the water, maximising the useable surface area of the existing runway footprint.

The existing crossing will be reinstated and remain in its current position. To facilitate future services crossing the runway, new service ducts will also be installed under the runway. A turning circle will be added for aircraft to the east side at the southern end of the runway. Runway mechanical and electrical (M&E) works include the installation of a new airfield lighting system, which would reduce power consumption with the provision of light-emitting diode (LED) airfield lighting, including Runway Entrance Lights (REL), Runway End Identifier Lighting (REIL), and (Abbreviated) Precision Approach Path Indicator ((A)PAPI).

The proposed works to the runway aim to:

- Improve runway surface drainage;
- Restore runway running surface;
- Increase useable runway length;
- Provide a new turning circle for aircraft at southern end of runway;
- Upgrade airfield lighting system, improving airfield safety;
- Reduce power consumptions with the provision of the LED airfield lighting; and
- Improve runway/roadway safety with new traffic lights and warning sounders.

- **Friction Measurements on the Runway**
  From 2022-2023 onwards, BAS will undertake friction measurements on the runway at Rothera. These measurements will allow a better understanding of the friction of the runway to support work on performance, safety, and runway length calculations. The proposed friction test activities are considered to be an ongoing requirement to support the runway operations at Rothera.

- **HVO Trial**
  A trial of HVO fuel use in construction plant and electricity generation will be undertaken to test its effectiveness in cold conditions. HVO could be used as a low-carbon alternative to fossils fuels at Rothera.

### 3.2.2 Runway Upgrade

The proposed runway infrastructure upgrades are required to maintain effective Air Unit operations at Rothera. This upgrade is likely to entail an extension to the existing runway footprint, however the design of the upgrade is currently under review by the technical advisory team and the outcomes of the following preliminary SI are required to inform the design process. The construction and operation of the runway upgrade will be assessed at an appropriate time when sufficient information is available to confidently assess environmental impacts.

The proposed works covered in this IEE are only SI, condition survey and minor construction work to facilitate and inform the preferred runway design option, and are as follows:

[13] BAS January 2018, Rothera Wharf Reconstruction and Coastal Stabilisation Comprehensive Environmental Evaluation

- **Runway North Marine Surveys**
  Targeted diver visual inspections, intrusive grab sampling and probe surveys of the seabed are proposed to be undertaken to the north of the existing runway within the maximum proposed length of the extension to ensure that full coverage for any future design scenario is provided by the data. This will enable a better understanding of the ground conditions within the area of the runway extension. The marine surveys will provide more information on the nature, thickness, and properties of soft bed material over rock. The marine surveys will also provide a better understanding of the quantity and particle size of the material that could get disturbed and generate a sediment plume during underwater rock placement (anticipated to be required as part of the construction of the proposed runway extension).

- **Rock Revetment Investigation**
  An intrusive investigation of the rock quality, rock grading, rock quantity and condition of the existing revetment will be undertaken. This will establish the feasibility of the reuse of existing revetment material, the quantity of material available and should design criteria change, the feasibility of partial repair instead of full repair.

- **Sea Ice Thickness Investigation**
  Intrusive sea ice thickness measurements along the north runway coastline are required to confirm the armour design requirements of any future runway upgrade and extension and to provide more information to support the design of the upgrade. This information will reduce the risk of damage to the runway from sea-ice and potential disruptions to runway operations by allowing sufficient sea ice protection to be included in the design of the potential runway extension. There would be a risk of overconservative design if no information on ice thickness is available.

- **Access Road Investigation**
  A geotechnical visual inspection will be undertaken, as well as intrusive trial pits at intervals of approximately 30 m along the route. In-situ testing (plate load/Light Weight Deflectometer (LWD) testing) will be carried out in between the trial pit locations. This will confirm the suitability of ground and groundwater conditions for a new access route to the Hangar and inform whether additional measures would be required. It will also assess the variability of ground conditions along the proposed route for pavement design.

- **Geophysical Marine Surveys**
  Geophysical surveys will include a bathymetric survey, sidescan sonar survey and single channel sparker survey in the nearshore zone and within the maximum proposed length of the extension. The bathymetric survey will fill the gap in information between the bathymetric and topographic surveys. There is existing bathymetric survey information available but not to the required extent and detail. The other two surveys will obtain widespread coverage of rock head levels and confirm thickness of superficial material on top of bedrock to inform rubble mound extension design. There is no alternative source of information on rock head levels offshore and depth of overlying sediment, and therefore a high risk of design being overconservative due to a lack of data if the surveys are not carried out.

- **Creation of non-engineered slipways**
  Two new non-engineered slipways are proposed to the area north of the windsock, and at the location of the temporary jetty to be removed in the 22/23 season. Available boat launch areas have reduced over the years, and the provision of the slipways will improve access and boat launching capability, which is required to enhance Search and Rescue (SAR) safety response.

### 3.2.3 Renewable Energy

The proposed works in this IEE include condition surveys of existing infrastructure and monitoring of wind and solar resource to inform future decision-making around renewable energy infrastructure. The proposed works align with the aims and objectives of the AIMP Sustainability Strategy as well as the Rothera Decarbonisation Strategy.

The proposed condition surveys and monitoring required to support the Renewable Energy project are outlined below.

- **Visual condition survey of roof structures**
  Visual condition surveys of roof structures of existing buildings will be undertaken at Rothera and will include Admirals House, New Bransfield House (NBH) and the Hangar building. These will provide an initial overview of the suitability of the structures surveyed for the installation of solar PV and solar thermal units on existing roofs and facades.

- **Condition survey of existing PV panels**
  Visual condition surveys of existing PV panels on NBH, Gerritsz Laboratory and Giants House buildings will be undertaken. These will provide better understanding of the feasibility of solar PV expansion and thermal generation across the site.

- **Energy demand metering of current buildings**
  The energy demand metering of current buildings at Rothera will be reviewed to provide more detail on the total energy demand of the site and specific equipment to ensure that the rates of renewable energy generation are able to meet the site operational requirements.

- **Solar irradiance, albedo, and soiling monitoring**
  Solar irradiance, albedo and soiling monitoring will be undertaken at various locations around the site to determine and monitor the efficacy of solar energy generation. Solar irradiance will be measured at one location at North Beach using an in-plane pyranometer, to measure the solar irradiance at a given angle to improve the accuracy of the energy yield assessment. Albedo will be monitored at North Beach and adjacent to the fuel farm area to obtain data on the impact of ground reflectivity on energy yield and to help identify whether the use of bifacial panels should be investigated further. Soiling monitoring will be undertaken at North Beach to provide data on the impact of salt and snow build up on the energy yield of PV panels.

- **Wind monitoring**
  Wind monitoring will be undertaken at a single location adjacent to the Hangar building using a Sound Detection and Ranging (SoDAR) device[14] to provide measured wind data to confirm the Weather Research and Forecasting (WRF) model output. The aim of the monitoring is to determine the most appropriate location for wind turbine mast installation.

[14] A SoDAR (sound detection and ranging) device is a remote sensing technology, sending directed sound pulses into the air volume above the device and from the reflections received, it is able to determine the wind speed, direction, and equivalent turbulence of the air mass.

### 3.2.4 Hangar Redevelopment

The Hangar Redevelopment project is considering options for the redevelopment of the Hangar building at Rothera in order to provide and maintain the infrastructure required to maintain effective Air Unit operations at Rothera.

The options under consideration broadly cover first major maintenance, refurbishment and western extension, refurbishment and southern extension, replacing the existing Hangar, or leaving the Hangar in its current state; 'do nothing'. This is discussed in more detail in Section 4.9.

This IEE only covers the SI and condition survey work to facilitate the design; no construction works associated with the Hangar redevelopment will take place prior to an appropriate EIA being carried out and approval from the FCDO.

Any SI and condition survey work that is required to inform the decision-making is captured in this IEE, as outlined below:

- **Apron Trial Pits and In-Situ Testing**
  This investigation will include intrusive trial pits, in-situ testing, and the collection of samples for testing. If the Hangar is extended or a new Hangar is constructed with the doors in a new position, it is anticipated that the tie-down points will have to be re-positioned to ensure they suit new operational requirements. The investigation is required to inform the design of the new tie-down points. The investigation will confirm location specific Apron build-up and strength/stiffness properties of the founding material.

- **Condition Survey of Hangar Substructure**
  The primary objective of the Hangar substructure survey is to assess the durability of the existing foundation concrete. This will involve excavation of inspection pits and concrete coring at selected foundations. The information gained will enable assessment of the existing condition of the Hangar substructure and confirm whether existing foundations are suitable for re-use.

- **Ground Investigation (GI) for Foundation Design**
  This GI is required to inform the design of new foundations for a new Hangar. This will involve up to 4 no. boreholes and 2 no. trial pits. This information is required to confirm ground and groundwater conditions at the location of new foundations. The GI will confirm the thickness of quarried rock fill overlying bedrock, the level and nature of bedrock surface, the strength and quality of bedrock, and assess the aggressivity of ground for buried concrete. Samples will also be obtained for geotechnical testing to enable design parameters to be derived.

- **Condition Survey of Primary Frame Material and Connection**
  The purpose of this survey is to assess the existing capacity of the Hangar superstructure in absence of full archive records or original design. This will enable structural analysis and design to be undertaken to assess the likely capacity of the existing portal frame to carry replacement cladding, additional building services, and equipment for the future operation of the Hangar.

- **Point Cloud Survey**
  A Point Cloud survey will be undertaken on the Hangar building. No measured survey exists of the Hangar and the data produced during the survey will be used to create an accurate

parametric 3D model that can be used to verify dimensions and to accurately define the deflected shape of the portal frames.

Following the above works, the condition of the Hangar building would be assessed and categorised.

### 3.2.5 Fuel Farm Infrastructure Upgrades

The works include the construction of a new fuel farm hut, two large steel platforms, and the relocation of the existing scaffolding storage area. The aim is that the fuel in all three Marine Gas Oil (MGO) bulk storage tanks can be circulated and filtered independently of the main fuel circulation. The existing fuel farm hut is to be retained in order to be incorporated into the planning connection to the new Discovery Building Site Wide Services.

The inclusion of fixed fuel polishing units will increase the quality of fuel (by reducing the amount of waxing) being consumed on site. This reduces the amount of waste fuel, providing greater efficiency of fuel use and less waste shipped out for disposal. Cleaner fuel will mean that all of the station boilers, generators and vehicles will run more efficiently. The new hut and associated plant will be fitted with individual bunds on each polishing skid with bund alarms, increasing our capacity to catch leaks in the system. The two steel platforms will store drummed fuel and compressed gas cylinders, enhancing control of these stores on station, and ensuring they are not lost during winter snowfall.

## 3.3 Operational Activities

The activities outlined in this IEE do not comprise of a change in operational activity. Therefore, no operational impacts have been considered as part of this IEE.

The proposed works outlined in Section 3.2 are proposed to be completed over two austral summer seasons, with the first commencing in November 2022 and ending April 2023 and the second commencing November 2023 and ending April 2024. Section 7: Programme of Activities, outlines when the proposed works are taking place across the two seasons.

## 3.4 Anticipated Waste

Waste volumes arising from the proposed works are not anticipated to be large due to their nature. All construction waste will be managed by BAM. Domestic waste from construction workers will be incorporated into the standard BAS waste management system. BAM aim to divert 80% of construction waste from landfill and 90% of all waste from landfill. See Section 6.2 Waste Management and Appendix 1: Rothera Runway Resurfacing and Lighting Site Waste Management Plan (SWMP) for further detail.

The SWMP identifies and monitors legislative requirements for waste management, types and quantities of waste expected to be generated, and defines selected waste management measures of prevention, reuse, recycling, and recovery and quantification at the end of the project. This allows a comparison to be made between forecast and actual waste quantities. Generation of waste material will be minimised at every stage of the project (design, procurement, and construction), and reduction strategies will be implemented as detailed in the SWMP. All materials whether they are imported, reused 'as is' on site, recycled (on or off site) or sent off site for disposal are identified within the plan.

### 3.5 Personnel

The station operates throughout the year. During the winter months, from April to mid-October, a 25-strong team continues the science work and maintains Rothera's infrastructure. More personnel will be on site at Rothera from November to April in both the 2022-2023 and 2023-2024 seasons, during which time other tasks on station will also be performed. It is understood that a cap of 51 construction personnel is in place for the construction works due to take place. The ongoing and continuous presence of operational and science personnel at Rothera are considered to fall outside the scope of this IEE, with the exception of any potential effects that would prevent the continued operations as a result of the proposed scope of works.

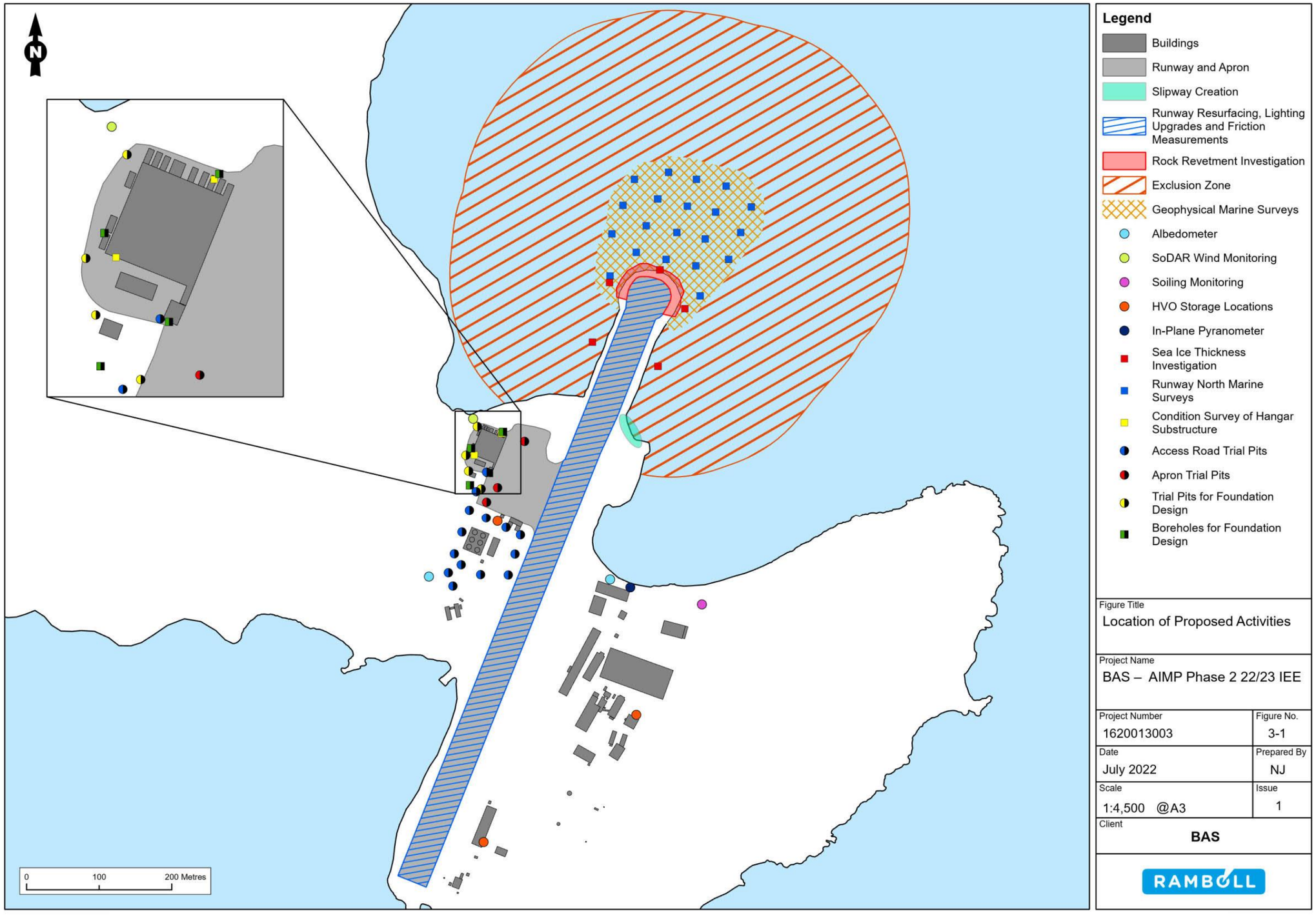



**Figure 3-1: Location plan of proposed activities at Rothera assessed within this IEE**

# 4. CONSTRUCTION, SI, CONDITION SURVEY AND MONITORING METHODOLOGIES

## 4.1 Runway Resurfacing and Lighting

The main activities associated with this project comprise rock processing, lighting civils works and M&E, and resurfacing works. The Runway Resurfacing and Lighting project is considered to be the only construction project that forms part of the scope of this IEE. Refer to Figure 4-1 for the proposed arrangement of the runway lighting civils and M&E works.

For all works associated with this project, prior to starting each shift, permission will be granted from the air traffic control (ATC) that works are safe to start on the runway. The general sequence of works are as follows:

**Season 1 (2022-2023)**

**Runway Rock Processing - December 2022 – April 2023**

Following site mobilisation and snow clearance at the start of the season in November, a team will begin to process the existing stockpiled rock to the size required by the project specification for use within the ducting network. No additional quarrying, drilling, or blasting will be required to obtain the necessary material for resurfacing activities as the existing stockpiled material on site is considered to be sufficient for these purposes. This surplus material was quarried during the Rothera Wharf Reconstruction project to help support future projects and reduce the duplication of quarrying activities, as assessed in the Rothera Wharf Reconstruction & Coastal Stabilisation CEE[13], and a subsequent PEA to assess the potential effects of additional quarried material. Under permit numbers 07/2018 and 12/2019-20 under Section 6 of the Antarctic Act 1994, 80,000 tonnes and 25,000 tonnes could be quarried respectively, permitting the extraction of a maximum of 105,000 tonnes of rock from the temporary quarry at Rothera. The Rothera Wharf Compliance Reports [15,16] provide further detail on the requirements for the surplus material and the reasons that additional material was required beyond the amount assessed as part of the original CEE.

Refer to Section 8.3.7 for more information on stockpiled material storage at Rothera, including stockpile locations and the grade of material stored at each stockpile. It is assumed that only the amount of rock required for the resurfacing works will be transported from the stockpile to be processed and used; therefore, any unused material will remain in the current stockpile location.

The material required for the resurfacing works will be processed using a cone crusher until the required grading is achieved. Three cycles of crushing and screening have been accounted for as part of the assessment of potential impacts – this is considered to be a conservative estimate of how many of cycles of crushing will be required to achieve the required grade. Further cycles of crushing would need to be recorded within the Register of Project Variations, the impacts of more than three cycles have not been assessed as part of this IEE. The crushing and screening activities will take place in the area previously used to supply material for Rothera Wharf. This area is currently being utilised as a cargo and material laydown area – see Figure 4-19, page 47.

[15] BAS Environment Office, November 2019. Rothera Wharf and Coastal Stabilisation CEE Update and Compliance Report

[16] BAS Environment Office, October 2020. Rothera Wharf and Coastal Stabilisation CEE Compliance Report

It is acknowledged that the cone crusher has already been shipped to Rothera and processed prior to the production of this IEE, therefore 'commencing' this activity with regards to support work to ship equipment to Rothera. This activity has been recorded and noted, and any biosecurity risks have been addressed within the cumulative impacts section of this report.

**Runway Lighting Civils Works – November 2022 – March 2023**

The majority of the materials required will be mobilised to Rothera in advance of the works, with some materials already transported to Rothera in late 2021. Mobilisation on site will commence in November 2022.

Containers containing drummed fuel will have to be relocated to accommodate the trenching for the runway lighting cables, as well as the installation of the PAPI lights, as outlined below. In both instances, containers will not be moved far from their original location and will avoid sensitive locations. Prior to starting duct installation works, a series of trial holes will be excavated to identify the location of services and highlight any potential clashes. This will allow works to progress with greater speed once it comes to the actual installation of duct works. Where services have been identified, trial holes are to be hand dug using insulated tools to confirm the position of the detected services. These trial holes will be completed adjacent to the service and never directly over the assumed line of the service.

Ducting and chamber installation is anticipated to take place between November 2022 and March 2023. Plastic ducting will be used. Ducting installation will be completed using a 13 T excavator with a gang of four skilled operatives. Where possible, trenches will be backfilled at the end of a shift once ducting is laid and completed, however if this is not feasible, trenches should be suitably covered, fenced, and signed; trenches will not be left open for longer than necessary. Following this, the installation of foundation and bases will take place to facilitate the subsequent runway resurfacing works. All work areas will be made safe prior to aircraft operations as outlined in the agreement with BAS Air Operations.

The runway crossing service installations are anticipated to be undertaken in March 2023. The runway crossing service installation will take place once the last flight from Rothera has taken off for the season. This will eliminate the need to plan works around the air traffic control requirements. With the services being installed across the runway the same process will be followed as per duct routes outside of the runway.

The main control measure for this will be close communication streams between the ATC and construction team. Each daily briefing will be checked in with the ATC to ensure they are aware that works are taking place on the runway.

An extended section of gravel runway at 0 to -17 m chainage is proposed to be constructed to maximise the useable surface area of the existing runway footprint without extending the reclaimed area further into the sea. This is anticipated to be undertaken in March 2023.

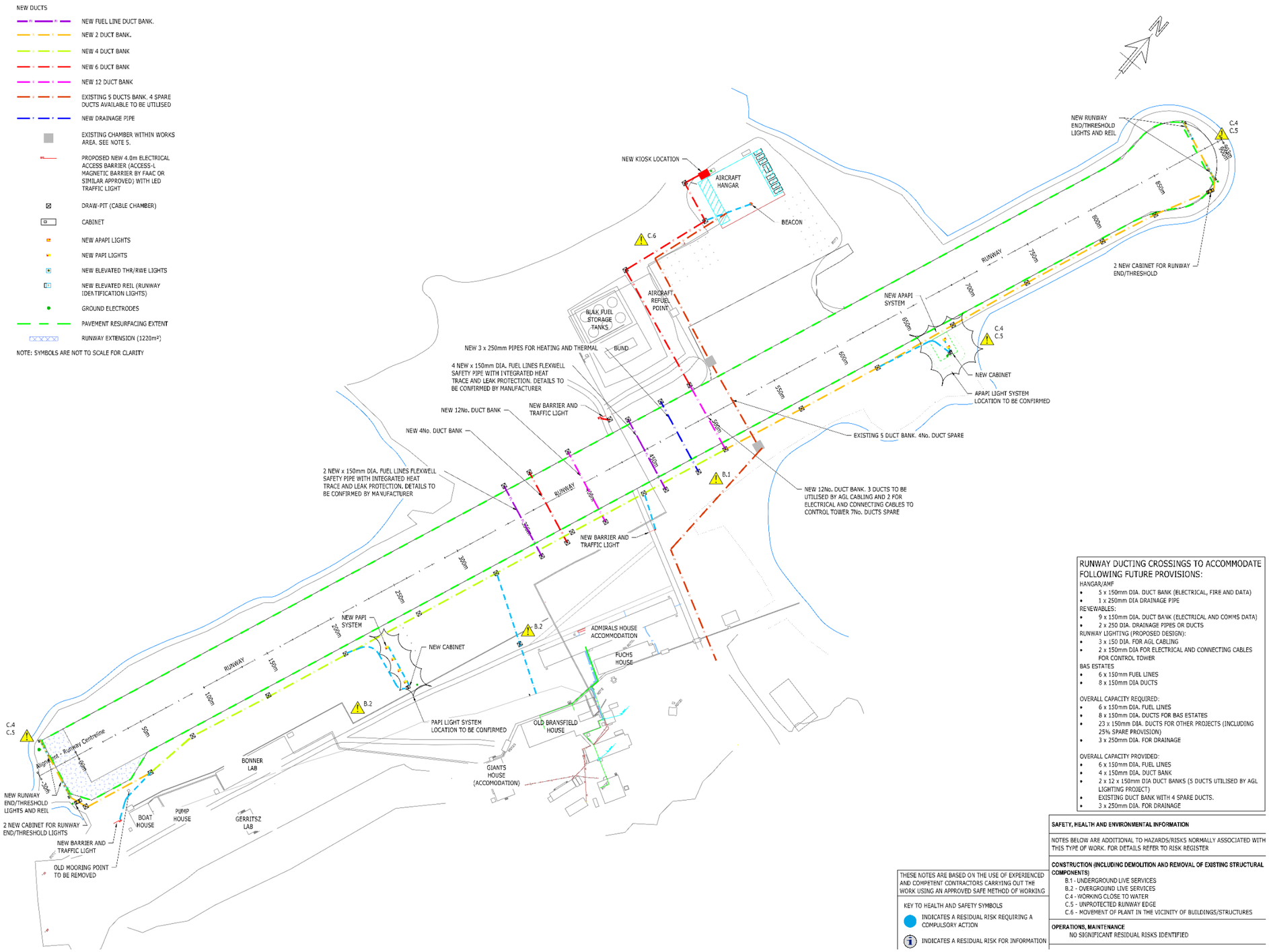



**Figure 4-1: Runway Resurfacing and Lighting proposed arrangement, Ramboll 2022**

**Runway Lighting M&E - February 2023 - April 2023**

The M&E installation and cable pulling will commence as sections of ducting feeding these areas are completed. All M&E work will be completed and commissioned, with training and handover to BAS prior to demobilising from site. Handover and commissioning will take place in April 2023. Lighting bulk material requirements are summarised in Table 4-1.

**Season 2 (2023-2024)**

**Runway Resurfacing – January 2024 – February 2024**

The runway resurfacing works will commence upon the delivery of the runway resurfacing plant and equipment on the RRS SDA between September 2023 and December 2023. Once mobilised, the anticipated duration of works is 6 weeks.

The resurfacing works are anticipated to commence between January 2024 and February 2024 and will be split into three (chainages -17-300 m, 300-600 m, and 600-900 m) across the full width of the runway. *In-situ* California Bearing Ratio (CBR)/plate bearing tests will be carried out on the exposed surface to determine the strength of the underlying soils; CBR testing can be applied to soils with a maximum particle size of 20 mm. For soils with bigger particles, plate bearing tests will be undertaken. These tests will confirm that material strength is adequate for the purposes of the runway operations by ensuring the test results are not less than 30%. Four CBR tests will be carried out along the runway.

The existing runway top surface layer is required to be scarified to a depth of 30 mm to 50 mm to get a suitable surface for the new material to bind to. Prior to starting scarifying works the top surface a stockpile of material will be transported to the construction area to ensure that in the event of an unscheduled flight landing, BAM are able to restore the runway to the required condition at short notice.

The aggregate will be placed in a series of layers, no less than 75 mm or more than 150 mm of compacted thickness. This thickness will be controlled using a robotic dozer which will be calibrated at intervals specified by the supplier.

During the resurfacing period the runway will be closed to all aircraft operations. With the exception of works to the 300-600 m chainage section, runway operations are not anticipated to cease entirely during the resurfacing works and the Twin Otters may be able to operate in compliance with air operations procedures, however, this will be BAS operations decision.

The size of plant and equipment required to carry out the works will be determined by both the capacity of the transportation vessel (cargo holds and cranes) as well as conditions on site. Material requirements for the runway resurfacing are summarised in Table 4-1.

**Table 4-1: Bulk material requirements for runway resurfacing and lighting upgrades**

| **Runway Resurfacing: Bulk Materials** | |
|---|---|
| **Item** | **Quantity ($m^3$)** |
| Surface Course – 16 mm Aggregate | 6600 |
| Base Course – 25 mm Aggregate | 1700 |

| | |
|---|---|
| Levelling Course – 75 mm Aggregate | 370 |
| Sub base – 100 mm Aggregate | 300 |
| **Runway Lighting Upgrade Materials** | |
| 3 mm Bedding | 345 |
| <=2 mm Bedding | 48 |
| **Total** | **9,363** |

Upon completion of the works, any waste generated would be removed from the station and returned to the UK on the SDA under appropriate permits and conditions.

### 4.1.1 Friction Measurements on the Runway

To obtain friction measurements along the runway, an existing vehicle already on-site such as a fire truck or quad bike, will be driven along the runway whilst towing the friction trailer behind it by members of the air unit ground coordination and estates team; the vehicle to be used is not yet confirmed. Vehicles will be driven in accordance with existing vehicle driving policies, and wildlife avoidance policies and will follow standard refuelling procedures. The staff undertaking this activity will receive training on how to use the equipment prior to deployment, alongside specific vehicle, wildlife, and environmental training received upon arrival on site.

### 4.1.2 HVO Trial

The HVO trial will use Green D+ fuel, which is an enhanced type of HVO produced from 100% waste materials. The use of 1 litre of HVO is calculated to reduce $CO_2$ by 90%, or a saving of 2.8 kg of $CO_2e$. To facilitate the trial of Green D+, two Western Global 2,000-litre Transcubes and one Western Global 950-litre Transcube are proposed to be delivered in a 20-foot container to Rothera. The tank required for transport and storage of the HVO fuel will be International Organisation for Standardisation (ISO) compatible, UN approved and include a bund which can contain 110% of the volume of the tank. Transportation of the fuel will be aboard the SDA.

The location for the HVO storage is required to be in a clear, flat, and easily accessible location. Two locations have been chosen as suitable for the storage of the containerised tank; the fuel farm and the Generator Shed. These locations were selected in consideration with early season conditions, snow clearing and slippery routes, therefore it is possible that multiple locations will be used during the season as conditions change. These are shown on Figure 4-2 below as red lozenges along with the proposed position for the 950-litre tank a smaller bowser to feed the BAM 65 kVA generator, which is south of the Bonner Lab, shown as a purple lozenge. The HVO trial will last one full season, including the winter, to ensure that the effects of cold conditions on HVO fuel are assessed. In the event of a HVO fuel spill, the existing Oil Spill Response Measures for MGO will be followed. A 1,100-litre spill kit will be supplied by BAM in a wheeled bin adjacent to the HVO tank.

The Green D+ fuel is proposed to be trialled on a limited range of plant initially but will be expanded to all engine types in use at Rothera in due course. Should the trial be successful it is calculated that approximately 14,000 litres of MGO and 3,500 litres of AVTUR could be replaced by HVO, in future construction seasons, based on existing fuel use estimates.

A number of factors will be available to determine whether the replacement of MGO with HVO is successful, these include;

- Testing vehicle exhaust emissions for NOx, CO, HC, CO2 and O2, using a RASI 800 portable emissions and flue exhaust gas analyser before and after the switch to Green D+;
- Maintenance records;
- Fuel use records; and
- Confirmation that fuel is usable after wintering.

In order for a trial of Green D+ to go ahead during the forthcoming season, the main priority is to ensure space is allocated aboard the SDA for the tank to transport the fuel which would require the removal of an existing allocated cargo item. The most important actions therefore going forward are:

- Confirmation of tank to be used for the trial;
- Procurement of tank; and
- Allocation space aboard the SDA.

Should the HVO trial be successful, it is possible for the existing tanks at the fuel farm to be changed from storing MGO to HVO.

**Figure 4-2: Proposed areas for the two 2,000-litre storage tanks (red) and the proposed position for the 950-litre tank (purple), BAM 2022**

## 4.2 Runway Upgrade Project

The elements of the Runway Upgrade project which are assessed in this IEE only include SI and condition survey activities. As such, for this initial stage of the Runway Upgrade project, there are no construction activities. Constructed elements of the Runway Upgrade project will be assessed in an appropriate EIA and submitted to the FCDO for approval at a later stage.

### 4.2.1 Runway North Marine Surveys

Based on the worst-case runway design extent, 10 samples are considered sufficient to provide a representative sampling array from within the survey area, however 20 sampling locations have been provided on the basis that it is unlikely that a sample will be successfully collected from every location (see Figure 4-3). The collection of samples will require Specialist Activity permits to remove material from Rothera for testing either on site or in the UK; this IEE will be used in the application process.

Sampling will be undertaken by a dive team to obtain grab samples from the seabed. These surveys are understood to be undertaken by BAS. At each marine survey point, a photograph and/or video footage will be collected of representative seabed material to visually confirm the nature of the seabed. A description of the seabed material and seabed surface will be determined from this visual information using the particle size fractions listed in Table 4-2.

**Table 4-2: Particle Size Fractions**

| Soil fractions | Sub-fractions | Symbol | Particle Sizes (mm) |
|---|---|---|---|
| Very Coarse Soil | Large Boulder | LBo | > 630 |
| | Boulder | Bo | > 200 - 630 |
| | Cobble | Co | > 63 - 200 |
| Coarse Soil | **Gravel** | **Gr** | **> 2 – 63** |
| | Coarse Gravel | CGr | > 20 – 63 |
| | Medium Gravel | MGr | >6.3 – 20 |
| | Fine Gravel | FGr | >2.0 – 6.3 |
| | **Sand** | **Sa** | **>0.063 – 2.0** |
| | Coarse Sand | CSa | >0.63 – 2.0 |
| | Medium Sand | MSa | >0.2 – 0.63 |
| | Fine Sand | FSa | >0.063 – 0.2 |
| Fine Soil | **Silt** | **Si** | **>0.002 – 0.063** |
| | Coarse Silt | CSi | >0.02 – 0.063 |
| | Medium Silt | MSi | > 0.0063 – 0.02 |
| | Fine Silt | FSi | >0.002 – 0.0063 |
| | Clay | Cl | ≤0.002 |

If the divers are able to access the seabed at the proposed inspection point, a sample will be obtained of the representative seabed material, alongside measurements with a hand-held probe with length markers to estimate the thickness of any soft or silt/clay material.

The size of the samples will depend on the material collected; a larger number of samples are required for coarser grained material. Although, it is estimated that each sample will measure up to 5 kg based on there being some medium to coarse gravel present, with sand and silt. The samples will be taken to the Rothera site lab for Particle Size Distribution (PSD) testing and will not be removed from Rothera. An application for a Specialist Activity Permit will be submitted with this IEE for this activity.

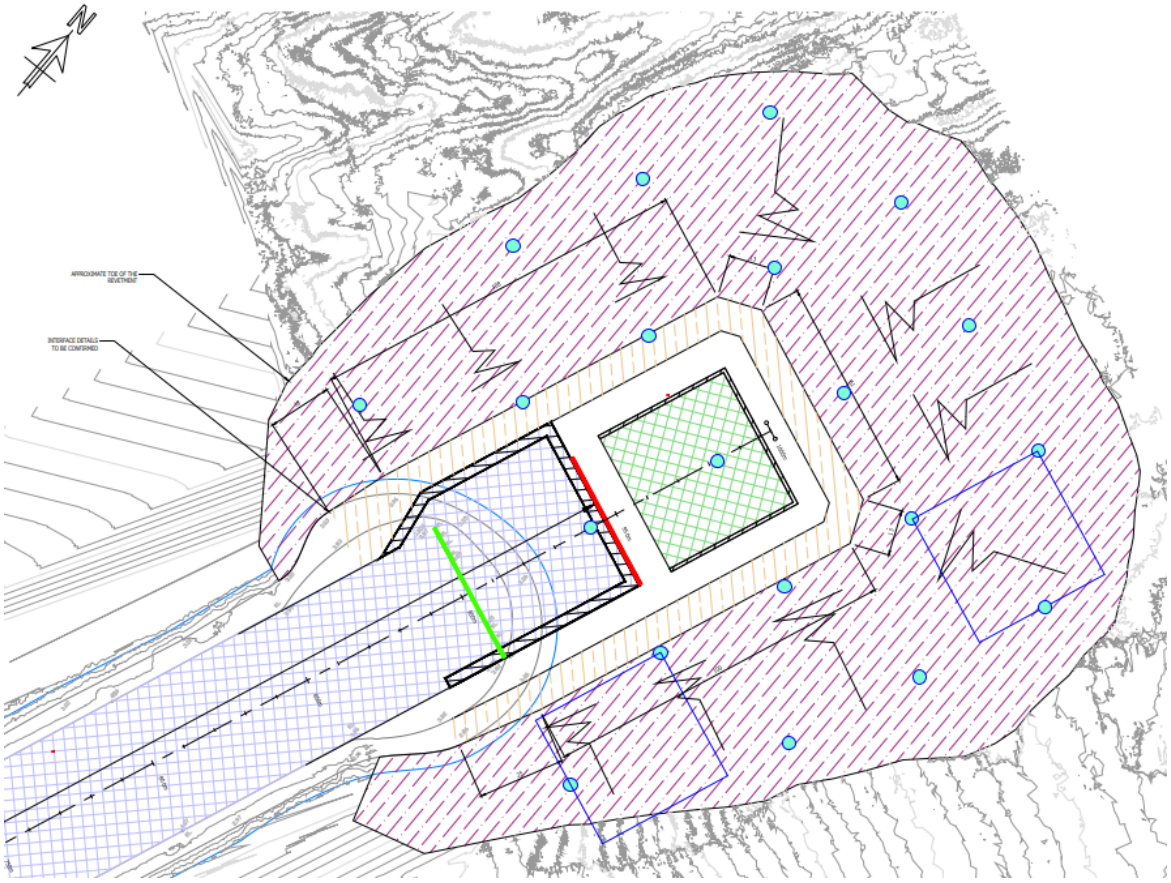


**Figure 4-3: Runway North Marine Survey Sampling Points, Blue Squares Indicate A 40 M Spacing for Scale Reference, Ramboll 2022**

The dive team would obtain photographs at each survey point and use a hand-held probe for estimation of the thickness of any silt or soft material. The details of method statement for the dive survey would need to be discussed with the BAS divers such as the maximum depth and duration for divers, health and safety requirements and the environmental conditions under which diving may safely be done. The survey points would be inspected by divers or a remotely operated vehicle (ROV), depending on water depth. Equipment required would be an underwater camera (for taking stills and/or video) with a Global Positioning System (GPS) locator, up to 5 m long probe with length markers, ROV, sample bags, a dive container, BAS hyperbaric chambers and a safety boat. This equipment is already on site as it is required for other dive work around Rothera.

The marine surveys will be undertaken during austral summer months, when sea ice is minimal, and divers are available at Rothera. The dives will be undertaken before the algal bloom to avoid poor underwater visibility.

### 4.2.2 Rock Revetment Investigation

The rock revetment investigation will comprise a walkover survey of the existing sections of the revetment that could potentially be reused for the runway upgrade. The long reach excavator will be used to undertake selected excavation of the revetment to establish the thickness of the armour layer and the condition of armour units. Excavation below water level will only take place in limited locations near to the beach or in areas deemed safe based on a site risk assessment undertaken with the BAS site representative. Disturbed rock will be placed in the exact location from where they were removed. The extent of the investigation is shown in Figure 4-4.

Sections of the revetment will be defined as good condition where sections of the revetment show rock armour in reasonable condition suitable for reuse. Good condition will be defined as 80-100% free of fracture, rounded edges and degradation including severely rounded edges and spalling or cracking. Rock above 250 mm will be considered suitable for reuse. Any eroded sections will have information on the length of the eroded section, maximum eroded width, and the setting out position recorded. Photographs of the existing revetment both at locations of minimal deterioration and otherwise will be recorded along with observations of areas where there is a loss of armour stone contact or interlock, breach or loss of crest elevation or core exposure, and/or evidence of slope steepening or sliding.

This would require one excavator operative, one banksman, and one inspection engineer. The locations will avoid science programmes or sites and no samples will be taken as part of this activity. The rock revetment investigations require access to the ground surface so would be carried out following snow clearance. The works are anticipated to take one month and will be programmed around priority Air Unit operations which take priority.

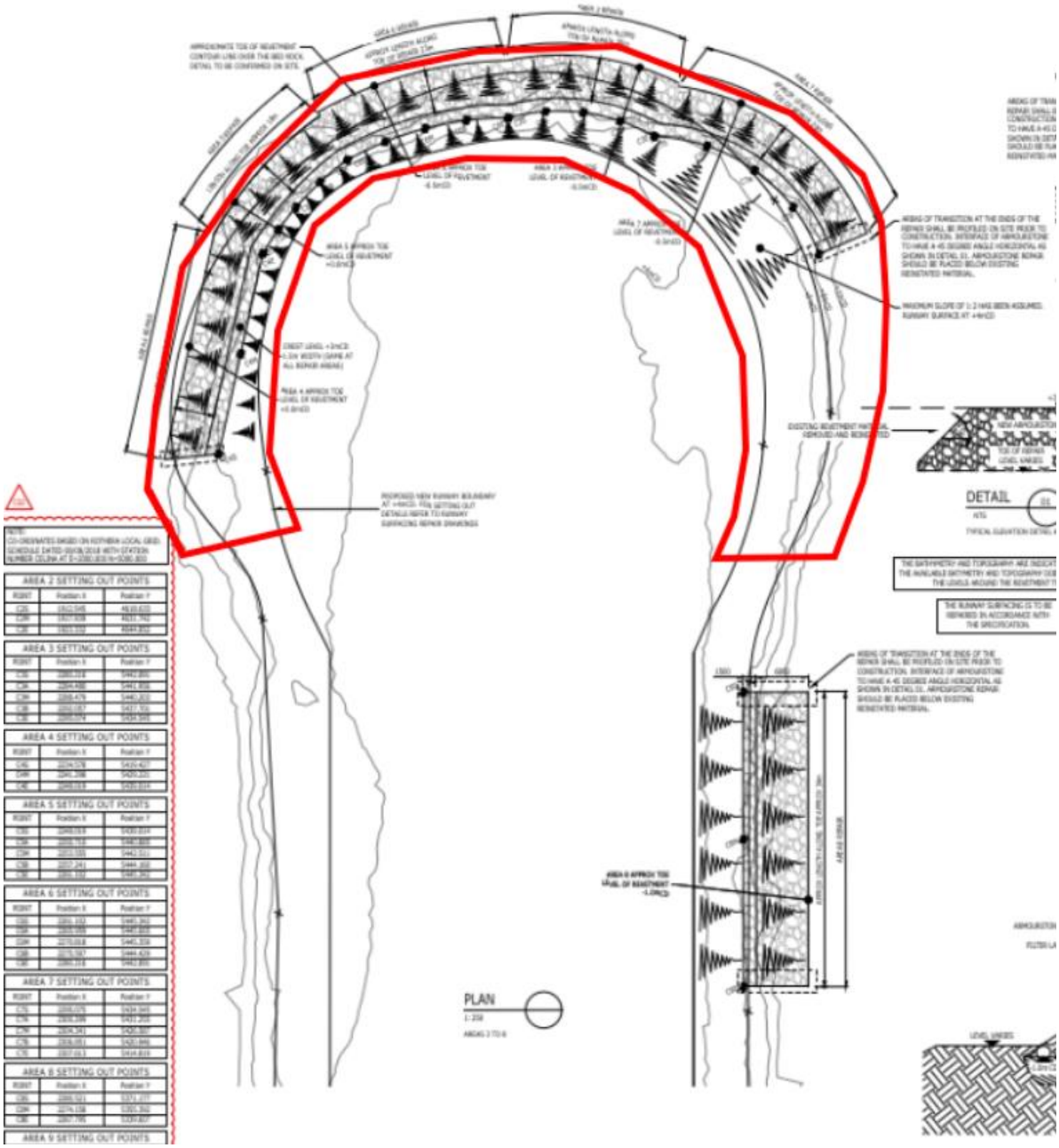



**Figure 4-4: Location of the Rock Revetment Investigation at the North End of the Runway**

### 4.2.3 Sea Ice Thickness Investigation

There are 5 no. locations for sea ice thickness measurements adjacent to the existing runway, at chainages 800 m and 900 m, and the northern tip of the existing revetment (Figure 4-5). Measurements will be taken over a min 5 m length at 1 m intervals and may be taken in a straight line. Measurements will be taken 5-10 m away from the revetment (closer if it is safe) and will be accompanied by photographs of the condition of the existing revetment and of the ice itself so as to ascertain the type of sea ice.

Measurements, photographs, and observations should be taken at the start of winter, mid-winter and near the end of winter, at the same locations to determine how the sea ice condition varies

over a typical season, including at least 5 no. observations over 4 weeks during the thaw period. 3 no. observations may be taken at other periods. The investigations will be undertaken using an ice corer (already on station at Rothera) and a measuring device during the winter diving exercises. The ice corer would be handheld and used until the full depth of sea ice is reached. At this point the core would be removed, measurements taken, and then the ice re-plugged where it came from. Handheld or head torches may be needed depending on lighting requirements.

During thaw periods, thicknesses may be measured from photographs. This investigation will be undertaken by BAS.

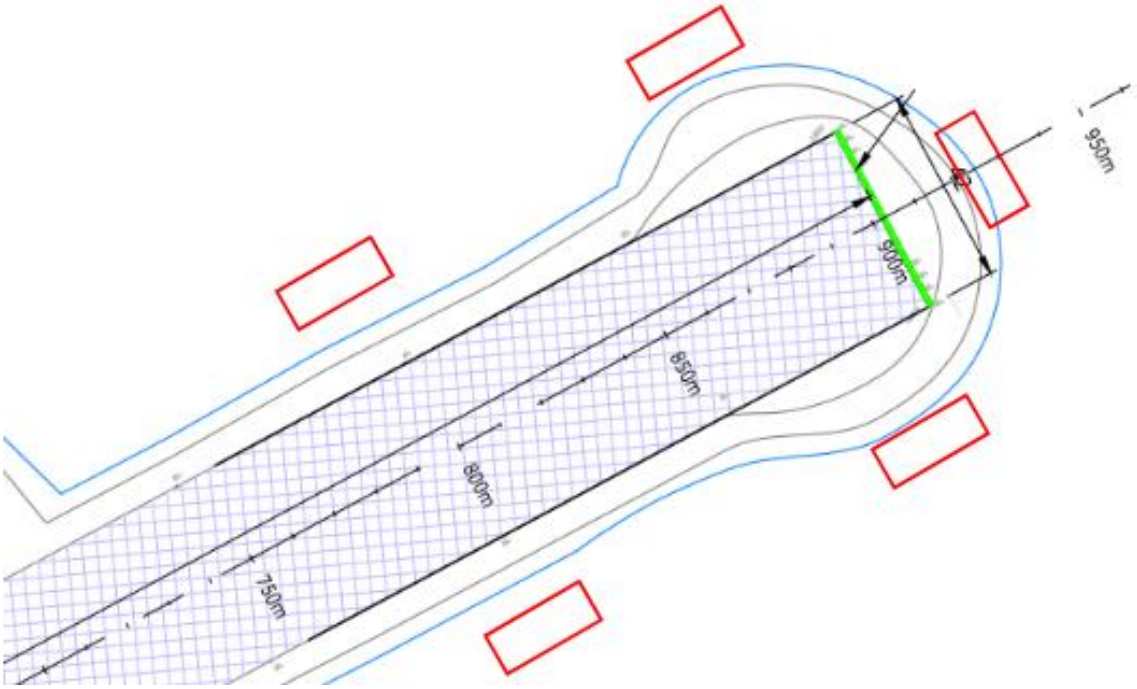



**Figure 4-5: Location of Sea Ice Thickness Measurement Points, Ramboll 2022**

### 4.2.4 Access Road Investigation

Four options for alternative access roads are being considered. There is a possibility that all routes will be investigated, which would mean taking 14 trial pits across all four of the options (Figure 4-6). The investigation will also comprise a geotechnical visual inspection and in-situ testing (plate load testing/LWD).

