RFA Rocket Factory

RFA
Launch Operator Licence Application

Assessment of Environmental Effects

Issue: 5

June 2024

Document Information

Project Name:	RFA SaxaVord AEE V5
Document Title:	Assessment of Environmental Effects
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Document Status:	Final for Issue
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Approved:	Gavin Bollan
Date:	2024-06-20
Version:	5.0
Project/Proposal Number:	5651
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Revision History

Version	Date	Authored	Reviewed	Approved	Notes
1.0	2023-02-06	Various	Ruth Fain	Gavin Bollan	Final for Issue
2.0	2023-09-20	Various	Ruth Fain	Gavin Bollan	Chapter 8/RFI updates
3.0	2023-11-30	Various	Ruth Fain	Gavin Bollan	RFI 2 updates included
3.0 Public Consultation	2023-11-30	Various	Ruth Fain	Gavin Bollan	Public Consultation Version
4.0	2024-01-17	Various	Ruth Fain	Gavin Bollan	V4 after CAA comments
4.1	2024-01-19	Various	Ruth Fain	Gavin Bollan	V4.1 after CAA comments
5.0	2024-06-20	Various	Ruth Fain	Gavin Bollan	RFI OL BlockB updates included

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Abbreviations and Glossary

Abbreviations & Glossary
Rocket Factory Augsburg SaxaVord AEE V5

Term	Expanded Term
'effect'	The term *'effect'* is defined as the consequences for the receptor of an impact.
'impact'	The term *'impact'* is defined as a change experienced by a receptor (this can be beneficial, neutral or adverse)
'receptor'	used throughout the Assessment of Environmental Effects (AEE) process and is defined as the element in the environment affected by a development (e.g. a bird in the case of ornithology)
AADF	Annual Average Daily Flow
AADT	Annual Average Daily Traffic
AD	Alert Distance
AEE	Assessment of Environmental Effects
Al	Aluminium
AIT	A forward position building close to the launch pads for Assembly, Integration and Testing
ALARP	As Low as Reasonably Practical
AOB	Apparently Occupied Burrows
AOD	Above Ordnance Datum
AON	Apparently Occupied Nests
AQAL	Air Quality Assessment Level
AQAP	Air Quality Action Plan
AQIA	Air Quality Impact Assessment
AQMA	Air Quality Management Area
AQOs	Air Quality Objectives
AQS	Air Quality Standards
BAP	UK Biodiversity Action Plan
BBPP	Breeding Birds Protection Plan
BRRC	Blue Ridge Research and Consulting LLP
C	Carbon
CAA	Civil Aviation Authority
CAFF	Conservation of Arctic Flora and Fauna
CCIA	Climate Change Impact Assessment
CCP	Climate Change Plan
CIEEM	Chartered Institute for Ecology and Environmental Management
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COMAH	The Control of Major Accident Hazards Regulations (2015)

Term	Expanded Term
CoNaW Regs	The Control of Noise at Work Regulations
CRTN	Calculation of Road Traffic Noise
Cu	Copper
Db	Decibel
Defra	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DMRB	Design Manual for Roads and Bridges
EAC	Environmental Assessment Criteria
EC	European Commission
EcIA	Ecological Impact Assessment
ECoW	Ecological Clerk of Works
EEZ	Exclusive Economic Zone
EfT	Emissions factor Toolkit (Defra)
EHO	Environmental Health Officer
EIA	Environmental Impact Assessment
ELV	Exposure Limit Value
EMODnet	European Marine Observation and Data Network
EPDM	Ethylene propylene diene monomer
EPS	European Protected Species
EPUK	Environment Protection UK
EZI	Environmental Zone of Influence
FCS	Favourable Conservation Status
FID	Flight Initiation Distance
FPM	Fluorocarbon rubber
GHG	Greenhouse Gas Emissions
GWDTE	Groundwater Dependent Terrestrial Ecosystems
Ha	Hectares
HDPE	High density polyethylene
HGVs	Heavy Goods Vehicles
HRAs	Habitat Regulations Assessments/Appraisals
IAQM	Institute of Air Quality Management
ICAO	The International Civil Aviation Organisation
ICES	International Council for the Exploration of the Sea
IEA	Institute of Environmental Assessment
IEMA	Institute of Environmental Management and Assessment
JNCC	Joint Nature Conservation Committee
LAmax	A-weighted, maximum sound level
LAQM	Local Air Quality Management

Term	Expanded Term
LAs	Local Authorities
LBAP	Shetland Local Biodiversity Action Plan
LEAV	Lower Exposure Action Value
LEO	Low Earth Orbit
LGVs	Light Goods Vehicles
Li	Lithium
LNM	Liquid Nitromethane
LOx	Liquid Oxygen
LRCC	Launch and Range Control Centre
LSPF	Launch Site Processing Facility
LSPs	Launch Service Providers
LULUCF	Land Use / Land Use Change Factor
LVs	Launch Vehicles
m^3	Cubic meters
MCA	Marine Coastguard Agency
MERA	Marine Environmental Risk Assessment
MMO	Marine Management Organisation
MOD	Ministry of Defence
MPAs	Marine Protected Areas
m/s	Meters per second
N_2O	Nitrous Oxide
NAMMCO	North Atlantic Marine Mammal Commission
NAQS	National Air Quality Strategy
NBN	National Biodiversity Network
NCMPA	Nature Conservation MPAs
NEAFC	North East Atlantic Fisheries Commission
NHZ	Natural Heritage Zone
NIRs	Natura Impact Reports – information/Reports to inform an Appropriate Assessment, shadow habitats regulations assessment
NISs	Natura Impact Statements
NMPs	Noise Monitoring Positions
NO_x	Nitrogen oxides
NPF	National Planning Framework
NSIDC	National Snow and Ica Data Centre
NOAA	National Oceanic and Atmospheric Administration
NSRs	Noise Sensitive Receptors
NTS	Non-Technical Summary
NVC	National Vegetation Classification
OS	Ordnance Survey

Term	Expanded Term
OSA	Outer Space Act
OTV	Orbital Transfer Vehicle
PAN	Planning Advice Note
PCA	Peatland Condition Assessment
PM_{10}	Particulate Matter with a diameter of 10 micrometers or less
$PM_{2.5}$	Particulate Matter with a diameter of 2.5 micrometers or less
PPE	Personal Protective Equipment
ppm	Parts per million
PTFE	Polytetrafluoroethylene
PTS	Permanent Threshold Shift
PVC	Polyvinyl chloride
RCP	Representative Concentration Pathway
RepLV	Representative Launch Vehicle used in SaxaVord Spaceport AEE
RFA	Rocket Factory Augsburg AG
RFA ONE NOM	Launch Vehicle
RIES	Reports on the Implications for European Sites
RP-1	Highly refined form of kerosene similar to jet fuel or Rocket Propellant
RSPB	Royal Society for the Protection of Birds
SACs	Special Areas of Conservation
SAs	Sustainability Appraisals
SBL	The Scottish Biodiversity List
SEAs	Strategic Environmental Assessments
SEL	Sound Exposure Level
SENEL	Single Event Noise Exposure Level
SEPA	Scottish Environment Protection Agency
SIA	Space Industry Act
SLM	Sound Level Meter
SNH	Scottish Natural Heritage (now NatureScot)
SoNA	Survey of Noise Attitudes Study
SPA	Special Protection Area
SSO	Sun Synchronous Orbit
SSSI	Site of Special Scientific Interest
STMP	Spectator Traffic Management Plan
SWBSG	Scottish Windfarm Bird Steering Group
TAN	Technical Advice Note
Ti	Titanium
TTS	Temporary Threshold Shift
TVC	Thrust Vector Control

Term	Expanded Term
UEAV	Upper Exposure Action Value
µg	Microgram
µm	Micrometer
UKSA	UK Space Agency
VHF	Very High Frequency radio
VMEs	Vulnerable Marine Ecosystems
VOCs	Volatile` Organic Compounds
VSRs	Vibration Sensitive Receptors
WFDAs	Water Framework Directive Assessments
WHO	World Health Organisation
Zr	Zirconium
ZTV	Zone of Theoretical Visibility

Glossary

Aborted Launch	**Aborted Launch** A launch event where the Launch Operator calls off the attempted launch following ignition – either resulting in the Launch Vehicle remaining on the pad, or the Applicant activating the flight termination system in flight.
AEE	**Assessment of Environmental Effects** The systematic process of identifying, quantifying and evaluating the potential effects of the proposed activities on the environment. The purpose of AEE is *'to ensure that applicants for spaceport licences have considered the potential environmental effects of their intended activities and, if necessary, taken appropriate and proportional steps to avoid, mitigate or offset the risks and their potential effects'*. (CAA et. al. 2021).
AOD	**Above Ordnance Datum** In the British Isles, an ordnance datum or OD is a vertical datum used by an ordnance survey as the basis for deriving altitudes on maps. A spot height may be expressed as AOD for "above ordnance datum".
AQMA	**Air Quality Management Area** Since December 1997 each local authority in the UK has been carrying out a review and assessment of air quality in their area. This involves measuring air pollution and trying to predict how it will change in the next few years. The aim of the review is to make sure that the national air quality objectives will be achieved throughout the UK by the relevant deadlines. These objectives have been put in place to protect people's health and the environment. If a local authority finds any places where the objectives are not likely to be achieved, it must declare an Air Quality Management Area there. This area could be just one or two streets, or it could be much bigger. Then the local authority will put together a plan to improve the air quality - a Local Air Quality Action Plan.
AQS	**Air Quality Strategy** This strategy sets out the comprehensive actions required across all parts of government and society to improve airy quality. The strategy sets out how we will protect the nations health and protect the environment.
BBPP	**Breeding Bird Protection Plan** All birds, their nests and eggs are protected by the Wildlife & Countryside Act 1981 as amended by the Nature Conservation (Scotland) Act 2004.
COMAH	**The Control of Major Accident Hazards Regulations (2015)** The Control of Major Accident Hazards (COMAH) Regulations ensuring that businesses: "Take all necessary measures to prevent major accidents involving dangerous substances. Limit the consequences to people and the environment of any major accidents which do occur".
CoNaW Regs	**The Control of Noise at Work Regulations** The Control of Noise at Work Regulations 2005 place a duty on employers within Great Britain to reduce the risk to their employees health by controlling the noise they are exposed to whilst at work. The regulations replaced the 'Noise at work regulations 1989' which previously covered noise in the workplace.