A visual inspection will comprise an engineering description of the materials encountered along the proposed route, with photographs obtained at each inspection location. Trail pits will be taken at approximately 30 m intervals to assess the variability of the ground conditions along the route. This will include information on the thickness and nature of the superficial material and depth to bedrock (if encountered at a shallow depth). Trial pits will be up to 1 m deep to enable assessment of the shallow soils for pavement design. There is no minimum plan size of the trial pits, they are to be sufficient size to enable excavation down to the required depth. Trial pits will be logged and photographed (from the surface) in accordance with the recommendations of British Standard (BS) 5930: 2015 Code of Practice for Ground Investigations by a suitably experienced geotechnical engineer / engineering geologist. Backfilled material will be compacted using the excavator and excavator bucket and the ground surface re-instated to the original

condition. Reinstatement to be confirmed satisfactory by BAS Station Leader / BAS Air Unit prior to moving on to the next position. Any observations regarding groundwater and frozen ground / ice will be recorded. Trial pits will not be left unattended at any time and will be backfilled as soon as possible on the day of excavation.

In-situ testing will take place in between trial pits at approximately 30 m centres, to assess the strength and stiffness of the ground along the route. Plate load testing will derive an equivalent CBR value. Plate loading testing to be carried out in general accordance with BS 1377 - 9: 1990: Methods of test for Soils for civil engineering purposes - Part 9: In-situ tests, Section 4.1. CBR value to be calculated from plate load testing results using IAN 73/06 Rev 1, 2009 – Design Guidance for Road Section 4, Chapter 7. Results from the plate load test to be plotted on a load-settlement curve, from which the load corresponding to a deflection of 1.25 mm can be obtained. This is used to calculate the CBR as per IAN 73/06. Plate diameter will be 300 mm. The load shall be applied in five increments. The load increments should be roughly equal and up to a maximum load that causes the plate to settle by 1.25 mm or more. For a 300 mm diameter plate load increments of 3 kN (42 kN/m2), up to 15 kN (212 kN/m2) are proposed. The applied load may need to be increased if the plate does not deflect by 1.25mm or more under the highest load or reduced if too much deflection occurs in the first load stages.

Existing services and underground structures have been identified and located prior to the intrusive ground works. Trial pits and in-situ testing will be moved to avoid spatial conflict with services or due to environmental or airfield operational constraints. The trial pit investigation will require an excavator and excavator operative, a banksman, and an inspection engineer. The in-situ testing will require an LWD, plate load testing equipment and trained personnel required for using LWD and carrying out plate load test.

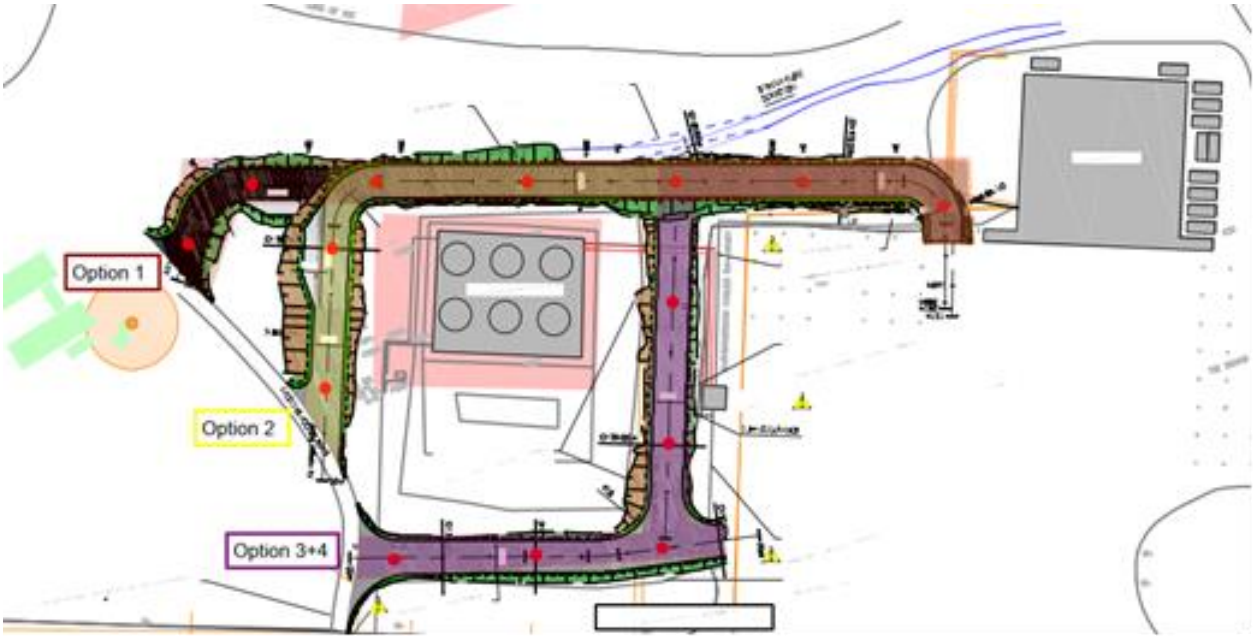



**Figure 4-6: Access Road Options and Indicative Trial Pit Locations**

### 4.2.5 Geophysical Marine Surveys

All surveys will be in the nearshore zone and this survey is based on the worst-case potential runway extension. All geophysical surveys will be undertaken in the austral summer months when there is no sea ice.

For the bathymetric survey, full coverage is required within the survey areas and the survey will be carried out using approved methods and equipment. It would require use of the 21 ft 'Sea Rover' that is normally used for scientific work at Rothera, in addition to a fabricated frame to allow the installation of survey equipment rigidly onto the vessel. A bathymetric survey engineer / technician would also be required. A sidescan sonar survey would detect objects / obstructions on the seabed and lower sections of the existing runway revetment. A single channel sparker survey would identify and classify the sub-surface geology and map bedrock level. This would be carried out by specialist contractors using their specific methods and equipment – this would be approved by BAS. These two surveys would require two surveyors and one boatman, a survey boat, a rig, and the necessary sonar equipment. This would be an EdgeTech 4125i side scan sonar system and a Seaprobe DT Combined Sidescan and Sub-Bottom System.

A 200 m acoustic exclusion zone will be established around the full extent of the survey works, as no injury to marine mammals is expected beyond this exclusion zone[17]. Although the size of the area impacted by sound is typically small, they can impact marine mammals at close ranges, mostly within 200 m.

### 4.2.6 Creation of Non-Engineered Slipways

The creation of a non-engineered slipway is proposed to the area north of the windsock and one at the location of the temporary jetty to be removed in the 22/23 season, both locations are shown in Figure 4-7. The slipways will be 6.5 m wide and will extend to a depth of 1.5 m below the water line at a 20% gradient, in order to provide sufficient under keel clearance. The slipways will be made with an excavator on the beach using processed stone already available on site at Rothera. The required quantity (less than 100 tonnes) of 30-80 mm crushed rock for each slipway will be transported from the appropriate stockpile using a dump truck, deposited carefully at the location of the slipway, and spread into position using an excavator with sufficient reach to avoid having to go into the water. The finished surface and levels will be checked by an engineer prior to acceptance, including dipping from a boat at the outer areas. The works will be undertaken by BAM across two days in February 2023, with the slipway at the location of the temporary jetty being carried out in conjunction with the deconstruction of the existing structure.

[17] Available at: Bureau of Ocean Energy Management - https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Atlantic-Region/GandG-Overview.pdf [Accessed 21 July 2022].

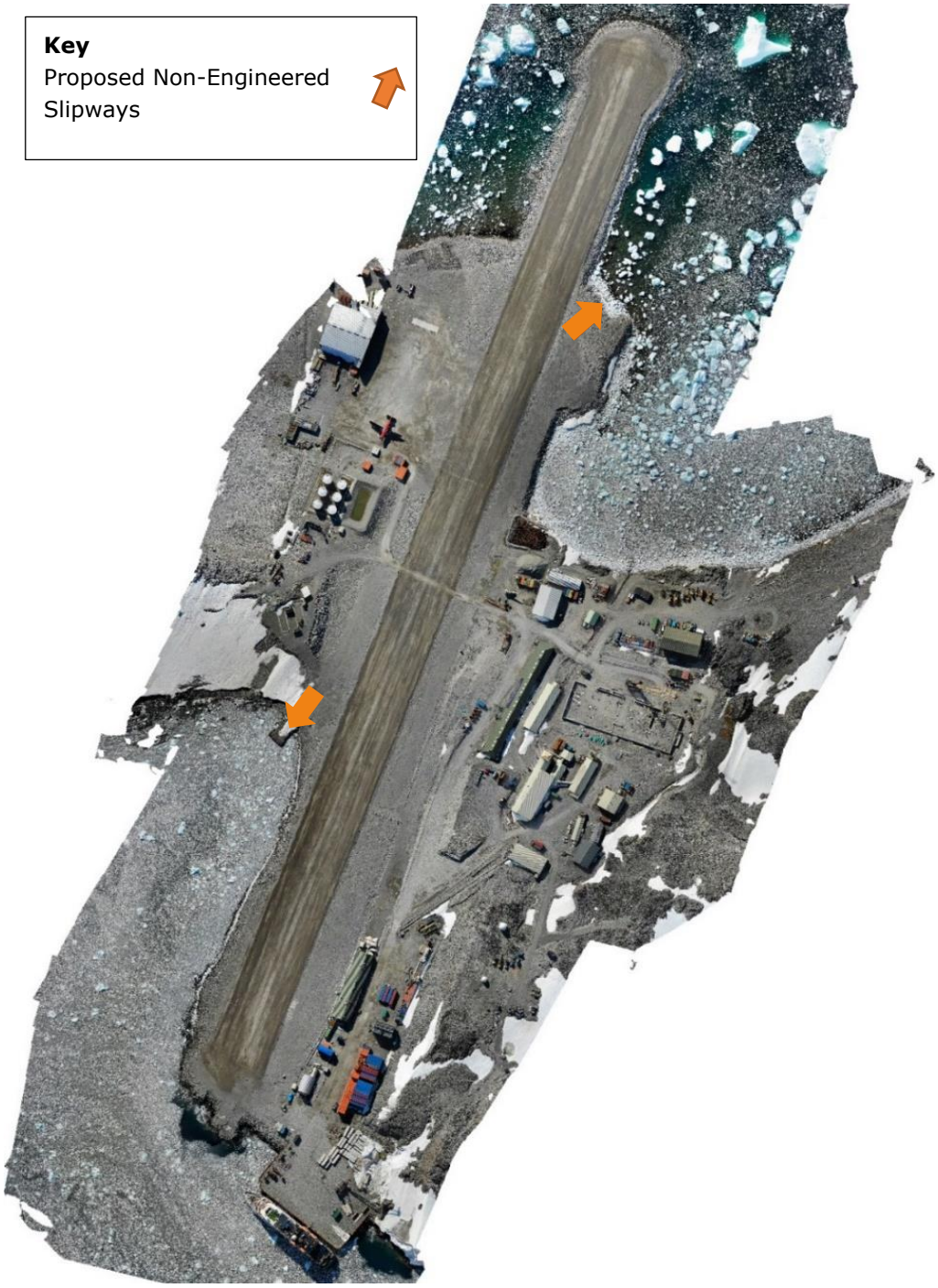



**Figure 4-7: Proposed Location of the Non-Engineered Slipway in the Area North of the Windsock and at the Location of the Temporary Jetty**

## 4.3 Renewable Energy

The elements of the Renewable Energy project assessed in this IEE include condition survey activities, environmental monitoring and the HVO trial. As such, for this initial stage of the Renewable Energy project, there are no construction activities. Works to improve renewable energy generation at Rothera require detailed knowledge and understanding of the most effective

locations and methods to employ renewable energy infrastructure. The renewable energy generation methods being explored predominantly comprise the use of wind and solar power through the use of turbines and PV panels respectively. Where available, maintenance requirements are provided for each activity, but likely maintenance activities include cleaning equipment and sensors, and checking power and communications connections frequently. The minimum monitoring period will be 12 months, but this may be extended.

The scope of investigation and condition survey works applicable to the Renewable Energy project are summarised in more detail here.

### 4.3.1 Visual Condition Survey of Roof Structures

The visual condition survey of roof structures of three existing buildings at Rothera (Admirals House, New Bransfield House (NBH) and the Hangar building) will require one inspection engineer and one Mobile Elevating Work Platform (MEWP) operator.

### 4.3.2 Condition Survey of Existing PV Panels

A visual survey of the condition of existing PV panels on NBH, Gerritsz Laboratory and Giants House buildings will require one inspection engineer and one MEWP operator.

### 4.3.3 Energy Demand Metering of Current Buildings

The energy demand metering of current buildings at Rothera requires two electricians and associated electrical equipment such as meters.

### 4.3.4 Solar Irradiance, Albedo and Soiling Monitoring

Solar irradiance, albedo and soiling monitoring will be undertaken at various locations around the site. At each location specified, an insulated and waterproof battery box will be installed as a back-up supply. Data will be obtained using a datalogger and manually collected using a USB stick.

Solar irradiance will be measured at one location at North Beach using an in-plane pyranometer. Albedo will be monitored at North Beach and adjacent to the fuel farm area. Each albedo monitoring location will require its own black tripod. Soiling monitoring will be undertaken at North Beach. This will be achieved through the installation of two PV panels: one soiled and one clean to determine the difference in the outputs between the two panels. The locations of these activities are shown in Figure 4-8.

All solar monitoring equipment requires an 8-10 ft mast mounted to a tripod that can be staked to the ground or weighed down using sandbags to prevent movement due to wind (the exact ground fixing is not known at this stage). This will require one MEWP operator and an inspection engineer.

Solar PV modules should be cleaned regularly, especially before the start of summer season to remove snow and accumulated dirt and salt. The front of the glass layer needs to be wiped gently with a soft cloth to avoid cracks. Snow removal should be carried out with the utmost prudence in order to protect the glass integrity. It is also recommended to check module connection and replace any damaged cable connection.

Inverters generally require very little maintenance, and regular preventative maintenance should, as a minimum, include:

- Visual inspection;
- Cleaning and replacing cooling fan filters;
- Tightening of any loose connections; and
- Any additional analysis and diagnostics recommended by the manufacturer.

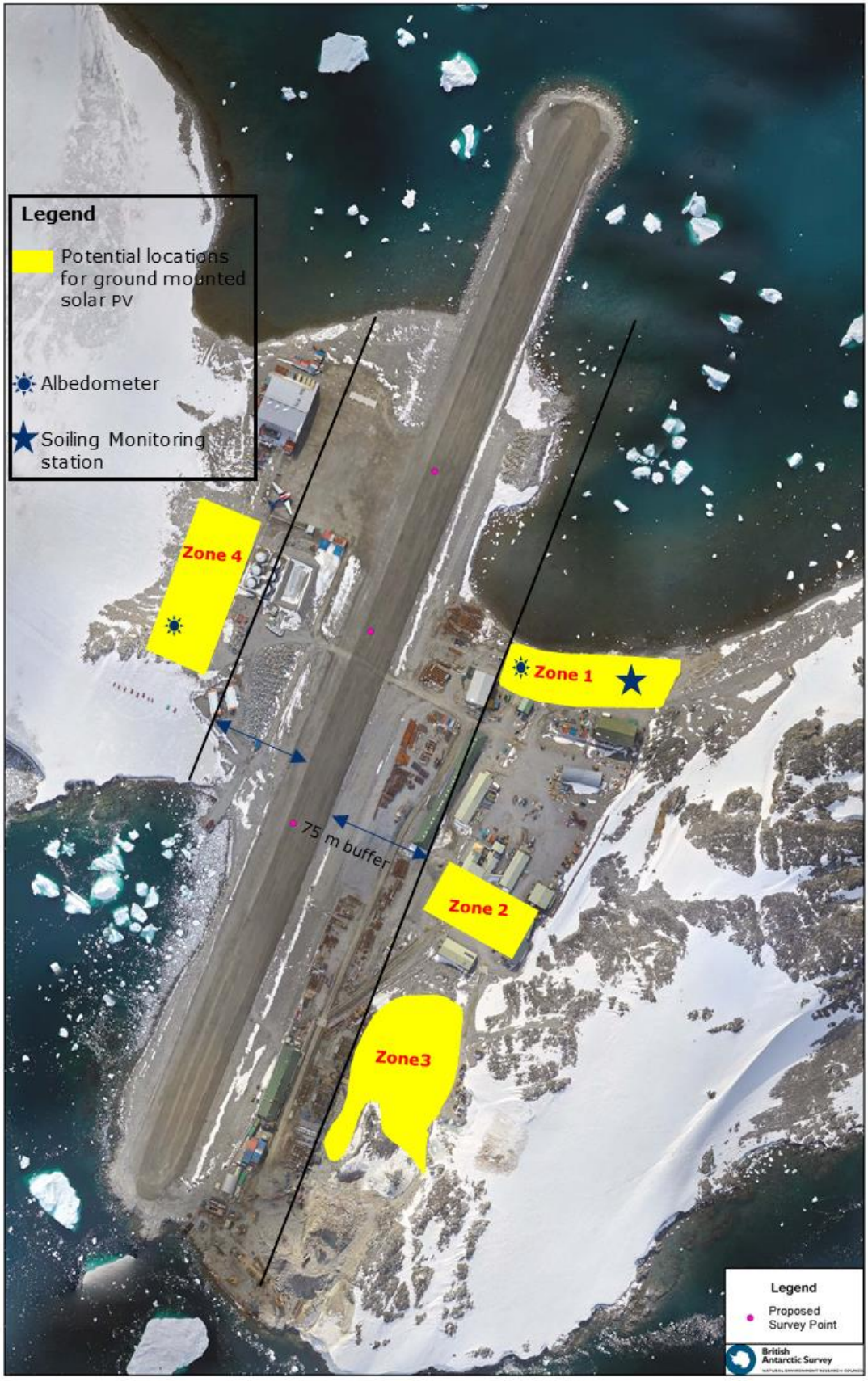



**Figure 4-8: Proposed Location of Solar Monitoring Activities**

### 4.3.5 Wind Monitoring

Wind monitoring will be undertaken at a single location adjacent to the Hangar building using a Sound Detection and Ranging (SoDAR) device[18] (an AQ510CW). This data will not be used to inform the daily decision on which activities can go ahead or for impact assessment purposes. The location of this activity is shown in Figure 4-9.

Other locations and monitoring methods were considered but it was decided that this location is the most suitable, and Light Detection and Ranging (LIDAR) was discounted due to technical constraints with the use of this type of monitor.

The device will be installed in a trailer for ease of movement at the site and to protect the SoDAR device. The trailer dimensions are 430 cm x 190 cm x 245 cm, and it weighs 1,200 kg. The system communicates through General Packet Radio Service (GPRS) or satellite communication. Electrical power can be supplied by a diesel-powered generator or by connection to a nearby fixed supply. Heating can be supplied by diesel-powered heaters. This requires two engineers to set up and calibrate the device. Maintenance activities will include snow clearance and refuelling of the generator, approximately every three months (if one is required). The maximum measurable wind speed is 40 m/s.

The location of the SoDAR device behind the Hangar building has the benefit of blocking some of the sound propagation towards residential buildings at Rothera. The monitoring unit will produce sound pulses (short beeps in the range 3-4 kHz) which are audible up to a few hundred metres distance. The SoDAR device emits sound on a repeating 3 beep cycle, with 110 cycles every 10 minutes, for a total of 330 beeps per ten minutes. Anticipated noise levels with distance from the receptor are presented in Table 4-3; measurements were recorded during summer months and therefore a reduction from these levels presented during winter months is considered likely due to the dampening effect of snow.

**Table 4-3: Sound Power Levels for the AQ510 Sodar Device, Data From AQ Systems**

| Distance (m) | Noise (decibels (dB)) |
|---|---|
| 0 | 71 |
| 5 | 60 |
| 10 | 56 |
| 25 | 47 |
| 50 | 43 |
| 100 | 36 |
| 200 | 30 |

[18] SoDAR is a remote sensing technology, sending directed sound pulses into the air volume above the device and from the reflections received, it is able to determine the wind speed, direction, and equivalent turbulence of the air mass.

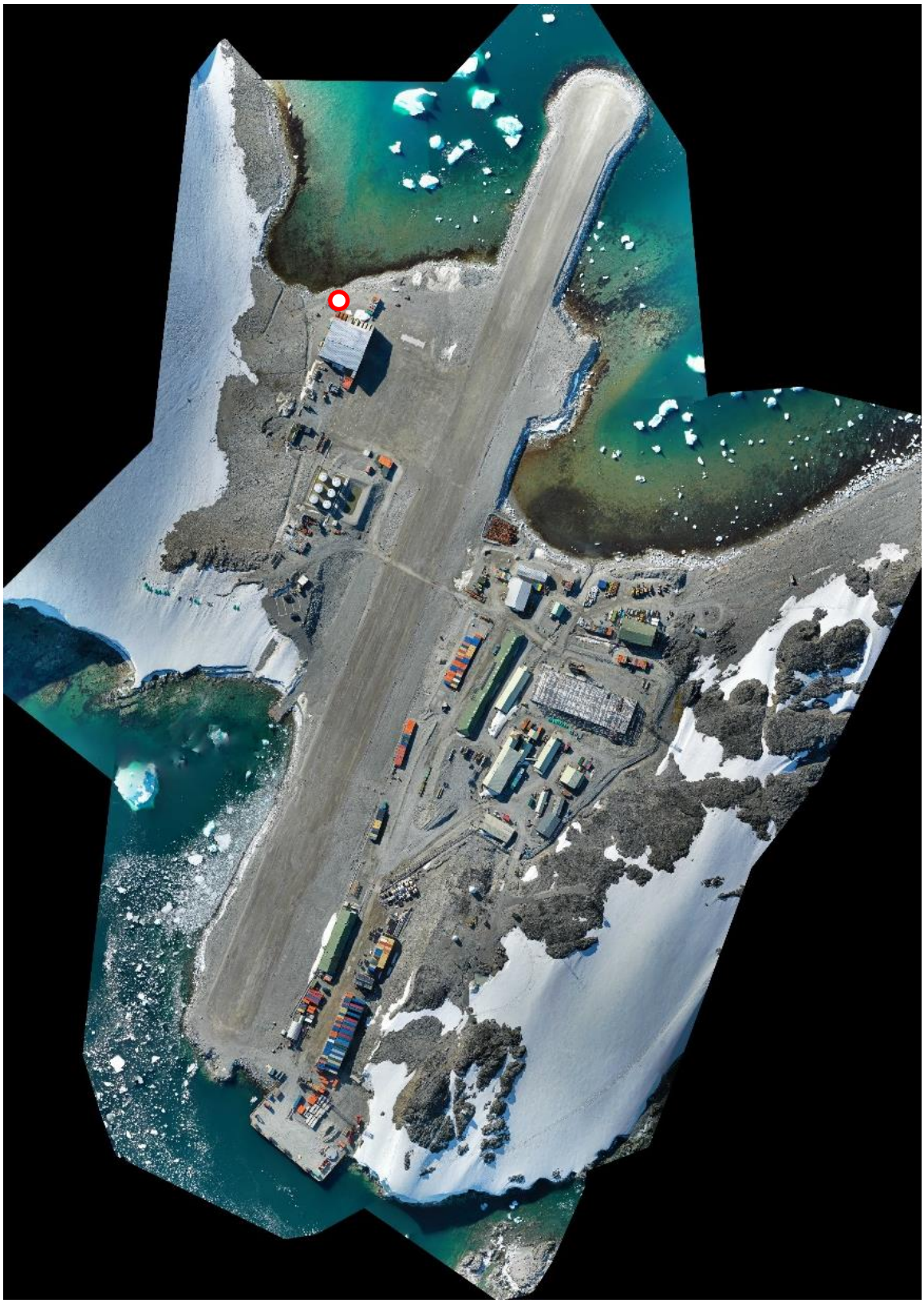


**Figure 4-9: Proposed Position Of The Sodar Device**

### 4.4 Hangar Redevelopment

The existing Hangar is located on the western side of the station at the opposite side of the runway to the main station area. The Hangar is a 1,293 $m^3$ rectangular building with a pitched roof. The walls and roof are clad in colour coated, steel cladding panels. The substructure of the Hangar steel columns consists of *in-situ* reinforced concrete plinths that extend 3 m below ground level (bgl) to reinforced concrete pad foundations, which are weighed down by surrounding gravel to resist uplift and sliding forces created by wind loading on the Hangar superstructure. The Hangar is over 30 years old, and previous survey findings in recent years have recommended a number of actions and repairs to the structure. The condition surveys and SI of the Hangar superstructure and substructure will be undertaken as part of the Hangar Redevelopment project have used these previous findings to inform the scope of works.

The key issues identified for the Hangar are:

- Roof sheeting repairs and leaks;
- Low level cladding corrosion; and
- Hangar door operation.

The following repair and maintenance works are required for the structure to be considered appropriate for continued use:

- Clean off surface corrosion and loose paint from all relevant areas of primary steel and holding down bolts and then apply new paint;
- Remove the corroded bottom section of cladding and replace. New panels need to be robustly fixed to the existing cladding sheets at the top and the ground floor reinforced concrete slab at the bottom. These connections are recommended to be fully weathertight.
- Replace damaged cladding and secondary steelwork on the southern elevation, with the same consideration for fixings as above;
- Trace all seams in the roof that are not watertight and seal;
- Replace insulation that has been removed;
- Remove surface corrosion from door runners and apply new corrosion protection; and
- Patch concrete that has been worn away over the wiring along the door runners.

In addition to the repair requirements outlined above, the option to redevelop and extend the Hangar in its entirety is currently being considered, and the outcomes of this SI will inform the optioneering process. The proposed options for the Hangar redevelopment currently under review are:

1. Do nothing;
2. First major maintenance;
3. Refurbishment and western extension;
4. Refurbishment and southern extension; and
5. New build option.

Indicative locations for the Hangar SI works are provided in Figure 3-1, page 17.

#### 4.4.1 Apron Trial Pits and In-Situ Testing

The investigation will include 3 no. trial pits at the existing apron to 1 m bgl and 2 no. in-situ tests (plate load test/LWD for CBR value) within each trial pit at depths of 0.7 m bgl and 1 m bgl.

Samples from each layer of material (as per the above depths) will be taken for grading/PSD testing. PSD testing will be carried out using equipment already on site and no soil material will be removed from Rothera.

The location of the trial pits are shown in Figure 4-10. Trial pits will be up to 1 m deep to enable assessment of the shallow soils for tie-down design. There is no minimum plan size of the trial pits, they are to be sufficient size to enable excavation down to the required depth in a safe manner. Trial pits will be logged and photographed (from the surface) in accordance with the recommendations of BS 5930: 2015 Code of Practice for Ground Investigations by a suitably experienced geotechnical engineer/engineering geologist. Backfilled material will be compacted using the excavator and excavator bucket and the ground surface re-instated to the original condition. Reinstatement to be confirmed satisfactory by BAS Station Leader/BAS Air Unit prior to moving on to the next position. Any observations regarding groundwater and frozen ground/ice will also be recorded. The works will require one excavator operative, one banksman and one inspection engineer. The works will require access to the ground surface so will be undertaken once snow has been cleared.

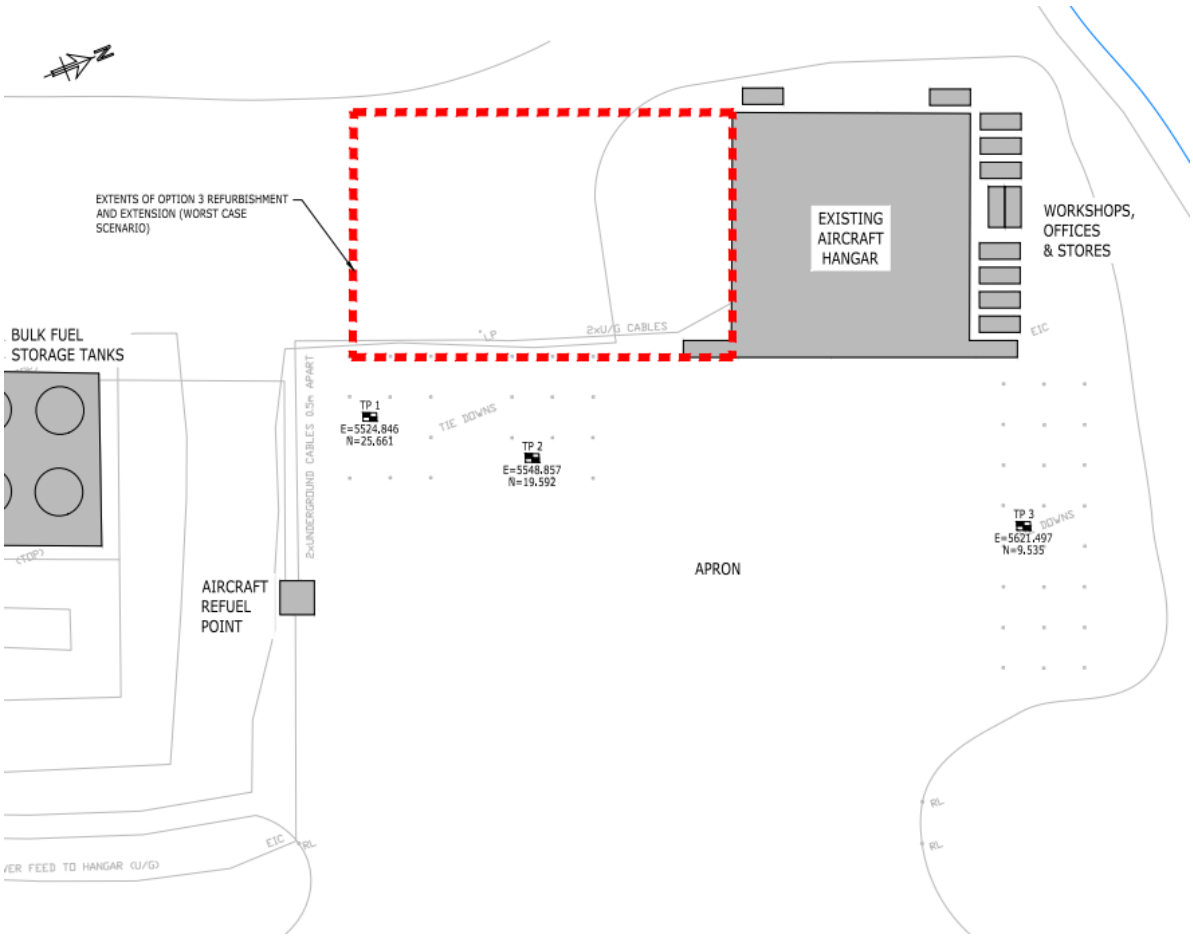



**Figure 4-10: Location of the 3 no. Trial Pits at the Apron**

### 4.4.2 Condition Survey of Hangar Substructure

The survey comprises 2 no. inspection pits to be excavated at two foundation locations, one to the north and one on the south elevation (Figure 4-11). A suitably qualified person will inspect the concrete, take photographs, and record any quality of concrete issues (i.e., deterioration in

concrete condition, cracks and/or exposed aggregate). One concrete core will be obtained per foundation, and cores will have a minimum diameter of greater than three times the maximum nominal size of the coarse aggregate, or 50 mm. For strength tests, the cores will have a length of at least twice their diameter. To avoid cutting the reinforcement, reference will be made to the as-built reinforcement drawings and other available information, such as construction photographs, to determine the expected position of the reinforcing steel. It is recommended that ferroscanning equipment is used to confirm the position of the reinforcement prior to coring. The reinforcement cover will be checked using a cover meter or by visual assessment.

The excavation, visual inspection and coring works at the foundations will be supervised by a suitably experienced structural engineer or geotechnical engineer/engineering geologist to ensure all necessary data is collected and no damage is caused to the foundations. The inspection pits will be logged and photographed in accordance with the recommendations of BS 5930: 2015 Code of Practice for Ground Investigations. The side slopes of the inspection pits will be battered to an angle that is observed to be safe and stable during the initial excavation of the pit. If water flow from the ground surrounding the pit causes instability the angle of the side slopes of the pit will be reduced to ensure the stability of the excavation whilst inspections are carried out. Excavation arisings/spoil from the inspection pits should be stockpiled at least 2 m away from the edge of the inspection pit to prevent the excavation from collapsing. The stockpiled material will be used to backfill the inspection pit once it is complete. The backfill material will be carefully placed in the reverse order to how it was excavated. Backfilled material will be compacted using the excavator, excavator bucket and lightweight compaction plant and the ground surface re-instated to the original condition. Work will be supervised by a structural/geotechnical engineer, to ensure that ground conditions are reinstated. Reinstatement will be confirmed satisfactory by the Site Supervisor/Project Manager and Estates Facilities Engineer prior to moving on to the next position.

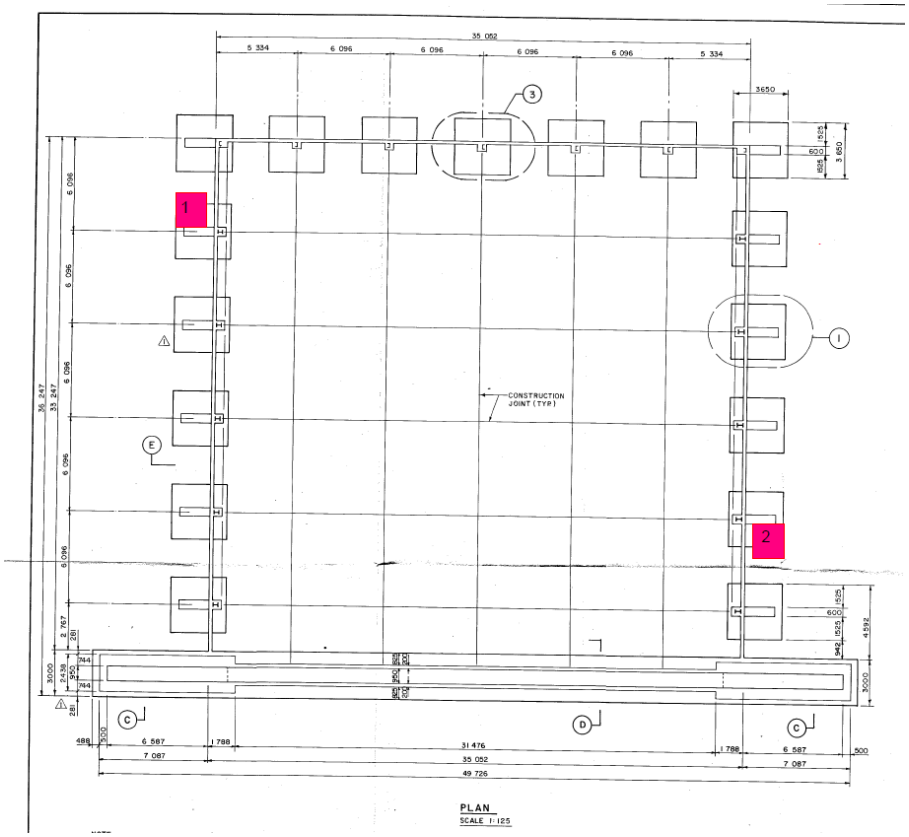



**Figure 4-11: Two no. Trial Pit Locations at the Foundations of the Hangar Building**

The risks associated with excavating at the foundations include damaging the foundation with excavator bucket and temporarily reducing the performance of the foundation (resistance to uplift and sliding) when surrounding backfill is removed during the excavation. Therefore, the extent of the excavation at the foundations is to be kept to a minimum but will be sufficient to assess the size and condition of the foundations safely.

The excavation will be carried out carefully, supervised by a structural/geotechnical engineer, to ensure that as little concrete as possible is exposed to gather sufficient information. The excavation will be left open for a minimum amount of time. Trial pits will be backfilled as soon as information has been gathered.

The foundations support the portal steel frames which will exert vertical and horizontal forces. The granular backfill surrounding the foundations prevent sliding as well as uplift under wind loading and it is therefore important that the excavation and backfilling/reinstatement works are carried out carefully and supervised by a suitably qualified person. The 2 no. foundations highlighted for inspection have been selected as they should be at lower risk from uplift than the corner foundations and should also have some ability to shed load to adjacent columns and foundations once exposed. These foundations have been selected as they have been subject to the greatest wind loading throughout the lifetime of the structure. If the concrete at this foundation is in good condition, it is likely that the remaining foundations are also in good condition, so there will be no need to expose additional foundations.

These works will require one excavator operative, one banksman, one inspection engineer and one concrete corer. The works are understood to be undertaken by BAM. These works will

require access to the ground surface and so will be undertaken once snow is cleared; the exact duration of works is not yet known, although they will take place during the 2022-2023 season.

### 4.4.3 GI for Foundation Design

The level of GI required varies for different Hangar redevelopment options due to the degree of modification to the structural form of the Hangar associated with that option. The level of GI required also depends on the foundation type. The preferred Hangar redevelopment option has not been selected and therefore the exact location of this GI is still to be confirmed. Therefore, this scope covers the GI associated with all Hangar redevelopment options. This includes three options, as shown in

Figure 4-12, Figure 4-13 and Figure 4-14 below, with indicative locations for boreholes and trial pits.

The proposed GI comprises the following:

- Up to 4 no. rotary boreholes, 20 m bgl with soil/rock sampling and geotechnical laboratory testing; and
- 2 no. trial pits, 3 m bgl with soil sampling, in-situ testing (plate load testing) and geotechnical laboratory testing.

The boreholes will be formed using rotary coring methods, with an open hole to rockhead and core to final depth. No hydrocarbon based or bentonite drilling fluids will be used. Water or air will be used as a flush medium to progress the boreholes. The drilling contractor will take appropriate measures to obtain the best possible core run (total core recovery > 90 %). A triple tube coring system is required such that core samples will be collected in a plastic liner. Rotary core drilling will produce cores of circular cross section not less than 100 mm diameter throughout the core length. Sub-samples are required for laboratory testing and are to be undertaken following core preparation and prior to destructive logging. Cores will be securely packed in labelled core boxes at the drill rig.

Core samples are to be exported to the UK for geotechnical testing (point lead and unconfined compressive strength) and chemical testing (pH value and sulphate). The removal of samples from site and the transportation of the samples back to the UK will be covered by the necessary environmental permits. In-situ testing in boreholes is not required.

Boreholes will be logged in accordance with the recommendations of BS 5930: 2015 Code of Practice for Ground Investigations by a suitably experienced geotechnical engineer/engineering geologist. Boreholes will be surveyed and levelled, and the as-built location marked on a plan of the site. Photographs of the core shall be taken as per the recommendations of BS 5930: 2015 Code of Practice for Ground Investigations.

As for trial pits, these will be machine excavated up to 3 m deep to enable assessment of the shallow soils, carry out in-situ testing and obtain samples for geotechnical testing. There is no minimum plan size of the trial pits, they are to be sufficient size to enable excavation down to the required depth in a safe manner. 3 no. bulk samples will be taken from each pit for grading/PSD testing. Samples will be of soil or completely weathered/fractured rock which can be removed using the excavator bucket – no coring is required to obtain samples. PSD testing will be carried out using equipment already on site and no material will be removed from Rothera. Small sub samples will be obtained for pH and sulphate testing (sent to UK for offsite testing). The removal of samples from site and the transportation of the samples back to the UK will be covered by the necessary environmental permits. In-situ testing in the form of plate load testing will be carried out at a depth of 0.5 m bgl in each trial pit.

Trial pits will be logged and photographed in accordance with the recommendations of BS 5930: 2015 Code of Practice for Ground Investigations by a suitably experienced geotechnical engineer/engineering geologist. The trial pits and arisings will be logged and photographed from the surface. All trial pit faces will be photographed from the surface and a survey staff or equivalent should be used to provide a scale in the photographs. A photo board will be used to identify each trial pit. Photo board will display the following: site name, date, trial pit reference and trial pit final depth. Excavation arisings/spoil from the trial pits will be stockpiled at least 2 m away from the edge of the trial pit to prevent the excavation from collapsing. The stockpiled material will be used to backfill the trial hole once the trial hole is complete. The backfill material will be placed in the reverse order to how it was excavated. Backfilled material will be compacted using the excavator and excavator bucket and the ground surface re-instated to the original condition. Reinstatement will be confirmed satisfactory by BAS Station Leader/BAS Air Unit prior to moving on to the next position.

Soil samples obtained will be representative of the strata encountered. The samples will be sealed in bulk bags and labelled with the trial pit name and depth from which the sample was obtained. Samples will be retrieved from the excavator bucket. The size, depth, and orientation of the trial pit, as well as the plant used and stability of pit side walls, will be noted on the logs. Any observations regarding groundwater and frozen ground/ice will also be recorded. The trial pit location and level should be surveyed, and the as-built location will be recorded on a plan of the site and the general location of the trial pit be photographed. The plant will be operated by appropriately qualified personnel and will be in safe working order, with all the necessary and up-to-date operation certificates/tickets. Pits will not be left unattended at any time and shall be backfilled as soon as possible on the day of excavation, or suitably covered, fenced, and signed.

These works will require access to the ground surface and will be undertaken once snow is cleared. The exact duration of works is not yet known although they will take place during the 2022-2023 season. The work will require a C6 casagrande drill, borehole casings, an excavator,

core liner and core boxes, 2 x C6 drill operatives, and one geotechnical engineer logger. A Specialist Activity Permit will be submitted with the IEE for the collection of samples of rock material from trial pits and removal to the UK for testing.

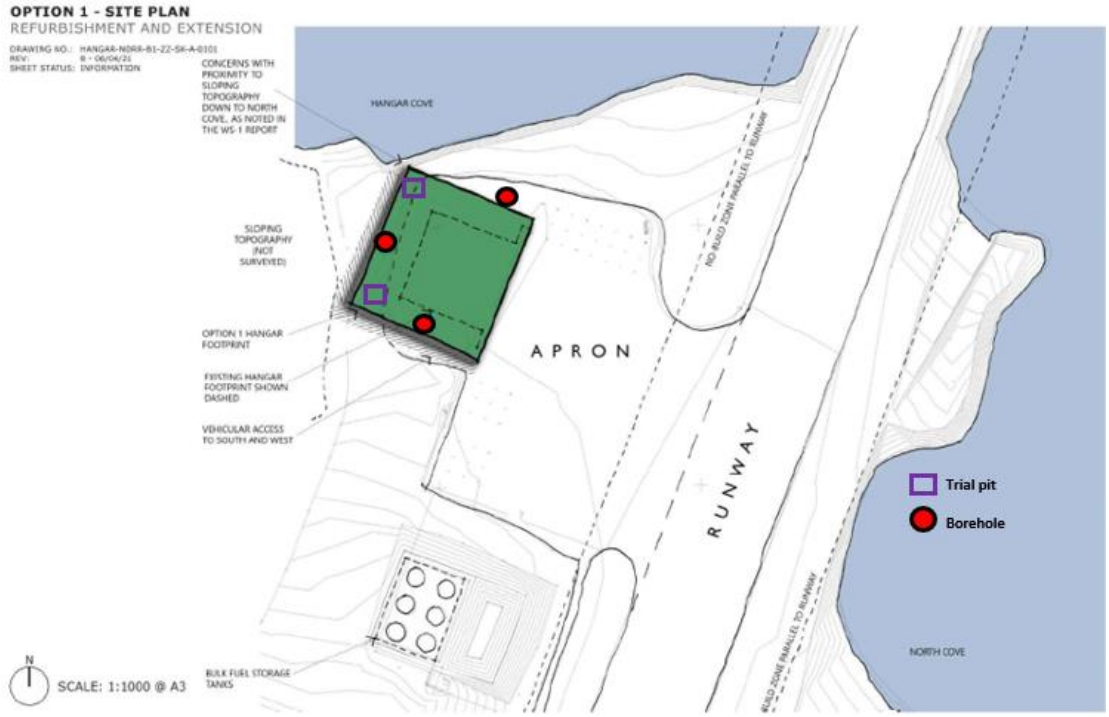



**Figure 4-12: Option A (Formerly Known as Option 1) Borehole and Trial Pit Locations (The Existing Hangar Footprint is Shown as Dashed Lines)**


**Figure 4-13: Option B (Formerly Known as Option 2) Borehole and Trial Pit Locations**


**Figure 4-14: Option C (Formerly Known as Option 4) Trial Pit and Borehole Locations**

### 4.4.4 Condition Survey of Primary Frame Material and Connection

An assessment of the existing capacity of the Hangar superstructure will be undertaken through both intrusive and non-intrusive surveys. This will involve taking a 150 x 150 mm sample of steel web from the central side portal for strength testing in the UK. Survey connections investigation will include taking full dimensions, plate sizes, weld sizes and extents, bolt sizes and number for apex, eaves, splices, and baseplate to foundation. This will require one inspection engineer and one MEWP operator. The works are anticipated to take two to three days.