DMRB	**Design Manual for Roads and Bridges** Information about current standards relating to the design, assessment and operation of motorway and all-purpose trunk roads in the UK.
EZI	**Environmental Zone of Influence** The Environmental zone of influence is the area whose environmental features could be affected by the specific launch(es) to be carried out under the prospective licence.
FCS	**Favourable Conservation Status** Conservation Status will be taken as Favourable when population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and the natural range of the species is neither being reduced nor is likely to be reduced.
FID	**Flight Initiation Distance** The distance at which a bird flees from perceived danger is defined as the flight initiation distance and could be used to designate separation distances between birds and stimuli that might cause disturbances.
Flight Corridor	**Flight Corridor** An area on the Earth's surface estimated to contain the hazardous debris from nominal flight of a launch vehicle and off-nominal flight of a launch vehicle, assuming a functioning flight termination system or other flight safety system.
GPPs	**Guidance for Pollution Prevention** GPPs provide environmental good practice guidance for the whole UK, and environmental regulatory guidance directly to Northern Ireland, Scotland and Wales only.
GWDTE	**Groundwater Dependent Terrestrial Ecosystems** Groundwater Dependent Terrestrial Ecosystems (GWDTE) are wetlands which critically depend on groundwater flows or chemistries. As part of the assessment of groundwater status you have to assess if it has been significantly damaged and if the pressure causing this damage has happened via a groundwater body.
Hotfire Test	**Static Hotfire Test** Hotfire tests (also known as static hotfire tests) are when a Launch Operator carries out a hotfire test of their first stage engine(s). Hotfire tests are usually completed as part of the launch sequence and act as a dress rehearsal for actual launch, where all parts of the launch operation are simulated to ensure things go as planned on launch day.
Impact	**Impact** The change experienced by a receptor (this can be beneficial, neutral or adverse)
Impact Zone	**Impact Zone** The area representing an orbital launch vehicle's maximum impact range area, determined by computing the launch vehicle's maximum range trajectory and potential impact locations of returning components.
Launch Azimuth	**Launch Azimuth** The horizontal angular direction initially taken by a launch vehicle at lift-off, measured clockwise in degrees from true north.

Launch Vehicle	**Launch Vehicle** A launch vehicle or carrier rocket is a rocket propelled vehicle used to carry a payload from Earth's surface to space usually to Earth orbit or beyond.
LBAP	**Local Biodiversity Action Plan** Local Biodiversity Action Plan Partnerships operate at the local authority level. They were set up in the UK following the Rio Earth Summit in 1992 in response to the UK becoming a signatory to the Convention on Biological Diversity. Most local authorities work in partnership with both national environmental agencies and local biodiversity organisations to deliver local biodiversity action plans. Either the local authority employs a dedicated biodiversity officer or, as part of other posts in the local authority, an officer supports the partnership.
Nominal	**Nominal** In reference to launch vehicle performance, trajectory, or stage impact point, a launch vehicle flight where all launch vehicle aerodynamic parameters are as expected, all vehicle internal and external systems perform as planned, and there are no external perturbing influences (e.g., winds) other than atmospheric drag and gravity.
NMPI	**National Marine Plans Interactive** Is an interactive tool which is part of the Marina Scotland Open Data Network, and has been designed to assist in the development of national and regional marine planning. Allows you to view different types of information and, where appropriate, links have been provided to the related parts of Scotland's Marina Atlas, the National Marina Plan as well as links to data sources to facilitate data download.
Off-nominal Launch Event	**Off-nominal Launch Event** A launch event where the launch event proceeds beyond ignition but does not perform within expected/acceptable limits.
Orbital	**Orbital** Connected with the orbit of a planet (Earth) or object in space. In relation to launch vehicles - An orbital launch vehicle is used to deliver a payload from our planet into the Earth's orbit.
PTS	**Permanent Threshold Shift** The damage can become permanent (permanent threshold shift, PTS) if sufficient recovery time is not allowed before continued sound exposure. When the hearing loss is rooted from a traumatic occurrence, it may be classified as noise-induced hearing loss, or NIHL.
Receptor	**Receptor** Used throughout the AEE process and is defined as the element in the environment affected by a development (e.g., a bird in the case of ornithology)
Scrubbed Launch	**Scrubbed Launch** A launch event where the Launch Operator calls off the attempted launch prior to ignition.
SLM	**Sound Level Meter** Used for acoustic measurements, commonly handheld with a microphone. They provide readings on the noise level in an environment and usually return a measurement in decibels (dB).

Sounding Rocket	**Sounding Rocket** Sounding rockets are one or two stage rockets used for probing the upper atmospheric regions and for space research. They also serve as easily affordable platforms to test or prove prototypes of new components or subsystems intended for use in launch vehicles and satellites.
SPA	**Special Protection Areas** A Special Protection Area is a designation under the European Union Directive on the Conservation of wild birds. Under the Directive, Member States of the European Union (EU) have a duty to safeguard the habitats of migratory birds and certain particularly threatened birds.
Space activity	**Space activity** Space activities are defined as: (a) launching or procuring the launch or the return to earth of a space object or of an aircraft carrying a space object (b) operating a space object, or (c) any activity in outer space They are also referred to as 'spaceflight activities'.
Spacecraft	**Spacecraft** A space object, a rocket or other craft that is capable of operating above the stratosphere or a balloon that is capable of reaching the stratosphere carrying crew or passengers, that is used for spaceflight activities. It includes satellites.
Space Object	**Space Object** The component parts of a space object, its launch vehicle and the component parts of that.
SPP	**Scottish Planning Policy** A statement of Scottish Government Policy on how nationally important land use planning matters should be addressed across the country.
SSSI	**Site of Special Scientific Interest** A Site of Special Scientific Interest (SSSI) is a formal conservation designation. Usually, it describes an area that's of particular interest to science due to the rare species of fauna or flora it contains - or even important geological or physiological features that may lie in its boundaries.
SST	**Sea Surface Temperature** Sea surface temperature (SST) is the water temperature close to the ocean's surface. The exact meaning of surface varies according to the measurement method used, but it is between 1 millimetre (0.04 in) and 20 metres (70 ft) below the sea surface.
Sub-orbital	**Sub-orbital** Suborbital flights may go into space, then their path (or trajectory) carries them back to earth.

Sub-orbital activity	**Sub-orbital activity** Launching, procuring the launch of, operating or procuring the return to earth of: (a) a rocket or other craft that is capable of operating above the stratosphere (b) a balloon that is capable of reaching the stratosphere carrying crew or passengers, or (c) an aircraft carrying such a craft but does not include space activity. The regulator uses the International Standard Atmosphere (47km) as the stratopause for the purposes of determining whether an activity is 'sub-orbital'.
TAN	**Technical Advice Note** Technical Advice Notes provide guidance which may assist in the technical evaluation of noise assessment.
Test Launch	**Test Launch** A research/test launch event that proceeds beyond ignition and lift off.
Trajectory	**Trajectory** The position and velocity components as a function of time of a launch vehicle relative to an x, y, z coordinate system, expressed in x, y, z, $\dot{x}$, $\dot{y}$, $\dot{z}$.
UKVEA	**Upper Exposure Action Value** The upper exposure action value is set at a daily or weekly average noise exposure of 85 dB, above which the employer is required to take reasonably practicable measures to reduce noise exposure, such as engineering controls or other technical measures.
VOCs	**Volatile` Organic Compounds** Volatile organic compounds (VOCs) are compounds that easily become vapours or gases. VOCs are released from burning fuel such as gasoline, wood, coal, or natural gas. They are also released from many consumer products such as; cigarettes and solvents.
WHO	**World Health Organisation** WHO's primary role is to direct international health within the United Nations' system and to lead partners in global health responses.
WHO ENG	**World Health Organisation Environmental Noise Guidelines** The WHO guideline values are public health-oriented recommendations, based on scientific evidence of the health effects and on an assessment of achievable noise levels.

Volume I Non-Technical Summary

Non-Technical Summary

Volume I – Non-Technical Summary

1. Non-Technical Summary

1.1 Introduction

1.1.1 ITPEnergised has prepared this Assessment of Environmental Effects Report (AEE Report) on behalf of Rocket Factory Augsburg ('the Applicant') regarding their application to the Civil Aviation Authority (the regulator) for a license under the Space Industry Act 2018.

1.1.2 The Applicant intends to launch the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland and as such is applying to the UK Civil Aviation Authority (CAA) for a launch operator licence as required by the Space Industry Act 2018.

1.1.3 As set out in the National Space Policy (UK Government 2018) and the later National Space Strategy, the UK aims to become the European hub for commercial spaceflight and related sector technologies. The UK Government is committed to building one of the most innovative and attractive space economies in the world, supporting the growth of a robust and competitive commercial space sector growing the value of the UK Space Sector to £40 billion by 2030, representing approximately 10 % of the global market.

1.1.4 The Applicant's mission is to 'build rockets just like cars' – transferring factory concepts and serial production strategies from classical machine construction to provide short-term leaps in production efficiency. At their production facilities in Augsburg, Germany, and Matosinhos, Portugal, the Applicant combines the highest design principles with extremely cost-effective manufacturing.

1.1.5 Engineered and manufactured in Germany, the RFA ONE NOM Launch Vehicle is a three stage, ground-launched rocket with a maximum capacity of 1,300 kg payload to polar, sun synchronous and low earth orbit. The RFA ONE NOM Launch Vehicle combines three key competitive advantages: precise in-orbit delivery, extremely cost-effective architecture, and superior propulsion technology.

Space Industry Act 2018

1.1.6 The Space Industry Act 2018 received Royal Assent on 15 March 2020 and provides a legal framework for the licensing of space activities, sub-orbital activities and associated activities carried out in the UK.

1.1.7 The Act requires that person or organisation wishing to undertake the following to obtain a relevant license:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities form the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

1.1.8 As the Applicant wishes to become a spaceflight operator and launch RFA ONE NOM Launch Vehicles from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

1.1.9 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence and the regulators licensing rules, which specify what information the CAA, the regulator, requires in support of an application.

Relevant Guidance

Guidance for the Assessment of Environmental Effects

1.1.10 The CAA, with the UK Space Agency, the Department for Business, Energy and Industrial Strategy and the Department for Transport, issued guidance note '*CAP2215 Guidance for the Assessment of Environmental Effects*' in July 2021. The guidance sets out what is required by the regulator regarding assessment of environmental effects as part of a licence application under the Act.

1.1.11 The guidance describes the licence required by the Applicant as follows:

- *A launch operator licence means an operator licence within section 3 of the Act which authorises a person or organisation to carry out spaceflight activities… A person or organisation holding a launch operator licence is referred to as a spaceflight operator, or in some circumstances, launch operator licensee. If a launch operator licensee wishes to return a launch vehicle launched from the UK or the UK's territorial waters to land in the UK, it can apply to do so under the launch operator licence and does not need to apply for a separate return operator licence.*

1.1.12 AEE is relevant to applications for launch operator licences and so this document has been prepared in support of the launch operator licence application.

Guidance to the regulator on environmental objectives relating to the exercise of its functions under the Space Industry Act 2018

1.1.13 The Department for Transport issued its document '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK:

The environmental objectives for spaceflight are to:

- *Minimise emissions contributing to climate change resulting from spaceflight activities;*
- *Protect human health and the environment from the impacts of emissions on local air quality arising from spaceflight activities;*
- *Protect people and wildlife from the impacts of noise from spaceflight activities;*
- *Protect the marine environment from the impact of spaceflight activities.*

1.1.14 The objectives presented in the guidance are noted to be consistent with the environmental topics that must be addressed in an AEE. Consideration of the environmental objectives has been included as relevant in the AEE technical assessment chapters..

Location

1.1.15 The Proposed Project will operate at the SaxaVord Spaceport located at Lamba Ness in Unst, the most northerly of the Shetland Islands. The Applicant will own all of Launch Pad 1 and will launch from Launch Pad Area 1c.