### 4.4.5 Point Cloud Survey

Point Cloud condition surveys will be undertaken as a critical part of establishing the adequacy of the existing Hangar for reuse. The survey uses a laser to produce an internal and external scan of the Hangar building.

The outcomes of this survey will provide information to support the evaluation of any reduction in serviceability, such as:

- Unacceptable deformations which affect the efficient use; and
- Local damage which may reduce the working life of the structure.

It is understood that the equipment required for the survey is available at Rothera to use. This would be carried out at a time agreed with the Air Operations Unit in order to minimise disruptions to Hangar operations.

## 4.5 Fuel Farm Infrastructure Upgrades

The existing layout of the proposed working area is shown in Figure 4-15. Following snow clearance, the existing scaffolding storage area to the south of the Fuel Farm will be disassembled and relocated over 2-3 days in December. This will require use of an excavator as well as personnel using shovels. This will be relocated later in the season, potentially further south to the orange area in Figure 4-16 below. This will hold the estates store of scaffolding, and it is intended to consolidate this material and reduce the storage space required.

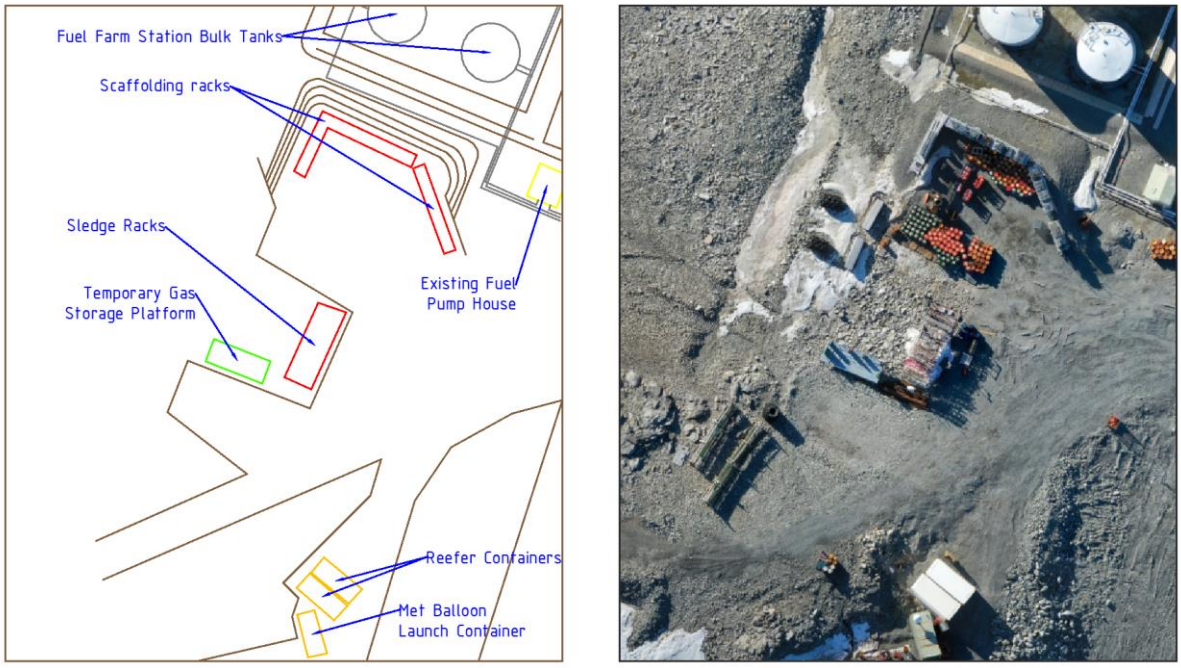



**Figure 4-15 Existing Layout of the Proposed Working Area (diagram on the left and aerial image on the right)**

All cargo required for the work will be shipped on the SDA in December and all works will be undertaken by the BAS Estates team. The materials required for concrete mixing (sand and cement) are already stored in a container on site at Rothera. BAS Estates will operate in a similar way to BAM from a construction perspective and will follow the same on-site procedures and protocols. Concrete mixing will be required on site to facilitate this work, with 25.8 $m^3$ required for the new fuel farm hut and 5.5 $m^3$ for the foundations of the platforms.

### Fuel Farm Hut

The proposed location of the new hut is shown in yellow below (far right), adjacent to the existing hut and within the confines of the existing fuel farm. The prepared area will be levelled off and graded using an excavator, banksman, and an operator. No material will be removed or added. The rock itself will not be removed from the area or inserted from other areas, only levelled., the excavator will scrape the surface to provide an even base for the foundations of the fuel hut. It is expected that less than 500 kg of rock will be moved.

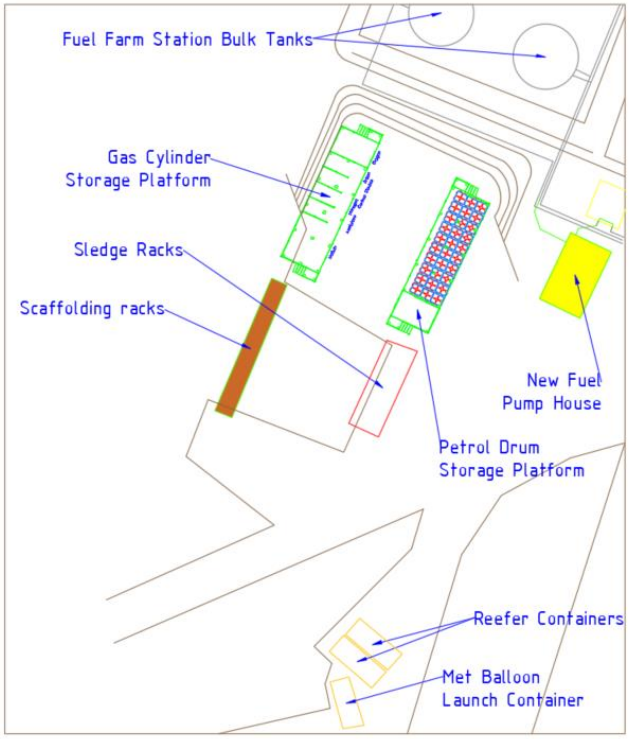



**Figure 4-16 Proposed Layout of New Structures**

A new concrete pad and streel frame hut will be constructed, as shown in Figure 4-17 below. A concrete pad will be laid ahead of the 8 m x 5 m hut construction. The concrete pad will comprise of a 600 mm x 600 mm concrete edge beam, with the infill 200 mm thick. Once the pad has cured the steel structure can be constructed. This will require two builders and one MEWP and is likely to take up to two weeks.

As work is being carried out on the concrete pad and the hut, the welders can start welding up the 2" pipe runs from the existing MGO storage tanks as well as preparing the additional sections of 4" pipework for the ring main to the new fuel farm hut (timescale of six weeks). The six fuel lines from the three MGO storage tanks can be assembled and installed prior to works on the existing fuel circulation ring main.

Once the new hut and pipework is complete the internal fit out can take place. This will include placing the three no. polishing skids and securing them to the floor. The new pipe runs will then be brought into the hut and the connection to the skids will be made. Power will be connected to the new incoming distribution board and the lighting will be installed.

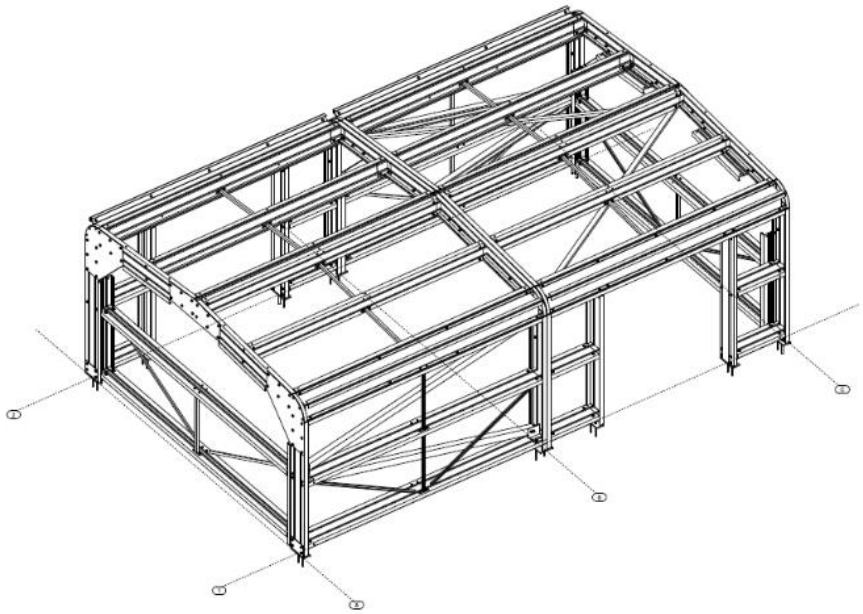


**Figure 4-17 New Hut Steel Frame Design**

After the installation is completed and tested in the new hut, the existing station ring main will be isolated and drained around the fuel farm in order to add in the section that will run through the new hut. The old pump will be decommissioned but will only be removed once the new pumps have been fully set to work.

The pipework has been painted prior to shipping and will be shipped in a purpose-built stillage to protect it from damage. A marine grade two-component paint will need to be hand painted over the welds to protect them from the environment. This is a regular maintenance activity for the existing infrastructure.

### Two Steel Platforms

At the same time the ground works are being completed for the hut, the lay down area will be graded and levelled off ready for the platform installation. This will require minimal ground works as the platforms are intended to sit above broken ground on concrete pads. The footings will be placed in the below arrangement for both platforms, as shown in Figure 4-18. The platform locations, as shown in, will not be finalised until the area has been surveyed during the season.

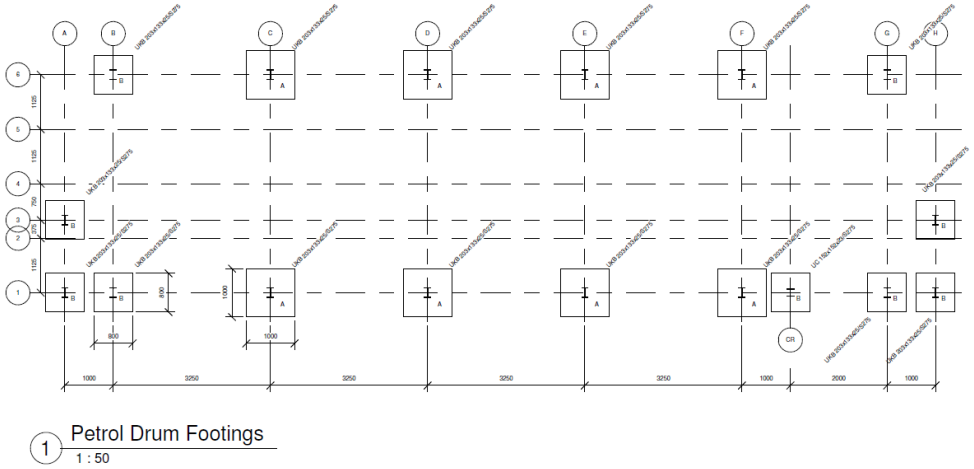



**Figure 4-18 Platform Footings Layout**

Each platform will have eight 1 m x 1 m x 0.4 m concrete pads to support the main part of the platform, along with eight 0.8 m x 0.8 m x 0.4 m concrete pads to support the ends and stairs. Once the footings have cured, the platforms will be constructed by two builders with vehicle support as required. Platforms will be loaded by telehandler or excavator lifts.

## 4.6 Construction Carbon Emissions

Carbon emissions have been estimated for the Runway Resurfacing and Lighting project. This allows a comparison to be made between estimated and actual emissions, which are reported in the BAS Energy and Carbon Dashboard post season. Carbon emissions for the other activities in this IEE have not been estimated. Post season figures will show the actual fuel used and therefore actual carbon emissions can be reported.

All fuel used for construction at Rothera is currently Marine Gas Oil (MGO). The amount of fuel estimated to be required for the construction is 231,961 litres in total; 177,047 litres for Season 1 and 54,914 litres for Season 2. The 4,500 litres of HVO that will be trialled on a range of construction plant is included in the carbon calculations for this project.

Based on a conversion factor for MGO of 0.0027754 tonnes (t) of $CO_2$ per litre, estimated emissions relating to fuel for Runway Resurfacing and Lighting plant and equipment (with contingency) are:

| | MGO fuel use (litres) | HVO fuel use (litres) | Equivalent $CO_2$ (tonnes) |
|---|---|---|---|
| Season 1 | 177,047 | 4,500 | 492.63 |
| Season 2 | 54,914 | | 152.41 |
| **Total** | **231,961** | **4,500** | **645.04** |

The estimates presented are equivalent tonnes of $CO_2$ and are all taken from the latest available data at the time of writing this IEE.

## 4.7 Site Set Up and Laydown

Specifically for the Runway Resurfacing and Lighting project, a site layout plan has been produced, as shown in Figure 4-19 below. This illustrates the site access plan and main laydown areas that are proposed to be used for the storage of materials, equipment, and plant. This drawing also provides a useful overview of the general layout of infrastructure at Rothera. A Station Integration Plan will be prepared to demonstrate how the proposed works will integrate with the wider ongoing operations at Rothera.

Discussions between BAM and relevant BAS departments have taken place in order to identify the most appropriate location for these areas and have considered key operational and science requirements including:

- Sufficient clearance to allow flight operations to proceed with minimal interruption;
- Sufficient clearance to existing buildings to limit additional snow accumulation;
- Access routes which minimise crossings with existing services and facilities;
- Minimal disruption to ongoing science programmes and research; and
- Utilising the existing station footprint and avoiding encroaching on relatively undeveloped areas.

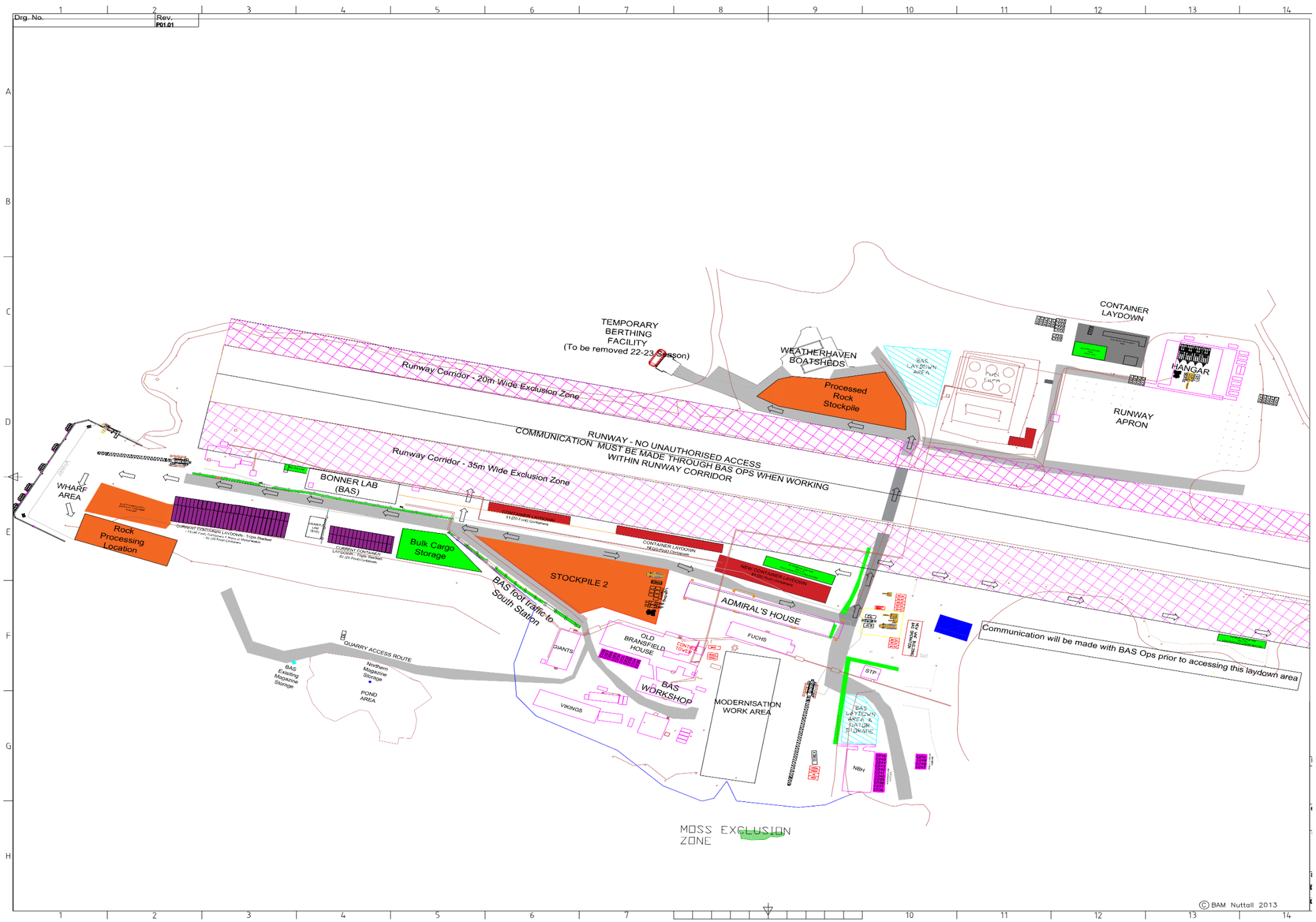



**Figure 4-19: Site Layout Plan Including Main Laydown and Storage Areas, BAM 2022**

## 4.8 Predicted Lifespan

The only permanent constructed elements that forms part of the proposed works is the runway resurfacing and the construction of the new fuel farm hut. The runway resurfacing is considered to remain safe and operable for approximately 30 years. This operational lifetime was established following a detailed design process and will be provided to BAS in the form of an operation and maintenance manual. The expected life of the new fuel farm hut is 25 years.

## 4.9 Alternatives Considered

Alternatives to the proposed works could include consideration of different locations, different technologies (i.e., which technologies to use to construct or which technology to implement in operation), the use of pre-existing facilities and different timing of the activities. The "do nothing" scenario should also form a part of the alternatives assessment.

For the proposed works, the only constructed element is the runway resurfacing works. The runway resurfacing works activity is largely considered a maintenance activity to ensure that the runway can maintain current operations, although it is acknowledged that improvements are being made to lighting, as well as ducting and fuel pipe provision. The do-nothing scenario in this instance is considered to result in a more significant programme of repair and refurbishments in the future, with the potential to reduce the frequency of aircraft operations at Rothera.

The proposed resurfacing works will return the crown of the runway at Rothera back to the original shape. This will allow meltwater to drain off the runway rather than pooling on the runway surface and refreezing. Ice on the runway creates unsafe conditions and can cause delays in getting staff to Rothera. A do-nothing scenario would mean a significant reduction in air operations capability, with more frequent instances and longer periods of snow and ice accumulation on the runway precluding safe air operations. This would have a detrimental impact on BAS' capacity to deliver the logistics required to support the programme of science, operations, and construction.

From a lighting upgrade perspective, the do-nothing scenario has been considered but is not considered an option as the existing lighting arrangement is limited and in need of replacement; much of the lighting has failed or has been damaged by snow blowers throughout the years of operation. The runway lighting is imperative to provide situational awareness for pilots which enables them to see where the runway starts and ends, which is often hard to determine due to snow and sea ice. Undershooting or overshooting the runway would lead to a major incident at Rothera. The proposed lighting arranged is considered to provide an improvement to the existing arrangement.

Furthermore, a programme of this type would leave BAS with a significant ongoing maintenance burden which could pose a health and safety risk to station occupants if aircraft were not able to take off or land safely at all times. It would also mean that the new aircraft could not land in the first season of operation. As such the "do nothing" option is not considered viable.

The production and implementation of project specific SMPs ensures that sustainability is integrated into the design of the proposed activities. The production of SMPs at an early stage of the design process ensures that alternative designs can be implemented which reduce the environmental impacts of the proposed design, through minimising the footprint, material requirements and operational impacts (where relevant). The sustainability of the proposed Hangar redevelopment forms an important part of the design process, and at this stage the final

design of the Hangar redevelopment is not yet confirmed. A number of design scenarios are being considered that require various SI proposals, which form the basis of the proposed SI works for the Hangar redevelopment.

There are currently five design options being considered for the proposed Hangar redevelopment. These include doing nothing, maintenance, refurbishment and extension to create two spaces linked internally, and a new build option. The new build option is focused on the construction of a new Hangar adjacent to the existing building to provide two separate buildings that will support the new aircraft alongside the existing aircrafts. The SI proposals are considered to provide sufficient information to inform the detailed design of the Hangar at the appropriate stage of the project process.

The alternatives for the renewable energy project have been considered within the Rothera Point Wind Monitoring Options Technical Memo[19]. The two identified suitable options reviewed included a bespoke mast designed for the specific site conditions and an off-the-shelf tilt-up mast of 34 m height. The measurement instrumentation would be procured and be pre-configured for installation directly on the mast before it is raised. A do-nothing scenario relies solely on existing data and would not install the proposed monitoring infrastructure to inform future renewable energy installation. However, it is strongly recommended to install additional temporary measurement infrastructure to provide accurate validation data which would in turn support estimations of the available energy resource and the suitability of the wind turbine technology for the site.

There are a number of different design scenarios for a potential runway upgrade, and these include different lengths, surfacing and material requirements. For the purposes of the runway upgrade project, no alternative options are available for consideration as part of this IEE; the proposed SI is required to provide information to inform the design at the appropriate time. An assessment of alternatives will be provided within the relevant EIA at the appropriate time.

### 4.10 Decommissioning Plan

Following the works, the resurfaced runway has a design life of 30 years, and it is considered unlikely that the runway will be decommissioned in this time. Routine maintenance will be undertaken throughout its operational lifetime. However, should decommissioning due to site abandonment be required, surface-level lighting, cabling, and infrastructure, such as the traffic barrier, are anticipated to be removed.

The main structure of the runway, the foundations, and ducts, would be subject to a more detailed assessment at the time of decommissioning, if required. The foundations would likely not be removed due to the huge carbon and ecological implication. The runway has been in situ for many decades and locally sourced material has been used for bedding and backfill around the foundations. The removal of this material would likely have a greater adverse effect on the local environment than leaving the main structure of the runway in place.

The plastic ducting will need to be removed, either at the end of design life to be replaced, or if the runway is ever decommissioned. Due to the nature of plastic, there may be some degradation of the material over the time it remains in situ, which could lead to minor contamination of the environment with microplastics. This potential degradation of the plastic ducting is not considered to create a level of contamination that would result in a significant

[19] Ramboll, 2022. Rothera Point Wind Monitoring Options, RENEW-RAM-XX-RO-T-EG-0003, Version 1

environmental incident. In addition to this, the material specified is expected to be suitable for Antarctic conditions and therefore minimal degradation should occur.

The expected life of the new fuel farm hut is 25 years. At the end of its life, the structure and fuel delivery system will be reviewed, and an evolution or replacement plan will be developed in accordance with AIMP activity and any modernisation or maintenance programmes at the time. The aim would be to dismantle the structure and reuse the majority of the materials on site or return any materials that cannot be reused to the UK for recycling, where possible.

The other works proposed in this IEE are not considered to need a decommissioning plan. The temporary monitoring equipment would be removed after a specified time as outlined in Section 7.

# 5. SUPPORT ACTIVITIES

## 5.1 Shipping and Air Freight

Containers were shipped to the South Atlantic Gateway for pick up by the SDA during April 2022 as part of one of its round trips to Rothera during the 2021-2022 season. Further required items for the project will be transported from the UK to Rothera on the SDA during November 2022. Additional items may be required to be shipped to the South Atlantic Gateway via the South American Atlantic Service (SAAS) during November 2022 for delivery in December 2022, dependent upon the SDA capacity. The final M&E lighting items will then be picked up from the South Atlantic Gateway in January 2023 by the SDA and arrive in Rothera in February 2023. In the 2023/2024 season the SDA would deliver all equipment for the runway resurfacing works from the UK arriving in first call in December 2023 at Rothera.

Prior to and during loading, biosecurity measures as outlined in Appendix 2: Runway Resurfacing and Lighting Project-Specific Biosecurity Plan will be followed, as well as measures outlined in the BAS Biosecurity Regulations (2021). Inspections will be undertaken by trained personnel under the direction of the BAM Environmental Engineer. Visits to suppliers are also carried out to ensure that premises used for manufacture, storage and packing address biosecurity issues. Fumigation and biosecurity inspections are carried out when materials are consolidated into containers for shipment. 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 the BAS Environment Office within 24 hours.

## 5.2 Personnel

Personnel will be transported to Rothera either by sea or by air. Personnel will fly from the UK to the 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 the SDA to or from Rothera. All cargo and personnel will adhere to the necessary biosecurity procedures and requirements.

## 5.3 Accommodation

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

## 5.4 Energy Use

Electrical power at Rothera is provided by 4 x Volvo TAD 752GE diesel engines, coupled to AC generators housed in the generator shed, producing 144 kW. 24-hour continuous power is provided by having two online at any time but with an automated means of changing over from one set to another. Power generation for all construction activities will be provided independently to normal BAS operations. Additional electrical load from construction works will likely result in the third generator being used on a more regular basis rather than just for back up. Two portable generators are available on site for emergency power or additional power demand.

Domestic power for lighting, heating, and other domestic requirements will be provided through the existing systems. Currently the main power to the station is provided by two online diesel

generators with a third on standby and a fourth being serviced. There are also some auxiliary units providing back-up power. Currently the station uses the majority of the power generated and therefore BAS is seeking alternative ways to support ongoing operations at Rothera, through the incorporation of renewable energy infrastructure.

Power usage is minimised wherever possible and any equipment to be installed at Rothera that requires electrical power must be approved through the planning process prior to installation.

## 5.5 Water

BAS will provide all domestic and construction fresh water required for the project, generated by the onsite reverse osmosis plant. There will be higher than usual potable water requirements due to the additional site personnel at Rothera. Activities will be carried out in a way that minimises water consumption as far as reasonably practicable to ensure water and energy associated with its creation is used efficiently. Wherever possible, sea water will be used e.g., dust suppression.

For the Runway Resurfacing and Lighting project, the compaction of runway surface material requires significant volumes of water; this activity will use sea water as it would not be possible with the equipment on site to produce sufficient quantities of fresh water. It has been agreed by all parties that saltwater will achieve the desired material compaction parameters. The remainder of the runway resurfacing activities that require fresh water are estimated to need no more than 2 $m^3$ of fresh water for mixing and some cleaning requirements. No additional fresh water is expected to be required for any of the other activities in this IEE. Water usage will be reported at the end of each season and as per project-specific SMPs.

# 6. OPERATIONAL PROCEDURES

## 6.1 Fuel Management and Spill Response

### 6.1.1 Fuel Use, Fuel Storage and Refuelling

The following oil storage facilities are located at Rothera Station: six main bulk fuel tanks, fuel drum depots, two day holding tanks, a boiler fuel tank, and several other small bulk fuel tanks. Also, as outlined in Section 4.1.2, 4,500 litres of HVO will be stored at Rothera for the HVO trial. All fuel required will be stored by BAS in one of the above storage facilities, and oil spill equipment will be located adjacent and accompany the fuel bowser at all times. Additionally, all mechanical plant will carry spill kits. Refuelling of plant and equipment will be carried out by nominated refuellers and compliant with the BAM refuelling procedures. The Standard Operation Procedure (SOP) for refuelling at Rothera applies.

### 6.1.2 Rothera Oil Spill Contingency Plan (OSCP)

The purpose of the Rothera OSCP is to describe the procedures that will be used by BAS/BAM to enable a timely, effective, and coordinated response effort in the event of an oil spill at Rothera. Any spills will be reported to the Rothera Station Leader and to the BAS Environment Office at the time of occurrence.

Oil spill incidents within BAS are classed in Tiers 1, 2, and 3, as detailed below. This classification into tiers identifies the oil spill response capabilities required to mitigate any potential oil spill scenario.

- Tier 1: Incident can be dealt with by one or two station personnel or a small subset of the station response team using local response equipment;
- Tier 2: Incident requires the full response capability of the station and assistance from BAS Cambridge; and
- Tier 3: Incidents which exceed the response capability of the station and BAS Cambridge. Outside assistance is required.

BAM staff are responsible for dealing with any Tier 1 spill but must report them to the Station Leader as soon as possible for inclusion on Maximo (BAS Incident Reporting System). The Station Leader has overall responsibility for all Tier 2 or 3 incidents on station. BAS will be responsible and respond to any spills on water. All site operatives will be briefed on the OSCP prior to works commencing.

## 6.2 Plant Management

A BAM Plant Management Plan has been produced and defines the minimum requirements for the management of all plant and equipment used at Rothera. It describes the procedures for safe operation, maintenance, inspections, and emergency repairs. Furthermore, it describes the personnel requirements with, but not limited to, required certification for safe operations of the equipment. Plant selection, procurements and overall strategy is also described. This plan is currently a live document and subject to change following review.

## 6.3 Waste Management

BAM are responsible for managing all construction waste on site at Rothera.

BAM are required to take all reasonable steps to keep waste safe and secure so that it does not cause pollution or injury. In particular BAM are required to:

- Fulfil the legal requirement to apply the waste hierarchy;
- Ensure safe and correct packing and containment. This is of particular importance while the waste is in transit;
- Check that waste contractors are appropriately registered with the Environment Agency;
- Describe the waste on a Duty of Care transfer note so that the waste carrier can avoid committing an offence under the regulations; and
- Liaise with BAS Environment Office over the importation of wastes to the UK via transit ports and ensure that the appropriate approvals are sought.

The waste hierarchy will be applied – the measures outlined in Table 6-1 will be employed to reduce and reuse waste on site.

**Table 6-1: Measures Implemented to Reduce and Reuse Waste on Site**

| **General** | |
|---|---|
| **Reduction Measures** | **Reuse Measures** |
| Packaging to be discussed with suppliers and reduced as much as possible | All unused excavated material (except any hazardous materials) will be added to existing stockpiles for use in future projects or general station maintenance |
| All operatives to receive training on the agreed reduction measures | All useful surplus construction materials to be offered to the Research Station Manager for re-use within the station |
| Accurate measurement and minimal wastage will be allowed when ordering materials | |
| Materials are to be stored and transported correctly so as to avoid damage | |
| Materials are to be kept off the ground by the use of pallets or timber pieces | |
| **Excavated soil and stone** | |
| **Reduction Measures** | **Reuse Measures** |
| | Excavated soil and stone to be redistributed on site |
| **Timber** | |
| **Reduction Measures** | **Reuse Measures** |
| | All construction waste materials to be offered to the Research Station Manager for re-use within the station |
| **Concrete and hardcore** | |

| Reduction Measures | Reuse Measures |
|---|---|
| Concrete ducting to be packed and transported with care to avoid damage | Waste concrete to be crushed and added to existing stockpiles for use in future projects or general station maintenance |

All waste that cannot be-reused at Rothera will be returned to the UK for recycling or disposal at a licenced waste management facility. The SDA will remove construction waste from Rothera at the end of the 2023-2024 season. Consignments will be packed and labelled in accordance with international shipping regulations. 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. All waste will be packaged and consigned in accordance with BAS's standard waste management procedures set out in the BAS Waste Management Handbook.

Table 6-2 shows the estimated types and quantities of waste that will be produced on site. See Appendix 1 for further details. This will be updated, and a final copy produced prior to mobilisation to site.

**Table 6-2: Estimated Type and Quantity of Excavation and Construction Waste**

| Type | Estimated Total Quantity kg/($m^3$) | Re-use / Recycle / Recover / Dispose | Waste Management Action in Detail |
|---|---|---|---|
| Inert Soil and Stone | 630 (300) | Re-use | Stockpile for re-use on site |
| Concrete | 2800 (2.8) | Re-use | Whole lengths of pipe retained as spares. Remainder crushed and stockpiled for re-use. |
| Plastic | 3800 (15.2) | Re-use 1900 (7.6), Recycle 1900 (7.6) | Ducting and accessories retained as spares. Offcuts and damaged parts returned to UK for recycling. |
| Timber | 2500 (5.0) | Re-use 1000 (2.0), Recycle 1500 (3.0) | Re-use offered to BAS for fuel for incinerator, remainder returned to UK for recycling. |
| Cable off-cuts | 30 (0.5) | Recover | |
| Oil | 750 (0.75) | Recover | Return to UK for use as fuel |
| Oil filters | 20 (0.2) | Recycle | Return to UK for recycling |
| Oil contaminated rags | 10 (0.5) | Dispose | Return to UK for disposal |

| | | | |
|---|---|---|---|
| Alkaline batteries | 5 (0.05) | Recycle | Return to UK for recycling |
| Clothing / Textiles | 10 (0.5) | Recycle | Return to UK for recycling |
| Cardboard | 50 (0.8) | Recycle | Return to UK for recycling |
| Paper | 10 (0.2) | Recycle | Return to UK for recycling |

The incinerator runs frequently to burn waste, such as food waste, sewage sludge and biosecurity risks. BAM will provide BAS with wood to re-use as fuel for the incinerator. A full record will be kept, and internal waste transfer notes produced if required. Waste sent for incineration is carefully managed and agreed with BAS site personnel who operate the incinerator.

All domestic waste generated during the construction period will be managed by BAS as per the standard Rothera waste management procedures. All staff will comply with the waste storage and segregation requirements as directed by the Rothera Station Leader.

### 6.4 Biosecurity

Many species of plants, animals and microorganisms are moved around the world through human activity to areas they would not reach naturally. If these species become invasive, they can have severe impacts on local species and ecosystems. The Antarctic continent currently has few confirmed invasive non-native species. However, reports of species introductions are increasing and awareness of biological invasions as a major conservation threat, within the context of increased human activities and climate change scenarios, has grown within the Antarctic community. It is essential that all necessary precautions are taken to prevent the introduction of non-native species to Rothera from other locations. BAS have produced their own Biosecurity Regulations which set out clear instructions and procedures for BAS personnel and external collaborators detailing how to reduce the risk of non-native species introduction and how to respond should an introduction inadvertently occur.

The AIMP will involve an increased input of cargo to Rothera over an extended timescale. This intensification of import activity therefore has the potential to increase the risk of non-native species introductions into the local environment. Rodent infestations present a significant risk to local and endemic species at Rothera, in the unlikely event of a rodent detection, immediate efforts will be taken to isolate the rodent in the location identified and for it to be killed. If this is not possible then bait stations will be deployed in the vicinity of the last known sighting and left for 48 hours.

A Runway Resurfacing and Lighting Project-Specific Biosecurity Plan (Appendix 2) has been prepared to provide guidance to BAM personnel on the measures to be taken when moving plant, materials, or personnel to Rothera. The plan has been developed with reference to the BAS Biosecurity Regulations (2021) and the CEP Non-Native Species (NNS) Manual (2019). All personnel will be briefed on the plan and will be required to read and understand its content prior to deployment.

The measures include actions that require pre-departure checks on personal items and cargo, and pre and post disembarkation of cargo and personnel on arrival at Rothera.

### 6.5 Health and Safety of Staff

The health and safety of staff at Rothera is considered to be covered by standard operational procedures that are in place for all operations at BAS. Specific risk assessments are carried out for all construction activities. For example, construction personnel will wear appropriate personal protective equipment (PPE) whilst working with noisy plant and equipment. Risk assessments are briefed to health and safety staff and the operations team present on station prior to commencement of an activity, and this aids the safety of air operations and reduces risk around collisions between pedestrians and construction vehicles. There are also health and safety inspections and audits throughout the season. Monitoring is also in place which can indicate health risks. Although humans are considered a receptor, this is not assessed specifically within this IEE.

# 7. PROGRAMME OF WORKS

| | | Season 1 | | | | | | | | Season 2 | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2022 | | 2023 | | | | | | | | | | | | 2024 | | | | |
| | **Scope of Works / Activity** | N | D | J | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M |
| **Runway Resurfacing Project** | Runway Rock Processing | | | | | | | | | | | | | | | | | | | |
| | Runway Lighting Civils Works | | | | | | | | | | | | | | | | | | | |
| | Ducting and chamber installation | | | | | | | | | | | | | | | | | | | |
| | Runway crossing service installation | | | | | | | | | | | | | | | | | | | |
| | Gravel surface extension (0 to -17 m chainage) | | | | | | | | | | | | | | | | | | | |
| | Runway Lighting M&E Works | | | | | | | | | | | | | | | | | | | |
| | Handover and commissioning | | | | | | | | | | | | | | | | | | | |
| | Runway Resurfacing | | | | | | | | | | | | | | | | | | | |
| | Friction Measurements on the Runway | | | | | | | | | | | | | | | | | | | |
| | HVO Trial | | | | | | | | | | | | | | | | | | | |
| **Runway Upgrade Project** | Runway North Marine Surveys | | | | | | | | | | | | | | | | | | | |
| | Rock Revetment Investigation | | | | | | | | | | | | | | | | | | | |
| | Sea Ice Thickness Investigation | | | | | | | | | | | | | | | | | | | |
| | Access Road Investigation | | | | | | | | | | | | | | | | | | | |
| | Geophysical Marine Surveys | | | | | | | | | | | | | | | | | | | |
| | Creation of non-engineered slipways | | | | | | | | | | | | | | | | | | | |
| **Renewable Energy Project** | Visual condition survey of roof structures | | | | | | | | | | | | | | | | | | | |
| | Visual condition survey of existing PV panels | | | | | | | | | | | | | | | | | | | |
| | Energy demand metering of current buildings | | | | | | | | | | | | | | | | | | | |
| | Solar irradiance, albedo, and soiling monitoring | | | | | | | | | | | | | | | | | | | |
| | Wind monitoring | | | | | | | | | | | | | | | | | | | |
| **Hangar Redevelopment Project** | Apron trial pits and in-situ testing | | | | | | | | | | | | | | | | | | | |
| | Condition survey of hangar substructure | | | | | | | | | | | | | | | | | | | |
| | GI for foundation design | | | | | | | | | | | | | | | | | | | |
| | Condition survey of primary frame material and connection | | | | | | | | | | | | | | | | | | | |
| | Point cloud survey | | | | | | | | | | | | | | | | | | | |
| **Fuel Farm Infrastructure Upgrades** | Construction of a new fuel farm hut, two large steel platforms, and the relocation of the existing scaffolding storage area. | | | | | | | | | | | | | | | | | | | |

| **Key** |
|---|
| Planned Period of Works |
| Refer to methodology for proposed duration of works |

# 8. DESCRIPTION OF SITE

## 8.1 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 8-1).

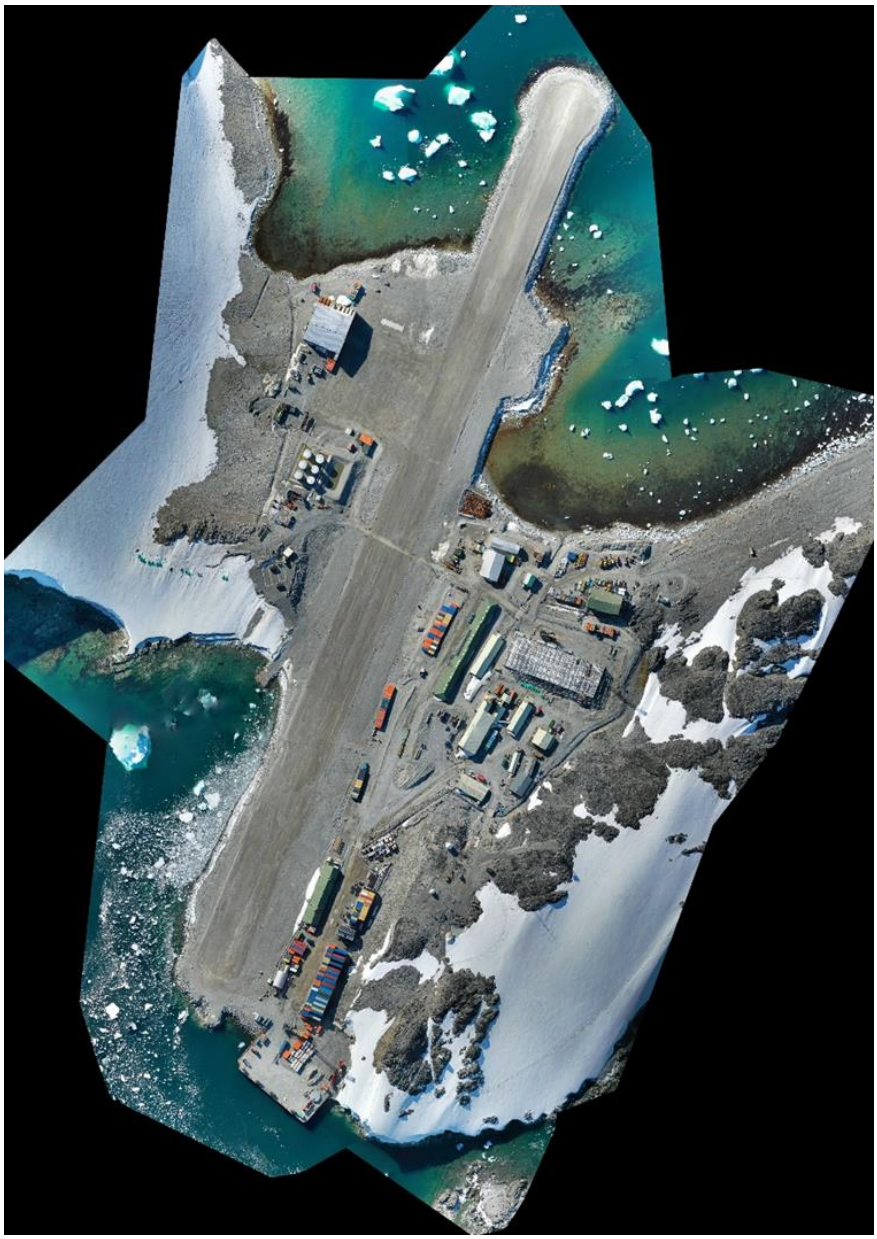


**Figure 8-1: Drone Image of Rothera in 2022, Jonathon Witherstone – BAS**

## 8.2 History of Site

Rothera Research Station has been used operationally, on a continuous basis since 25 October 1975. The extent of human modification of the landscape at Rothera is described in Table 8-1 and is visible in Figure 8-2 and Figure 8-3. The station was initially planned and constructed in phases which meant that infrastructure development was constructed as operational requirements and demands changed. The eastern side of Rothera Point is largely free of buildings; however, several antennae have been erected here.

**Table 8-1: Chronology of Construction on Rothera Point**

| Order | Phase or infrastructure | Notes |
|---|---|---|
| 1 | Phase I | A small accommodation hut was erected on 1 Feb 1976. |
| 2 | Phase II | Phase II was built in 1976/77, which included the main accommodation block, powerhouse and tractor shed. An old storage shed from Adelaide (Station T) was erected close to Phase I and known as the Bingham building after Surgeon Commander EW Bingham, Leader of BAS 1945-47. |
| 3 | Phase III | Phase III was erected 1978/79 and included scientific offices and a travel store and cold room. In 2001 the travel store was named Fuchs House after Sir Vivian Fuchs, Director of BAS 1958-73. Further building work has been undertaken when required. |
| 4 | Phase IV | Phase IV, begun Nov 1985 and completed in the 1986/87 season was an extension to Phase II. In 2001 it was named Bransfield House (after BAS ship RRS *Bransfield*). |
| 5 | Runway and aircraft infrastructure | A wharf and gravel runway (with bulk fuel tanks and aircraft hangar) became operational in the 1991/92 season. Substantial rock blasting occurred, including the removal of 'Flagstaff Hill'. The wharf was named Biscoe Wharf after the BAS ship RRS *John Biscoe*. A new storage hut, now used primarily for waste management activities, was also constructed in 1991/92. |
| 6 | Boat shed, accommodation and generator shed | Under the next phase of development, a boatshed was completed in 1994/95, a transit accommodation block in 1996/97 (named Giants House in 2001 after the Rothera sledge dog team "Giants"), and a new generator shed. |
| 7 | Bonner Laboratory | The Bonner Laboratory became operational in 1997, housing biological research facilities when Signy (Station H), was reduced to summer only operations. It was named after W N Bonner, biologist 1953-86 and Deputy Director of BAS 1986-88. |
| 8 | Accommodation and air operations control tower | A new accommodation building was erected during the 1999/00 and 2000/01 seasons. It was named Admirals House after the Rothera dog team "Admirals". Also in 1999/00 an air operations control tower was added to the north end of Bransfield House. |
| 9 | Replacement Bonner Lab and sewage treatment facility | The Bonner Laboratory was destroyed by fire on 29 Sep 2001 but rebuilt in the 2002/03 season, when a sewage treatment plant was also erected. |

| Order | Phase or infrastructure | Notes |
|---|---|---|
| 10 | NBH | A new living block, including canteen, library and recreational facilities, was completed in 2007/08 and named New Bransfield House. The original Bransfield House then became known as 'Old Bransfield House'. |
| 11 | Dirck Gerritsz Laboratory | The Dirck Gerritsz Laboratory was opened on Sunday 27 Jan 2013 by Leo le Duc on behalf of the Ministry of Education, Culture and Science of the Netherlands. The laboratory is a collaboration between the British Antarctic Survey and the Netherlands Organisation for Scientific Research (NWO) and hosts four research projects. |
| 12 | Rothera Wharf | The redevelopment of Rothera Wharf commenced in the 2018 -2019 season and was completed in the 2020-2021 season. |
| 13 | Discovery Building | The construction of the new Discovery Building is currently ongoing, anticipated to be completed in April 2026. |

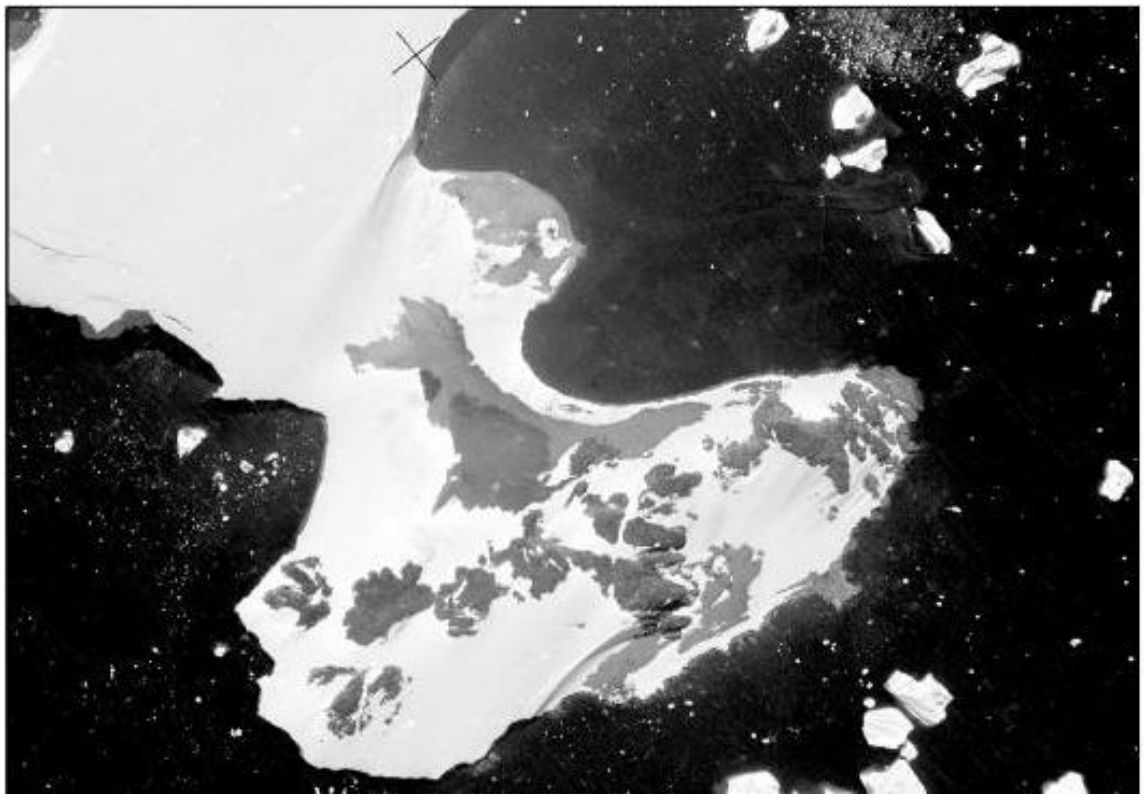


**Figure 8-2 Aerial Image of Rothera in 1957, BAS**

Figure 8-3: Aerial Image of Rothera in 2013, BAS.