1.1.16 For the purposes of this AEE, the boundary of the Proposed Project has been assumed as the areas within SaxaVord Spaceport where the delivery, preparation and launch of the RFA ONE NOM Launch Vehicle will take place. The Proposed Project site boundary is shown on Drawing 3.1 in Volume III, centred on national grid reference 466470 E, 121550 N and occupies an area of approximately 28 hectares. It is approximately 2.5 km north-east of the settlement of Norwick.

1.2 Approach to AEE

1.2.1 AEE is the systematic process of identifying, quantifying, and evaluating the potential effects of the proposed activities on the environment. This AEE Report sets out the conclusions of the AEE process undertaken in relation to the Proposed Project (Chapters 4 to 10). Where appropriate, it sets out mitigation measures designed to prevent, reduce and, if at all possible, offset significant effects. An assessment of residual effects, those expected to remain following implementation of mitigation measures, is also presented as Chapter 11.

1.2.2 As required by the CAA guidance, this launch operator AEE covers all operations and activities intended to be carried out that may have an environmental effects. Effects on the following environmental features have been considered:

- Population and human health;
- Biodiversity (ecology and ornithology);
- Air quality;
- Noise and vibration;
- Water;
- Climate;
- Marine environment;
- Land, Soils and Peat;
- Landscape, Seascape and Visual Impact;
- Material assets and cultural heritage; and
- Accidents and Disasters.

1.2.3 Of these, due to the temporary nature of each proposed launch and the fact that the delivery, assembly and launch of the RFA ONE NOM Launch Vehicle will not have significant effect on land condition due to the SaxaVord Spaceport infrastructure already in place, it is considered that the Proposed Project has no potential for significant effects on either the water environment or land, soils and peat. As such, these elements have been scoped out of the AEE.

1.2.4 As the RFA ONE NOM Launch Vehicle is only 10 m longer than the RepLV (limiting case launch vehicle) assessed for the SaxaVord Spaceport AEE, it is considered that no further assessment of landscape, seascape and visual impact is required on top of that previously submitted in the SaxaVord spaceport operator licence application AEE (reference SR-APP-001019). As discussed with the CAA om July 2023, the Applicant confirms that there have been no material changes to the SaxaVord Spaceport infrastructure required for the Proposed Project and therefore the original SaxaVord Spaceport assessment of landscape, seascape and visual impact can be an equivalent assessment for the purposes of this AEE. A letter further detailing the reasoning for this position is included as Appendix 2.1. As such, landscape and visual assessment has been scoped out of this AEE.

1.2.5 Similarly, it is considered that assessment of population effects is not required as, launch vehicle height aside, the Proposed Project is within the limiting case envelope assessed for the SaxaVord Spaceport - sub-orbital and orbital launches of small satellites into either polar or sun-synchronous, low-earth orbits. As such the assessment of population effects completed for the SaxaVord Spaceport AEE is considered appropriate to this AEE.

1.2.6 A precis of the SaxaVord Spaceport population effects chapter, updated to reflect how the Proposed Project sits within the wider SaxaVord Spaceport assessment, is included as Appendix 2.2. Relevant effects on Human Health from the Proposed Project are discussed in detail in the relevant technical chapters of the AEE Report.

1.2.7 Due to the small number of launches proposed by the Applicant (maximum 10 per year), the temporary nature of each proposed launch and the fact that the delivery, assembly and launch of the RFA ONE NOM Launch Vehicle will not have significant effect on ground condition due to the SaxaVord Spaceport infrastructure already in place, it is considered that the Proposed Project in isolation has no potential for significant effects on material assets and cultural heritage. As such, these elements have been scoped out of the AEE.

1.3 Proposed Project

1.3.1 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland. The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 orbital launches per year.

1.3.2 Following consultation with NatureScot during the planning application stage for the SaxaVord Spaceport, a commitment to a no-launch window whereby no satellite launches, or static tests will be carried out between mid-May and the end of June so as to avoid disturbing birds during the critical incubation and early brooding period was made by SaxaVord. The Applicant is aware of this operational constraint and will not schedule launches within the defined mid-May to end of June window.

1.3.3 Of the proposed 10 launches per year, when taking into account the no-launch window agreed between mid-May to the end of June, the Applicant anticipates that in any one month there will be a maximum of two launches of the RFA ONE NOM Launch Vehicle. Given the proposed frequency of launches and the short duration of the associated noise events adverse effects associated with sleep disturbance due to night-time launches are considered to be minimal.

1.3.4 The location of the Proposed Project is shown on Figure NTS-1 below.

Figure NTS-1 – Location of Proposed Project in Unst, Shetland

1.3.5 The infrastructure required for the Proposed Project will be provided by SaxaVord Spaceport, which is subject to regulation under the Act itself and has completed an AEE as part of its own Spaceport Operator Licence application (document reference LP-004-SAXA, application SR-APP-001019). The Proposed Project site layout plan shows the infrastructure of the SaxaVord Spaceport and is included as Drawing 3.2 in Volume III.

1.3.6 The Proposed Project will utilise the following existing SaxaVord Spaceport infrastructure:

- Launch Site: the most westerly of the three launch pads located on the Lamba Ness peninsula; Launch Pad 1. The Applicant will own all of Launch Pad 1 and will launch from Launch Pad 1 Area 1c. Launch Pad 1 incorporates ground services storage and control, lightning protection masts, liquid and compressed gas storage and water deluge tanks for launch operations;
- Satellite Tracking Station: an area of hardstanding housing satellite tracking and telemetry devices located on the Lamba Ness peninsula;
- Integration Hangars –
    - Launch Site Processing Facility (LSPF) hangar buildings (two): located on the Lamba Ness peninsula, the buildings where the RFA ONE NOM Launch Vehicles will be assembled and the payload(s) integrated in future years;
    - Administration Building and Hazardous Materials Store located adjacent to the LSPF on the Lamba Ness peninsula;
    - RFA AIT building: located on the Lamba Ness peninsula, a forward position building close to the launch pads for assembly, integration and testing (AIT) of launch vehicles. Prior to the LSPF being constructed, the RFA ONE NOM Launch Vehicles will be assembled and the payload(s) integrated in this building. When the LSPF buildings are in place, assembly of the Launch Vehicles will move to the LSPF and only final integration activities will take place in the RFA AIT building; and
- Support Infrastructure: located on the Lamba Ness peninsula including access, an internal track system and a series of small temporary buildings.