## 8.3 Current Use of Site

### 8.3.1 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 25 people on station.

### 8.3.2 Science

Rothera Research Station is a research centre that supports a wide range of collaborative science programmes between BAS and other research institutes, for example the Gerritsz Laboratory 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).

#### 8.3.2.1 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 from only 18 launch sites, so each site is crucial.

Precipitation quantities are difficult to accurately measure in windy and snowy conditions, as are present at Rothera. An array of precipitation sensors work side-by-side to provide the most accurate level of precipitation as is possible, and also provides information on which types of sensor work best in differing 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 (GSLOS).

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 d'Analyse par Observations Zénithales). SAOZ measures scattered sunlight in a way which allows scientists to determine how much ozone the light has passed through.

#### 8.3.2.2 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.

#### 8.3.2.3 Bonner Laboratory and 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.

### 8.3.3 Air Operations

To support science and logistics in Antarctica, BAS operate a fleet of five aircraft, specially adapted for flying in the 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 it to carry out airborne science surveys. Between them they undertake a wide variety of transport and science missions.

Due to the 876 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 it carries much smaller payloads it is more versatile, being able to land on wheels or skis and regularly transport scientists to remote deep field study sites within Antarctica.

### 8.3.4 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 BAM, the Facilities Engineer and the station management team. The current vehicle fleet at Rothera includes skidoos, tractors, trailers, forklift and bucket loaders, Sno-cat, dozers, cranes, gators, all-terrain vehicles, snowblower, fire truck, digger, tankers and excavator.

### 8.3.5 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 deployment of Conductivity, Temperature and Depth sensors (CTD). 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.

### 8.3.6 Fuel Storage

Rothera has provision for the bulk storage of 720,000 litres of marine gas oil (MGO) and 690,000 litres of AVTUR in drums. A further provision of 123,000-205,000 litres of AVCAT is stored in bulk tanks at Rothera (600-1000 205 litre tanks). All the long-term storage tanks are made from steel and are contained within a bund, thus ensuring containment should a spill or leak occur. The AVCAT and AVTUR dispenser is located at the south end of the aircraft apron and the MGO pump is located at the south-east corner of the tank containment area. The bulk fuel storage at Rothera is outlined in more detail in the OSCP.

### 8.3.7 Stockpiled Material Storage

A review of material stored within stockpiles at Rothera was undertaken in April 2021. This section of the IEE summarises the locations of these stockpiles and grade of material available. These are of relevance to the Runway Resurfacing and Lighting project, which will make use of this stockpiled material. There are 11 stockpile locations at Rothera, shown in Figure 8-4.

There is 0-30 mm material stockpiled in locations 1-6 and 9-11. However, material stockpiled in locations 9-11 is used for levelling storage areas and is therefore unavailable for the project. Material stockpiled in location 5 is also unavailable because the area is used by BAS for plant and equipment storage. Material from location 5 will only be recoverable if an alternate location can be agreed with BAS to store their plant. Of the available 0-30 mm material, approximately 200 T is used per season for creating footpaths and gritting roads and should therefore be taken off the total.

There is 30-80 mm material stockpiled in locations 9-11 which is largely recoverable. There is 30-80 mm material also stockpiled within containers in the wharf sub-structure, however it is

onerous to recover and therefore unavailable.  Material of various sizes is stockpiled in locations 1-4 and 9, this material is also largely recoverable.


**Figure 8-4 Stockpile Locations at Rothera**

### 8.3.8 Power Generation

Electrical power at Rothera is provided by 4 x Volvo TAD 752GE diesel engines, coupled to AC generators housed in the generator shed, producing 144 kW. 24-hour continuous power is provided by having two online at any time but with an automated means of changing over from one set to another. There are two mobile generator sets Volvo TAD 752GE which can be plugged into NBH or the Bonner Laboratory. There is an auxiliary power container behind the Hangar housing Cummins generators for emergency purposes to power the Hangar. Power usage is minimized wherever possible and any equipment to be installed at Rothera that requires electrical power must be approved through the planning process prior to installation.

Rothera requires on average 700 $m^3$ of MGO per year to maintain serviceability. Approximately 66% is required for power production, 29% for heating generation, 3% for vehicles and 2% is used to supplement the waste incinerator.

Most of the heating is supplied in conventional heating systems, oil boilers in larger buildings and electric heaters in small buildings. The larger buildings are also equipped with air handling units. Rothera uses on average 180 kW to 200 kW of power and any one time.

Rothera has several energy efficient measures in place:

- Heating controls and temperatures are closely monitored to improve efficiency;
- Power is monitored and reduced where practicable;
- Energy efficient lighting;
- Greater use of natural lighting; and
- Building Management System (BMS).

### 8.3.9 Water Generation

Fresh water is produced at Rothera by reverse osmosis (RO), filtering salt water to create fresh water through a process of desalination. The main Reverse Osmosis (RO) plant is online 24 hours a day and can produce up to 14 $m^3$ per day. Water is readily available unless there is a mechanical failure. To take the strain off the single operating machine, in 2022/23 season an additional containerised RO Plant will be installed at Rothera to work in a duty/assist arrangement ensuring continuous delivery of potable water to station. The additional plant will ensure supplementary capability of 10 $m^3$ per day and enable longer critical maintenance windows when required. Efficient use of water is encouraged to minimise fuel use. The new Discovery Building (formerly referred to as the new Operations Building) will operate two RO plants.

Potable water is initially stored in the RO room which has three tanks with a total volume of 28 $m^3$. This water is then pumped to smaller satellite tanks situated in other buildings. A melt tank is also available for emergency use. Salt water is used in three buildings for flushing toilets when potable water supply is low, however this requires the Sewage Treatment Plant (STP) to be bypassed as saltwater has a negative effect on the bacterial reaction within the plant resulting in the failure to properly break down the sewage from station. Station operations aim to remain on potable water as much as possible and it is only due to situations such as mechanical failure or peak usage where saltwater is used. Once the Discovery Building's RO plants are online, toilet flushing will be switched to potable water full time to improve operation of the STP. The Station Leader will remind all personnel to keep water usage to a minimum, particularly in summer when there are more people on station.

Water usage fluctuates throughout the year due to varying numbers of personnel present at Rothera; between March to September average potable water use is 70 $m^3$ per month and average saltwater use is 30 $m^3$ per month (21 personnel), whereas between October to December average potable water use is 200 $m^3$ per month and average saltwater use is approximately 90 $m^3$ per month (70-90 personnel average).

# 9. DESCRIPTION OF ENVIRONMENT

This section has been produced by BAS in the Environmental Baseline Conditions Report[9]. Reference is made in this section to Rothera Point. This is the area of land to the east of the Wormald Ice Piedmont shown in Figure 9-1, 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[20]). 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[21]). However, coastal sites are also often favoured as sites for logistics facilities by national operators and as visitation sites used by the tourism industry (Pertierra *et al.,* 2017[22]).

[20] Burton-Johnson, A., Black, M., Fretwell, P. and Kaluza-Gilbert, J., 2016. An automated methodology for differentiating rock from snow, clouds and sea in Antarctica from Landsat 8 imagery: A new rock outcrop map and area estimation for the entire Antarctic continent. The Cryosphere, 10. 1665-1677.

[21] Fretwell, P.T., Convey, P., Fleming, A.H., Peat, H. J., Hughes, K.A. (2011), Detecting and mapping vegetation distribution on the Antarctic Peninsula from remote sensing data. Polar Biology, 34. 273-281.

[22] Pertierra, Luis R., Hughes, Kevin A., Vega, Greta C., Olalla-Tárraga, Miguel Á. (2017), High Resolution Spatial Mapping of Human Footprint across Antarctica and Its Implications for the Strategic Conservation of Avifauna. PLOS ONE, 12. e0168280.

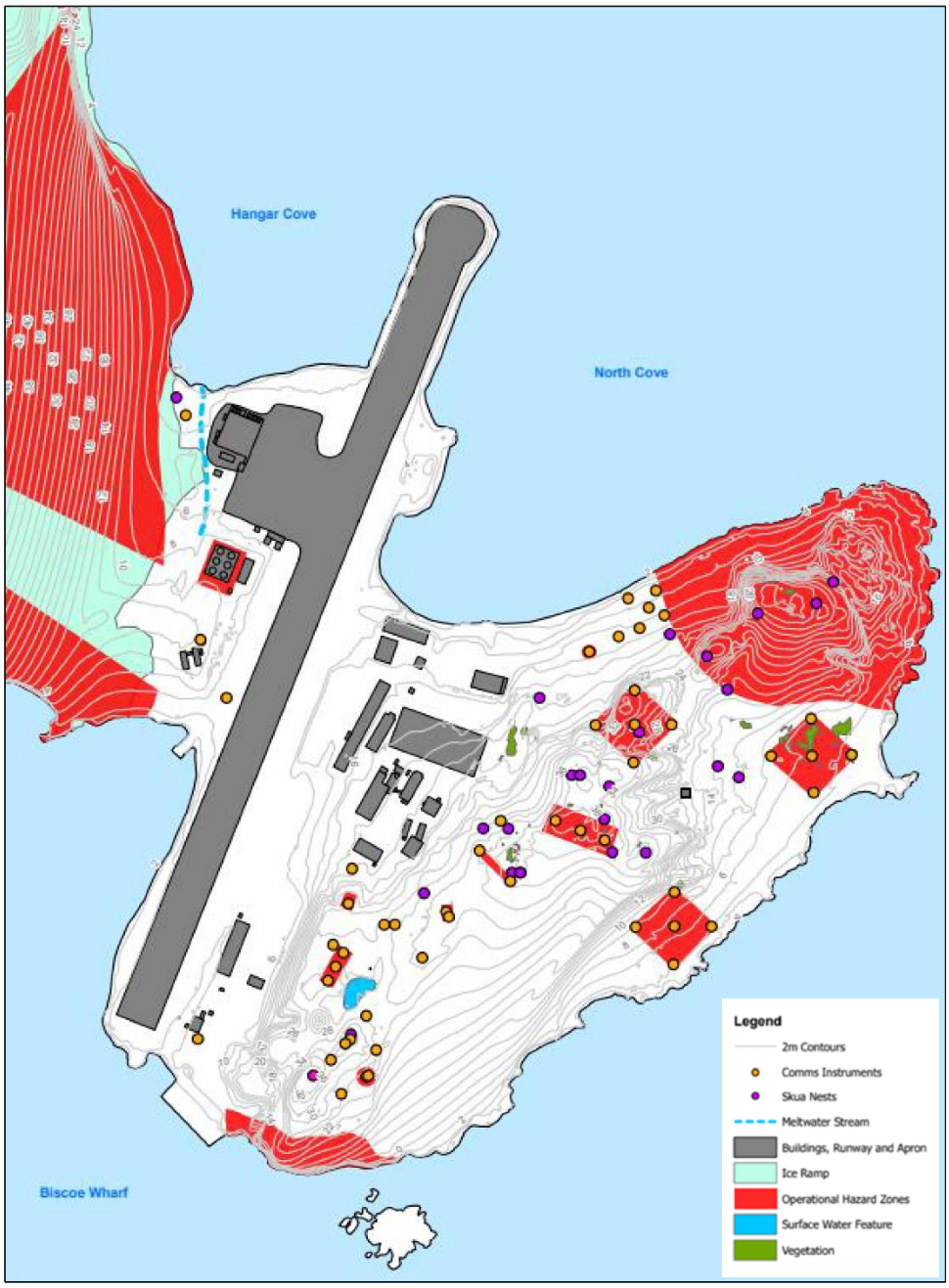



**Figure 9-1: Buildings and Other Minor Infrastructure (Aerials, Masts, Radars, Cairns, Etc.) Located on Rothera Point, BAS**

Figure 9-1 provides an environmental constraints map of Rothera, identifying the existing buildings, surface water features, vegetation, the ice ramp, and operational hazard zones alongside skua nests, heritage assets and communications instruments.

## 9.1 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[23]). In contrast, the near shore marine environment is considerably more species diverse and the subject of most biological research in the area.

### 9.1.1 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 $m^2$ adjacent to a transient melt stream in a gully 100 m south-southeast of New Bransfield House, marked as Area A in Figure 9-2. Confirming this, analysis of remote sensing imagery (using Normalised Difference Vegetative Index (NDVI) methodology) revealed that areas of significant green vegetation are spatially limited. Areas of high NDVI value on East Beach relate to algae and cyanobacteria in ephemeral pools fed seasonally by melting snow and ice (Figure 9-2, Area B). However, large, and dense concentrations of lichens and cryptogams are found across the Point, and in particular on rock bluffs.

[23] Convey, P. & Smith, R.I.L. (1997) The terrestrial arthropod fauna and its habitats in northern Marguerite Bay and Alexander Island, maritime Antarctic. Antarct. Sci. 9, 12-26.

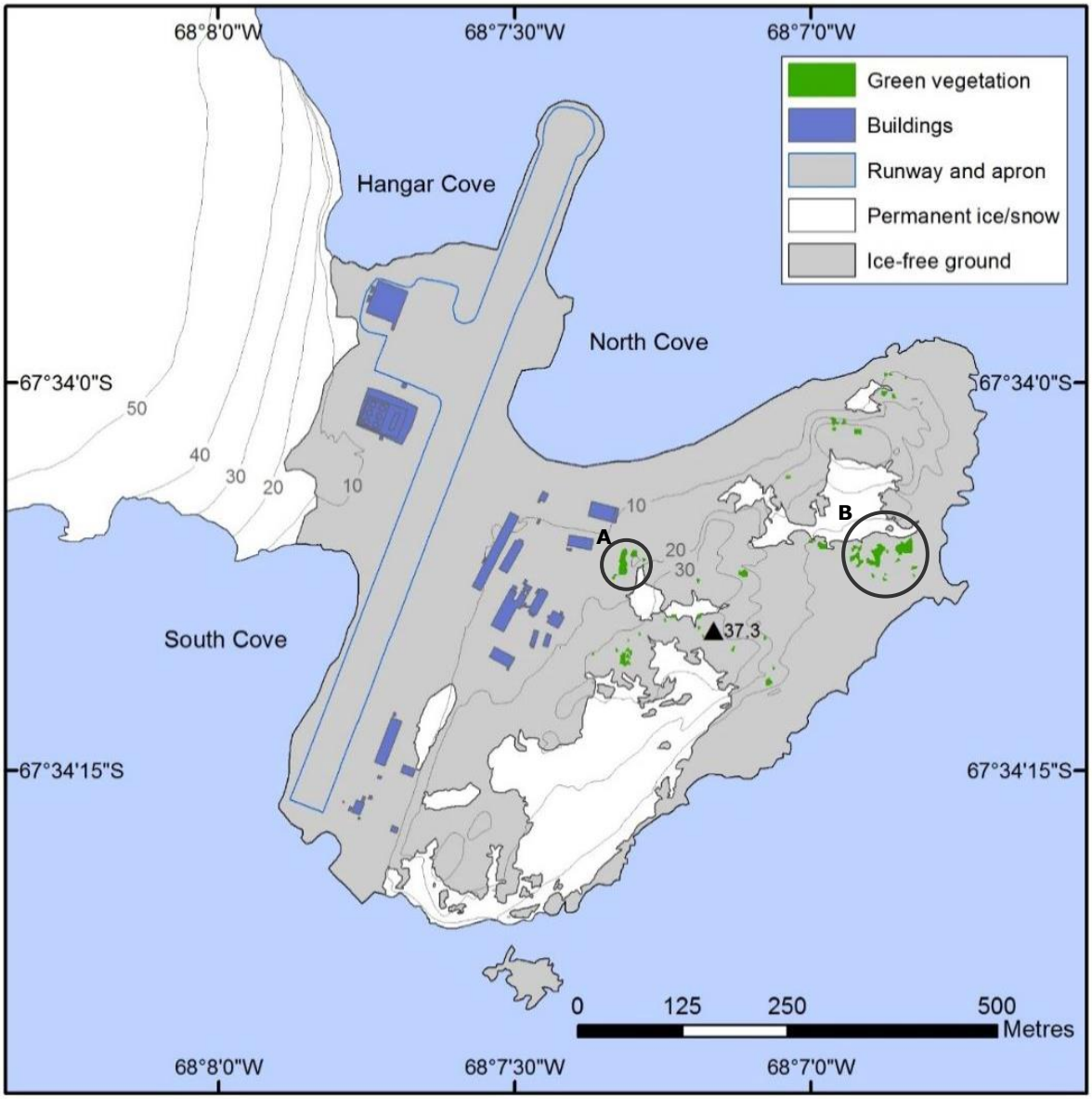



**Figure 9-2: Areas of Green Vegetation Detected on Rothera Point Using NDVI Methodology. Circled Areas A and B Denote the Location of Particularly Rich Areas of Moss/Liverwort and Algal Vegetation, Respectively**

#### 9.1.1.1 Cryptogams (mosses, liverworts, lichens, algae)

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*[24][25]. Numerous crustose lichens are found, but bryophytes (mainly *Andreaea* spp.) are sparse. Lichen vegetation is 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).

[24] Øvstedal, D.O. and Smith, R.I.L., 2001. Lichens of Antarctica and South Georgia. A Guide to their Identification and Ecology. Cambridge University Press, Cambridge, 411 pp.

[25] Cannone, N., Convey, P., Malfasi, F., 2018. Antarctic Specially Protected Areas (ASPA): a case study at Rothera Point providing tools and perspectives for the implementation of the ASPA network in the Antarctic Peninsula. Biodiversity and Conservation 27: 2641-2660.

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[26]. In the former habitat, although sparse on the summit plateau areas, 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 Rothera Point (see Section 9.3 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*.

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 the sandy/silty areas of East Beach (see Figure 9-2, Area B).

#### 9.1.1.2 Vascular Plants

A single very small population of Antarctic pearlwort (*Colobanthus quitensis*) has been observed below the northern cliff of the ASPA (Figure 9-3 and Figure 9-4). A small population of Antarctic pearlwort may continue to persist in a small gully at the base of crags under the ASPA's north-west cliffs. Sixteen separate plants or clumps of varying sizes were noted previously, at least two of which included mature and open seed heads; 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 Area (Figure 9-5). This plant also possessed a single mature seed head.

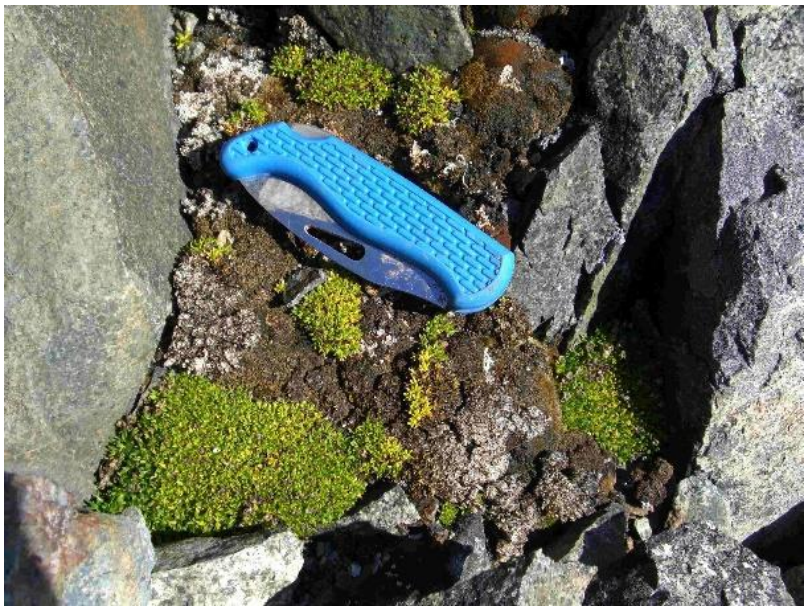


**Figure 9-3: Small population of Antarctic Pearlwort *C. quitensis,* BAS Jan 2022**

[26] Ochyra, R., Bednarek-Ochyra, H. and Smith, R. I. L., 2008. The Moss Flora of Antarctica. Cambridge University Press, Cambridge. pp 704.

**Figure 9-4: Plant with previous year's seed head, BAS Jan 2022**

**Figure 9-5: Location of Antarctic Hairgrass *Deschampsia antarctica,* BAS Jan 2022**

#### 9.1.1.3 Overview of plant diversity and distribution on Rothera Point

Cannone *et al*.[25] found 66 species: 1 vascular plant (*Deschampsia antarctica*), 10 mosses, 55 lichens (4 not determined), 1 green algae (*Prasiola crispa*), as well as the general category Cyanobacteria crust. Mosses had a very low coverage across the entire area, as is expected with the prevailing rocky substrata; they were almost absent in the ASPA and occurred predominantly in the non-ASPA area associated with the occurrence of loose sediments, with the dominant species being *Sanionia uncinata*. Vegetation mapping indicated that most of the study area was vegetated, with a total coverage exceeding 50% (see Figure 9-6) and the highest values on the top of rock bluffs where there was an abundant growth of lichens.

The prevailing vegetation sub-formations were a) the crustose and foliose lichen formation and b) the fruticose and foliose lichen formation (Figure 9-7).

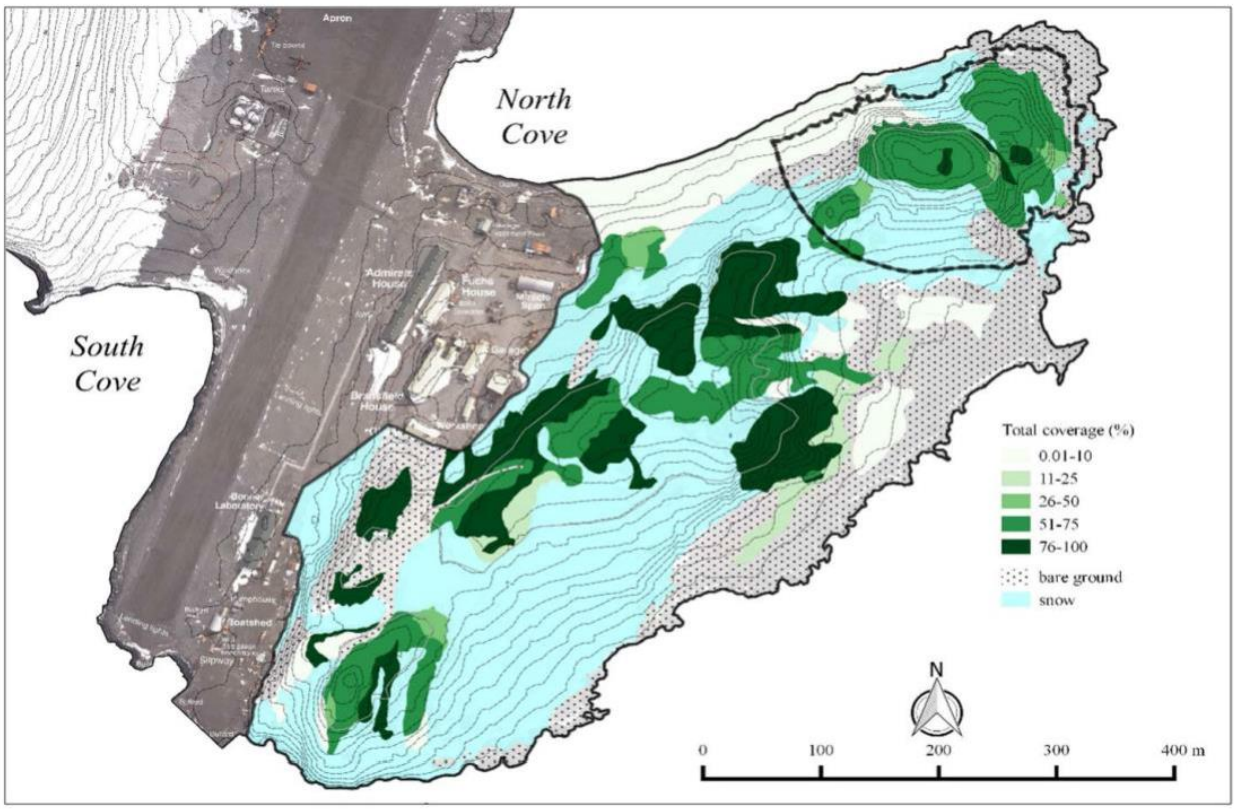



**Figure 9-6: Map Showing the Total Vegetation Coverage (%) at Rothera Point[25]**

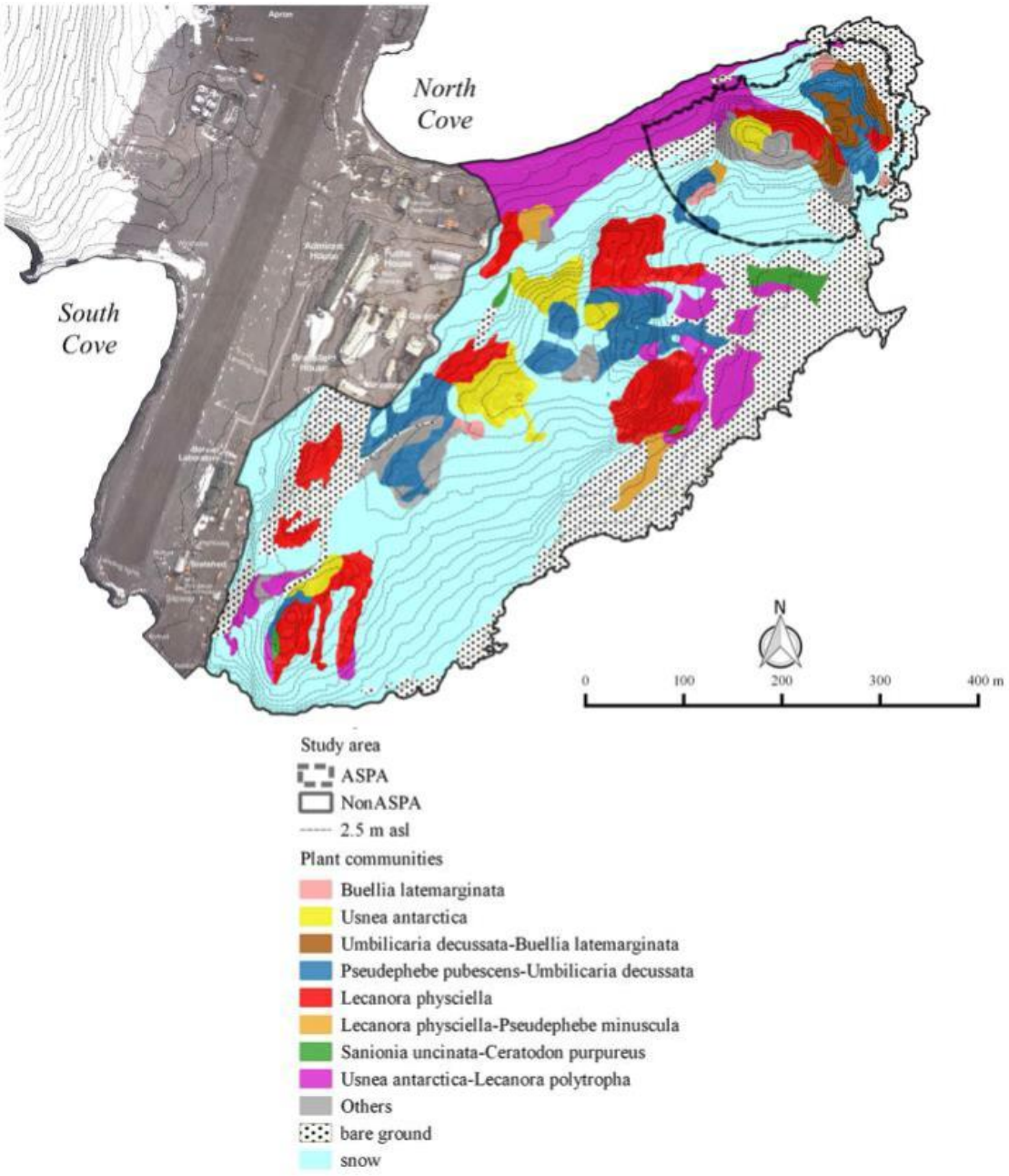



**Figure 9-7: Phytosociological Map of the Vegetation at Rothera Point[25]**

Cannone *et al*. (2018[25]) concluded that Rothera Point is representative of some of the floristic diversity typical of vegetation communities of the north-western Antarctic Peninsula. Furthermore, Rothera Point along with Leonie Island (part of which is included in the newly designated ASPA 177 Leonie Islands and southeast Adelaide Island) are the two sites with the largest floristic richness and more complex vegetation within the wider geographical context of Marguerite Bay and Adelaide Island. As such the vegetation on Rothera Point is of outstanding value, contrary to earlier assessments.

### 9.1.2 Terrestrial Fauna

Studies of the terrestrial invertebrate fauna on Rothera Point are few, but as far as is known, the 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. Research has not identified any special or rare terrestrial fauna on Rothera Point (Convey and Smith, 1997[23]). Extensive quarrying for rock to construct a 900 m airstrip in the early 1990s led to the draining of a small lake that caused the rare crustacean *Boeckella poppei* becoming locally extinct at Rothera Point.

### 9.1.3 Marine Benthic Communities

#### 9.1.3.1 Shallow Water

The shallow seas of Marguerite Bay (0-30 m) are within the Southern Ocean, the coldest ocean on Earth with one of the smallest annual temperature ranges; typically -2 to +2 °C. In contrast, shallow polar waters experience one of the highest seasonal changes in primary productivity as the photoperiod changes from 24-hour daylight to 24-hour darkness between summer and winter. Shallow water communities are also subject to high levels of disturbance from the impact of icebergs. However, while this might be considered a harsh physical environment, many marine benthic species flourish in the shallow waters. Many of these species show adaptations to life in the Southern Ocean, for example, limited temperature tolerance and seasonal energy saving strategies.

The shallow waters off the Western Antarctic Peninsula have experienced rapid warming over the last 50 years, which has led to reductions in sea ice, melting of glaciers and higher levels of iceberg disturbance. The change in the cryosphere has already led to changes in the patterns of primary productivity, which are expected to combine with warming and ocean acidification to result in severe impacts on shallow marine benthic communities.

Iceberg disturbance is a major structuring force of shallow water polar communities, particularly those living on rocky reefs. The very high disturbance levels in the shallows result in a fauna that is dominated by mobile species that are able to rapidly recolonize areas after an iceberg impact. Typically, this fauna consists of high numbers of gastropod molluscs and echinoderm species. It is only in deeper water, or in sheltered locations, where iceberg disturbance is reduced sufficiently that sessile communities can develop.

To determine the baseline state of marine benthic communities, surveys were conducted in January 2016 on three sites off the south coast of Rothera Point in depths of 9-10 m. The sites were, below the front of the current wharf (67.5723 S, 68.1296 W), the end of the runway (67.5717 S, 68.1312 W) and inside of South Cove (67.5697 S, 68.1319 W). The survey followed reef life survey methodology (www.reeflifesurvey.com), which provides a global standard to facilitate description, monitoring, and comparison of rocky reef marine communities. It involved laying a 50 m transect tape along a depth contour and then counting the number of individuals seen along this transect. Fish were counted in two 5 x 5 m bands parallel with the transect tape, which reduced to 3 x 3 m bands when the visibility dropped to 3 m. Selected groups of invertebrates were counted in 1 m wide by 2 m high bands on either side of the transect tape. Selected groups included all mobile fauna, except brittlestars.

The bottom consisted of a mixture of bed rock and loose cobbles with occasional pockets of mixed cobbles and sediment. The end of the runway had the highest proportion of bedrock with the steepest underwater gradient. The gradient was shallowest in South Cove and the substratum subsequently had the highest number of pockets of mixed cobbles and sediment. The wharf was an intermediate slope, but the substratum largely consisted of loose cobbles.

Whilst macro algae were relatively scarce in the shallow polar waters examined, there were occasional large clumps of the brown alga *Desmorestia antarctica* and an algal mat covered some of the seabed.

Community analysis showed a high degree of variation in density between species (Figure 9-8), but all three sites had similar diversity and densities of species. At all three sites, the most abundant species was the Antarctic limpet, *Nacella concinna*, with up 112 individuals per $m^2$, and the most speciose class was the Asteroidea with either 4 or 5 species. Fish numbers were very low, with only 5 individuals counted during the three surveys.

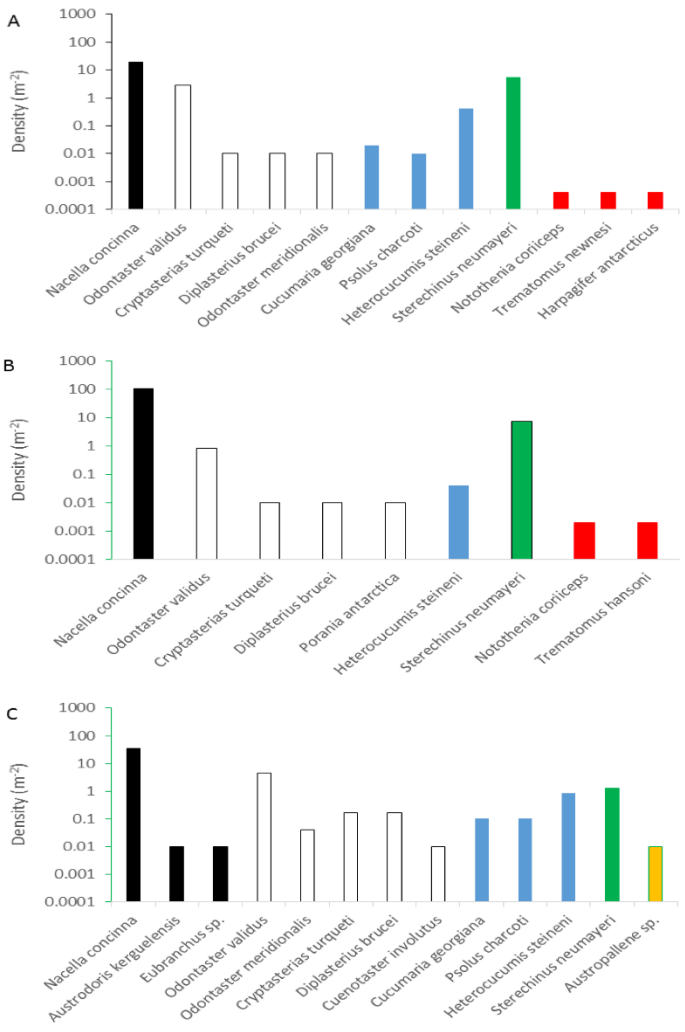



**Figure 9-8: Species densities from SCUBA diver counts using reef life survey methodology in depths of 9-10 m, A) Wharf, B) end of runway and C) South Cove. Black bars – snails and sea slugs, open bars – sea stars, blue bars – sea cucumbers, green bar – sea urchin, yellow bar – sea spider BAS Jan 2022.**

### 9.1.3.2 Deeper Water Benthic Communities

Underwater transect photos from site CTD3 showed the benthic community likely to exist around the wharf, due to proximity and similarity (Figure 9-9). A ROV was used for investigation, survey and recovery dives around the wharf, and video confirmed that the basic community pattern was

repeated at both locations. These descriptions are purely qualitative, and the pictures are provided to give a representation of the communities that exist at each depth.

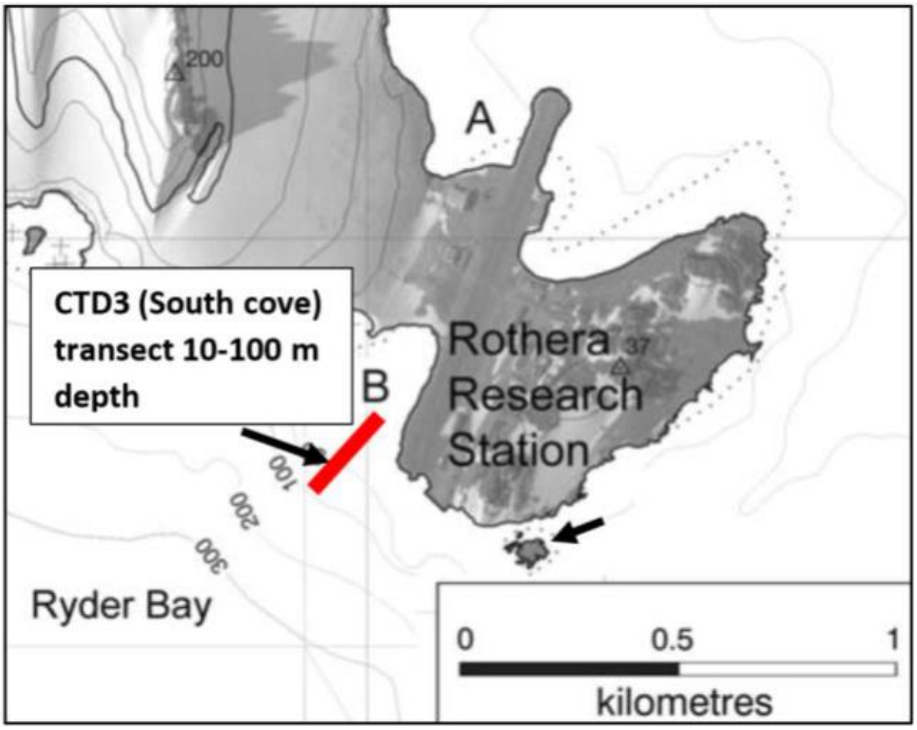



**Figure 9-9: Map of Rothera Point showing the location of the CTD3 transect in South Cove**

**Depth: 10-30 m**

At 10 m depth the majority of species are *Nacella concinna* (limpets) and *Odontaster validus* (sea star) and pink encrusting algae with relatively sparse densities. At 20 m, holothurians (sea cucumbers) such as *Heterocucumis steineni* become more common but only in summer, in winter they are absent in the epifauna (on surface) and are believed to be dormant and hidden. At 30 m anemones, such as *Isotaelia lacunifera* and ascidians (sea squirts) and *Cnemidocarpa verrucosa*, are more abundant along with a greater diversity of asteroids (sea stars).

**Depth: 40-60 m**

Between 40 to 60 m, bryozoan colonies (sea mats) become more common and dominant, and they also increase in size and become more foliose. There is also an increase in Octocorals, possibly *Primnoella* sp. The community tends to be less disturbed by iceberg impact, and more diverse. Species such as *Nacella concinna* (limpets) and *Odontaster validus* (sea star) are absent. The seafloor tends to be siltier, but where rocks are exposed, pink encrusting algae are still dominant, although at greater depths these are replaced by other encrusting organisms such as sponges and bryozoans.

**Depth: 70-90 m**

At greater depth the benthic community is dominated by slow growing sponges such as *Rossella* sp., bryozoans (*Reteporella* sp.) and ascidians (*Pyura setosa*). Siltation continues to increase with depth, but the presence - even in silted areas - of species that require hard substrate to attach

implies either sporadic siltation and/or hard substrate with a film of silt. Communities at these depths tend to be more complex and diverse with high competition for space, as is indicative of a low disturbance environment, which has taken a longer time to develop.

### 9.1.4 Avifauna

#### 9.1.4.1 Breeding Species at Rothera

For a comprehensive review of birdlife at Rothera Point, including reference to relevant literature, see Milius, 2000[27]. Of the species observed in the vicinity of Rothera Point, only some are known to breed: 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[28]).

**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.

**Imperial shag (*Phalacrocorax [atriceps] bransfieldensis*)**

Up to 24 pairs of the Antarctic Shag or Cormorant breed on a small rock just to the north of Killingbeck Island, c. six pairs on the north end of Killingbeck Island and c. 50 pairs on another small rock 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 January 2018 and contained 80 pairs (Phillips et al., 2019[28]). Imperial 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*)**

Rothera Point and adjacent islands contain over 10% of the global population of south polar skuas and the area is of international importance. In austral summer 2017/18, totals of 259 skuas at

[27] Milius, N. (2000), The birds of Rothera, Adelaide Island, Antarctic Peninsula. Marine Ornithology 28: 63-67.

[28] Phillips, R.A., Silk, J.R.D., Massey, A. and Hughes, K.A. (2019). Surveys reveal increasing and globally important populations of south polar skuas and Antarctic shags in Ryder Bay. Polar Biology 42: 423–432

club sites and 978 occupied skua territories were counted, in 2.3 km$^2$ of suitable habitat across Rothera Point and the islands in Ryder Bay.

South polar skuas breed at Rothera Point and the population has been monitored annually since the 1988/89 season. The locations of recorded nest sites are shown in Figure 9-10 (UK Polar Data Centre[29], Rothera Point and Anchorage skua data, 2017). Nest sites are often reused but may be inactive for a number of consecutive years.

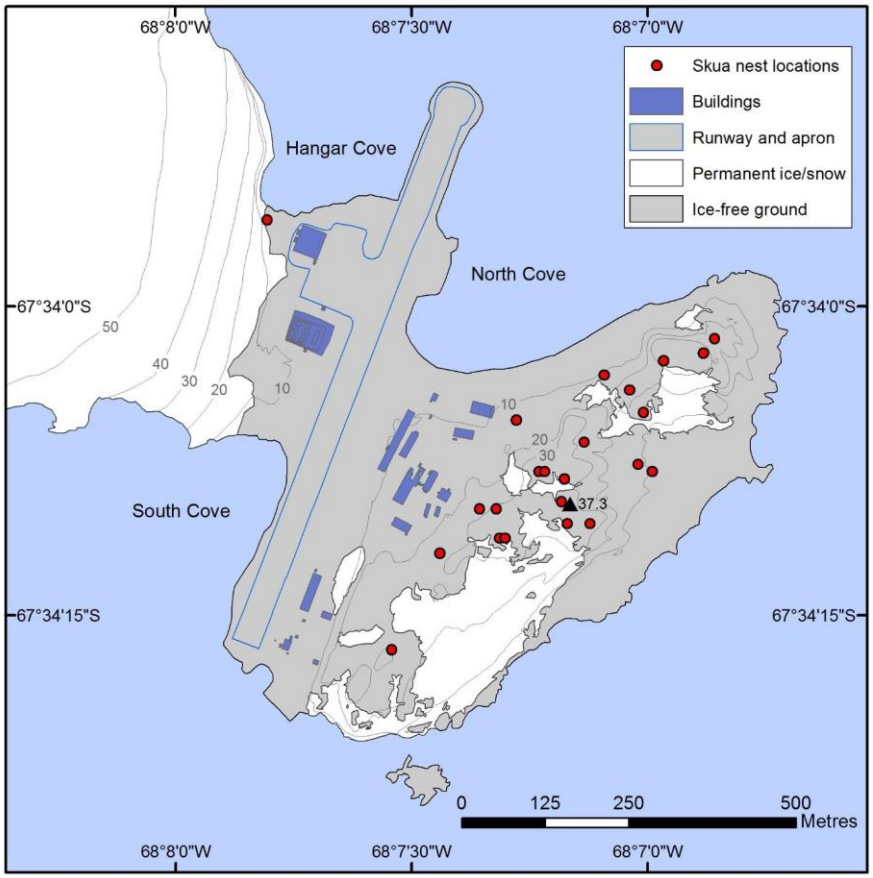



**Figure 9-10: Distribution of Skua Nesting Sites on Rothera Point, Adelaide Island (2005-2016). Note the Red Circles Mark the General Areas in Which Nests are Located as the Precise Location May Vary by a Few Metres Year on Year. BAS Jan 2022**

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 9-11). Additionally, up to almost 1000 birds breed on many of the other islands in Ryder Bay (Lagoon, Leonie, Killingbeck, Donnelly and Anchorage Islands) 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.

[29] BAS, 2022. UK Polar Data Centre/Discovery Metadata System, online. Available at: https://data.bas.ac.uk/

Ongoing monitoring of skua breeding takes place at Rothera to ensure that impacts as a result of human presence there are monitored and managed, if required. Two separate surveys are being undertaken in the 2021/2022 and 2022/2023 seasons to collect population counts and biometric data as well as bird flight path monitoring to inform the use of turbines in the renewables project.

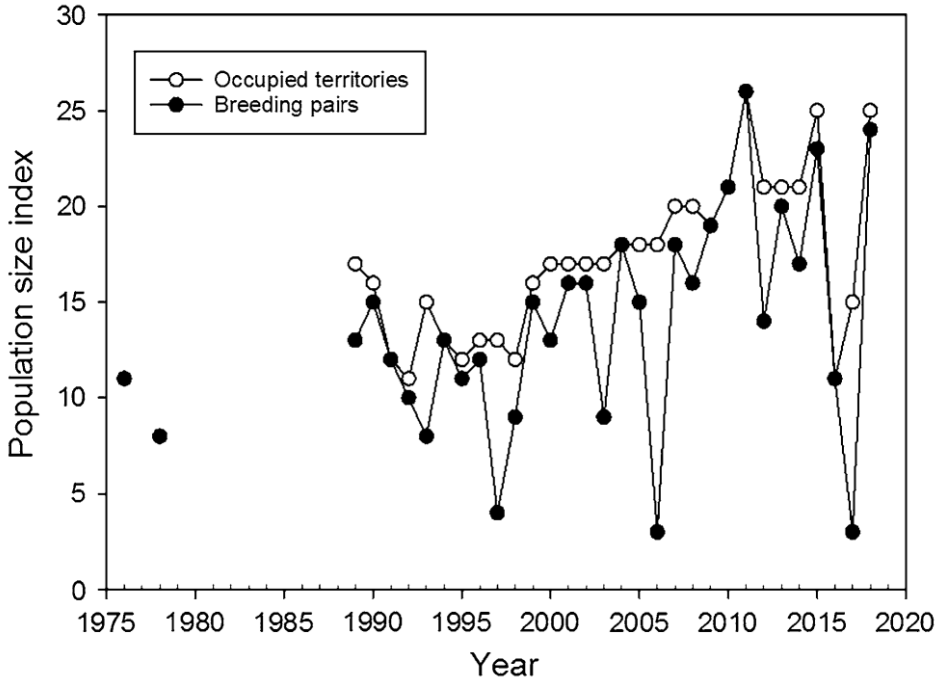



**Figure 9-11: Changes in Population Sizes of South Polar Skuas at Rothera Point, Ryder Bay (Antarctic Peninsula) From 1976 to 2018. Years Refer to the Time of Chick Fledging (I.E. 1976 Represents the 1975/76 Austral Summer), BAS Jan 2022**


**Figure 9-12: Location Map of Ryder Bay and Surrounding Area, BAS Jan 2022**

**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 (Killingbeck 1963) and Willey (1969) reported a nesting colony of 100+ birds at Rothera Point on 16 January 1969. However, the colony disappeared after the establishment of the base in 1976. Birds are seen commonly around Rothera Point between late September/early October and March and far more rarely in winter.

### 9.1.4.2 Non-breeding Species at Rothera

**Emperor penguin (*Aptenodytes forsteri*)**

Emperor penguins are rare, although almost annual, visitors, with seldom more than single birds seen. A group of 19 was recorded on 7 November 1977 (Fletcher 1978). Nearly all records of this species 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 c. 120 birds observed on East Beach at one time. 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 eggshell in soil provide evidence of ancient penguin, probably Adélie penguin, colonies on Rothera Point.

**Chinstrap penguin (*Pygoscelis antarctica*)**

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

### 9.1.5 Marine Mammals

**Seals**

Seals haul out at low lying sites around Rothera Point (Figure 9-13). Weddell seals (*Leptonychotes weddelli*) are the most obvious mammal and are present all year round. 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[30]).

[30] Muir, S.F., Barnes, D.K.A., Reid, K. (2006), Interactions between humans and leopard seals. Antarctic Science, 18. 61-74.

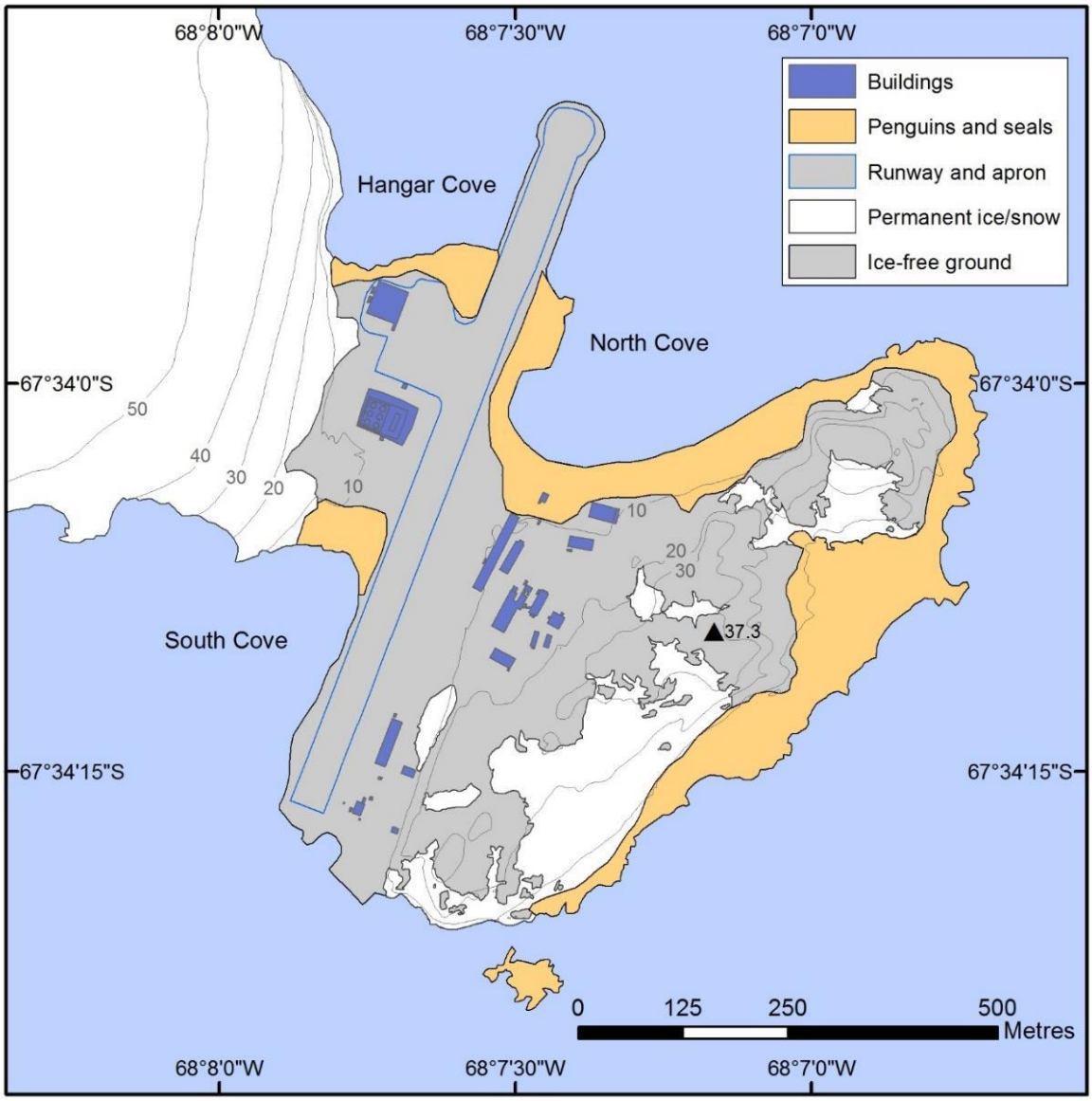



**Figure 9-13: Low Lying Area of Rothera Point Where Low Densities of Seals And Penguins May Be Found Commonly, BAS Jan 2022**

## 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 (Širović and Hildebrand, 2011[31]). Killer whales (*Orcinus orca*) inhabit the larger Marguerite Bay area and are usually seen from the station several times each summer.

[31] Širović, A., and Hildebrand J. A. (2011), Using passive acoustics to model blue whale habitat off the Western Antarctic Peninsula. Deep-Sea Research Part II 58:1719-1728.

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 southeastern end of Adelaide Island (Friedlaender et al., 2011[32]).

### 9.1.6 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 *Hypogastrura viatica* at Leonie Island, Marguerite Bay (Hughes et al., 2015[33]; 2017[34]). This is the most southerly record of the presence of a non-native species in the natural environment on the Antarctic Peninsula (see Figure 9-14). A monitoring project was initiated in January 2015 to establish the presence and distribution of *Hypogastrura viatica* on the islands in Marguerite Bay and on Rothera Point. No evidence for the presence of *Hypogastrura viatica* or any other non-native invertebrate was found in the c. 36,796 specimens collected. From these data it cannot categorically be stated that *Hypogastrura viatica* is absent from the area, but given the number and distribution of samples collected, it is likely that it is present in only very low numbers, and it is possible that it has become locally extinct.

[32] Friedlaender, A.S., Johnston, D.W., Fraser, W.R., Burns, J., Halpin, P.N., Costa, D.P. (2011). Ecological niche modeling of sympatric krill predators around Marguerite Bay, Western Antarctic Peninsula. Deep Sea Research II 58: 1729–1740.

[33] Hughes, K. A., Pertierra, L.R., Molina-Montenegro, M. A., Convey, P. (2015), Biological invasions in terrestrial Antarctica: what is the current status and can we respond? Biodiversity and Conservation, 24. 1031-1055.

[34] Hughes, K. A., Greenslade, P., and Convey, P. (2017), The fate of the non-native collembolon, Hypogastrura viatica, at the southern end of its introduced range in Antarctica. Polar Biology 40: 2127-2131.

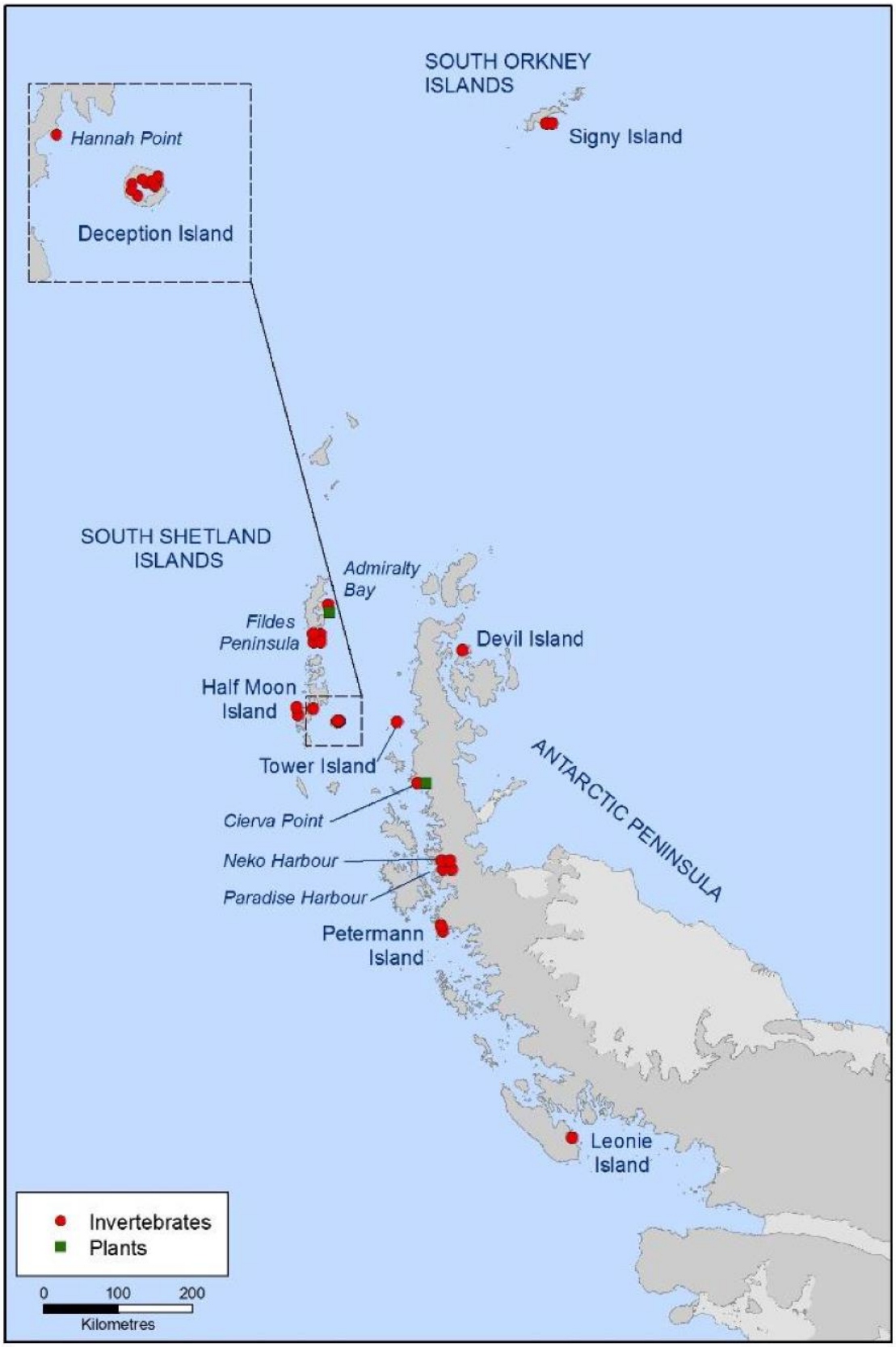



**Figure 9-14: Map of Antarctic Peninsula Region Showing the Distribution of Known Non-Native Species, BAS 2022**

## 9.2 Physical Characteristics

### 9.2.1 Meteorological Conditions

A programme of surface synoptic meteorological measurements commenced at Rothera Research Station in 1977. The climate is cold and dry and represents a transition from that typical of the more oceanic influenced 'maritime' Antarctic to the north and the more extreme climate of 'continental' Antarctica to the south. Mean monthly air temperatures range between c. - 10.5 and + 1.4 °C (Figure 9-15). The prevailing wind is north-north-easterly and averaging at 12.1 $ms^{-1}$, but often exceeding 20 $ms^{-1}$ (Figure 9-16).

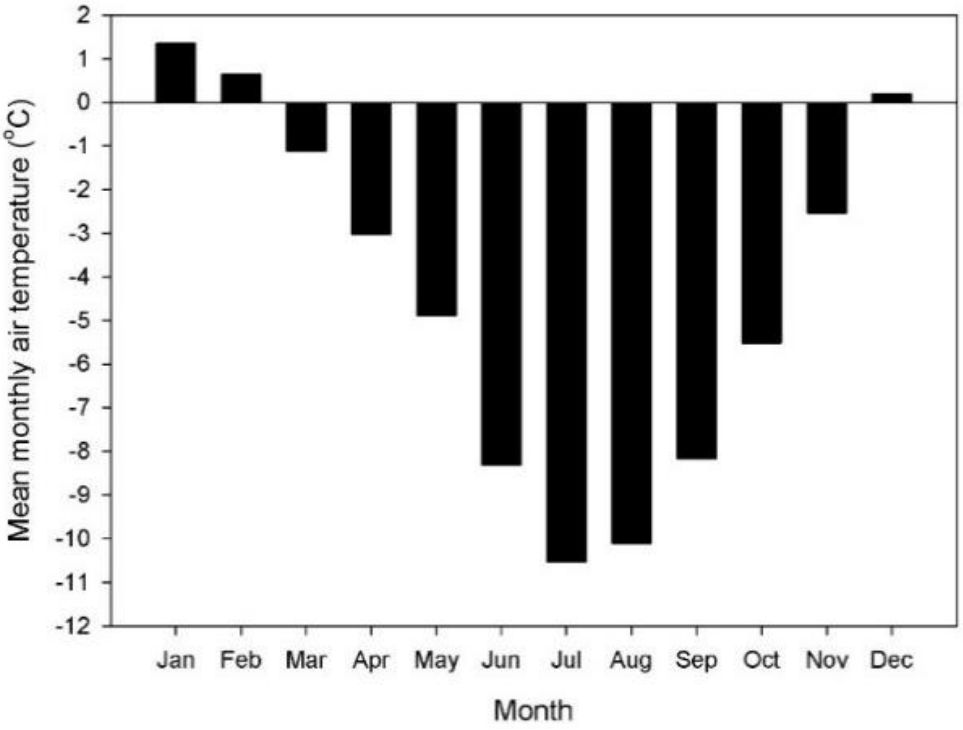



**Figure 9-15: Mean Monthly Air Temperature at Rothera Point, Adelaide Island, BAS Jan 2022**

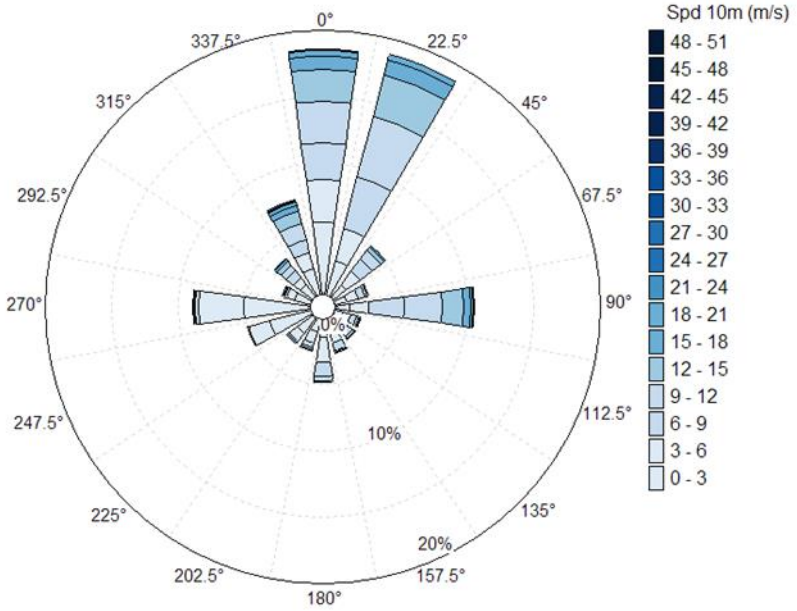



**Figure 9-16: Wind direction and Frequency Distribution at Rothera for the Period 2000-2021. Ramboll, 2022**

### 9.2.2 Air Quality

No air quality data exist for Rothera Point; however, significant volumes of hydrocarbons are combusted in the vicinity of the station by power station generators and the engines of vehicles, ships, small boats and aircraft. The station also has an incinerator which emits combustion gasses. 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[35]). Beyond this area the concentrations progressively declined with increasing distance from the station. Substantial levels of building activity in recent years have generated dust, but the levels have been minimised through the use of dust suppression techniques. 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. Dust monitoring has occurred during recent construction seasons. The latest dust monitoring was undertaken in the 2021-2022 season, in which there were only three exceedances reported.

### 9.2.3 Tides and Waves

#### Tides

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 Table 9-1.

[35] Bonner, W.N., Lewis-Smith, R.I. and Walton, D.W.H. (1989), Final Comprehensive Evaluation for the proposed construction of an airstrip at Rothera Point, Antarctica. NERC, Swindon.

**Table 9-1: Astronomical tides for Rothera Point are given on Admiralty chart 3462 as follows (CD: chart datum)**

| State of the Tide | Level |
|---|---|
| Mean Higher High Water (MHHW) | +1.3 m CD |
| Mean Lower Low Water (MLLW) | +0.4 m CD |
| Mean Sea Level (MSL) - taken as the mean of MHHW and MLLW | +0.85 m CD |

**Waves**

Based on preliminary calculations using a wind speed of 40 knots (3 hour average), a 50 year return period wave height of Hs = 4.0 m is estimated.

### 9.2.4 Bathymetry

The seabed around Rothera Point shelves steeply and depths in excess of 500 m can be found within 5 km of the station. Water less than 50 m deep is restricted to the immediate fringes of the coastline. Currents along the coastline are minimal; however, the channel between Rothera Point and Killingbeck Island experiences current speeds in excess of 0.5 knots.

A bathymetric survey was conducted at Biscoe Wharf, Rothera Point, during February 2016. The seabed was found to be steeply sloping (majority steeper than 25 ° angle) and consisted primarily of rock. Seawater depths reach 40 m within close proximity of the shoreline (c. 25 – 35 m).

### 9.2.5 Geomorphology

Rothera Point is a small peninsula situated on the southeast of Adelaide Island. Rothera Point is a low rocky headland of about 0.4 $km^2$ comprising a north-east to south-west trending, dissecting ridge rising to 39 m altitude, 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 smoothed 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 shorelines were distinguished by more than 20 narrow terraces, but these are now largely indistinguishable due to station construction activities (Shears, 1995[36]). 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 above sea level (ASL). Other areas of ice-free topography are widespread elsewhere in Laubeuf Fjord and northern Marguerite Bay, but few possess extensive level ground.

[36] Shears, J. R. (1995), Initial Environmental Evaluation – expansion of Rothera Research Station, Rothera Point, Adelaide Island, Antarctica. British Antarctic Survey, Cambridge, 80 pp.

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.

### 9.2.6 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[37]). 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[38]). Otherwise, there are no accumulations of organic matter, except for a very shallow layer of decaying moss peat beneath patches of moss.

### 9.2.7 Surface Water

No large areas of freshwater exist on Rothera Point, with the exception of a c. 50 m 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. Should the landscape topography be altered in this region, appropriate drainage from this pool may need to be considered.

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, moss and cyanobacterial communities. The flat area to the west of the Hangar may contain small transient meltwater pools.

### 9.2.8 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[39]). The lithological unit that is directly relevant to Rothera Point and the surrounding area is the 'Adelaide Island intrusive suite'; a series of isolated and composite granitoid plutons. A large part of the exposed geology on Adelaide Island consists of plutonic rocks of the Adelaide Island intrusive suite. 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. The plutons are seen to intrude the volcano-sedimentary sequences at several localities, including Reptile Ridge which lies at the top of the Rothera ice ramp.

[37] Antarctic Treaty Secretariat, (2017), Management Plan for Antarctic Specially Protected Area No. 129 Rothera Point, Adelaide Island. Available at: http://www.ats.aq/devPH/apa/ep_protected.aspx?lang=e

[38] Emslie, S.D., McDaniel, J. (2002), Adelie penguin diet and climate change during the middle to late Holocene in northern Marguerite Bay, Antarctic Peninsula. Polar Biology 25, 222-229.

[39] Riley. T. R., Flowerdew, M. J. and Whitehouse, M. J. (2012), Chrono- and lithostratigraphy of a Mesozoic–Tertiary fore- to intra-arc basin: Adelaide Island, Antarctic Peninsula. Geological Magazine 149: 768-782.

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 9-17). 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 9-17: Magma Mingling on Rothera Point, BAS Jan 2022**

### 9.2.9 Glaciology

Access from Adelaide Island to Rothera Point is via an ice ramp forming the southern limit of the Wormald Ice Piedmont (Figure 9-18).

**Figure 9-18: The Ice Ramp That Connects Rothera Point to the Wormald Ice Piedmont, BAS Jan 2022**

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 (Figure 9-19). 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. The deposition of dust on the ramp originating from the runway may also be contributing to surface lowering, and mitigation measure 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.

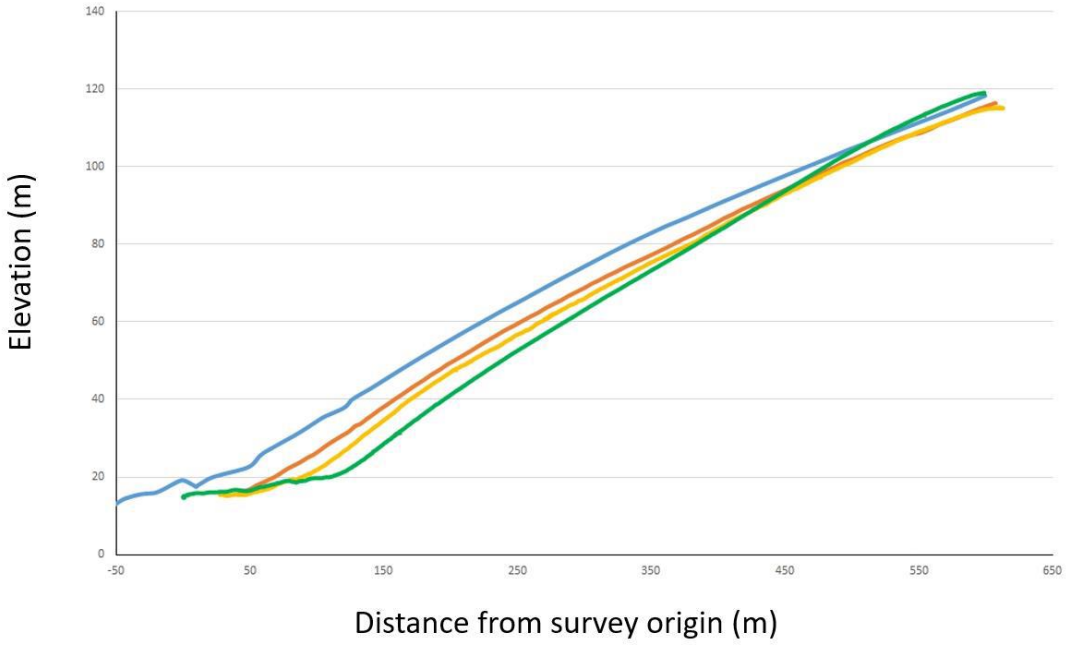



**Figure 9-19: Elevation of the Rothera ice ramp between 1989 and 2021. Line colours correspond to ramp profiles surveyed during different years: blue (1989), orange (1998), yellow (2008), green (2021). The base of the ice ramp has receded by > 100 metres in the past 30 years, BAS Jan 2022.**

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 Areas No. 129.

### 9.2.10 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 a*l., 2014[40]). 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 with the similar mean annual air temperature in Maritime Antarctica, because vegetation and a soil organic horizon are absent at the study site. Zero annual amplitude in temperature 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.

[40] Guglielmin, M, Worland, RM, Baio, F. (2014) Permafrost and snow monitoring at Rothera Point (Adelaide Island, Maritime Antarctica): Implications for rock weathering in cryotic conditions. Geomorphology 225: 47–56.

### 9.2.11 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.

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.

### 9.2.12 Noise and 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 and 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. Adélie penguins that may congregate on East Beach are subject to less noise originating from the station and runway. Local noise/vibration monitoring has been undertaken during construction work for the wharf and the Discovery Building.

## 9.3 Protected Areas

### 9.3.1 Antarctic Specially Protected Areas

The primary reason for the designation of ASPA No. 129 Rothera Point, Adelaide Island (Lat. 68°07'S, Long. 67°34'W), as an Antarctic Specially Protected Area (ASPA) is to protect scientific values, and primarily that the area serves as a control area, against which the effects of human impact associated with the adjacent Rothera Research Station (UK) could be monitored in an Antarctic fellfield ecosystem (see
Figure 9-20). Rothera Point was originally designated in Recommendation XIII-8 (1985, SSSI No. 9) after a proposal by the United Kingdom.

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 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 heavy metal concentrations in gravel and soils; and
iii. survey of the breeding bird populations.

Nevertheless, the appropriateness of the ASPA as a control site for monitoring studies has been put into question due to the close proximity of the ASPA to the station building and infrastructure,

the footprint of which has expanded in recent years. A management plan is in place for ASAP No. 12941. Monitoring activities are now also being duplicated on Donnelly Island, within ASPA 177 Leonie Islands and southeast Adelaide Island, which was designated in 2021 (see Figure 9-20). This contains six sites selected to protect important scientific and environmental values as set out in Table 9-2.

Contrary to earlier assessments, recent research has shown that the vegetation of Rothera Point is representative of the floristic diversity typical of vegetation communities of the north-western Antarctic Peninsula. Furthermore, Rothera Point, including ASPA 129, has some of the largest floristic richness and more complex vegetation within the wider geographical context of Marguerite Bay and Adelaide Island. As such, the vegetation on Rothera Point is of outstanding value.

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

[41] ATS, 2016. Management Plan for Antarctic Specially Protected Area (ASPA) No. 129, Rothera Point, Adelaide Island, online. Available at: http://www.ats.aq/documents/recatt/Att509_e.pdf [Accessed 07/04/2022]

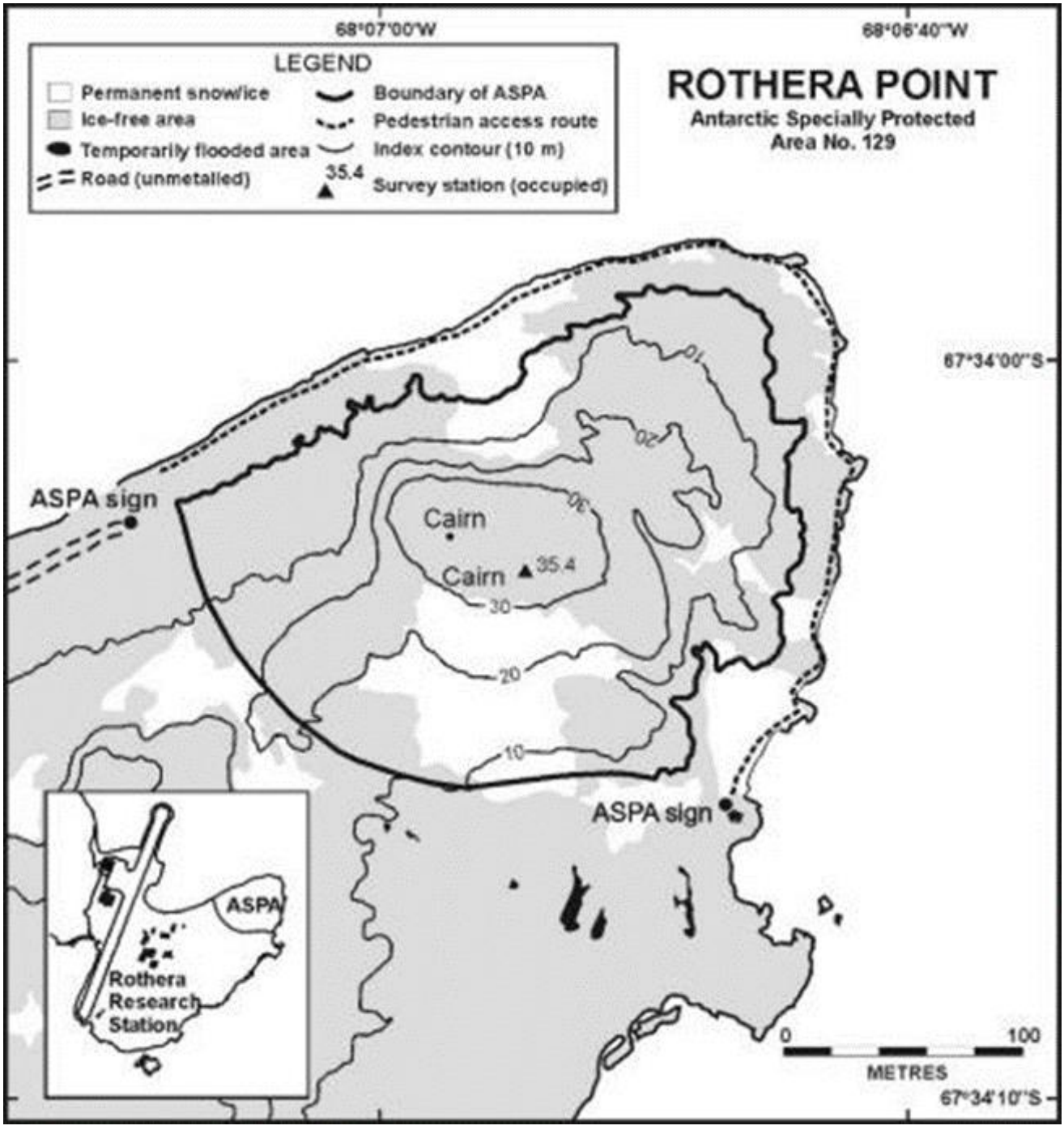



**Figure 9-20: Map of ASPA No. 129 Rothera Point, Adelaide Island, BAS 2019**

**Table 9-2: ASPA 177 Sites and their designated features**

| ASPA Site | Defining features |
|---|---|
| Anchorage Island | Protects scientific research activities by UK and international scientists. The island, along with other sites in the ASPA, protects approximately 8.1% of the global population of south polar skuas. |
| Donnelly Island | As a site that has been only rarely visited, acts as a pristine control site against which to monitor impact due to station activities on Rothera Point. |
| East Lagoon Island | Protects rich and vulnerable terrestrial communities and nesting skuas. |
| Walton Terraces, Léonie Island | Protects unusually rich terrestrial vegetation fed by meltwater from the snow slopes above. |
| Mucklescarf Island | Protects a breeding population of Antarctic shags, representing 2.2% of the global population. The birds are easily disturbed and access to the island should not be made without a permit. |
| Horton, Hurley and Turner Glaciers | Encompasses the western skyline as visible from Rothera Point. Protects the wilderness and aesthetic values of the area. |

### 9.3.2 Important Bird and Biodiversity Area (IBA)

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 9-21). The IBA extends to the islands in Ryder Bay, many of areas of which are protected under the Antarctic Treaty System through designation of ASPA 177 Leonie Islands and southeast Adelaide Island (shown in part in the inset of Figure 9-21).

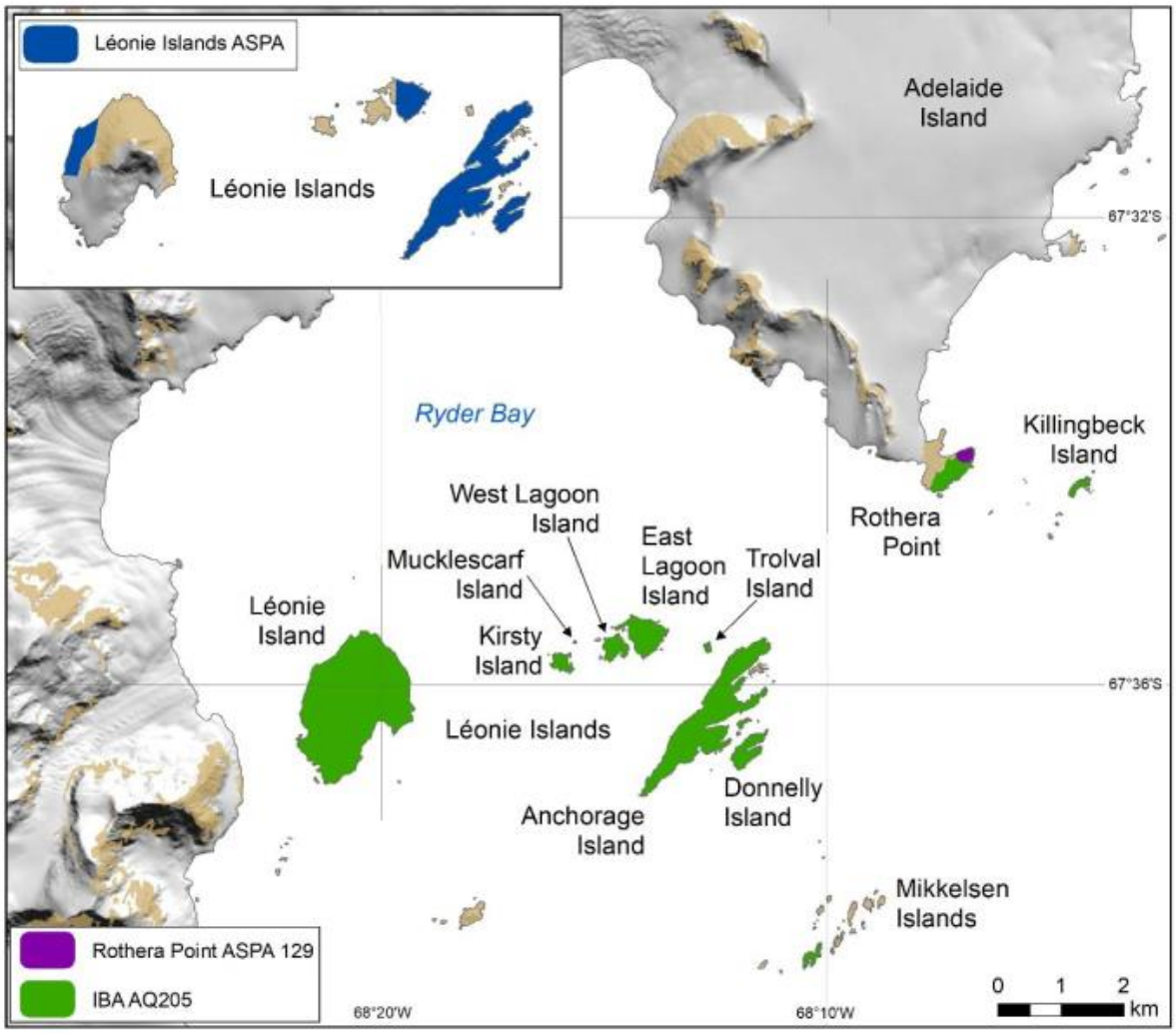



**Figure 9-21: Map of the Ryder Bay area showing the extent of ASPA 129 Rothera Point (purple), ASPA 177 Leonie Islands and south-east Adelaide Island (blue) and Important Bird and Biodiversity Areas (IBA) AQ205 (green)**

## 9.4 Cultural Heritage

BAS has operated from Rothera Point since 1975. Whilst there are no formally designated Historic Sites and Monuments (HSMs) at Rothera, the station does have a rich cultural heritage which has developed over the years. Heritage is important to BAS and the wider UK Antarctic community, so potential impacts to heritage were considered in the Rothera Modernisation Phase 1 IEE (2019).

A heritage survey (Appendix 4) was undertaken at Rothera in December 2016 to identify objects with potential heritage significance. The purpose of the survey was:

- to identify those items of heritage value which will require on-going management and/or extraction prior to the Rothera re-development;
- to ensure that those items of heritage value put at risk by the station and wharf redevelopment are appropriately protected;
- to elicit the views of station personnel, as stakeholders, with regard heritage in general, and the heritage value of items at Rothera; and

to enable these views to be factored into the redevelopment process and the assessment of heritage value.

The review was undertaken using the Heritage Selection Process, written in conjunction with the United Kingdom Antarctic Heritage Trust (UKAHT). This process aims to provide a systematic and consistent methodology for the identification of those objects (defined as either an artifact, building or site) with heritage value. Heritage is here defined as all inherited resources which people value for reasons beyond mere utility (Historic England, 2008[42]). This definition includes the widest range of physical 'things'. It also encompasses the range of emotional and intellectual values attached to them (Hopkins, 2017[43]).

The survey identified a number of objects with potentially broad heritage significance (i.e., significance to stakeholders other than station personnel, including former BAS staff, historians/heritage professionals and the general public. Numerous items were also found to have significance to those personnel living on the station, but not necessarily more broadly.

The views of staff on station with regard to the importance of heritage were also collected. A staff discussion on the subject of heritage was held and involved a large proportion of the staff at Rothera. The importance of a sense of continuity and connection with the past was an aspect of heritage that was repeatedly voiced, as was a sense of trusteeship and respect for the heritage created and left by previous staff.

A copy of the survey results is available in Appendix 4. Instructions on how each artifact should be handled have been included in the results.

Six key heritage artefacts were identified in the survey, namely, Bingham's House, Rothera ceiling, dog genealogies, dog pen doors, Rothera span diagram, and the trace and harness hooks. Specific details of what constitutes the artefact is included as well as details on how the item should be conserved or otherwise.

### 9.5 Landscape, Visual and 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[44]).

For over 40 years the British Antarctic Survey has concentrated its southern Antarctic Peninsula station infrastructure 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, evidence of human presence is visible from most areas of Rothera Point; however, the great majority of infrastructure has been constructed 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 ASPA No. 129. Indeed, it is common for station

[42] Historic England, 2022. Heritage Definitions, website. Available at: https://historicengland.org.uk/advice/hpg/hpr-definitions/#cat_H

[43] Hopkins, I., 2017. Rothera Visit – Heritage Survey Review, Unpublished Internal BAS Report.

[44] Tin T., and Summerson R, 2013. Growing human footprint, diminishing wilderness in Antarctica. International Journal of Wilderness 19 (3): 10–13, 36.

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. The benefit to the mental health of station personnel cannot be overstated. 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 9-22).

**Figure 9-22: View From Rothera Point Across Marguerite Bay to Leonie Island, and the Princess Royal Range Beyond, the Wilderness and Aesthetic Values of Which are Protected Through ASPA 177 Leonie Islands and South-East Adelaide Island**

## 9.6 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. Due to the high levels of uncertainty in modelled outputs in the polar regions, it is difficult to accurately predict climate change impacts at Rothera, however changes observed to date such as increased temperatures, give a strong indication of likely climate change impacts. 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.

### 9.6.1 Changes in Ice Scour of the Benthic Environment

Losses of fast ice around Rothera Research Station have led to higher iceberg scouring rates and rising mortality of some benthic species. Daily records of fast-ice presence/absence from 1986 to 2010 and annual ice-scour impact rates have shown a decreasing trend in the duration of fast-ice years and a coincident increase in scouring. However, three more years of data revealed that this is more aptly described as a decrease to a tipping point in 2006, after which fast-ice has been anomalously brief each year and ice scour has been high (see Figure 9-23).

The annual survey of iceberg disturbance at Rothera Research Station is thought to be the longest running and most comprehensive direct measure of marine ice disturbance. The number of annual iceberg impacts has, similarly to fast ice, varied much between years but impacts have increased in recent years. The fewest impacts matched the years which had the longest duration of fast-ice within the study period and likewise the years with most impacts were the two years with briefest fast-ice. Fast-ice duration explains 72.4% of the variation in annual ice scour. Markers at 5 and 10 m depth were hit more than twice as often as those at 25 m. The link between fast-ice duration and iceberg scouring is important because scouring is the dominant cause of mortality to fauna in the shallows. Previous work has shown that survival from ice scouring at this depth can be less than 1% of the fauna. Both the shallows and deep shelf are mosaics of faunas recovering from impacts; the former is dominated by pioneers and free space whilst the latter are a mixture including 'climax' assemblages perhaps thousands of years old. This study was conducted in South Cove, which is generally shallower and more sheltered than the wharf area. It is likely that impact damage around the wharf could be more severe due to the larger scale of icebergs that can reach the wharf due to the deeper water and steeper seabed slope angle (see Section 9.2.4).

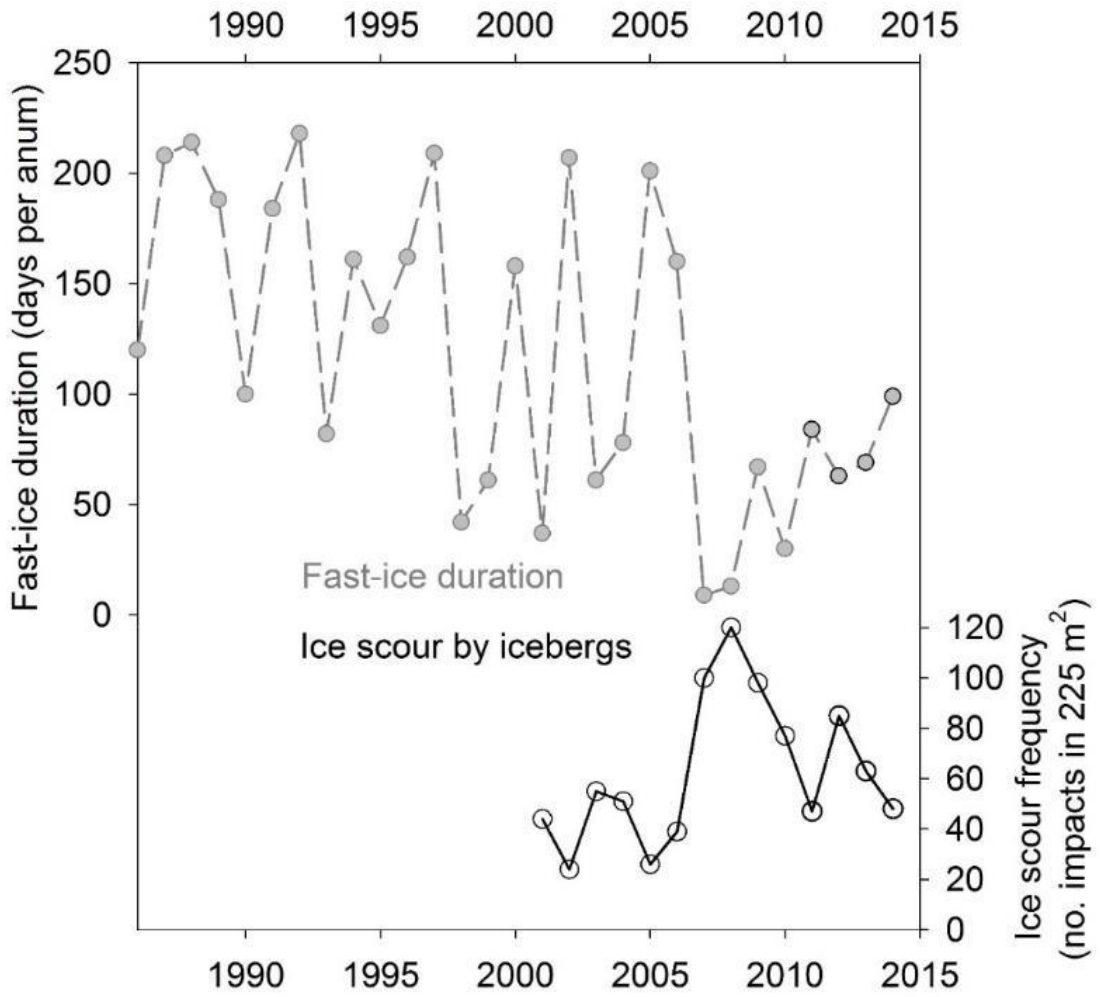



**Figure 9-23: Prevalence Of Fast Ice and Ice Scour At South Cove, Rothera Point. Fast-Ice Duration (Top), the Number of Experimental Markers Hit By Icebergs (Bottom), BAS Jan 2022**

## 9.7 Future Environmental Reference State

The proposed works are all within the current footprint of Rothera Research Station and are largely on previously disturbed ground. On completion of all the proposed activities it is not anticipated that the future state of the environment will differ greatly from the existing condition, as result of the works. As discussed within the assessment of impacts, the majority of the potential impacts associated with the proposed scope of works will be undertaken within one season, and the longest duration impacts will take place over one year. Overall, the potential impacts are considered to be largely temporary. The runway resurfacing works will construct a new runway surface that will remain at Rothera for the operational lifetime.