1.3.7 The Applicant will use only Launch Pad 1 at the SaxaVord Spaceport.

1.3.8 Subject to securing the appropriate permissions, consents and licences, the intention is to initiate first demonstration launch as soon as Q2 2024 and then increase cadence to 10 launches per year.

1.3.9 The layout of the Proposed Project, within the context of the wider SaxaVord Spaceport, is shown on Figure NTS-2.

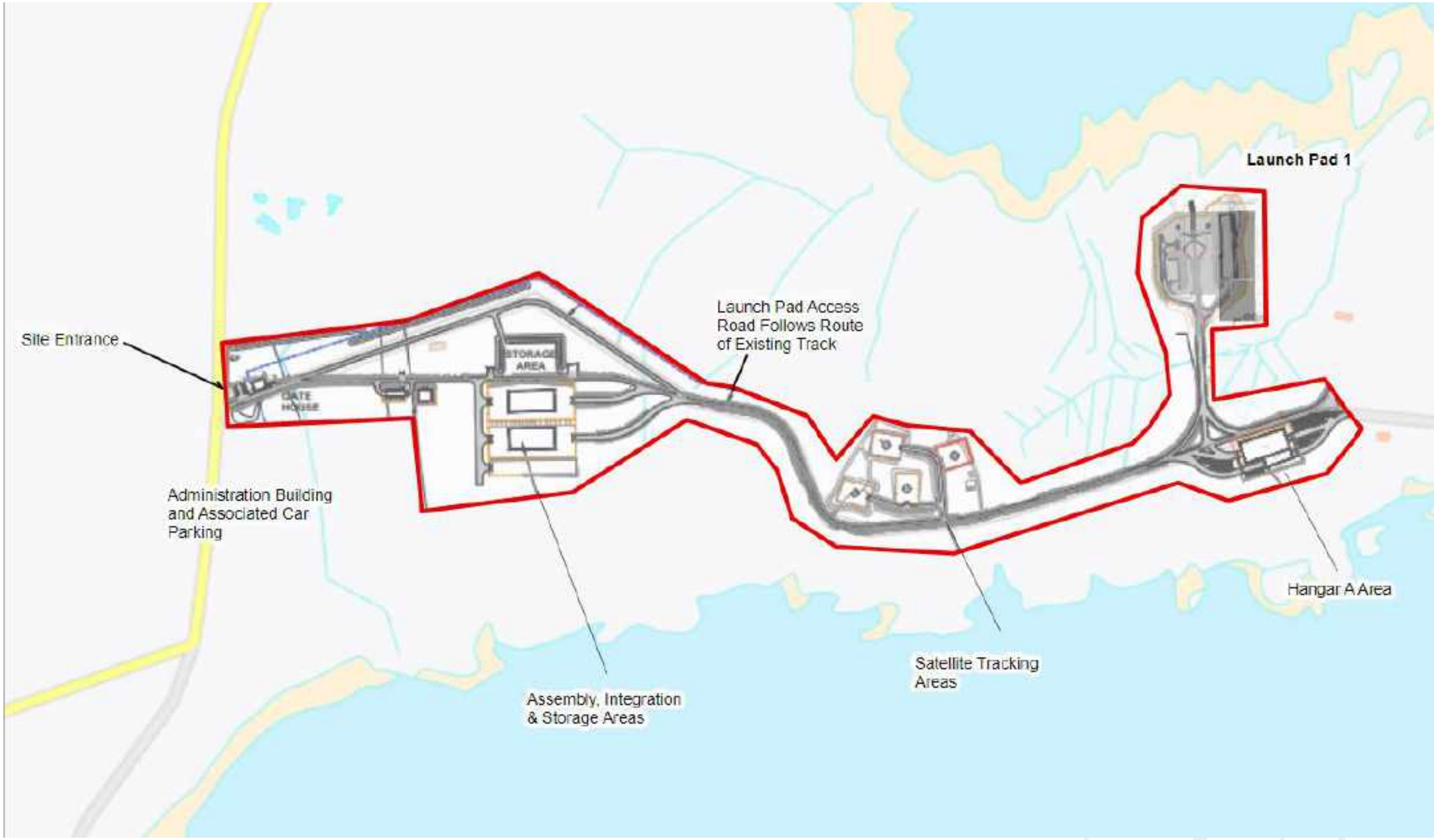

Figure NTS-2 Proposed Project Site Layout

Environmental Budget

1.3.10 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 launches per year.

1.3.11 Whilst the Applicant has not yet determined a specific timeframe for launch operations, when required for the purposes of this AEE an operational period of 30 years has been assumed, aligning with the current land lease for the SaxaVord Spaceport. This applies in particular to the process of calculating total mass of returning components, required for the Marine and Transboundary assessment (Chapter 10).