## 9.9 Summary

The key environmental receptors which are most likely to be impacted by the proposed works are terrestrial flora and fauna (e.g., the moss patch[45], nesting skuas and biosecurity risks) and local glaciology.

[45] The moss patch has been erroneously referred to as moss "bank" in historic documents, however, it will be given the correct name in future EIAs.

# 10. ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

## 10.1 Methodology

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

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

- Identifying the proposed activities of the project;
- Identifying the environmental aspects – the way in which any of the proposed activities interact with the environment such as atmospheric emissions, dust, noise, fuel spills, waste, introduced non-native species etc;
- Identifying the environmental impact – the change in environmental value or resource as a result of the activity; and
- Assessing the significance of the identified impact – 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.

## 10.2 Proposed Activities

The nature and the scale of the proposed activities have been described in Sections 3 to 7. For the purposes of the assessment of potential impacts, these activities have been divided into categories based on the nature of the works. The impact assessment categories are summarised here:

- Construction Activities;
- SI Works and Condition Surveys (intrusive and non-intrusive);
- Monitoring Activities; and
- Support Activities.

## 10.3 Environmental Aspects

ATS EIA Guidelines[7] state that:

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

The environmental aspects associated with the activity categories listed above are shown in Table 10-1.

**Table 10-1: Environmental Aspects of the Proposed Activities**

| No. | Activities | Environmental Aspects | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Atmospheric Emissions | Noise Emissions | Dust Emissions | Waste | Light (external) | Physical Presence and Use of Space | Physical or Mechanical Disturbance on Land | Fuel or Hazardous Substance Release | Non-Native Species Introduction | Disturbance to Native Flora and Fauna | Visual | Heritage |
| **Construction Activities** | | | | | | | | | | | | | |
| 1 | Rock processing and crushing of rock material | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | ☒ | | ☒ | | |
| 2 | Screening, loading, transporting, and tipping of rock | ☒ | ☒ | ☒ | | | ☒ | ☒ | ☒ | | ☒ | | |
| 3 | Excavation of hand dug trial holes | | | ☒ | | | ☒ | ☒ | | | ☒ | | |
| 4 | Ducting and chamber installation | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 5 | Services crossing the runway | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 6 | Installation of foundation and bases | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 7 | Lighting M&E works | | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 8 | Runway resurfacing works | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 9 | Creation of non-engineered slipways | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 10 | Fuel Farm Infrastructure Upgrades | ☒ | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| **SI and Condition Surveys** | | | | | | | | | | | | | |
| 11 | Targeted diver visual inspections | | | | | ☒ | ☒ | | | | ☒ | | |

| No. | Activities | Environmental Aspects | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Atmospheric Emissions** | **Noise Emissions** | **Dust Emissions** | **Waste** | **Light (external)** | **Physical Presence and Use of Space** | **Physical or Mechanical Disturbance on Land** | **Fuel or Hazardous Substance Release** | **Non-Native Species Introduction** | **Disturbance to Native Flora and Fauna** | **Visual** | **Heritage** |
| 12 | Collection of marine samples | | | | | | ☒ | ☒ | | | ☒ | | |
| 13 | Probe survey | | | | | | ☒ | ☒ | | | ☒ | | |
| 14 | Rock revetment investigation | ☒ | ☒ | ☒ | | | ☒ | ☒ | ☒ | | ☒ | | |
| 15 | Sea ice thickness investigation | ☒ | ☒ | | | | ☒ | ☒ | ☒ | | ☒ | | |
| 16 | Condition surveys (visual and/or non-intrusive) | | | | | | ☒ | | | | ☒ | | |
| 17 | Borehole drilling | ☒ | ☒ | ☒ | | | ☒ | ☒ | ☒ | | ☒ | | |
| 18 | Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples | ☒ | ☒ | ☒ | | | ☒ | ☒ | ☒ | | ☒ | | |
| 19 | Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys) | ☒ | ☒ | | | ☒ | ☒ | ☒ | ☒ | | ☒ | | |
| 20 | Sampling of steel | ☒ | ☒ | | ☒ | | ☒ | | ☒ | | | | |
| 21 | Friction measurements | ☒ | ☒ | ☒ | | | ☒ | | ☒ | | ☒ | | |
| **Monitoring Activities** | | | | | | | | | | | | | |
| 22 | Energy demand metering of current buildings | | | | | | ☒ | | | | | | |

| No. | Activities | Environmental Aspects | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Atmospheric Emissions** | **Noise Emissions** | **Dust Emissions** | **Waste** | **Light (external)** | **Physical Presence and Use of Space** | **Physical or Mechanical Disturbance on Land** | **Fuel or Hazardous Substance Release** | **Non-Native Species Introduction** | **Disturbance to Native Flora and Fauna** | **Visual** | **Heritage** |
| 23 | Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor) | ☒ | ☒ | | | | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 24 | Wind monitoring (installation of a SoDAR device) | ☒ | ☒ | | | | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| 25 | HVO trial | ☒ | ☒ | | | | ☒ | ☒ | ☒ | | ☒ | ☒ | |
| **Support Activities** | | | | | | | | | | | | | |
| 26 | Shipping cargo to Rothera | ☒ | ☒ | ☒ | ☒ | | | | ☒ | ☒ | ☒ | | |
| 27 | Transport of personnel to Rothera | ☒ | ☒ | ☒ | ☒ | | | | ☒ | ☒ | ☒ | | |
| 28 | Storage of cargo | | | | | | ☒ | ☒ | | ☒ | | ☒ | |
| 29 | Site set-up and presence of personnel | ☒ | ☒ | ☒ | ☒ | | ☒ | | | | ☒ | ☒ | |
| 30 | Vehicle, plant, and equipment operation | ☒ | ☒ | ☒ | | ☒ | ☒ | ☒ | ☒ | | ☒ | | |
| 31 | Fuel management and refuelling | | ☒ | | | | ☒ | | ☒ | | ☒ | | |
| 32 | Provision of accommodation, power, and domestic services | ☒ | | | ☒ | ☒ | ☒ | | ☒ | | | | |
| 33 | Incineration of waste | ☒ | | ☒ | | | ☒ | | | | ☒ | | |

## 10.4 Identification of Environmental Impacts and Mitigation Measures

This section identifies the potential environmental impacts of the project on the environmental aspects identified within Table 10-1. Impacts are considered to be any changes in environmental value or resource that will or may occur as a result of the identified activities listed below. This section presents the worst-case scenario of potential impacts that could occur as a result of the proposed activities, without the consideration of any mitigation measures.

Potential impacts of the identified core activities have been presented for each environmental aspect, where relevant. These core activities are:

- Construction Activities;
- SI and Condition Surveys;
- Monitoring Activities; and
- Support Activities.

Each impact has been identified as either direct, indirect, cumulative, or unavoidable, and these are 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)7.
- 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)7.
- 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.

Impacts have been grouped by environmental aspect and presented for each type of activity proposed to be undertaken as part of this IEE (e.g., construction activities, SI and condition surveys, and support activities). Each proposed activity has been given a unique number which is used to refer to it throughout the assessment.

Where relevant, mitigation and or monitoring activities have been suggested after each impact, which allows for an assessment of the residual impacts once mitigation measures have been considered according to the significance criteria as outlined in Table 10-2 allowing for residual impacts to be assessed. A full monitoring plan is included in Chapter 11.

The following sections present the worst-case assessment of effects of the proposed activities on the environmental aspects at Rothera, before mitigation and monitoring are considered, all numbers relate to activities as listed within Table 10-1.

### 10.4.1 Atmospheric Emissions Impacts

**Construction Activities**

Atmospheric emissions associated with construction activities 1, 2, 4-6, and 8-10 are considered to cause a **direct** and **cumulative** contribution to global atmospheric pollution and heavy metal and particulate fallout locally.

Construction carbon emissions have been estimated using estimated fuel requirements for the Runway Resurfacing and Lighting project. These calculations demonstrate that approximately 645 tonnes of $CO_2$ equivalent will be emitted during these construction works. This value is based on a total MGO and HVO fuel use estimate of approximately 236,500 litres. The total $CO_2$ equivalent emitted during the full scope of works is not known or able to be estimated accurately, however, the runway resurfacing, and lighting works are considered to represent the largest proportion of atmospheric emissions. As calculated in the BAS Carbon Footprint, construction works represent a large proportion of the carbon emissions at Rothera. The atmospheric emissions associated with the activities outlined above are considered to be temporary in duration and will only occur during the programme of works.

**SI and Condition Surveys**

Atmospheric emissions associated with SI and conditions survey activities 14, 15, and 17-21 are considered to cause a **direct** and **cumulative** contribution to global atmospheric pollution and heavy metal and particulate fallout locally.

Carbon emissions have not been calculated for these activities, however the fuel use and atmospheric emissions associated with SI and condition surveys are expected to be minimal and temporary in duration.

**Monitoring Activities**

Atmospheric emissions associated with monitoring activities 23-25 are considered to cause **direct** and **cumulative** contribution to global atmospheric pollution and heavy metal and particulate fallout locally.

Carbon emissions have not been calculated for these activities, however the fuel use and atmospheric emissions associated with monitoring activities are expected to be minimal. In addition, the SoDAR device has the ability to adjust the output power depending on the atmospheric conditions, resulting in lower power usage, which is anticipated to range between 20-250 W instead of a fixed 250 W.

**Support Activities**

Atmospheric emissions associated with support activities 26, 27, 29, 30, 32, and 33 are considered to cause **direct** and **cumulative** contribution to global atmospheric pollution and heavy metal and particulate fallout locally.

Due to the location of Rothera and the challenges in accessing the location, the atmospheric emissions associated with the support activities, notably the transport of personnel and cargo to the site are largely unavoidable, and no alternative means of transport are available that would

emit fewer emissions. Measures to reduce emissions associated with support activities are implemented wherever practicable as outlined below.

The total BAS carbon footprint for 2021-2022 has been calculated at 24,010 tonnes of $CO_2e$ (for all BAS operations); given the similarities in support activities, the 2022-2023 values are anticipated to be similar to the values presented for the 2021-2022 season. The largest contributors to these emissions are ships (61.4%), travel (8.9%) and BAS aircraft journeys (8.5%). Rothera station activities account for 6.5% of this total.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- Ensure that all operations at Rothera are as efficient as possible to reduce excess fuel use;
- Generators and plant will be selected which balance efficiency and reduced emissions, with reliability, serviceability, and available fuel at Rothera;
- Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently, as per the BAM Plant Management Plan;
- Where practical, all drivers will be instructed to turn off engines during periods of waiting for 15 minutes or more;
- No mitigation has been provided for the emissions associated with the production of any construction materials required for the proposed activities. However, the AIMP Sustainability Strategy encourages the selection of materials with a lower embodied carbon;
- Due to the limited number of beds and environmental impacts of transport to Rothera, only staff essential to the proposed works will be deployed to Rothera;
- Rationalisation of plant and equipment shipped to station will be undertaken; and
- All staff will be briefed on energy efficiency whilst on station as part of the pre-deployment training.

Monitoring requirements are as follows:

- Data will be collected and the increased contribution to atmospheric pollution from the deployment of personnel and cargo will be accounted for in the BAS Energy and Carbon Dashboard;
- Fuel use during construction will be recorded and reported in the BAS Energy and Carbon Dashboard; and
- Ongoing and long-term monitoring in the ASPA for metal and particulate fallout (due to fuel combustion).

### 10.4.2 Noise Emission and Vibration Impacts

**Construction Activities**

Noise emissions associated with construction activities 1, 2, and 4-10 are considered to cause **direct** and **cumulative** noise impacts to local fauna, potentially resulting in avoidance or stress behaviour and/or nest abandonment.

For the purposes of the assessment of noise emissions during construction activities, it has been assumed that the entire length of the runway is resurfaced and under construction at the same time to allow the assessment of potential risks and impacts to sensitive receptors in proximity of this location. This assumption has been taken to be the worst-case scenario for environmental

assessment purposes and is not intended to indicate the exact runway operations. The duration of works is therefore anticipated to span over one season but are still considered to be temporary in duration.

The location of the proposed runway resurfacing, and lighting works is not directly adjacent to sensitive ecological receptors; the nearest active skua nest is adjacent to the Hangar building. At their closest point, the works are approximately 185 m east of this skua nest which is considered sufficient distance for noise to propagate and dissipate. As outlined in Section 6.5, human receptors have not been considered as part of the impact assessment.

A soft-start methodology will be used during noisy construction works that could cause vibration effects also. To allow this to occur, the noise source should be operated for 30 seconds and then switched off, to allow any animals in the vicinity the opportunity to move away. Once any disturbed animals have stopped moving, the equipment/noise source will be operated for another 30 seconds and then the response of the animals will be observed. This cycle will continue until the wildlife has moved away to a distance where the noise no longer causes further movement away. At this point the equipment may be used continuously.

**SI and Condition Surveys**

Noise emissions associated with SI and condition survey activities 14, 15, and 17-21 are considered to cause **direct** and **cumulative** noise impacts to local fauna, potentially resulting in avoidance or stress behaviour and/or nest abandonment.

The skua nest adjacent to the Hangar building is considered to be the most sensitive ecological receptor in relation to noise emissions and vibration associated with the SI and condition survey works. The Hangar is approximately 60 m east of the nest site. Mitigation measures for this sensitive ecological receptor are listed below, however should be read in conjunction with the mitigation measures recommended for disturbance to native flora and fauna which will be implemented to prevent and minimise impacts. Noise and vibration levels associated with the SI works adjacent to the Hangar building are not currently known, and as a precautionary measure, it is therefore recommended that an acoustic screen is implemented to effectively screen the skua nest from noise. If agreed vibration levels are exceeded (as outlined in Section 11.1.2), works in that area will cease. The noise and vibration emissions associated with these activities are considered to be temporary in duration.

**Monitoring Activities**

Noise emissions associated with monitoring activities 23-25 are considered to cause **direct** and **cumulative** noise impacts to local fauna, potentially resulting in avoidance or stress behaviour and/or nest abandonment. The wind monitoring activity has the potential to interfere with existing science monitoring equipment and residential receptors.

For noise emissions generated by the SoDAR device, a distance of 200 m to any occupied building and scientific equipment sensitive to sound is considered a sufficient distance to prevent significant adverse noise effects on these receptors; at 200 m the noise level is reduced to approximately 30 dB. For this reason, the chosen location for the SoDAR device is behind the Hangar building. However, this selected location does present the potential for noise to adversely affect the nesting skua located behind the Hangar building; at 60 m the anticipated noise levels (during summer months) are approximately 40 dB. Given the proximity of the Hangar building to this nest and the frequent noise levels at this location associated with the operation of the

runway, it is considered that the noise level associated with the SoDAR device will not result in nest abandonment or stress behaviour. The noise and vibration emissions associated with these activities are considered to be in effect for a medium-term duration, as monitoring will be undertaken throughout the year.

**Support Activities**

Noise emissions associated with support activities 26, 27 and 29-31 are considered to cause **direct** and **cumulative** noise impacts to local fauna, potentially resulting in avoidance or stress behaviour and/or nest abandonment.

Noise emissions associated with support activities are not considered to significantly differ to those experienced in previous seasons. These activities, such as SDA arrivals, plane landings on the runway and site-set and presence of personnel on site occur frequently and continuously throughout the year and are highly managed to ensure impacts to the local environment are minimised. Wildlife is considered to be habituated to the noise emissions associated with the support activities that occur at Rothera, as demonstrated through the continued presence of active skua nests and wildlife present on and around the site.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- Regular maintenance of all equipment to ensure it is working efficiently;
- 10 mph speed limit maintained and enforced on site, as is standard procedure for all vehicles at Rothera;
- Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors;
- Regular maintenance of all plant and vehicles to ensure they are working efficiently and generating as little noise as possible;
- A soft-start procedure will be implemented for all noisy construction and survey equipment to give animals on land (except nesting birds) as well as marine life the opportunity to move away from the noise source before it reaches its highest levels. Consideration of the impact of noisy activities to all wildlife in the vicinity will be given;
- For works at the Hangar building and apron only, an acoustic screen shall be implemented to effectively screen the adjacent skua nest from any noisy works;
- If agreed noise levels are exceeded (outlined in Section 11.1.2.4), works in that area will cease until additional mitigation measures can be implemented, e.g., acoustic screening; and
- If agreed vibration levels are exceeded (outlined in Section 11.1.2.5), works in that area will cease until additional mitigation measures can be implemented.

Monitoring measures are as follows:

- Continuous noise monitoring will take place at Rothera to ensure noise levels do not exceed agreed levels of 75 dBA equivalent 12-hour and 80 dBA equivalent 1-hour, which could cause adverse impacts to local fauna (notably seals and birds);
- Continuous vibration monitoring will take place at Rothera to ensure vibration dose values (VDV) do not exceed 2.4 ms–1.75 and vibration levels measured as Peak Particle Velocity (PPV) do not exceed the values outlined in DIN 4150-3 Effects of Vibration Line 2 (Figure 11-2, Section 11.1.2).

### 10.4.3 Dust Emission Impacts

**Construction Activities**

Dust emissions associated with all construction activities are considered to cause **direct** and **cumulative** effects to local flora and fauna through smothering due to dust deposition. The process of loading, transporting, and crushing rock, as well as concrete mixing (a requirement under the Fuel Farm Infrastructure Upgrades project) will produce dust which has the potential to damage soil organisms and vegetation through direct contact. Dust deposition on areas of adjacent ice will decrease albedo and increase rates of ice melt at these locations.

For the purposes of the assessment of dust emissions during construction activities, it has been assumed that the entire length of the runway is resurfaced and under construction at the same time to allow the assessment of potential risks and impacts to sensitive receptors in proximity of this location. The duration of works is therefore anticipated to span over one season but are still considered to be temporary in duration. Of particular note is the ice ramp, adjacent to the central runway chainage, and although no specific mitigation is required, the mitigation measures outlined below must be followed.

**SI and Condition Surveys**

Dust emissions associated with SI and condition survey activities 14, 17, 18, and 21 are considered to cause **direct** effects to local flora and fauna through smothering due to dust deposition. The process of loading, transporting, and crushing rock will produce dust which has the potential to damage soil organisms and vegetation through direct contact. Dust deposition on areas of adjacent ice will decrease albedo and increase rates of ice melt at these locations.

The skua nest adjacent to the Hangar building is considered to be the most sensitive ecological receptor in relation to dust emissions associated with the SI and condition survey works. The Hangar is approximately 60 m east of the nest site. Mitigation measures for this sensitive ecological receptor are listed below, however should be read in conjunction with the mitigation measures recommended for disturbance to native flora and fauna which will be implemented to prevent and minimise impacts. The dust emissions associated with these activities are considered to be temporary in duration.

**Monitoring Activities**

There are no potential dust emission impacts associated with the proposed monitoring activities.

**Support Activities**

Dust emissions associated with support activities 26, 27, 29, 30, and 33 are considered to cause **direct** effects to local flora and fauna through smothering due to dust deposition.

Due to the location of Rothera and the challenges in accessing the location, the dust emissions associated with the support activities, notably the transport of personnel and cargo to the site are largely unavoidable. Measures to reduce dust emissions through vehicle, plant and equipment operation are implemented wherever practicable as outlined below.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- For activities likely to produce high levels of dust and when dust levels are exceeded (as outlined in Section 11.1.2.7), dust suppression equipment should be used and/or roadways sprayed down with sea water;
- Where practicable, keep activities which create dust downwind of sensitive receptors and avoid close proximity to known vegetation and ice locations;
- All routes used by vehicles and plant will be well maintained and have compacted surfaces;
- Limit the drop height of materials during stockpiling, processing, and loading operations;
- Minimise double handling of materials to reduce the overall number of tipping actions;
- 10 mph speed limit maintained and enforced on site, as is standard procedure for all vehicles at Rothera;
- All plant and equipment will be maintained on a regular basis, as per the BAM Plant Management Plan;
- Cement will not to be mixed externally on windy days;
- If agreed dust levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and
- The Met team will provide a weather forecast to the Site Manager every morning. This will be reviewed by the Site Manager in conjunction with the Rothera Station Leader to inform the decision on which activities can proceed that day and if any activities need to be suspended or additional mitigation measures put in place. During excessively dry, windy conditions, especially where the wind direction will blow dust towards sensitive receptors, it may be necessary to temporarily suspend operations if it is not possible to control dust by other means; and
- As outlined in Section 4.5, 31.3 $m^3$ of cement is required for the Fuel Farm Infrastructure Upgrades project. All cement mixing will be carried out in accordance with the method statement and cement will not to be mixed externally on windy days, as advised by the Site Manager and Rothera Station Leader as above.

Monitoring requirements are as follows:

- Continuous dust monitoring will take place to ensure dust levels do not exceed agreed levels. A PM10 limit of 50µg/m3/24 hours is proposed and a total suspended particle (TSP) limit of 250µg/m3/15 minutes, as outlined in Section 11.1.2.7; and
- Wind level data to continue to be captured from the Met Mast by the Met team every morning to ensure construction works and supporting operations are safe to continue as normal or if additional mitigation is required, as outlined above.

### 10.4.4 Waste Impacts

**Construction Activities**

Waste generation associated with construction activities 5, and 7 and 10 is considered to cause a **direct** impact on international landfill capacity due to the increased quantities of waste required to be removed from station and sent to landfill in the UK. There is also an increased risk of waste being released into the local environment which could cause marine and terrestrial pollution and a hazard to local wildlife if suitable waste management procedures are not followed.

The use of raw materials and finite resources (energy and water) for construction at Rothera is managed and minimised as far as reasonably possible through a range of measures, such as the reuse of site won materials, for example previously quarried rock material, minimising water

consumption for construction and using sea water wherever practicable. These measures in turn reduce the environmental impact of construction activities. Where required, the import of raw materials is undertaken to support construction and this is strictly managed through the SWMP; the waste hierarchy applied at Rothera aims to minimise waste production, and raw materials will only be imported in the quantities required to avoid surplus material import and associated energy consumption. Waste associated with construction activities can be managed through effective implementation of the SWMP (Appendix 1) and is not anticipated to be significant.

**SI and Condition Surveys**

Waste generation associated with SI and condition survey activity 20 is considered to cause a **direct** impact on UK landfill capacity. The quantity of steel sampled will be minimal and standard measures of storage and removal will be followed, with anticipated impacts negligible.

**Monitoring Activities**

There are no potential waste impacts associated with the proposed monitoring activities.

**Support Activities**

Waste generation associated with support activities 26, 27, 29, and 32 are considered to cause a **direct** and **cumulative** impact on UK landfill capacity due to the increased quantities of waste that that is required to be removed from station and sent to landfill in the UK. There is also an increased risk of waste being released into the local environment which could cause marine and terrestrial pollution and a hazard to local wildlife if suitable waste management procedures are not followed. There may be increased time spent in the processing of waste on site.

Increased production of sewage and grey water through the presence of personnel at Rothera will lead to a greater volume of wastewater discharged into the marine environment, which could contribute to local marine pollution. The current number of people on station each summer season exceeds the STP capacity. Salt water is regularly being used for flushing toilets and this reduces the effectiveness of the STP. Additional RO plant capacity being installed in the new Discovery Building will improve STP operation and capacity by allowing toilets to be flushed with fresh water.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- The SWMP (Appendix 1) will be followed for all construction waste;
- Metal/carbon steel waste will be generated during the Fuel Farm Infrastructure Upgrades project, and this will be managed on site in accordance with the BAS Waste Management Handbook;
- Waste storage options and waste streams to be segregated for recycling/recovery off site are outlined in the SWMP (Appendix 1);
- 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 to Antarctica;
- BAM commitment to achieving an 80% diversion of construction waste from landfill and a 90% diversion of all waste from landfill;
- Pre-deployment training on waste management for all operatives;
- Waste to be stored in the appropriate storage method;

- Provision of a BAM staff member dedicated to environmental management who will ensure that all waste is managed appropriately;
- Daily checks to ensure waste is contained to avoid being blown around site;
- Sewage is biologically treated, and ultraviolet (UV) will be irradiated at the STP prior to discharge to mitigate the impact of the discharge. The installation of the new RO plant, as outlined in Section 8.3.9, will improve the operation of the STP; and
- Any cementitious wash waters produced during construction will be neutralised to a pH of 7.0 using citric acid prior to discharge to ground. Cementitious materials are mixed in the BAM Fitters Workshop and the wash water, once neutralised, will be discharged away from sensitive receptors to the west of the BAM Fitters Workshop.

Monitoring measures are as follows:

- Waste statistics will be collated for future monitoring and assessment purposes.

### 10.4.5 Light (external) Impacts

**Construction Activities**

Light emissions associated with construction activities 1, and 4-9 are considered to cause a **direct** impact as a result of the use of artificial light in low light conditions (or to increase visibility where required). This could increase the risk of disturbance to local fauna and could potentially lead to increased bird strikes, injuries, and fatalities. The external light emissions associated with these activities are considered to be temporary in duration.

**SI and Condition Surveys**

Light emissions associated with SI and condition survey activities 11 and 19 are considered to cause a **direct** impact as a result of the use of artificial light in low light conditions (or to increase visibility where required). This could increase the risk of disturbance to local fauna and could potentially lead to increased bird strikes, injuries, and fatalities. The external light emissions associated with these activities are considered to be temporary in duration.

The proximity of the skua nest to the Hangar building is considered to be a sensitive receptor with regards to light emissions, however, the SI works, and condition surveys will be undertaken during austral summer and therefore light emissions are not considered to cause a significant effect.

**Monitoring Activities**

There are no potential external light emissions impacts associated with the proposed monitoring activities and therefore no impacts anticipated.

**Support Activities**

Light emissions associated with support activities 30 and 32 are considered to cause a **direct** impact as a result of the use of artificial light in low light conditions (or to increase visibility where required). This could increase the risk of disturbance to local fauna and could potentially lead to increased bird strikes, injuries, and fatalities.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- Undertake works during daylight hours as far as reasonably possible, and minimise the use and intensity of lighting during low light hours as far as reasonably possible;
- If required, lighting rigs to be angled towards the ground, not horizontally;
- Lights to be turned off when not in use and where possible external lighting should incorporate movement sensors or similar technology to minimise the duration of illumination;
- In the event of a bird strike, as per the BAS Wildlife Interaction Manual (Appendix 4), a suitably trained bird strike response staff member will take charge of the bird's care; and
- Lights will be switched off immediately if more than five bird strikes occur in one period of works;
- All bird strikes will be recorded on Maximo for monitoring and management purposes.

In addition to the construction and support activities, the installation of replacement lighting as part of the Runway Resurfacing and Lighting project will introduce external light sources to this area of the site during operation. This lighting is considered to be essential for the safe operation of the runway and no alternatives are available. The lighting replacement is not anticipated to introduce additional light sources beyond those already in place.

### 10.4.6 Physical Presence and Use of Space Impacts

**Construction Activities**

Physical presence and use of space impacts associated with all construction activities are considered to cause a **direct, indirect,** and **cumulative** impact to all ongoing operations at Rothera and the working relationship between BAM and BAS staff. There is potential for science activities to be disrupted or reduced and for science equipment to be damaged as a result of the proposed construction activities. Additionally, the presence of the construction project has the potential to disrupt day-to-day station operations and hamper good housekeeping.

Construction activities are largely contained on the runway so will impact runway operations above all else, with laydown and storage areas adjacent to the runway, as shown in Figure 4-15. In addition, the impacts relating to physical presence and use of space associated with the activities above are considered to be temporary in duration.

**SI and Condition Surveys**

Physical presence and use of space impacts associated with all SI and condition survey activities are considered to cause a **direct, indirect,** and **cumulative** impact to all ongoing operations at Rothera and the working relationship between BAM and BAS staff. There is potential for science activities to be disrupted or reduced and for science equipment to be damaged as a result of the proposed SI and condition survey activities. Additionally, the presence of the investigative activities has the potential to disrupt day-to-day station operations. The impacts relating to physical presence and use of space associated with the activities above are considered to be temporary in duration.

**Monitoring Activities**

Physical presence and use of space impacts associated with all monitoring activities are considered to cause a **direct, indirect,** and **cumulative** impact to all ongoing operations at Rothera and the working relationship between BAM and BAS staff. There is potential for data collection for science activities to be disrupted or reduced during installation of the proposed monitoring equipment. Additionally, the presence of the monitoring activities has the potential to disrupt day-to-day station operations. The impacts relating to physical presence and use of space associated with the activities above are considered to take place for one year (more than a season) however are still considered to be temporary in duration.

**Support Activities**

Physical presence and use of space impacts associated with support activities 28-33 are considered to cause a **direct, indirect,** and **cumulative** impact to all ongoing operations at Rothera and the working relationship between BAM and BAS staff. There is potential for science activities to be disrupted or reduced and for science equipment to be damaged as a result of the proposed monitoring activities.

**Proposed Mitigation and Monitoring Measures**

**Preventative or mitigating measures are as follows:**

- Survey and sampling locations are confined to agreed areas as outlined in Section 4;
- Construction, SI, and condition survey methodologies are to be undertaken in line with agreed methods as outlined in Section 4;
- Changes to the locations used for any activities are to be agreed with BAS Operations, the BAS Environment Office and FCDO;
- Evacuation plans will be agreed with station management to ensure appropriate safe evacuation occurs with minimal disturbance to day-to-day activities on site;
- A Rothera Station Integration Plan will be prepared by the BAS Project Support Coordinator to demonstrate adequate space use on site for the proposed activities; and
- Pre-deployment training sessions to be held with all BAM and BAS staff.

### 10.4.7 Physical or Mechanical Disturbance on Land Impacts

**Construction Activities**

Physical or mechanical disturbance on land impacts associated with all construction activities are considered to cause a **direct** and **cumulative** contribution to ground disturbance at Rothera as a result of intrusive construction works proposed to be undertaken. Disturbance on land is also considered to contribute to the deterioration of existing roads used at Rothera.

The location of the construction activities is within previously disturbed ground (the existing runway extent) and therefore mechanical disturbance during resurfacing is not considered to cause additional disturbance to previously undisturbed land at Rothera. There is a risk of sediment disturbance during the creation of the two slipways.

**SI and Condition Surveys**

Physical or mechanical disturbance on land impacts associated with SI and condition survey activities 12-15 and 17-19 are considered to cause a **direct** and **cumulative** contribution to ground disturbance at Rothera as a result of intrusive works proposed to be undertaken for sampling and geotechnical analysis.

The requirement to undertake intrusive SI is essential to support the design development for the future proposed Runway Upgrade and Hangar Redevelopment projects; it is not considered possible to avoid the mechanical disturbance to land at Rothera and achieve the same information through non-intrusive means. The location of the sampling points has sought to avoid environmental constraints as far as reasonably possible.

**Monitoring Activities**

Physical or mechanical disturbance on land impacts associated with monitoring activities 23-25 are considered to cause a **direct** and **cumulative** contribution to ground disturbance at Rothera as a result of monitoring installation required to facilitate monitoring activities.

**Support Activities**

Physical or mechanical disturbance on land impacts associated with support activities 28 and 30 are considered to cause a **direct** and **cumulative** contribution to ground disturbance at Rothera as a result of storage of cargo and vehicle, plant and equipment operation.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- To prevent excess sediment disturbance beyond unavoidable levels, the material for the slipway creation will be placed carefully using an excavator with sufficient reach to avoid having to go into the water;
- Once the ice core has been removed and measurements taken, the core will be re-plugged where it came from and assumed to re-freeze and re-integrate;
- Minimise the footprint of works through careful SI design;
- Locate borehole, trial, and inspection pits away from sensitive environmental constraints;
- Where possible, trenches and trial pits will be backfilled at the end of a shift, however if this is not feasible, trenches and trial pits will be suitably covered, fenced, and signed and not be left open for longer than necessary;
- If contamination is encountered during the trial pit works, all equipment will be cleaned between trial holes to prevent cross contamination. Any occurrences of contamination should be reported to the Rothera Station Leader; and
- Regarding potential degradation of the plastic ducting, during replacement or decommissioning there will be an over-excavation of material to compensate for any potential localised movement of degraded plastic in the environment.

Monitoring measures are as follows:

- Daily checks on all routes used by construction vehicles; and
- Monitoring and maintenance of road and runway once resurfaced to ensure that surface remains in a safe and working condition.

### 10.4.8 Fuel or Hazardous Substance Release Impacts

**Construction Activities**

Fuel and hazardous substance release impacts associated with construction activities 1, 2, and 4-10 are considered to cause **direct**, **indirect,** and **cumulative** impacts to the local environment (marine and terrestrial). Pollution incidents could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste would be generated if absorbents are used as a result of a spill.

**SI and Condition Surveys**

Fuel and hazardous substance release impacts associated with SI and condition monitoring activities 14, 15, and 17-21 are considered to cause **direct**, **indirect,** and **cumulative** impacts to the local environment (marine and terrestrial). Pollution incidents could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste would be generated if absorbents are used as a result of a spill.

The proximity of the skua nest to the Hangar building is considered to be a sensitive receptor with regards to fuel or hazardous substance release.

**Monitoring Activities**

Fuel and hazardous substance release impacts associated with monitoring activities 23-25 are considered to cause **direct**, **indirect,** and **cumulative** impacts to the local environment (marine and terrestrial). Pollution incidents could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste would be generated if absorbents are used as a result of a spill.

**Support Activities**

Fuel and hazardous substance release impacts associated with support activities 26, 27, and 30-32 are considered to cause **direct**, **indirect,** and **cumulative** impacts to the local environment (marine and terrestrial). Pollution incidents could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste would be generated if absorbents are used as a result of a spill.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- Refuelling will be undertaken in accordance with the OSCP refuelling requirements at Rothera to ensure continual inspections are made of fuelling equipment and drip trays are placed under hose joints as a precaution - this procedure is reviewed annually;
- Spill kits will be in all vehicles and in key easily accessible locations on site;
- Plant nappies will be used for all static plant;
- A core oil spill response team of a minimum of 24 station staff will be formed and receive pre-deployment oil spill response training led by the BAS Environment Office and delivered by BAS and Oil Spill Response Ltd. This training is in addition to on-site training delivered by the Rothera Station Leader;
- The OSCP will be followed for Tier 1, 2 and 3 spills;

- De-winterising checks will be undertaken in accordance with the OSCP;
- All plant will be inspected daily for potential leaks and condition of hydraulic oil hoses - these checks will be recorded on the daily plant check sheets and the daily activity plan compliance record;
- All fuel storage tanks to be checked weekly and recorded on the BAM Environmental Inspection Checklist EC01, as current procedure;
- All spills will be reported to Rothera Station Lead and BAS Environment Office;
- The drilling management plan will be followed at all times during borehole works;
- Safe drilling procedures to be followed at all times to reduce risk of loss of drill. Only experienced operatives will use the drill; and
- The loss of any equipment will be reported in Maximo.

### 10.4.9 Non-Native Species Introduction Impacts

**Construction Activities**

There are no potential non-native species introduction impacts associated with the proposed construction activities.

**SI and Condition Surveys**

There are no potential non-native species introduction impacts associated with the proposed SI and condition survey activities.

**Monitoring Activities**

There are no potential non-native species introduction impacts associated with the proposed monitoring activities.

**Support Activities**

Non-native species impacts associated with the support activities 26-28 are considered to cause an **indirect** impact as a result of species introduction through importation. Introduced species may become established in ice-free areas with negative impacts upon local ecosystem structure and function, endemic species and associated scientific research.

The proposed works involve an increased input of cargo and construction equipment to Rothera. This intensification of import activity has the potential to increase the risk of non-native species introductions into the local environment.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- All personnel being deployed to Rothera will receive a pre-deployment briefing from a member of the BAS Environment Office which will cover biosecurity;
- All activities will be undertaken in accordance with the BAS Biosecurity Regulations, the CEP NNS Manual and the Runway Resurfacing and Lighting Project-specific Biosecurity Plan (Appendix 2);
- A trained manager will inspect all plant, equipment, materials prior to loading onto the vessel and on disembarkation/offloading at Rothera;

- All equipment and materials required for the proposed activities will be thoroughly cleaned before dispatch to Antarctica;
- The materials required for the new fuel farm hut under the Fuel Farm Infrastructure Upgrades project will be treated prior to import to Rothera, including kiln dried sand and heat-treated wood;
- Should soil, seeds or propagules be imported unintentionally, they must be carefully collected and removed. Rodents and insects must be exterminated immediately. In the unlikely event of a rodent detection, immediate efforts will be taken to isolate the rodent (in the container or room spotted) and for it to be killed. If this is not possible then bait stations will be deployed in the vicinity of the last known sighting and left for 48 hrs. Visitation to the bait stations is to be avoided during this time period to allow the rodent uninterrupted time to find and eat the bait. Disposal may include incineration at Rothera or removal from Antarctica; and
- The Rothera Station Leader and the BAS Environment Office must be informed immediately if a biosecurity incident occurs.

Monitoring measures are as follows:

- Evidence of the measures undertaken will be provided in the form of completed biosecurity audit checklists; and
- Any biosecurity incursions will be reported immediately to the BAS Environment Office and on Maximo.

### 10.4.10 Disturbance to Native Flora and Fauna Impacts

**Construction Activities**

Disturbance to native flora and fauna impacts associated with all construction activities are considered to cause a **direct** and **cumulative** effect on local flora and fauna. Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds could result in avoidance or stress behaviour, nest abandonment, hearing damage or reductions in local populations. The duration of disturbance due to transient impacts such as noise and light are considered to be temporary in nature.

**SI and Condition Surveys**

Disturbance to native flora and fauna impacts associated with SI and condition survey activities 11-19 and 21 are considered to cause a **direct** and **cumulative** effect on local flora and fauna. Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds could result in avoidance or stress behaviour, nest abandonment or hearing damage. The duration of disturbance due to transient impacts such as noise and light are considered to be temporary in nature.

The skua nest adjacent to the Hangar building is considered to be the most sensitive ecological receptor in relation to disturbance associated with the SI and condition survey works. The Hangar is approximately 60 m east of the nest site. As outlined in Section 10.4.2, Noise, it is recommended that an acoustic screen is implemented in an appropriate way to effectively screen the skua nest from noise.

Potential impacts of SI works include bird collisions and strikes on any drill rigs and equipment. The geophysical marine survey acoustic sources are known to be detectable by marine mammals.

However, the sound will diminish rapidly with distance from the source, and no injury to marine mammals is expected outside of the implemented 200 m acoustic exclusion zone.

**Monitoring Activities**

Disturbance to native flora and fauna impacts associated with monitoring activities 23-25 are considered to cause a **direct** and **cumulative** effect on local flora and fauna. Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds could result in avoidance or stress behaviour, nest abandonment or hearing damage. The duration of disturbance due to transient impacts such as noise and light are considered to be temporary in nature.

**Support Activities**

Disturbance to native flora and fauna impacts associated with support activities 26, 27, 29-31, and 33 are considered to cause a **direct** and **cumulative** effect on local flora and fauna. Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds could result in avoidance or stress behaviour, nest abandonment or hearing damage.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- All staff will receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife;
- In the unlikely circumstance of the displacement of seals, only trained personnel will be involved– the BAS Wildlife Interaction Manual (Appendix 4) will be referred to for any contact with wildlife;
- All vehicles will be inspected, and wheels checked for the presence of seals and penguins before engines are started;
- Someone suitably trained in wildlife interaction, as per the BAS Wildlife Interaction Manual (Appendix 4), will be present at the start of works adjacent to any known nests to determine if they are inhabited at the time of works and to provide a final decision on when works can commence. Noisy works will not commence without express permission of the suitably trained person present;
- If drilling rigs for SI works are to be left in one location for an extended duration, they will be fitted with reflective tags in order to prevent bird collisions;
- New solar monitoring masts installed will be fitted with reflective tags in order to prevent bird collisions;
- The BAS Facilities team will maintain the demarcation of the no-go zone around the moss patch and ensure it is communicated to relevant personnel on station;
- For the geophysical marine surveys, a 200 m acoustic exclusion zone will be established around the full extent of the survey works; and
- A dedicated mammal observer will be present on the vessel to continuously monitor the exclusion zone for the presence of marine mammals and call for immediate shut down of sound sources if marine mammals are detected or approaching the exclusion zone. Works can recommence once the exclusion zone is confirmed to be clear by the mammal observer.

Monitoring measures are as follows:

- Skua monitoring will continue throughout the construction programme to obtain updated information on nest activity that can be used to inform any additional mitigation methods and

future AIMP works. Particular attention will be paid to the skua nest adjacent to the Hangar building during and after works are complete; and
- Any impacts to the moss patch will be monitored at monthly intervals through photographic records, implemented throughout the Rothera modernisation programme.

### 10.4.11 Visual Impacts

**Construction Activities**

Visual impacts associated with construction activities 4-10 are considered to cause a **direct** and **cumulative** impact to the built and natural landscape at Rothera by changing the visual and local aesthetic values of the surrounding landscape.

Visual impacts associated with activities 4-7 are considered to be temporary in nature either due to the short-term presence of construction equipment to facilitate the installation of services or due to the belowground nature of the works, thus although potential impacts are considered they will not present a permanent visual impact at Rothera.

**SI and Condition Surveys**

There are no potential visual impacts associated with the proposed SI and condition surveys.

**Monitoring Activities**

Visual impacts associated with monitoring activities 23-25 are considered to cause a **direct** and **cumulative** impact to the built and natural landscape at Rothera by changing the visual and local aesthetic values of the surrounding landscape due to the presence of newly installed masts and ancillary equipment.

**Support Activities**

Visual impacts associated with support activities 28 and 29 are considered to cause a **direct** and **cumulative** impact to the built and natural landscape at Rothera by changing the visual and local aesthetic values of the surrounding landscape due to the presence of additional cargo, construction sites and personnel.

Due to the nature of the proposed works, the duration of visual impact is considered to be short-term and temporary. Although the Runway Resurfacing and Lighting project involves an increase in the usable length of the runway as well as other upgrades, upon completion of the works in 2024, visual impacts are not expected to present a material difference to the existing visual baseline.

**Proposed Mitigation and Monitoring Measures**

Preventative or mitigating measures are as follows:

- Construction activities will be confined to agreed areas on site. Any changes to the locations used by BAM will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office and FCDO.

### 10.4.12 Heritage Impacts

There are no potential heritage impacts associated with the construction, SI and condition survey, monitoring and support activities proposed.

### 10.4.13 Assessment of Climate Change Resilience (CCR)

It is important to consider the vulnerability of the proposed works and activities to climate change. Due to high levels of variability in climate modelling in the Antarctic, the accuracy of current climate change trends and potential impacts at Rothera are difficult to ascertain. Climate impacts are already being observed at Rothera and therefore an assessment of these changes alongside the potential for future exacerbation of these changes has been considered. Climate projections for this region are continued periods of cold temperatures and snowfall alongside increased frequencies of rainfall and higher temperatures. The confidence in increased storm events is lower than with other changes, however the occurrence of storm events is acknowledged. This section considers the vulnerability of the constructed elements of the proposed works, in other words those elements that will remain *in situ* and be subject to a future climate.

For the purposes of this CCR assessment, the impacts of increasing temperatures and additional climate change impacts as described in Section 9.6, on the Runway Resurfacing and Lighting project have been considered as this is the only activity that will construct a permanent feature that will remain in place at Rothera. The duration of the construction period of approximately two years is considered to be short term. The effects of climate change are not considered to give rise to significant adverse effects during this time period, although the climatic changes currently observed at Rothera are considered.

When determining the sensitivity of receptors in relation to climate change effects the susceptibility (ability to be affected) and vulnerability (potential for exposure) of the receptor are considered. The consequence of effects has considered the impacts on safety and disruption to construction or operation of the proposed development. Professional judgement has been used to determine the sensitivity of receptors and consequence of effects.

**Construction Effects**

During construction, snowfall and ice will continue at Rothera which could lead to damage to equipment alongside delays to the construction programme. Equipment at Rothera is considered sufficient to withstand cold temperatures and snowfall, and method statements are in place to ensure that only suitably qualified personnel use equipment during appropriate weather conditions. Storm events and high winds during construction could occur, causing erosion of stockpiles, dust generation and transmission and damage to equipment. Stockpile coverings are required to be resilient to storm events, and during winter snow covering stockpiles is considered to add additional protection. In addition, strong winds could impact support operations such as transport of personnel and cargo to Rothera. Periods of heavy snowfall are projected to continue at Rothera during the construction phase. The selected gravel surface material has proven to be an effective solution in the extreme climatic conditions experienced at Rothera over the last 30 years and is resilient to cold temperatures and can be constructed in hard environments, the construction programme includes consideration of 'lost' days due to adverse weather. More vulnerable activities should take place in appropriate weather conditions (considering construction timescale constraints). Increasing temperatures have the potential to increase the risk of non-native species being transported to Rothera.

The measures in place within the Rothera Runway and Lighting Project Method Statement alongside the proposed mitigation measures to manage stockpiled material and dust management are considered sufficient to manage the construction risks due to climate change. The biosecurity risks presented by climate change are considered to be suitably managed through the project-specific Biosecurity Plan and BAS Biosecurity Regulations. The transport of cargo and personnel to Rothera is considered to be appropriately managed through operational and voyage procedures.

Construction method statements include a requirement to use appropriate equipment for cold weather conditions and for maintenance to be undertaken by suitably qualified personnel. The AGL kiosk will be pre-fabricated and fitted out with equipment prior to being shipped to Rothera to reduce the onsite construction time. The construction of the runway resurfacing, and lighting upgrades are not considered to be significantly susceptible or vulnerable to the effects of climate change on the short term and is therefore considered to be climate change resilient and no significant effects are expected.

The potential for significant adverse effects due to climate change are considered to be in the medium to long-term, and so the focus of this assessment is on the operational stage during the operational lifetime of the resurfaced runway which is considered to be 30 years.

**Operational Effects**

During the operational period of the proposed development, increased temperatures and more frequent periods of high winds are anticipated. This could result in disruptions to the air operations to and from Rothera. Increased temperatures during operation could increase the shrinking of permafrost and cause differential settlement of the runway surface; the selection of gravel surface material reduces the risk of degradation as gravel is not susceptible to heave and shrinkage. Increased temperatures could also result in more frequent incursions of seals and an increased occurrence of skua nests on the runway surface, although this is known to occur in current climatic conditions and so the wildlife interaction and handling procedures in place are considered to be sufficient to manage this increased risk even in future climates, despite an increased frequency. Increased temperatures are therefore not anticipated to impact the operation of the runway when resurfaced.

Periods of heavy snowfall are anticipated to continue at Rothera during the operational phase, the replacement of the runway lighting is considered to increase the safety of operations as these will increase the visibility of the runway during adverse weather conditions. Snow clearance procedures will continue to be followed; in addition the traffic barrier will be at a height of 1 m to prevent snow burial.

The proposed runway resurfacing will ensure that the surface of the runway remains safe throughout the operational lifetime in a variety of weather conditions and increases resilience to the effects of climate change. The design of the runway will restore the original camber which will reduce the risk of water pooling and freezing on the runway, which could occur more frequently with warmer temperatures. The gravel surface is free-draining and a review of the capacity of the meltwater drainage ditch will be undertaken as part of the runway upgrade to ensure that this is sufficient to withstand increased meltwaters. The potential effects of sea level rise are acknowledged; however, the effects of sea level rise are not considered to significantly impact the runway on the medium term.

Consideration of the future runway upgrade works that are proposed as part of the AIMP scope should be noted here, as the design of the runway upgrade will consider the risks of climate change throughout the operational lifetime of the redevelopment and ensure that these are managed as far as reasonably possible through design. For example, a reduction in sea ice extent to the north of the runway could result in damage to the revetment from wave action.

The operation of the runway once resurfaced is not considered to be significantly susceptible or vulnerable to the effects of climate change on the medium term and is therefore considered to be climate change resilient and no significant effects are expected.

## 10.5 Evaluation of the Environmental Impacts

In Section 10.4 the potential environmental impacts associated with the proposed activities have been identified. This section evaluates those impacts in order to identify both the significance and risk of the impact occurring.

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 criterion for each impact is given a score from 1 – 5 to identify whether it is considered 'very low', 'low', 'medium', 'high' or 'very high'. Table 10-2 provides an explanation and definition of the scale used.

**Table 10-2: Impact Significance Criteria**

| | Definition of Scoring Values | | | | |
|---|---|---|---|---|---|
| **Impact Criteria** | **Very Low (VL)**<br>**1** | **Low (L)**<br>**2** | **Medium (M)**<br>**3** | **High (H)**<br>**4** | **Very High (VH)**<br>**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 |

### 10.5.1 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, it produces a risk score between 1 and 625. 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 Table 10-3, they are aligned to the three levels of impact significance identified in Article 8(1) of the Environmental Protocol.

**Table 10-3: Risk Scoring Criteria**

| Description | Risk Score | Environmental Impact and Assessment† |
|---|---|---|
| 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 |

† As defined in Article 8(1) of the Environmental Protocol and outlined in section 1.2

### 10.5.2 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.

## 10.6 Impact Assessment

Table 10-4, Table 10-5, Table 10-6 and Table 10-7 detail the environmental impacts associated with the proposed AIMP Phase 2 IEE activities and provides a summary of the risk response and the residual risk once mitigation measures have been assigned, if appropriate and available.

**Table 10-4: Construction Activity Impact Assessment**

| **Construction Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| 1. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | Atmospheric emissions | Contribution to regional and global atmospheric pollution and local heavy metal and particulate fallout | Direct/ Cumulative | 5 | 2 | 5 | 2 | 100 | Reduce | • Ensure that all operations at Rothera are as efficient as possible to reduce excess fuel use;<br>• Generators and plant will be selected which balance efficiency and reduced emissions, with reliability, serviceability, and available fuel at Rothera;<br>• Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently, as per the BAM Plant Management Plan;<br>• Where practical, all drivers will be instructed to turn off engines during periods of waiting for 15 minutes or more;<br>• Only staff essential to the proposed works will be deployed to Rothera;<br>• Rationalisation of plant and equipment shipped to station will be undertaken; and<br>• All staff will be briefed on energy efficiency whilst on station as part of the pre-deployment training. | 5 | 2 | 5 | 2 | 100 | No more than minor or transitory |
| 2. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock<br>• Excavation of hand dug trial holes<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | Noise emissions | Disturbance to local fauna resulting in stress and avoidance behaviour, nest abandonment | Direct/ Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • Regular maintenance of all equipment to ensure it is working efficiently;<br>• 10 mph speed limit maintained and enforced on site;<br>• Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors;<br>• Regular maintenance of all plant and vehicles to ensure they are working efficiently and generating as little noise as possible;<br>• Implementation of a soft start procedure for all noisy construction and survey equipment and consideration given to the impact on wildlife;<br>• If agreed noise levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and<br>• If agreed vibration levels are exceeded, works in that area will cease until additional mitigation measures can be implemented. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

| **Construction Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| 3. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock<br>• Excavation of hand dug trial holes<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | Dust emissions | Impact from dust deposition on ice ramp resulting in increased melt and smothering of local flora | Direct / cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • Use of dust suppression equipment and spraying down roadways with sea water when required;<br>• Where practicable, keep activities which create dust downwind of sensitive receptors and avoid close proximity to known vegetation and ice locations;<br>• All routes used by vehicles and plant will be well maintained and have compacted surfaces;<br>• Limit the drop height of materials during stockpiling, processing, and loading operations;<br>• Minimise double handling of materials to reduce the overall number of tipping actions;<br>• 10 mph speed limit maintained and enforced on site;<br>• All plant and equipment to be maintained on a regular basis, as per the BAM Plant Management Plan;<br>• Cement will not be mixed externally on windy days;<br>• If agreed dust levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and<br>• During excessively dry, windy conditions, it may be necessary to temporarily suspend operations if it is not possible to control dust by other means. The Met team will provide a weather forecast every morning and this will be reviewed by the Site Manager in conjunction with the Rothera Station Leader; and.<br>• All cement mixing will be carried out in accordance with the method statement and cement will not to be mixed externally on windy days, as advised by the Site Manager and Rothera Station Leader as above. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 4. | • Services crossing the runway<br>• Lighting M&E works<br>• Fuel Farm Infrastructure Upgrades | Waste | Impact due to increased waste sent to UK landfill and waste release to the local environment | Direct | 2 | 2 | 4 | 2 | 32 | Reduce | • The SWMP (Appendix 1) will be followed for all construction waste;<br>• There will be a dedicated area for storing and segregating waste;<br>• All construction waste will be returned to the UK and disposed of by licensed contractors;<br>• Packaging will be minimised where possible prior to consigning cargo to Antarctica; | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

| **Construction Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | | | | | | | | | | | • BAM commitment to achieving an 80% diversion of construction waste from landfill and a 90% diversion of all waste from landfill;<br>• Pre-deployment training on waste management for all operatives;<br>• Waste will be stored in the appropriate storage method;<br>• Provision of a BAM staff member dedicated to environmental management who will ensure that all waste is managed appropriately;<br>• Daily checks to ensure waste is contained to avoid being blown around site; and<br>• Any cementitious wash waters produced during construction will be neutralised to a pH of 7.0 using citric acid prior to discharge to ground. Cementitious materials are mixed in the BAM Fitters Workshop and the wash water, once neutralised, will be discharged away from sensitive receptors to the west of the BAM Fitters Workshop. | | | | | | |
| 5. | • Rock processing and crushing of rock material<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways | External light emissions | Impact due to disorientation of birds resulting in injury or mortality due to strikes | Direct | 1 | 2 | 4 | 3 | 24 | Reduce | • Works to be undertaken during daylight hours as far as reasonably possible, and the use and intensity of lighting will be minimised during low light hours;<br>• If required, lighting rigs to be angled towards the ground, not horizontally;<br>• Lights to be turned off when not in use and where possible external lighting should incorporate movement sensors or similar technology to minimise the duration of illumination;<br>• In the event of a bird strike, a suitably trained bird strike response staff member will take charge of the bird's care; and<br>• Lights to be switched off immediately if more than five bird strikes occur in one period of works. | 1 | 2 | 3 | 2 | 12 | Less than minor or transitory |
| 6. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock | Physical presence and use of space | Impacts from disruption to station operations and science. Breakdown of relations between BAM & BAS staff. | Direct, indirect/ cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • Survey and sampling locations confined to agreed areas;<br>• Methodologies to be undertaken in line with agreed methods; | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

| **Construction Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | • Excavation of hand dug trial holes<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | | | | | | | | | | • Changes to the locations used for any activities to be agreed with BAS Operations, the BAS Environment Office and FCDO;<br>• Evacuation plans will be agreed with station management;<br>• A Rothera Station Integration Plan will be prepared and followed; and<br>• Pre-deployment training sessions to be held with all BAM and BAS staff. | | | | | | |
| 7. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock<br>• Excavation of hand dug trial holes<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | Physical or mechanical disturbance on land | Impacts due to ground disturbance deterioration of land at Rothera including roadways and the runway due to increased volume of heavy plant | Direct / Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • To prevent excess sediment disturbance beyond unavoidable levels, the material for the slipway creation will be placed carefully using an excavator with sufficient reach to avoid having to go into the water;<br>• Minimise the footprint of works through careful design;<br>• Locate trial and inspection pits away from sensitive environmental constraints;<br>• Where possible, trenches and trial pits will be backfilled at the end of a shift, however if this is not feasible, trenches and trial pits will be suitably covered, fenced, and signed and not be left open for longer than necessary; and<br>• Regarding potential degradation of the plastic ducting, during replacement or decommissioning there will be an over-excavation of material to compensate for any potential localised movement of degraded plastic in the environment. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 8. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock<br>• Ducting and chamber installation | Fuel or hazardous substance release | Impact due to pollution to local environment. Mortality to flora and fauna. Secondary contamination to birds if ingested. Hazardous waste | Direct, indirect / cumulative | 2 | 2 | 3 | 3 | 36 | Reduce | • Refuelling will be undertaken in accordance with the OSCP refuelling requirements at Rothera;<br>• Spill kits will be in all vehicles and key locations on site;<br>• A core oil spill response team of a minimum of 24 station staff will be formed and receive pre-deployment oil spill response training. This training will be in addition to on-site training; | 2 | 2 | 2 | 2 | 16 | Less than minor or transitory |

| **Construction Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | • Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | | associated with spill materials. | | | | | | | | • The OSCP will be followed for Tier 1, 2 and 3 spills;<br>• De-winterising checks will be undertaken in accordance with the OSCP;<br>• All plant will be inspected daily for potential leaks and condition of hydraulic oil hoses;<br>• All fuel storage tanks to be checked weekly and recorded on the BAM Environmental Inspection Checklist EC01;<br>• All spills reported to the Rothera Station Leader and BAS Environment Office; and<br>• The loss of any equipment will be reported in Maximo. | | | | | | |
| 9. | • Rock processing and crushing of rock material<br>• Screening, loading, transporting, and tipping of rock<br>• Excavation of hand dug trial holes<br>• Ducting and chamber installation<br>• Services crossing the runway<br>• Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | Disturbance to flora and fauna | Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds resulting in avoidance or stress behaviour, nest abandonment or hearing damage. | Direct | 2 | 2 | 4 | 3 | 48 | Reduce | • All staff will receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife;<br>• In the unlikely circumstance of the displacement of seals, only trained personnel will be involved – the BAS Wildlife Interaction Manual (Appendix 4) will be referred to for any contact with wildlife;<br>• All vehicles will be inspected, and wheels checked for the presence of seals and penguins before engines are started;<br>• Someone suitably trained in wildlife interaction will be present at the start of works adjacent to any known nests and noisy works will not commence without express permission of the suitably trained person present;<br>• If drilling rigs for SI works are to be left in one location for an extended duration, they will be fitted with reflective tags in order to prevent bird collisions;<br>• The BAS Facilities team will maintain the demarcation of the no-go zone around the moss patch and ensure it is communicated to relevant personnel on station. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 10. | • Ducting and chamber installation<br>• Services crossing the runway | Visual | Visual change to the built and natural landscape altering aesthetic value of Rothera. | Direct/ cumulative | 2 | 2 | 4 | 3 | 48 | Accept | • Construction activities will be confined to agreed areas on site. Any changes to the locations used by BAM will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office and FCDO. | 2 | 2 | 4 | 3 | 48 | Less than minor or transitory |

| **Construction Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | • Installation of foundation and bases<br>• Lighting M&E works<br>• Runway resurfacing works<br>• Creation of non-engineered slipways<br>• Fuel Farm Infrastructure Upgrades | | | | | | | | | | | | | | | | |
| † Type of impact identified as: direct, indirect, cumulative, or unavoidable<br>‡ According to Article 8 of the Environmental Protocol – as described in section 1.2 | | | | | | | | | | | | | | | | | |

**Table 10-5: SI and Condition Survey Works Impact Assessment**

| **SI and Condition Survey Works** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| 1. | • Rock revetment investigation<br>• Sea ice thickness investigation<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys)<br>• Sampling of steel<br>• Friction measurements | Atmospheric emissions | Contribution to regional and global atmospheric pollution and local heavy metal and particulate fallout. | Direct/ Cumulative | 5 | 2 | 5 | 2 | 100 | Reduce | • Ensure that all operations at Rothera are as efficient as possible to reduce excess fuel use;<br>• Generators and plant will be selected which balance efficiency and reduced emissions, with reliability, serviceability, and available fuel at Rothera;<br>• Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently, as per the BAM Plant Management Plan;<br>• Where practical, all drivers will be instructed to turn off engines during periods of waiting for 15 minutes or more;<br>• Only staff essential to the proposed works will be deployed to Rothera;<br>• Rationalisation of plant and equipment shipped to station will be undertaken; and | 5 | 2 | 5 | 2 | 100 | No more than minor or transitory |

| **SI and Condition Survey Works** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | | | | | | | | | | | • All staff will be briefed on energy efficiency whilst on station as part of the pre-deployment training. | | | | | | |
| 2. | • Rock revetment investigation<br>• Sea ice thickness investigation<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys)<br>• Sampling of steel<br>• Friction measurements | Noise emissions | Disturbance to local fauna resulting in stress and avoidance behaviour, nest abandonment. | Direct/ Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • Regular maintenance of all equipment to ensure it is working efficiently;<br>• 10 mph speed limit maintained and enforced on site;<br>• Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors;<br>• Regular maintenance of all plant and vehicles to ensure they are working efficiently and generating as little noise as possible;<br>• Implementation of a soft start procedure for all noisy construction and survey equipment and consideration given to the impact on wildlife;<br>• For works at the Hangar building and apron only, an acoustic screen shall be implemented to effectively screen the adjacent skua nest from any noisy works;<br>• If agreed noise levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and<br>• If agreed vibration levels are exceeded, works in that area will cease until additional mitigation measures can be implemented. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 3. | • Rock revetment investigation<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Friction measurements | Dust emissions | Impact from dust deposition on ice ramp resulting in increased melt and smothering of local flora. | Direct / cumulative | 2 | 2 | 3 | 3 | 36 | Reduce | • Use of dust suppression equipment and spraying down roadways with sea water when required;<br>• Where practicable, keep activities which create dust downwind of sensitive receptors and avoid close proximity to known vegetation and ice locations;<br>• All routes used by vehicles and plant will be well maintained and have compacted surfaces;<br>• Limit the drop height of materials during stockpiling, processing, and loading operations;<br>• 10 mph speed limit maintained and enforced on site;<br>• All plant and equipment to be maintained on a regular basis, as per the BAM Plant Management Plan;<br>• If agreed dust levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and | 2 | 2 | 2 | 2 | 16 | Less than minor or transitory |

| **SI and Condition Survey Works** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | | | | | | | | | | | • During excessively dry, windy conditions, it may be necessary to temporarily suspend operations if it is not possible to control dust by other means. The Met team will provide a weather forecast every morning and this will be reviewed by the Site Manager in conjunction with the Rothera Station Leader. | | | | | | |
| 4. | • Sampling of steel | Waste | Impact due to increased waste sent to UK landfill and waste release to the local environment | Direct | 2 | 2 | 4 | 1 | 16 | Reduce | • There will be a dedicated area for storing and segregating waste;<br>• BAM commitment to achieving an 80% diversion of construction waste from landfill and a 90% diversion of all waste from landfill;<br>• Pre-deployment training on waste management for all operatives;<br>• Waste will be stored in the appropriate storage method; and<br>• Provision of a BAM staff member dedicated to environmental management who will ensure that all waste is managed appropriately. | 2 | 2 | 4 | 1 | 16 | Less than minor or transitory |
| 5. | • Targeted diver visual inspection<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys) | External light emissions | Impact due to disorientation of marine life resulting in injury | Direct | 2 | 2 | 4 | 3 | 48 | Reduce | • Works to be undertaken during daylight hours as far as reasonably possible, and the use and intensity of lighting will be minimised during low light hours; and<br>• Lights to be turned off when not in use and where possible external lighting should incorporate movement sensors or similar technology to minimise the duration of illumination. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 6. | • Targeted diver visual inspections<br>• Collection of marine samples<br>• Probe survey<br>• Rock revetment investigation<br>• Sea ice thickness investigation<br>• Condition surveys (visual and/or non-intrusive)<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys) | Physical presence and use of space | Impact from land-take and disruption to station operations and science. Breakdown of relations between BAM & BAS staff. | Direct, Indirect/ Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • Survey and sampling locations confined to agreed areas;<br>• Methodologies to be undertaken in line with agreed methods;<br>• Changes to the locations used for any activities to be agreed with BAS Operations, the BAS Environment Office and FCDO;<br>• Evacuation plans will be agreed with station management;<br>• A Rothera Station Integration Plan will be prepared and followed; and<br>• Pre-deployment training sessions to be held with all BAM and BAS staff. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

| **SI and Condition Survey Works** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | • Sampling of steel<br>• Friction measurements | | | | | | | | | | | | | | | | |
| 7. | • Collection of marine samples<br>• Probe survey<br>• Rock revetment investigation<br>• Sea ice thickness investigation<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys) | Physical or mechanical disturbance on land | Ground displacement could impact sensitive receptors. Land-take from sensitive and/or undisturbed areas. | Direct | 2 | 2 | 4 | 4 | 64 | Reduce | • Once the ice core has been removed and measurements taken, the core will be re-plugged where it came from and assumed to re-freeze and re-integrate;<br>• Minimise the footprint of works through careful SI design;<br>• Locate borehole, trial, and inspection pits away from sensitive environmental constraints;<br>• Where possible, trenches and trial pits will be backfilled at the end of a shift, however if this is not feasible, trenches and trial pits will be suitably covered, fenced, and signed and not be left open for longer than necessary; and<br>• If contamination is encountered during the trial pit works, all equipment will be cleaned between trial holes to prevent cross contamination. Any occurrences of contamination should be reported to the Rothera Station Leader. | 2 | 2 | 3 | 3 | 36 | Less than minor or transitory |
| 8. | • Rock revetment investigation<br>• Sea ice thickness investigation<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys)<br>• Sampling of steel<br>• Friction measurements | Fuel or hazardous substance release | Pollution to local environment, chemical contamination of ice. Mortality to flora & fauna. Secondary contamination to birds if ingested. Exposure of humans and wildlife to toxic materials contained in explosives. | Direct, indirect and cumulative | 2 | 2 | 3 | 4 | 48 | Reduce | • Refuelling will be undertaken in accordance with the OSCP refuelling requirements at Rothera;<br>• Spill kits will be in all vehicles and key locations on site;<br>• A core oil spill response team of a minimum of 24 station staff will be formed and receive pre-deployment oil spill response training. This training will be in addition to on-site training;<br>• The OSCP will be followed for Tier 1, 2 and 3 spills;<br>• De-winterising checks will be undertaken in accordance with the OSCP;<br>• All plant will be inspected daily for potential leaks and condition of hydraulic oil hoses;<br>• All fuel storage tanks to be checked weekly and recorded on the BAM Environmental Inspection Checklist EC01;<br>• All spills reported to the Rothera Station Leader and BAS Environment Office;<br>• The drilling management plan will be followed at all times during borehole works; | 2 | 2 | 2 | 3 | 24 | Less than minor or transitory |

| **SI and Condition Survey Works** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| | | | | | | | | | | | • Safe drilling procedures to be followed at all times to reduce risk of loss of drill. Only experienced operatives will use the drill; and<br>• The loss of any equipment will be reported in Maximo. | | | | | | |
| 9. | • Targeted diver visual inspections<br>• Collection of marine samples<br>• Probe survey<br>• Rock revetment investigation<br>• Sea ice thickness investigation<br>• Condition surveys (visual and/or non-intrusive)<br>• Borehole drilling<br>• Trial/Inspection pits, in-situ testing (plate load testing/LWD) and collection of terrestrial samples<br>• Geophysical marine surveys (bathymetric, sidescan sonar and single channel sparker surveys)<br>• Friction measurements | Disturbance to flora and fauna | Disturbance, injury or fatality to local fauna, notably marine mammals, and birds, within proximity to the construction works resulting in avoidance or stress behaviour, nest abandonment or hearing damage. | Direct/ Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • All staff will receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife;<br>• In the unlikely circumstance of the displacement of seals, only trained personnel will be involved – the BAS Wildlife Interaction Manual (Appendix 4) will be referred to for any contact with wildlife;<br>• All vehicles will be inspected, and wheels checked for the presence of seals and penguins before engines are started;<br>• Someone suitably trained in wildlife interaction will be present at the start of works adjacent to any known nests and noisy works will not commence without express permission of the suitably trained person present;<br>• If drilling rigs for SI works are to be left in one location for an extended duration, they will be fitted with reflective tags in order to prevent bird collisions;<br>• New solar monitoring masts installed will be fitted with reflective tags in order to prevent bird collisions;<br>• The BAS Facilities team will maintain the demarcation of the no-go zone around the moss patch and ensure it is communicated to relevant personnel on station;<br>• For the geophysical surveys, a 200 m acoustic exclusion zone will be established around the full extent of the survey works; and<br>• A dedicated mammal observer will be present on the vessel to continuously monitor the exclusion zone for the presence of marine mammals and call for immediate shut down of sound sources if marine mammals are detected or approaching the exclusion zone. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

| **SI and Condition Survey Works** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post mitigation) | Environmental Impact and Assessment‡ |
| † Type of impact identified as: direct, indirect, cumulative, or unavoidable<br>‡ According to Article 8 of the Environmental Protocol – as described in section 1.2 | | | | | | | | | | | | | | | | | |

**Table 10-6: Monitoring Activities Impact Assessment**

| **Monitoring Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
| 1. | • Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor)<br>• Wind monitoring (installation of a SoDAR device)<br>• HVO trial | Atmospheric emissions | Contribution to regional and global atmospheric pollution and local heavy metal and particulate fallout. | Direct/ Cumulative | 5 | 3 | 5 | 1 | 75 | Reduce | • Ensure that all operations at Rothera are as efficient as possible to reduce excess fuel use;<br>• Generators and plant will be selected which balance efficiency and reduced emissions, with reliability, serviceability, and available fuel at Rothera;<br>• Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently, as per the BAM Plant Management Plan;<br>• Where practical, all drivers will be instructed to turn off engines during periods of waiting for 15 minutes or more;<br>• Only staff essential to the proposed works will be deployed to Rothera;<br>• Rationalisation of plant and equipment shipped to station will be undertaken; and<br>• All staff will be briefed on energy efficiency whilst on station as part of the pre-deployment training. | 5 | 3 | 3 | 1 | 45 | Less than minor or transitory |
| 2. | • Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor) | Noise emissions | Disturbance to local flora and fauna, potentially resulting in avoidance or stress behaviour | Direct/Cumulative | 2 | 3 | 3 | 2 | 36 | Reduce | • Regular maintenance of all equipment to ensure it is working efficiently;<br>• 10 mph speed limit maintained and enforced on site;<br>• Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors; | 2 | 3 | 2 | 2 | 24 | Less than minor or transitory |

| **Monitoring Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
| | • Wind monitoring (installation of a SoDAR device)<br>• HVO trial | | and/or nest abandonment. | | | | | | | | • Regular maintenance of all plant and vehicles to ensure they are working efficiently and generating as little noise as possible;<br>• Implementation of a soft start procedure for all noisy construction and survey equipment and consideration given to the impact on wildlife;<br>• If agreed noise levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and<br>• If agreed vibration levels are exceeded, works in that area will cease until additional mitigation measures can be implemented. | | | | | | |
| 3. | • Energy demand metering of current buildings<br>• Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor)<br>• Wind monitoring (installation of a SoDAR device)<br>• HVO trial | Physical presence and use of space | Disruption to station operations and science. | Direct/Indirect/ Cumulative | 2 | 3 | 3 | 2 | 36 | Reduce | • Survey and sampling locations confined to agreed areas;<br>• Methodologies to be undertaken in line with agreed methods;<br>• Changes to the locations used for any activities to be agreed with BAS Operations, the BAS Environment Office and FCDO;<br>• Evacuation plans will be agreed with station management;<br>• A Rothera Station Integration Plan will be prepared and followed; and<br>• Pre-deployment training sessions to be held with all BAM and BAS staff. | 2 | 3 | 2 | 1 | 12 | Less than minor or transitory |
| 4. | • Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor)<br>• Wind monitoring (installation of a SoDAR device)<br>• HVO trial | Physical or mechanical disturbance on land | Ground disturbance could impact sensitive receptors. | Direct/Cumulative | 1 | 3 | 3 | 2 | 18 | Reduce | • Minimise the footprint of works through careful design. | 1 | 3 | 2 | 2 | 12 | Less than minor or transitory |
| 5. | • Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor)<br>• Wind monitoring (installation of a SoDAR device) | Fuel or hazardous substance release | Impact due to pollution to local environment. Mortality to flora and fauna. Secondary contamination to birds if ingested. | Direct / indirect / cumulative | 2 | 2 | 3 | 4 | 48 | Reduce | • Refuelling will be undertaken in accordance with the OSCP refuelling requirements at Rothera;<br>• Spill kits will be in all vehicles and key locations on site;<br>• A core oil spill response team of a minimum of 24 station staff will be formed and receive pre-deployment oil spill response training. This training will be in addition to on-site training; | 2 | 2 | 2 | 3 | 24 | Less than minor or transitory |

**Monitoring Activities**

| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | • HVO trial | | Hazardous waste associated with spill materials. | | | | | | | | • The OSCP will be followed for Tier 1, 2 and 3 spills;<br>• De-winterising checks will be undertaken in accordance with the OSCP;<br>• All plant will be inspected daily for potential leaks and condition of hydraulic oil hoses;<br>• All fuel storage tanks to be checked weekly and recorded on the BAM Environmental Inspection Checklist EC01;<br>• All spills reported to the Rothera Station Leader and BAS Environment Office; and<br>• The loss of any equipment will be reported in Maximo. | | | | | | |
| 6. | • Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor)<br>• Wind monitoring (installation of a SoDAR device)<br>• HVO trial | Disturbance to flora and fauna | Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds could result in avoidance or stress behaviour, nest abandonment or hearing damage. | Direct/Cumulative | 2 | 2 | 3 | 3 | 36 | Reduce | • All staff will receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife;<br>• In the unlikely circumstance of the displacement of seals, only trained personnel will be involved – the BAS Wildlife Interaction Manual (Appendix 4) will be referred to for any contact with wildlife;<br>• All vehicles will be inspected, and wheels checked for the presence of seals and penguins before engines are started;<br>• Someone suitably trained in wildlife interaction will be present at the start of works adjacent to any known nests and noisy works will not commence without express permission of the suitably trained person present;<br>• New solar monitoring masts installed will be fitted with reflective tags in order to prevent bird collisions; and<br>• The BAS Facilities team will maintain the demarcation of the no-go zone around the moss patch and ensure it is communicated to relevant personnel on station. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 7. | • Solar and soiling monitoring (installation of in-plane pyranometer, albedo, and soiling monitor)<br>• Wind monitoring (installation of a SoDAR device)<br>• HVO trial | Visual | Visual change to the built and natural landscape altering aesthetic value of Rothera. | Direct/Cumulative | 2 | 2 | 4 | 2 | 32 | Accept | • Activities will be confined to agreed areas on site. Any changes to the locations used by BAM will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office and FCDO. | 2 | 2 | 4 | 2 | 32 | Less than minor or transitory |

† Type of impact identified as: direct, indirect, cumulative, or unavoidable

‡ According to Article 8 of the Environmental Protocol – as described in section 1.2

**Table 10-7: Support Activities Impact Assessment**

| Support Activities | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
| 1. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Site set-up and presence of personnel<br>• Vehicle, plant, and equipment operation<br>• Provision of accommodation, power, and domestic services<br>• Incineration of waste | Atmospheric emissions | Contribution to regional and global atmospheric pollution and local heavy metal and particulate fallout. | Direct/ Cumulative | 5 | 2 | 5 | 2 | 100 | Reduce | • Ensure that all operations at Rothera are as efficient as possible to reduce excess fuel use;<br>• Generators and plant will be selected which balance efficiency and reduced emissions, with reliability, serviceability, and available fuel at Rothera;<br>• Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently, as per the BAM Plant Management Plan;<br>• Where practical, all drivers will be instructed to turn off engines during periods of waiting for 15 minutes or more;<br>• Only staff essential to the proposed works will be deployed to Rothera;<br>• Rationalisation of plant and equipment shipped to station will be undertaken; and<br>• All staff will be briefed on energy efficiency whilst on station as part of the pre-deployment training. | 5 | 2 | 5 | 2 | 100 | No more than minor or transitory |
| 2. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Site set-up and presence of personnel<br>• Vehicle, plant, and equipment operation<br>• Fuel management and refuelling | Noise emissions | Disturbance to local fauna resulting in stress and avoidance behaviour, nest abandonment. | Direct/ Cumulative | 3 | 2 | 4 | 3 | 72 | Reduce | • Regular maintenance of all equipment to ensure it is working efficiently;<br>• 10 mph speed limit maintained and enforced on site;<br>• Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors;<br>• Regular maintenance of all plant and vehicles to ensure they are working efficiently and generating as little noise as possible;<br>• Implementation of a soft start procedure for all noisy construction and survey equipment and consideration given to the impact on wildlife;<br>• If agreed noise levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and<br>• If agreed vibration levels are exceeded, works in that area will cease until | 3 | 2 | 3 | 2 | 36 | Less than minor or transitory |

**Support Activities**

| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | additional mitigation measures can be implemented. | | | | | | |
| 3. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Site set-up and presence of personnel<br>• Vehicle, plant, and equipment operation<br>• Incineration of waste | Dust emissions | Impact from dust deposition on ice ramp resulting in increased melt and smothering of local flora. | Direct / cumulative | 3 | 2 | 4 | 3 | 72 | Reduce | • Use of dust suppression equipment and spraying down roadways with sea water when required;<br>• Where practicable, keep activities which create dust downwind of sensitive receptors and avoid close proximity to known vegetation and ice locations;<br>• All routes used by vehicles and plant will be well maintained and have compacted surfaces;<br>• Limit the drop height of materials during stockpiling, processing, and loading operations;<br>• Minimise double handling of materials to reduce the overall number of tipping actions;<br>• 10 mph speed limit maintained and enforced on site;<br>• All plant and equipment to be maintained on a regular basis, as per the BAM Plant Management Plan;<br>• If agreed dust levels are exceeded, works in that area will cease until additional mitigation measures can be implemented; and<br>• During excessively dry, windy conditions, it may be necessary to temporarily suspend operations if it is not possible to control dust by other means. The Met team will provide a weather forecast every morning and this will be reviewed by the Site Manager in conjunction with the Rothera Station Leader. | 3 | 2 | 3 | 2 | 36 | Less than minor or transitory |
| 4. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Site set-up and presence of personnel | Waste | Impact due to increased waste sent to UK landfill and waste release to the local environment | Direct | 2 | 2 | 4 | 3 | 48 | Reduce | • The SWMP (Appendix 1) will be followed for all construction waste;<br>• There will be a dedicated area for storing and segregating waste;<br>• All construction waste will be returned to the UK and disposed of by licensed contractors; | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

**Support Activities**

| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | • Provision of accommodation, power, and domestic services | | | | | | | | | | • Packaging will be minimised where possible prior to consigning cargo to Antarctica;<br>• BAM commitment to achieving an 80% diversion of construction waste from landfill and a 90% diversion of all waste from landfill;<br>• Pre-deployment training on waste management for all operatives;<br>• Waste will be stored in the appropriate storage method;<br>• Provision of a BAM staff member dedicated to environmental management who will ensure that all waste is managed appropriately;<br>• Daily checks to ensure waste is contained to avoid being blown around site; and<br>• UV will be irradiated at the STP prior to discharge to mitigate the impact of the discharge. | | | | | | |
| 5. | • Vehicle, plant, and equipment operation<br>• Provision of accommodation, power, and domestic services | External light emissions | Impact due to disorientation of birds resulting in injury or mortality due to strikes | Direct | 1 | 2 | 4 | 3 | 24 | Reduce | • Works to be undertaken during daylight hours as far as reasonably possible, and the use and intensity of lighting will be minimised during low light hours;<br>• If required, lighting rigs to be angled towards the ground, not horizontally;<br>• Lights to be turned off when not in use and where possible external lighting should incorporate movement sensors or similar technology to minimise the duration of illumination;<br>• In the event of a bird strike, a suitably trained bird strike response staff member will take charge of the bird's care; and<br>• Lights to be switched off immediately if more than five bird strikes occur in one period of works. | 1 | 2 | 3 | 2 | 12 | Less than minor or transitory |
| 6. | • Storage of cargo<br>• Site set-up and presence of personnel<br>• Vehicle, plant, and equipment operation<br>• Fuel management and refuelling<br>• Provision of accommodation, power, and domestic services<br>• Incineration of waste | Physical presence and use of space | Impacts from disruption to station operations and science. Breakdown of relations between BAM & BAS staff. | Direct, Indirect/ Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • Changes to the locations used for any activities to be agreed with BAS Operations, the BAS Environment Office and FCDO;<br>• Evacuation plans will be agreed with station management;<br>• A Rothera Station Integration Plan will be prepared and followed; and<br>• Pre-deployment training sessions to be held with all BAM and BAS staff. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

| **Support Activities** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
| 7. | • Storage of cargo<br>• Vehicle, plant, and equipment operation | Physical or mechanical disturbance to land | Impact due to ground disturbance deterioration of land at Rothera including roadways and the runway due to increased volume of heavy plant | Direct/Cumulative | 2 | 2 | 4 | 2 | 32 | Reduce | • Minimise the footprint of works through careful design. | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |
| 8. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Vehicle, plant, and equipment operation<br>• Fuel management and refuelling<br>• Provision of accommodation, power, and domestic services | Fuel or hazardous substance release | Impact due to pollution to local environment. Mortality to flora and fauna. Secondary contamination to birds if ingested. Hazardous waste associated with spill materials. | Direct, Indirect / cumulative | 3 | 2 | 3 | 4 | 72 | Reduce | • Refuelling will be undertaken in accordance with the OSCP refuelling requirements at Rothera;<br>• Spill kits will be in all vehicles and key locations on site;<br>• A core oil spill response team of a minimum of 24 station staff will be formed and receive pre-deployment oil spill response training. This training will be in addition to on-site training;<br>• The OSCP will be followed for Tier 1, 2 and 3 spills;<br>• De-winterising checks will be undertaken in accordance with the OSCP;<br>• All plant will be inspected daily for potential leaks and condition of hydraulic oil hoses;<br>• All fuel storage tanks to be checked weekly and recorded on the BAM Environmental Inspection Checklist EC01;<br>• All spills reported to the Rothera Station Leader and BAS Environment Office; and<br>• The loss of any equipment will be reported in Maximo. | 3 | 3 | 2 | 3 | 54 | Less than minor or transitory |
| 9. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Storage of cargo | Non-native species introduction | Impact as a result of non-native species introduction to and establishment at Rothera altering the local ecosystem. Non-native species increase the risks to endemic species and on future science. | Indirect/Cumulative | 2 | 4 | 3 | 4 | 96 | Reduce | • All personnel being deployed to Rothera will receive a pre-deployment briefing from a member of the BAS Environment Office which will cover biosecurity;<br>• All activities will be undertaken in accordance with the BAS Biosecurity Regulations, the CEP NNS Manual and the Runway Resurfacing and Lighting Project-specific Biosecurity Plan (Appendix 2); | 2 | 4 | 2 | 3 | 48 | Less than minor or transitory |

**Support Activities**

| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | • A trained manager will inspect all plant, equipment, and materials prior to loading onto the vessel and on disembarkation/offloading at Rothera;<br>• All equipment and materials required for the proposed activities will be thoroughly cleaned before dispatch to Antarctica;<br>• The materials required for the new fuel farm hut under the Fuel Farm Infrastructure Upgrades project will be treated prior to import to Rothera, including kiln dried sand and heat-treated wood;<br>• Should soil, seeds or propagules be imported unintentionally, they must be carefully collected and removed. Rodents and insects must be exterminated immediately; and<br>• The Rothera Station Leader and the BAS Environment Office must be informed immediately if a biosecurity incident occurs. | | | | | | |
| 10. | • Shipping cargo to Rothera<br>• Transport of personnel to Rothera<br>• Site set-up and presence of personnel<br>• Vehicle, plant, and equipment operation<br>• Fuel management and refuelling<br>• Incineration of waste | Disturbance to flora and fauna | Disturbance, injury or fatality to marine mammals, marine benthic communities, and birds resulting in avoidance or stress behaviour, nest abandonment or hearing damage. | Direct/Cumulative | 2 | 2 | 4 | 3 | 48 | Reduce | • All staff will receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife;<br>• In the unlikely circumstance of the displacement of seals, only trained personnel will be involved – the BAS Wildlife Interaction Manual (Appendix 4) will be referred to for any contact with wildlife;<br>• All vehicles will be inspected, and wheels checked for the presence of seals and penguins before engines are started;<br>• Someone suitably trained in wildlife interaction will be present at the start of works adjacent to any known nests and noisy works will not commence without express permission of the suitably trained person present; and<br>• The BAS Facilities team will maintain the demarcation of the no-go zone around the moss patch and ensure it is | 2 | 2 | 3 | 2 | 24 | Less than minor or transitory |

**Support Activities**

| No. | Activities | Environmental Aspect | Potential Impact(s) | Type of Impact† | Extent | Duration | Probability | Significance/Severity | Risk Score (pre-mitigation) | Risk Response | Preventative or mitigating measures | Extent | Duration | Probability | Significance/Severity | Risk Score (post-mitigation) | Environmental Impact and Assessment‡ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | communicated to relevant personnel on station. | | | | | | |
| 11. | • Storage of cargo<br>• Site set-up and presence of personnel | Visual | Impacts due to visual change to the built and natural landscape altering the aesthetic value of Rothera. | Direct/Cumulative | 2 | 2 | 4 | 2 | 32 | Accept | • Activities will be confined to agreed areas on site. Any changes to the locations used by BAM will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office and FCDO. | 2 | 3 | 3 | 2 | 32 | Less than minor or transitory |

† Type of impact identified as: direct, indirect, cumulative, or unavoidable

‡ According to Article 8 of the Environmental Protocol – as described in Section 1.2

## 10.7 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[7]. When considered in this wider context, an activity may result in a potentially significant effect due to interactions with other activities that may occur over a longer period of time, at a particular location and in conjunction with other events, despite the implementation of effective mitigation and monitoring for each relevant activity.

### 10.7.1 Interaction with Present Activities at Rothera

Rothera Point has been used operationally since 1975 and has been developed and expanded ever since. The proposed works will not increase the overall footprint of the current station; however, they will require the use of a proportion of the accessible areas on station during construction periods. It is acknowledged that this area will be temporarily restricted for operational use during the construction period. To ensure the impact on day-to-day operations of the station is minimised, the demand on space and laydown areas will need to be managed effectively across the AIMP projects and business as usual. The implementation of the Rothera Station Integration Plan will be essential if the planned operational and science delivery is to continue unaffected.

It is noted that the delivery of the cone crusher required for the Runway Resurfacing and Lighting project has already taken place, and therefore the biosecurity risks of this activity were not able to be captured and assessed as part of this IEE. Nonetheless, the existing stringent biosecurity measures in place at Rothera are considered sufficient to mitigate and manage this potential impact.

### 10.7.2 Interaction with Previous Activities at Rothera

The most recent projects at Rothera include activities assessed under the Rothera Wharf Reconstruction and Coastal Stabilisation CEE (and supporting PEA) and Rothera Modernisation Phase 1 IEE. The direct and indirect environmental impacts associated with these activities as independent activities are considered to be effectively managed through the implementation of mitigation measures, as identified with the relevant assessment. However, overlaps with the current scope of works due to either anticipated or unforeseen programme overlaps must be considered as a cumulative activity, which is discussed in more detail below.

#### 10.7.2.1 Rothera Wharf Reconstruction and Coastal Stabilisation Quarry Activity

The use of material quarried as part of the Rothera Wharf Reconstruction and Coastal Stabilisation CEE project during the Runway Resurfacing project is acknowledged as a cumulative effect. The environmental and visual effect of the quarrying activity undertaken has been assessed as a long-term and more than minor impact. While material from the quarry is no longer being actively extracted, the impact of these works on the local environment and visual setting will remain during the 2022-2023 season. The interaction of the current scope of works with the quarry activities is not considered to lead to an increase in the significance of this effect.

#### 10.7.2.2 Temporary Jetty Removal

The installation and removal of the temporary jetty was assessed in the Rothera Wharf Reconstruction and Coastal Stabilisation CEE project. The removal of the temporary jetty will

take place between mid-December 2022 to mid-January 2023. An activity plan has been produced which outlines steps to dismantle the temporary jetty. A high-level summary of this includes:

- Establishing the working area, including set-up of access routes and exclusion zones;
- Positioning/movement of excavator and removal of stone;
- Removal of container connections; and
- Moving and disposing of containers and reinstatement works. A marine life inspection is to take place and confirmation that containers are clear of marine life will be needed to allow the activity to continue.

The impacts associated with the removal of the jetty are considered to be highly localised to the area in which the removal activity takes place. However, there are potential cumulative effects which are detailed in Section 10.7.3.

#### 10.7.2.3 Discovery Building Construction Programme Overlap

The Discovery Building construction programme has experienced significant challenges in the form of changes and delays to which the programme has been amended to suit. These changes have occurred since the production of the Rothera Modernisation Phase 1 IEE. The full details of these changes will be included in the compliance report for Season 3, but a summary has been provided here for the purposes of the cumulative effects assessment.

The construction works as described in the Rothera Modernisation Phase 1 IEE were divided between four construction seasons with an original completion date of April 2023 (end of Season 4). Construction Season 1 (2019-2020) was shortened due to the COVID-19 pandemic. Impacts of this continued into Season 2 (2020-2021), and Construction Season 3 (2021-2022). Construction Season 2 was also impacted by delays as a result of an extreme 1 in 10-year weather event, which caused delayed mobilisation to Rothera and additional snow clearance requirements before works could commence.

Construction Season 3 was further impacted due to initial DASH7 mobilisation delays which led to the programme for Construction Season 3 needing to be revised to suit the amended DASH7 schedule. Ground-floor slabs and the primary steel frame were installed and erected during this season and wind modelling of this steel structure indicated that this could be left as an open-sided structure until the Season 4 works could commence. As part of the reprogramming, six key activities were deferred to Construction Season 4 (2022-2023). These were making the building wind and weathertight, installation of the windows, communications tower, wind deflector and science balcony.

The runway resurfacing works are programmed to start in Season 4 and complete during Construction Season 5 (2023-2024), and these works are being given priority over the Discovery Building construction programme. To accommodate the resurfacing works, an amended programme was produced for the Discovery Building to ensure that the combined resource available at Rothera are able to undertake the proposed construction works effectively and safely.

MEP installation will commence in Season 5 alongside finalising the runway resurfacing. Construction Season 6 (2024-2025) is a full season to focus on the Discovery Building construction, and will include the completion of MEP, internal finishings and starting the handover and commissioning process. Dismantling redundant buildings will be started during Construction Season 7 (2025-2026). The finalisation of dismantling of these buildings will mark completion of

the handover and demobilisation process by March 2026. It is anticipated that plant on station at the end of Season 7 will be utilised for future Phase 2 projects and this will reduce the impact of transporting this plant from Rothera.

### 10.7.3 Cumulative Impact Assessment

The activities detailed above, and the proposed works assessed as part of this IEE, have the potential to have a cumulative impact. The impacts listed below are those which are not considered to have been assessed in previous EIAs and are not explicitly referenced within Section 10.4 of this IEE.