1.3.12 For other technical disciplines the appropriate timeframe for assessment varies – for example for ecology/ornithology the appropriate timeframe is considered generally to be a year due to breeding seasonality, and similarly cumulative noise effects are assessed over the period of a year. Whereas for air quality, due to the fact that only one launch will occur at any given time and launches will be phased with time enough for the EZI to return fully to the baseline state for all environmental topics between launches (i.e., no more than one launch within a 24-hour period) the appropriate assessment period is considered to be a single launch. Due to this variance between technical disciplines, appropriate timescales for assessment are detailed in each technical chapter.

1.4 Climate Change

1.4.1 An assessment of the potential effects of greenhouse gas (GHG) emissions associated with the Proposed Project on climate change has been undertaken.

1.4.2 The assessment considered emissions arising from the operation of the Proposed Project including transportation and combustion of RFA ONE NOM Launch Vehicle fuel.

1.4.3 A climate resilience assessment has been carried out to assess the vulnerability of the Proposed Project to climate change.

1.4.4 The assessment evaluated the impact of climatic variables such as wind speed, precipitation and temperature on sensitive receptors associated with the Proposed Project.

1.4.5 The climate baseline has been characterised using Met Office climate data for the period 1981-2010.

1.4.6 Potential climate change effects caused by GHG emissions associated with the Proposed Project should be considered significant in accordance with IEMA best practice guidance. These GHG emissions in the context of overall annual emissions by the Shetland Islands are considered of minor significance.

1.4.7 Mitigation measures including the development of low carbon kerosene substitutes and the continued decarbonisation of passenger and freight transport will contribute to reducing GHG emissions.

1.4.8 Climate resilience impacts on the Proposed Project associated with high temperatures are considered to be of negligible significance.

1.4.9 High wind speeds are predicted to have an effect of minor significance on the Proposed Project.

1.4.10 The effects of heavy precipitation on the Proposed Project are considered to be minor.

1.4.11 Standard mitigation has been considered in the inference of effect significance. Committed mitigation measures include suspending activities during extreme weather events and providing personnel with appropriate PPE.

1.5 Ornithology

1.5.1 Targeted and licensed breeding bird surveys were undertaken following agreed standardised survey methods between 2018 and 2020 within the ornithological study area. A total of 135 bird species were recorded during breeding bird surveys. There was direct evidence of potentially sensitive and specially protected bird species breeding within, and adjacent to, the Proposed Project boundary.

1.5.2 Ornithological designated site interests on the Hermaness, Saxa Vord and Valla Field SPA (and overlapping Hermaness SSSI and Saxa Vord SSSI) and the following non-designated wider countryside ornithological birds are taken forward for assessment: red-throated diver, merlin, black guillemot, common guillemot, puffin, razorbill, shag, kittiwake, fulmar, ringed plover, golden plover, whimbrel, curlew, dunlin, Arctic tern, Arctic skua, great skua and a confidential Schedule 1 species.

1.5.3 To understand potential impacts of loud, short duration noise events, a background literature review of noise impacts on relevant bird species was undertaken. This literature review looked at how impulsive noise (from various sources including aircraft, fireworks, military ranges and rocket launches) impacted on birds in order to help assess the potential noise impacts of the launches.

1.5.4 Potential impacts from the Proposed Project (preparation and launch of the RFA ONE NOM Launch Vehicle) have been assessed. The magnitude of predicted operational effects is either 'no effect' or 'negligible' for all bird species considered except one. Minor operational impacts are predicted for a confidential Schedule 1 breeding species (although there was no evidence of this species recorded during breeding bird surveys in 2022).

1.5.5 Confidential bird species information has been submitted to and assessed previously by the local planning authority, as part of the planning process for the Proposed Project.

1.5.6 All likely effects are assessed as non-significant, apart from a confidential Schedule 1 species, where minor magnitude operational effects are considered likely to be significant in the absence of mitigation.

1.5.7 Confidential bird species information has been submitted to and assessed previously by the local planning authority, as part of the planning process for the Proposed Project.

1.5.8 Mitigation measures inherent to operation of the Proposed Project, as confirmed and implemented through planning conditions for the SaxaVord Spaceport, are outlined in Appendix 5.3: Habitat Management Plan and comprise of the following elements that will benefit ornithological receptors: large-scale peatland restoration, creation of native broadleaved riparian woodland, coastal grassland management, offsite red-throated diver lochan habitat restoration/protection, habitat creation for a Schedule 1 breeding bird and whimbrel chick habitat creation.

1.5.9 After mitigation, all residual effects are predicted likely to be not significant.

1.6 Ecology

1.6.1 Targeted and licensed baseline ecology surveys, following best practice guidance, were undertaken between 2018 and 2020 with updated walkover and pre-construction surveys undertaken in 2022.

1.6.2 The Habitats Study Area was dominated by four Phase 1 habitats: wet modified bog/wet heath, wet modified bog, coastal grassland, and semi-improved acid grassland. The Habitat Study Area was walked over during the summer months in 2022 by the same experienced habitat surveyor that completed the original habitat survey work and no substantive changes were recorded other than the construction works commencing.

1.6.3 Numerous otter field signs were recorded during targeted surveys in 2018 and 2020. There were six-seven otter holts within the Otter Study Area. The holts were invariably within inaccessible cliff locations, between boulders or inside caves/crevices. Scats and footprints, including those of adults and young, were also recorded in the abandoned buildings across Lamba Ness. Similar evidence of otter holts and otter activity was recorded in the 2022 pre-construction surveys.

1.6.4 Otter use of an underpass was particularly noticeable in 2018, 2020 and 2022. It was considered likely that otters use this underpass as a regular route to cross from the north to south side of Lamba Ness (and vice versa) and so is likely to be functionally important to otter use of the Lamba Ness area.

1.6.5 Potential impacts of the Proposed Project on potential receptors were assessed.

1.6.6 The assessment does not predict any likely significant ecological residual effects associated with the Proposed Project.