- Increased noise disturbance to local fauna due to concurrent activities;
- Increased dust deposition on the local flora and areas of adjacent ice;
- Increased quantities of waste generated during a single season, putting a strain on waste processing resource. Waste generation also implies the unnecessary use of materials which have been transported to Rothera and must be removed as waste;
- Increased light pollution through the use of artificial lighting;
- Increased and concurrent physical presence and use of space resulting in disturbance to operations and science activities;
- Increased risk of fuel or hazardous substance release due to concurrent activities;
- Increased risk of disturbance to native flora and fauna due to concurrent activities; and
- Increased temporary visual impacts to Rothera due to greater construction presence.

The mitigation and monitoring measures proposed for the works, alongside the standard operational procedures at Rothera, are considered to be sufficient to manage the environmental impacts associated with the potential cumulative effects listed above.

In addition to previously assessed phases, there are also further works planned under the AIMP for Rothera, including those under Phase 2 and Phase 3 of the AIMP outlined in Section 1.2. Continuous activity at Rothera, as required for the realisation of the AIMP, may result in a potentially significant cumulative impact over this longer period of time.

Potential long-term cumulative impacts particularly include disturbance to native flora and fauna, through continuous noise and vibration disturbance, light pollution, and dust emissions. Monitoring is in place for this purpose to ensure levels are not exceeded during construction seasons and over time; should significant effects on a particular species be observed, for example through a reduction in skua breeding activity at Rothera, it is anticipated that works would be ceased while a management plan can be agreed and implemented.

At the appropriate time for assessment, future AIMP phases will incorporate cumulative effects associated with any ongoing works at Rothera and their interaction with the scope of works for that particular season. Impacts are assessed individually and cumulatively, and mitigation measures are put in place to reduce impacts where necessary.

# 11. MONITORING AND AUDIT REQUIREMENTS

## 11.1 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. 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). Monitoring is being undertaken for this IEE to allow assessment of the impacts of ongoing activities, including the verification of predicted impacts and to facilitate early detection of the possible unforeseen effects of activities.

Information within this section of the IEE has been taken from the 2021-2022 AIMP Environmental Monitoring Review Report[10] and the BAM AIMP Environmental Monitoring Proposal[46], alongside monitoring proposals as recommended within this IEE.

To monitor the impacts of construction on noise, vibration, and dust pollution due to the AIMP works, environmental monitoring has been taking place as part of the AIMP construction projects at Rothera since the wharf reconstruction began in 2018. If monitored variables are found to exceed thresholds as set out later in this section, a report must be made to the BAS Environment Office within 24 hours and mitigation must be put in place to reduce the environmental impact of the activity. Where thresholds are exceeded, and further mitigation measures are required, this is incorporated into any future works to ensure greater compliance with the Environmental Protocol.

### 11.1.1 Existing Monitoring Arrangement

The current set up at Rothera uses six monitors in total, shown in Table 11-1. These consist of:

- 1 no. monitor measuring noise, vibration, and dust (ASPA).
- 3 no. monitors measuring noise and vibration (Bonner, Admirals and Bentham).
- 2 no. monitors monitor dust (Moss Patch and Ice Ramp).

Table 11-1 outlines the environmental aspects monitored at each of the six monitoring locations.

**Table 11-1: Existing Monitoring Locations and Aspects Monitored**

| | ***Noise*** | ***Vibration*** | ***Dust*** |
|---|---|---|---|
| *Bentham Container* | X | X | |
| *Bonner Lab* | X | X | |
| *Admirals* | X | X | |
| *Moss Patch* | | | X |
| *ASPA* | X | X | X |
| *Ice Ramp* | | | X |

[46] BAM, 2022. AIMP Phase 2 Environmental Monitoring Proposal, P01

Monitoring tasks are split into three types of activities as described below.

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

- Wildlife displacement;
- Moss Patch condition;
- Neutralisation of cement contaminated waters;
- Noise from various activities;
- Vibration from various activities; and
- Airborne dust.

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.

3. Environmental management activities – these will be undertaken by BAM as indicated in Table 11-2 and the data or findings reported to the BAS Environment Office.

**Table 11-2: Environmental Management Activities**

| Environmental Management Activity | Location in EIA | Reporting Output |
|---|---|---|
| **Waste Management:** segregation, packaging, storage, and disposal of waste as per the SWMP and BAS WMH | Section 6.3 and Appendix 1 | • Waste Transfer Notes<br>• Waste Quantity and Type Data |
| **Biosecurity:** Implementation of the Biosecurity Plan at all stages of cargo and personnel movement | Section 6.4 and Appendix 2 | • Biosecurity Checklists<br>• Biosecurity breaches reported |
| **Fuel Management:** daily refuelling as per refuelling procedure. | Section 6.1 | • Training records of staff<br>• Fuel spills reported<br>• Fuel consumption for carbon accounting |
| **Oil Spill Response**: BAM staff will respond to all Tier 1 spills and follow the direction of Rothera Station Leader for all Tier 2 and Tier 3 spills. BAM will provide appropriate spill response equipment. | Section 6.1.2 | • Fuel spills reported<br>• Spill kits used and disposed of appropriately |

### 11.1.2 Proposed Monitoring Arrangement

Four monitoring locations are proposed to measure noise, vibration, and dust. The positioning of these monitors has considered the confirmed and potential projects during phase 2 of the AIMP, as well as the latest information regarding sensitive receptors, particularly those that are part of the natural environment of Rothera Point.

Monitoring will take place at the four locations as shown in Figure 11-1 and outlined below:

1. Moss Patch – the monitors at Bentham Container and the Moss Patch are relatively close to each other and will be combined into a single unit measuring noise, vibration, and dust at the current Moss Patch location. It should be noted that the "Moss Patch" monitoring location is different to the location of the moss patch itself, as shown in Figure 11-1.
2. Bonner Lab – this is close to potential quarry locations and is required to ensure scientific work can continue undisturbed by vibrations (although limits for science have never been specified). Monitoring will continue at Bonner Lab with a minor adjustment of position (approx. 10 m).
3. Ice Ramp – with works planned in the forthcoming seasons in the area to the west of the runway, noise and vibration monitoring will be extended into this area to supplement the dust monitoring already being undertaken.
4. ASPA – current monitor location is to be retained.

Further detail on monitoring activities can be found in Appendix 5: Environmental Monitoring Proposal and in the sub-sections below.

In addition to environmental monitoring, additional information is required to be recorded, including:

- Collection of data on the increased contribution to atmospheric pollution from the deployment of personnel and cargo to be incorporated into the BAS Energy and Carbon Dashboard;
- Fuel use during construction will be recorded and reported in the BAS Energy and Carbon Dashboard; and
- Waste statistics will be collated for future monitoring and assessment purposes.

The monitoring equipment will be inspected and calibrated in the UK prior to deployment to Rothera. No maintenance is anticipated to be required on site for the duration of the monitoring period.

Monitors will be set-up at all four locations on the 19 November 2022; this is considered the earliest date monitors can be installed, 3.5 weeks into the proposed construction programme. This is due to delays to the availability of cargo space on the DASH 7 (preventing earlier delivery to Rothera) and snow clearance requirements to be able to access the locations and install the monitors. The works that will be undertaken during this period will be site set-up and snow clearance activities and are not expected to generate noise, vibration, or dust exceedances; the absence of monitoring equipment during this 3.5-week period is not likely to result in any significant impacts. This is discussed in more detail in Section 12: Gaps in Knowledge and Uncertainties.

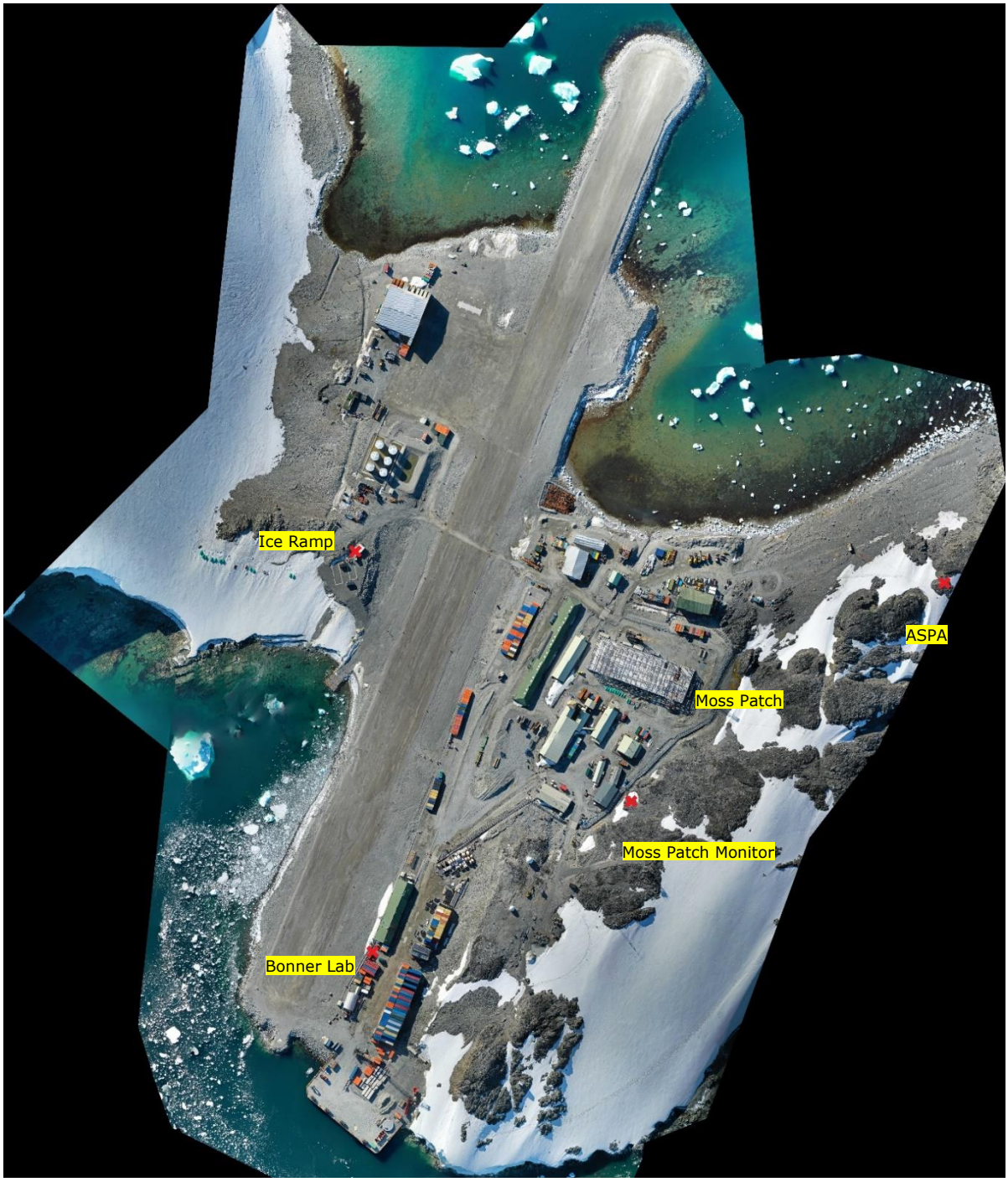



**Figure 11-1 Agreed Monitoring Locations for the 2022-2023 Season (BAM, 2022)**

### 11.1.2.1 Wildlife Displacement

| | |
|---|---|
| Monitoring type and purpose | Recording of wildlife displacement such as herding of seals and penguins located on land to remove them from areas where work is being undertaken or within designated vehicle access routes. |
| Description | Records must be kept of all wildlife displacement events involving seals and penguins. |

| | |
|---|---|
| | Such events may include the movement or herding of seals or penguins to allow the site to be secured (to enable, for example, building work to commence) or for vehicle movement around Rothera Point. |
| Methodology | All those moving or herding wildlife must have undergone training on station by BAS management<br>No bird nest sites are to be moved or physically disturbed by individuals or machinery<br>Visual observations and recording of species displaced.<br>Thresholds for displacement:<br>• more than five seal displacement events per day<br>*OR*<br>• More than five penguin displacement events per day |
| Duration of monitoring | Recording to be undertaken during the full construction period (when BAM present on site) |
| Frequency | As required. Displacement events must be recorded following every occurrence. |
| Actions should thresholds be exceeded | BAM shall contact the BAS Environment Office within 24 hours to discuss the feasibility of mitigation measures should thresholds be exceeded |
| Recording and management of data | For each displacement event the following information shall be recorded:<br>• Number, type and maturity of displaced seals (if known)<br>• Reason for displacement<br>• Location of displacement event and where the wildlife was moved to |
| Method of communication to the BAS Environment Office | Monitoring data to be presented to the BAS Environment Office every two weeks unless thresholds are exceeded as part of the BAM Monitoring and Reporting Schedule, and in a final report submitted at the end of each season.<br>Any wildlife injury or fatality associated with the work should be reported immediately to the BAS Environment Office and reported in the BAS Incident Reporting System (Maximo). |

#### 11.1.2.2 Moss Patch

As described in Section 10.4.10, the moss patch will be monitored at monthly intervals through photographic records to monitor any impact during construction activities.

#### 11.1.2.3 Neutralisation of Cement Contaminated Waters

| | |
|---|---|
| Monitoring type and purpose | Measurement of the pH of cement contaminated water, to ensure only pH neutral water is discharged to the ground. |
| Description | Use of cement may produce waste water that is strongly alkali. Before release to the ground, the waste water should be neutralised using citric acid. |

| | |
|---|---|
| Methodology | A pH meter will be used to ensure waste water is neutral before it is discharged to the ground. |
| Duration of monitoring | Monitoring only needs to occur during the period of cement use and when waste water is generated e.g., when equipment is cleaned. |
| Frequency | During period of neutralisation of cement contaminated waste water, and immediately prior to subsequent disposal. |
| Actions should thresholds be exceeded | Should the pH not be reduced to pH 7, the waste water will not be released until the required pH is achieved. |
| Recording and management of data | For each water release event, the following information will be recorded and reported to the BAS Environment Office:<br>• The volume of neutralised water released to the environment;<br>• The pH of the water. |
| Method of communication to the BAS Environment Office | Monitoring data to be presented to the BAS Environment Office every two weeks unless thresholds are exceeded as part of the Monitoring and Reporting Schedule, and in a final report submitted at the end of each season.<br>Should any waste water be released to the environment that has not been adequately neutralised (pH 7.0) then the BAS Environment Office shall be informed immediately, and it will be reported on Maximo. |

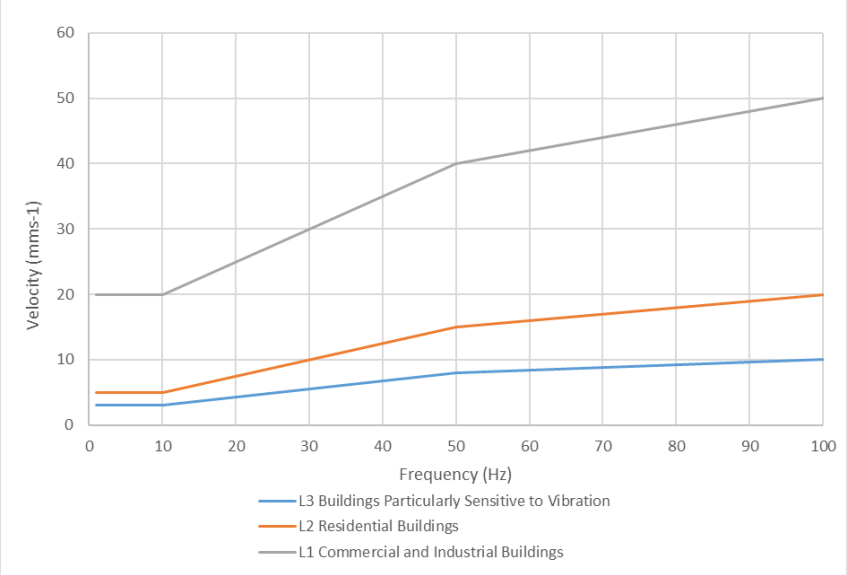
#### 11.1.2.4 Noise

| | |
|---|---|
| Monitoring type and purpose | Excessive noise may cause disturbance and potential injury to local wildlife and needs to be monitored to ensure thresholds are not exceeded. |
| Description | Before commencing noisy activities and the use of noisy equipment, consideration should be given to the impact upon wildlife. Animals on land are likely to move away from the noise source at the commencement of the activity.<br>Monitoring will occur at sites around Rothera Point, to estimate noise generation by construction activities, rock crushing and grading and plant operation and movement.<br>A Terrestrial Noise Assessment (Appendix 6) caried out in July 2019 demonstrated that noise levels at this limit are unlikely to cause temporary or permanent damage to the hearing of the wildlife at Rothera. Disturbance of wildlife from noise at these limits cannot be assessed due to lack of available research. |
| Methodology | Noise shall be monitored at:<br>• Moss Patch;<br>• Bonner Lab;<br>• Ice Ramp; and<br>• ASPA. |

| | |
|---|---|
| | Noise will be sampled at 51.2 kHz and reported each minute. Two limits have been set for noise levels:<br>LAeq 12 hour (the equivalent average noise over the 12-hour working period) < 75dB<br>LAeq 1 hour (the equivalent average noise over a 1-hour period) < 80dB<br>The 12-hour limit of 75dB is derived from BS 5228 Part 1 - Code of practice for noise and vibration control on construction and open sites. Appendix E of the standard discusses the significance of noise effects. Section E.2 states "Noise levels, between say 07.00 and 19.00 hours, outside the nearest window of the occupied room closest to the site boundary should not exceed:<br>• 70 dBA in rural, suburban and urban areas away from main road traffic and industrial noise; and<br>• 75 dBA in urban areas near main roads in heavy industrial areas.<br>As Rothera features a runway, it was decided that the limit of 75 dBA was more applicable to the site.<br>Noisy activities will be scheduled to occur sequentially and not simultaneously to reduce noise levels. |
| Duration of monitoring | Recording to be undertaken continuously during the construction period, ideally during set-up and eventual site demobilisation (when BAM present on site) |
| Frequency | Continuous monitoring, real time reporting |
| Actions should thresholds be exceeded | Activities related to vehicle movement and construction must cease and noise management measures be reassessed. Acoustic screens may be used to further reduce noise levels. |
| Recording and management of data | Monitors to be hard wired into BAS IT system and transferred via VLAN. Provision for manual data collection to be retained for early season data capture |
| Method of communication to the BAS Environment Office | Monitoring data to be presented to BAS on a fortnightly basis, unless a threshold exceedance has been recorded. If a threshold is exceeded this is required to be reported to the BAS Environment Office within 24 hours of the incident occurring. The regular noise monitoring reporting is part of the BAM Monitoring and Reporting Schedule, when noisy activities have occurred, and in a final report submitted to the BAS Environment Office at the end of each season. Raw data files must be made available.<br>Should mitigation measures and practices be insufficient to keep noise levels below the threshold, contact must be made with the BAS Environment Office at the earliest opportunity to discuss further options. |

#### 11.1.2.6 Vibration

| | |
|---|---|
| Monitoring type and purpose | Vibration will be monitored to ensure levels do not significantly impact upon local wildlife. |
| Description | Monitoring of vibration from activities (e.g., vehicle movement) shall be done to ensure local receptors are not impacted above threshold levels.<br>Monitoring will occur at sites around Rothera Point, as outlined within this section of the report, to estimate vibration generation by construction activities, rock crushing and grading and plant operation and movement. |
| Methodology | Vibration from construction activities will be monitored using triaxial accelerometers.<br>Vibration shall be monitored at:<br>• Moss Patch;<br>• Bonner Lab;<br>• Ice Ramp; and<br>• ASPA.<br>The lack of research on the effects of vibration on animals means that no specific limit of vibration can be set for animal receptors, although data is available for the effects of vibration on humans and these limits are applied to manage effects to wildlife.<br>Measurements of human exposure to vibration expressed as VDVs combine the magnitude of vibration and the time for which it occurs and are measured in $ms^{-1.75}$. BS 6472 - Guide to evaluation of human exposure to vibration in buildings provides guidance on how vibration is perceived by humans in residential buildings, offices and workshops. Rothera feature all three building types assessed.<br>BS 6841 - Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock states that vibration dose values in the region of 15 $ms^{-1.75}$ will usually cause severe discomfort.<br>Based on the above information, a limit of 2.4 $ms^{-1.75}$ is proposed for VDV, representing the level at which adverse comment is probable in workshops during daytime.<br>DIN 4150-3 Effects of Vibration on structures proposes three vibration limits, depending on the building assessed. These limits depend on the frequency of vibration as shown in Figure 11-2. This standard is regularly used when setting limits for vibration to protect structures and items within them.<br>From the perspective of ensuring no damage to existing buildings occurs, L2 Residential Buildings would be a suitable limit for Rothera. Therefore, vibration levels measured as PPV should not exceed the values outlined in DIN 4150-3 Effects of Vibration Line 2. |

| | |
|---|---|
| |  <br>**Figure 11-2 Guideline limits for vibration velocity with respect to vibration** |
| Duration of monitoring | Recording to be undertaken continuously during the full construction period (when BAM present on site) |
| Frequency | Continuous monitoring, real time reporting |
| Actions should thresholds be exceeded | Activities must cease and vibration management reassessed. If thresholds are exceeded, activities likely to produce substantial vibration should not be undertaken simultaneously, but rather rescheduled to occur sequentially and thereby reduce the total level. |
| Recording and management of data | Monitors to be hard wired into BAS IT system and transferred via VLAN. Provision for manual data collection to be retained for early season data capture |
| Method of communication to the BAS Environment Office | Monitoring data will be presented to BAS on a fortnightly basis unless a threshold exceedance has been recorded. If a threshold is exceeded, this is required to be reported to the BAS Environment Office within 24 hours of the incident occurring.<br>A full summary of the monitoring data must be presented to the BAS Environment Office in a report submitted at the end of each season. The raw data files must also be made available.<br>Should mitigation measures and practices be insufficient to keep vibration levels below the threshold, contact must be made with the BAS Environment Office at the earliest opportunity to discuss further options. |

#### 11.1.2.8 Dust

| | |
|---|---|
| Monitoring type and purpose | Dust and particulate deposition may have adverse impacts upon the melting rate of the ice ramp, the small areas of vegetation present on Rothera Point and the breathing of personnel. |
| Description | Monitoring of dust will be undertaken to ensure excessive generation is avoided for the duration of the construction process. |
| Methodology | UK and EU air quality standards concentrate on smaller particles, which are known to have greater effects on human, and therefore animal health. Based on the UK and EU air quality limits, a $PM^{10}$ limit of 50µg/$m^3$/24 hours is proposed. Although an additional expense, it is also proposed that the monitoring of TSP continues for a least one season to compare future dust volumes to past concentrations. It is also more applicable to the smothering of vegetation. The current limit for TSP is 250µg/$m^3$/15 minutes. The two different particle sizes can be monitored using a single instrument with an additional filter. $PM^{2.5}$ and $PM^{1}$ will also be monitored, but there are no agreed limits. |
| Duration of monitoring | Recording to be undertaken continuously during the full construction period (when BAM present on site). |
| Frequency | Continuous monitoring, real time reporting |
| Actions should thresholds be exceeded | Dust suppression strategies will be investigated to reduce dust levels associated with construction activities. |
| Recording and management of data | Monitors to be hard wired into BAS IT system and transferred via VLAN. Provision for manual data collection to be retained for early season data capture |
| Method of communication to the BAS Environment Office | Monitoring data will be presented to BAS on a fortnightly basis, unless a threshold exceedance has been recorded. If a threshold is exceeded, this is required to be reported to the BAS Environment Office within 24 hours of the incident occurring.<br>A summary of the monitoring data must be presented to the BAS Environment Office in a report at the end of each season. The raw data files must also be made available.<br>Should mitigation measures and practices be insufficient to keep dust levels below the threshold, contact must be made with the BAS Environment Office at the earliest opportunity to discuss further options. |

#### 11.1.2.9 Skua Breeding Success on Rothera Point

| | |
|---|---|
| Monitoring type and purpose | Skua breeding success on Rothera Point. |
| Description | Nesting skua populations on Rothera Point may be vulnerable to disturbance associated with the proposed works. Ongoing monitoring work to assess the impact of construction activities on skua breeding success will be maintained. |

| | |
|---|---|
| | BAS routinely undertake monitoring of skua breeding success as part of long-term monitoring commitments |
| Methodology | Breeding parameters that will be recorded include:<br>• Laying dates<br>• Clutch size<br>• Egg dimensions<br>• Hatching success<br>• Fledging success<br>• Chick condition<br>• Adult attendance (an indicator of foraging effort).<br>Monitoring includes re-sighting of colour-ringed adults which can be used as an indicator of adult survival, breeding frequency and divorce rates and to determine breeding histories of individuals and the effects of mate change.<br>Monitoring of birds on Anchorage Island will provide a control data set. |
| Duration of monitoring | BAS Bonner Lab Manager will undertake monitoring each summer (November to March) for each season. |
| Frequency | Weekly |
| Actions should thresholds be exceeded | Should any direct or indirect physical damage to birds or nest be noted, this will be communicated to the BAS Environment Office immediately and reported on Maximo. |
| Recording and management of data | Data are routinely recorded by the Bonner Lab Manager and submitted to the BAS Data Centre |
| Method of communication to the BAS Environment Office | A summary of the monitoring data must be presented to the BAS Environment Office at the end of each breeding season.<br>Should any physical damage to birds or nests be noted, this will be communicated to the BAS Environment Office immediately and reported on Maximo. |

### 11.2 Data Collection and Reporting

The current system uses manual data collection which requires an individual to visit each monitor and download the data. This is then copied onto the master data spreadsheet. Whilst this method is reliable, it fails to provide real time monitoring and requires time to collect and process the data.

The inability to gain real time data means the ability to attribute exceedances to individual events and address them in a timely manner is severely hampered. Trials of a wi-fi system were undertaken at Rothera during the 2021-2022 season however it was not possible to gain a reliable data connection. Monitors will now be hardwired to the station local area network to provide real time data. Real time data collection will allow BAS and BAM to fully understand the cause of any exceedance, which can then be actioned to mitigate the potential environmental impact within a suitable time frame.

The BAM Monitoring and Reporting Schedule will be used to report any exceedances and/or environmental incidents. This will be reported on the BAS Maximo system.

### 11.3 Audit Programme

An audit programme will be undertaken during the construction works by the site supervisor to ensure that the actions and mitigation measures committed to in this document are being adhered to. This will follow a BAS Environment Office approved checklist.

The audits will also be conducted against the ISO14001:2015 standard to which BAS is registered. Updated audit proformas are currently being produced. A minimum of two onsite audits will be undertaken during each season and a further EIA review which will include a site visit to Rothera will be undertaken on completion of the works.

Any changes to activities proposed as a result of the monitoring data, will be made by the Construction Manager in conjunction with the BAS Environment Office. All monitoring data will be communicated to the BAS Environment Office and be available on request for auditing purposes.

### 11.4 Summary of Actions and Commitments

This section summarises the actions and commitments presented within this IEE to ensure that mitigation and mitigation owners are clearly communicated and can be used as part of the auditing process.

The actions and commitments presented in Table 11-3 have been confirmed by all parties.

**Table 11-3: Summary of Actions and Commitments**

| IEE Section | Agreed Actions, Mitigation and/or Monitoring Measures | Owner |
|---|---|---|
| 4: Construction, SI, Condition Survey and Monitoring Methodologies | Prior to starting each shift, permission will be granted from the ATC that works are safe to start on the runway | ATC |
| | Specialist Activity Permits will be sought for:<br>**Runway Upgrade Project**<br>• Collection of samples (Runway North Marine Surveys)<br>Samples will be tested in the labs at Rothera<br><br>**Hangar Redevelopment SI Project**<br>• Collection of core samples (GI for Foundation Design)<br>Samples will be exported to the UK for testing | BAS Environment Office and BAS Project Manager |
| 10.6: Impact Assessment<br>Atmospheric emissions mitigation<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Ensure that all operations at Rothera are as efficient as possible to reduce excess fuel use | BAM |
| | Generators and plant will be selected which balance efficiency and reduced emissions, with reliability, serviceability, and available fuel at Rothera | BAM |
| | Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently, as per the BAM Plant Management Plan | BAM |
| | Where practical, all drivers will be instructed to turn off engines during periods of waiting for 15 minutes or more | BAM/BAS |
| | Only staff essential to the proposed works will be deployed to Rothera | BAM/BAS |
| | Rationalisation of plant and equipment shipped to station will be undertaken | BAM/BAS |
| | All staff will be briefed on energy efficiency whilst on station as part of the pre-deployment training | BAM/BAS |
| | Data will be collected and the increased contribution to atmospheric pollution from the deployment of personnel and cargo will be accounted for in the BAS Energy and Carbon Dashboard | BAM/BAS |

| | | |
|---|---|---|
| | Fuel use during construction will be recorded and reported in the BAS Energy and Carbon Dashboard | BAM/BAS |
| | Ongoing and long-term monitoring in the ASPA for metal and particulate fallout (due to fuel combustion) | BAM |
| 10.6 Impact Assessment<br>Noise emissions and vibration mitigation<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Regular maintenance of all equipment to ensure it is working efficiently | BAM/BAS |
| | 10 mph speed limit maintained and enforced on site | BAM/BAS |
| | Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors | BAM/BAS |
| | Regular maintenance of all plant and vehicles to ensure they are working efficiently and generating as little noise as possible | BAM/BAS |
| | Implementation of a soft start procedure for all noisy construction and survey equipment and consideration given to the impact on wildlife | BAM/BAS |
| | If agreed noise levels are exceeded, works in that area will cease until additional mitigation measures can be implemented | BAM/BAS |
| | If agreed vibration levels are exceeded, works in that area will cease until additional mitigation measures can be implemented | BAM/BAS |
| | For works at the Hangar building and apron only, an acoustic screen shall be implemented to effectively screen the adjacent skua nest from any noisy works | BAM/BAS |
| | Continuous noise monitoring will take place to ensure noise levels do not exceed agreed levels | BAM |
| | Continuous vibration monitoring will take place to ensure vibration levels do not exceed agreed levels | BAM |
| 10.6 Impact Assessment<br>Dust emissions mitigation<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Use of dust suppression equipment and spraying down roadways with sea water when required | BAM |
| | Where practicable, keep activities which create dust downwind of sensitive receptors and avoid close proximity to known vegetation and ice locations | BAM/BAS |
| | All routes used by vehicles and plant will be well maintained and have compacted surfaces | BAM/BAS |

| | | |
|---|---|---|
| | Limit the drop height of materials during stockpiling, processing, and loading operations | BAM/BAS |
| | Minimise double handling of materials to reduce the overall number of tipping actions | BAM/BAS |
| | 10 mph speed limit maintained and enforced on site | BAM/BAS |
| | All plant and equipment to be maintained on a regular basis, as per the BAM Plant Management Plan | BAM |
| | Cement will not be mixed externally on windy days | BAM |
| | If agreed dust levels are exceeded, works in that area will cease until additional mitigation measures can be implemented | BAM/BAS |
| | During excessively dry, windy conditions, it may be necessary to temporarily suspend operations if it is not possible to control dust by other means. The Met team will provide a weather forecast every morning and this will be reviewed by the Site Manager in conjunction with the Rothera Station Leader | BAM/BAS |
| | Continuous dust monitoring will be undertaken to ensure dust levels do not exceed agreed levels | BAM |
| 10.6 Impact Assessment Waste (Tables 10.4, 10.5, 10.6 and 10.7) | The SWMP (Appendix 1) will be followed for all construction waste | BAM |
| | There will be a dedicated area for storing and segregating waste | BAM |
| | All construction waste will be returned to the UK and disposed of by licensed contractors | BAM |
| | Packaging will be minimised where possible prior to consigning cargo to Antarctica | BAM |
| | BAM commitment to achieving an 80% diversion of construction waste from landfill and a 90% diversion of all waste from landfill | BAM |
| | Pre-deployment training on waste management for all operatives | BAM/BAS |
| | Waste will be stored in the appropriate storage method | BAM |
| | Provision of a BAM staff member dedicated to environmental management who will ensure that all waste is managed appropriately | BAM |

| | | |
|---|---|---|
| | Daily checks to ensure waste is contained to avoid being blown around site | BAM |
| | UV will be irradiated at the STP prior to discharge to mitigate the impact of the discharge | BAS |
| | Any cementitious wash waters produced during construction will be neutralised to a pH of 7.0 using citric acid prior to discharge to ground. Cementitious materials are mixed in the BAM Fitters Workshop and the wash water, once neutralised, will be discharged away from sensitive receptors to the west of the BAM Fitters Workshop | BAM |
| | Waste statistics to be collated | BAM |
| 10.6 Impact Assessment<br>External light emissions<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Works to be undertaken during daylight hours as far as reasonably possible, and the use and intensity of lighting will be minimised during low light hours | BAM/BAS |
| | If required, lighting rigs to be angled towards the ground, not horizontally | BAM |
| | Lights to be turned off when not in use and where possible external lighting should incorporate movement sensors or similar technology to minimise the duration of illumination | BAM/BAS |
| | In the event of a bird strike, a suitably trained bird strike response staff member will take charge of the bird's care | BAM/BAS |
| | Lights to be switched off immediately if more than five bird strikes occur in one period of works | BAM/BAS |
| | All bird strikes will be recorded on Maximo | BAM/BAS |
| 10.6 Impact Assessment<br>Physical presence and use of space<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Survey and sampling locations confined to agreed areas | BAM/BAS/Ramboll |
| | Methodologies to be undertaken in line with agreed methods | BAM/BAS/Ramboll |
| | Changes to the locations used for any activities to be agreed with BAS Operations, the BAS Environment Office and FCDO | BAS Operational Team, BAS Environment Office and BAM |
| | Evacuation plans will be agreed with station management | BAM/ BAS |
| | A Rothera Station Integration Plan will be prepared and followed | BAM/BAS |
| | Pre-deployment training sessions to be held with all BAM and BAS staff | BAM/BAS |

| | | |
|---|---|---|
| 10.6 Impact Assessment<br>Physical or mechanical disturbance on land<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Once the ice core has been removed and measurements taken, the core will be re-plugged where it came from and assumed to re-freeze and re-integrate | BAS/Ramboll |
| | Minimise the footprint of works through careful SI design | Ramboll |
| | Locate borehole, trial, and inspection pits away from sensitive environmental constraints | Ramboll |
| | Where possible, trenches and trial pits will be backfilled at the end of a shift, however if this is not feasible, trenches and trial pits will be suitably covered, fenced, and signed and not be left open for longer than necessary | BAM/BAS |
| | If contamination is encountered during the trial pit works, all equipment will be cleaned between trial holes to prevent cross contamination. Any occurrences of contamination should be reported to the Rothera Station Leader | BAM/BAS |
| | Daily checks on all routes used by construction vehicles | BAM |
| | Monitoring and maintenance of road and runway once resurfaced | BAM/BAS |
| 10.6 Impact Assessment<br>Fuel or hazardous substance release<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Refuelling will be undertaken in accordance with the OSCP refuelling requirements at Rothera | BAM/BAS |
| | Spill kits will be in all vehicles and key locations on site | BAM/BAS |
| | A core oil spill response team of a minimum of 24 station staff will be formed and receive pre-deployment oil spill response training. This training will be in addition to on-site training | BAM/BAS |
| | The OSCP will be followed for Tier 1, 2 and 3 spills | BAM/BAS |
| | De-winterising checks will be undertaken in accordance with the OSCP | BAM/BAS |
| | All plant will be inspected daily for potential leaks and condition of hydraulic oil hoses | BAM/BAS |
| | All fuel storage tanks to be checked weekly and recorded on the BAM Environmental Inspection Checklist EC01 | BAM |
| | All spills reported to the Rothera Station Leader and BAS Environment Office | BAM, BAS Operations, BAS Environment Office |
| | The drilling management plan will be followed at all times during borehole works | BAM/BAS |

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| | Safe drilling procedures to be followed at all times to reduce risk of loss of drill. Only experienced operatives will use the drill | BAM/BAS |
| | The loss of any equipment will be reported in Maximo | BAM/BAS |
| 10.6 Impact Assessment<br>Non-Native Species Introductions<br>(Tables 10.4, 10.5, 10.6 and 10.7) | All personnel being deployed to Rothera will receive a pre-deployment briefing from a member of the BAS Environment Office which will cover biosecurity; | BAS |
| | All activities will be undertaken in accordance with the BAS Biosecurity Regulations, the CEP NNS Manual and the Runway Resurfacing and Lighting Project-specific Biosecurity Plan (Appendix 2) | BAM/BAS |
| | A trained manager will inspect all plant, equipment, and materials prior to loading onto the vessel and on disembarkation/offloading at Rothera | BAM/BAS |
| | All equipment and materials required for the proposed activities will be thoroughly cleaned before dispatch to Antarctica | BAM/BAS |
| | Should soil, seeds or propagules be imported unintentionally, they must be carefully collected and removed. Rodents and insects must be exterminated immediately | BAM/BAS |
| | The Rothera Station Leader and the BAS Environment Office must be informed immediately if a biosecurity incident occurs | BAM/BAS |
| 10.6 Impact Assessment<br>Disturbance to native flora and fauna<br>(Tables 10.4, 10.5, 10.6 and 10.7) | All staff will receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife | BAM/BAS |
| | In the unlikely circumstance of the displacement of seals, only trained personnel will be involved – the BAS Wildlife Interaction Manual (Appendix 4) will be referred to for any contact with wildlife | BAM/BAS |
| | All vehicles will be inspected, and wheels checked for the presence of seals and penguins before engines are started | BAM/BAS |
| | Someone suitably trained in wildlife interaction will be present at the start of works adjacent to any known nests and noisy works will not commence without express permission of the suitably trained person present | BAM/BAS |

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| | If drilling rigs for SI works are to be left in one location for an extended duration, they will be fitted with reflective tags in order to prevent bird collisions | BAM/BAS |
| | New solar monitoring masts installed will be fitted with reflective tags in order to prevent bird collisions | BAS |
| | The BAS Facilities team will maintain the demarcation of the no-go zone around the moss patch and ensure it is communicated to relevant personnel on station | BAS Facilities Team |
| | For the geophysical surveys, a 200 m acoustic exclusion zone will be established around the full extent of the survey works | BAM/BAS |
| | A dedicated mammal observer will be present on the vessel to continuously monitor the exclusion zone for the presence of marine mammals and call for immediate shut down of sound sources if marine mammals are detected or approaching the exclusion zone | BAM/BAS |
| | Skua monitoring will continue throughout the construction programme to obtain updated information on nest activity | BAM/BAS |
| | Any impacts to the moss patch will be monitored at monthly intervals through photographic records | BAM |
| 10.6 Impact Assessment<br>Visual impacts<br>(Tables 10.4, 10.5, 10.6 and 10.7) | Construction activities will be confined to agreed areas on site. Any changes to the locations used by BAM will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office and FCDO | BAM, BAS, Rothera Station management |

# 12. GAPS IN KNOWLEDGE AND UNCERTAINTIES

## 12.1 Proposed Works

Exact timings of the works are not available for all activities, and where these are not available, an assumption has been made that these activities will take place within the 2022-2023 season, with the exception of finalising the Runway Resurfacing and Lighting project, as well as the geophysical surveys.

Any deviations to the information presented within this IEE will be accounted for within a Register of Project Variations; a live document that is actively managed and owned by BAS in close collaboration with BAM personnel in Rothera. Any variations will be reported in the Post Season Compliance Report, along with a full complement of the monitoring data collected in support of the works that season.

As highlighted in Section 11.1.2, monitoring equipment cannot be set-up until 19 November 2022. This represents a minor risk, as there will be no monitoring data available for noise, vibration, and dust for the first 3.5 weeks of the construction programme. However, the activities that will be undertaken during this period will be site set-up and snow clearance activities. The noise, vibration and dust levels generated during these activities are well known from past construction seasons and do not represent a gap in our knowledge. This gap in monitoring data is not considered to be a concern given the main construction works and associated increases in noise, vibration and dust levels will not have started on site, but it is acknowledged there will be a gap in the data in the early phase of the 2022-2023 season. Although the absence of monitoring equipment is acknowledged as a minor risk, this delay is considered acceptable given the challenges of delivering equipment and working in Antarctica.

Another area of uncertainty is the slipway design, construction methods and potential impacts to marine benthic ecology. Although shallow water benthic surveys around Rothera Point were undertaken in 2016 (as outlined in Section 9.1.3.1), it is acknowledged that the baseline information and construction methodology detail are limited, as there is no survey of the specific area where the slipways are proposed to be constructed, and no work specific measures in place to address these impacts to benthic ecology. However, it is described in the methodology (Section 4.2.6) that an excavator with sufficient reach to avoid having to go into the water will be used to deposit the rock, which is considered to limit the interaction with benthic ecology, as well as preventing excess sediment disturbance. The anticipated impacts assessed within this IEE are based on the available baseline alongside construction methodology detail at the time of writing, along with professional judgement on likely scale and duration of impacts. Although the absence of further information is acknowledged as a minor risk, this is considered acceptable given the nature and duration of the works.

Finally, the exact ground fixing requirements are not known for the solar monitoring equipment. It is acknowledged that the methodology for this is limited, however, the location of the monitoring equipment is at least known. The same therefore applies as above. Although the absence of further information is acknowledged as a very minimal risk, this is considered acceptable given the nature and duration of the works.

## 12.2 Future Phases of AIMP

The funding and full scope of these future phases has not yet been confirmed and will be considered in future environmental impact assessments. The works assessed as part of this IEE form part of Phase 2 of the works, in addition and at the current stage of planning, Phase 2 is anticipated to include:

- Construction of a new aircraft Hangar;
- Runway upgrades in the form of an extension;
- Construction of a new marine facility;
- New building to replace Giants House;
- Improved access route to East Beach; and
- Proof of concept for renewable energy (wind).

Professional judgement at the time of writing has been used to inform the most appropriate decommissioning approach for the runway from an environmental perspective. As addressed in this EIA, potential degradation of the plastic ducting is considered to have a less than minor or transitory impact on the environment, if any. A more detailed assessment at the time of decommissioning would be undertaken, if required, to assess the potential environmental impacts of different decommissioning scenarios.

At the current stage of planning Phase 3 is anticipated to include:

- A new building to replace the Bonner Laboratory;
- A new building to replace New Bransfield House;
- A new building to replace Admirals House;
- A new sewage treatment plant;
- Improved communications infrastructure; and
- Renewable energy installations.

# 13. CONCLUSIONS

The scope of works included in this IEE forms an important part of the overall AIMP ambition for BAS to be able to modernise and restore the Rothera infrastructure so that it remains cost effective and sustainable.

Due to the largely temporary nature of the proposed works and minimal constructed elements which will be located in already developed and occupied areas with a low environmental sensitivity, the additional footprint of the works is minimal. Associated impacts are considered to be manageable through existing BAS and BAM procedures and with the addition of specific mitigation and monitoring as outlined in Section 11.4. A full assessment of the potential environmental impacts has been provided within this IEE.

The most significant potential impacts predicted for all four of the impact assessment categories are:

- Introduction of non-native species;
- Cumulative noise impacts due to overlapping construction periods with the Discovery Building;
- Dust deposition on the ice ramp and impacts to local flora and fauna through smothering;
- Physical presence, use of space and disturbance to science activities and day-to-day operations;
- Physical and/or mechanical disturbance to land as a result of intrusive SI works; and
- Terrestrial (and potentially marine) pollution from fuel spills.

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.

Impacts associated with the generation of noise and dust can be significantly reduced with the implementation of robust and specific mitigation measures which are managed throughout the period of works.

Due to the nature of the works, the likelihood of impacts occurring that are associated with the physical presence and use of space is not considered to be high but will require mitigation to ensure any impacts are managed. A Station Integration Plan is being produced and integrated and collaborative working between BAS and BAM will be essential to avoid significant impacts.

The location of the intrusive SI has sought to avoid environmental constraints and the works will follow best practice methodology to minimise impacts.

The probability of impacts associated with fuel spills occurring will also be reduced if standard operational procedures are followed. In the unlikely event of a spill, the OSCP is in place to minimise the severity of the impact.

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

# 14. AUTHORS

This IEE has been prepared by Adam Carter and Julia Thompson at Ramboll with technical and quality reviews undertaken by Elisha Hearn and Amy Paraskeva. This IEE has been approved by Jeff Turner and Bruce Wulff. Additional inputs and contributors to this IEE have been provided within the acknowledgements section.

# 15. ACKNOWLEDGEMENTS

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Detail on the design elements of the project have been provided by the BAS and Ramboll Project Management Teams, and Joe Stebbing as well as BAM personnel Neil Goulding and David Robson. BAS Estates personnel Thomas Roberts and Geoffrey Wilson provided details for the BAS Estates project Fuel Farm Infrastructure Upgrade.

Thanks are given to those who have reviewed this IEE. Reviewers at BAS include Rachel Clarke Head of Environment, Joe Stebbing Assistant Project Manager for Rothera Modernisation, David Seaton Head of Construction for AIMP. Additional reviewers at BAS are Clare Fothergill, Katie Handford, Genevieve Hinde, Kevin Hughes, Ben Checkley, Andrew Barker. Reviewers at BAM include Neil Goulding, David Robson, and Robert Kerr. Ramboll reviewers include Bruce Wulff, Jeff Turner, Amy Paraskeva, Christopher Lloyd, Piyush Sheopuri, Emmanuel M. Ine Jr, Melinda Odum, and Hannah Osman.

# APPENDIX 1
# ROTHERA RUNWAY RESURFACING AND LIGHTING SITE WASTE MANAGEMENT PLAN

# APPENDIX 2
# RUNWAY RESURFACING AND LIGHTING PROJECT-SPECIFIC BIOSECURITY PLAN

# APPENDIX 3
# HERITAGE SURVEY RESULTS

# APPENDIX 4
# WILDLIFE INTERACTION MANUAL

# APPENDIX 5
# ENVIRONMENTAL MONITORING PROPOSAL

# APPENDIX 6
# TERRESTRIAL NOISE ASSESSMENT