1.7 Air Quality

1.7.1 Consideration has been given to the potential effects of the Proposed Project on local air quality. Potential impacts have been predicted at representative ecological and human health receptors in proximity to the Proposed Project and associated transportation routes.

1.7.2 Proposed project-generated traffic is predicted to have an effect of negligible significance on air quality, therefore resulting in no likely significant effect.

1.7.3 Launch emissions are predicted to have no perceptible impact at any identified receptors under prevailing wind directions. The maximum predicted impact at a sensitive receptor is predicted to occur with north-easterly winds which occur typically for less than 10 % of the year. The maximum predicted 8-hour concentration of CO is 0.61% of the AQS. Emissions from launches are therefore considered to have an effect of negligible significance on air quality, therefore resulting in no likely significant effect.

1.8 Noise

1.8.1 Potential noise and vibration effects associated with the Proposed Project have been assessed with regard to launches and associated non-launch activities. The assessment of noise and vibration relies primarily on modelling and calculations undertaken by BRRC.

1.8.2 Noise effects associated with road traffic and non-launch activities have been assessed as not significant, resulting in no likely significant effect.

1.8.3 Noise during engine tests and launches will be audible at NSRs within and beyond the study area and levels will exceed the criterion for community annoyance associated with aircraft noise. Instantaneous noise levels will be below the threshold at which damage to hearing may occur. However, the short duration of audible noise 'events' associated with engine tests and launches, and their infrequent occurrence, will reduce the associated levels of annoyance to below that which may be associated with aircraft noise from conventional airports. Accordingly, adverse health effects are not anticipated. Noise at NSRs associated with launches is below the level at which the potential for cosmetic damage to structures is likely. Noise effects associated with launches have therefore been assessed as not significant, resulting in no likely significant effect.

1.8.4 Vibration (air overpressure) associated with launches has been evaluated and found to result in a low likelihood of damage complaints and has therefore been determined to be not significant, resulting in no likely significant effect.

1.8.5 Standard mitigation has been considered in the derivation of effect significance. Committed mitigation measures include a commitment to meeting noise limits for fixed and mobile plant items and assisting SaxaVord Spaceport in maintaining good communications with the local community with regard to all activities of the Proposed Project.

1.9 Accidents

1.9.1 A list of potential events has been drawn up based on the Proposed Project activities.

1.9.2 Natural disasters including flooding and tectonic activity are considered highly unlikely given the location of the Proposed Project. Extreme weather effects have been addressed in Chapter 4 Climate Change of this AEE Report and it is considered that the proposed infrastructure design provides sufficient resilience to the effects of extreme weather events over the design life of the Proposed Project.

1.9.3 Accident events were subcategorised into failure of containment of propellant, diesel fuel and hazardous materials, ignition and off-nominal launch scenarios. The effects on generic on-site human and wildlife receptors and off-site designated habitat sites were considered for each of these events.

1.9.4 Failures of containment were generally considered to be minor or moderate significance and largely restricted to the areas immediately within the vicinity of the release point, given the quantities in use and the rapid expected evaporation and/or dispersion of the majority of bulk liquids and gases used. Mitigation will be through adherence to the Applicant's own and SaxaVord Spaceport management procedures, robust containment and restrictions on the quantities stored at the Proposed Project site.

1.9.5 Again, noting the environmental context, ignition events are considered to be major with potential for significant effects inasmuch as damage to health or loss of life to human and wildlife receptors would be possible if in close proximity to the event. In the unlikely event that ignition of kerosene occurred, the deflagration radius or resulting jet fire would be relatively small (likely within the spaceport boundary) and the subsequent blaze limited in duration by the quantities stored and used. Mitigation will be through the restriction of ignition sources from flammable materials through standard operating practices. Uncontrolled ignition events during launches are assumed to be managed through the RFA ONE NOM Launch Vehicle design process and integrity checks.

1.9.6 Off-nominal launch scenarios are considered to be of major significance should a ground strike take place, with potential for severe damage to human, wildlife and habitat receptors from impact and subsequent ignition of remaining propellant. Mitigation is inherent to the remote, northerly location of the Proposed Project and exclusively northward launch trajectories to be used. Water strikes were considered of moderate significance as wildlife and marine habitat receptors could potentially be impacted and are discussed in the Marine Effects Chapter (Chapter 10) of this AEE Report.

1.10 Marine and Transboundary Effects

1.10.1 An assessment of the potential effects of environmental effects associated with the Proposed Project on marine and transboundary receptors has been undertaken.

1.10.2 The assessment includes consideration of effects associated with the launch, and return to earth, of RFA ONE NOM Launch Vehicle components. Such marine effects may occur in Scottish waters or in the waters of other countries (i.e., transboundary effects), specifically; Denmark (Faroe Islands, Greenland), Iceland, and Norway (including Jan Mayen).

1.10.3 The Pacific EZI of the RFA ONE NOM Launch Vehicle may overlap with the Exclusive Economic Zones (EEZs) of other countries; however, the second stage will not be released on any trajectory where it will fall within the EEZs of any of these nations, unless prior permission is obtained pertinent to the specific launch.

1.10.4 The EZI encompasses an area between the SaxaVord Spaceport and approximately 4,007 km north of the launch pad. The North Atlantic and Pacific EZIs encompass the expected impact zones associated with debris from the first and second stage and payload fairing. The third stage will enter orbit.

1.10.5 The EZI comprises mostly deep water with a small amount of continental shelf and many bathymetric features. The water quality of the EZI is high, in that it does not have significant local input of anthropogenic contaminants such as metals, microplastics, and hydrocarbons. The EZI supports numerous marine biota such as plankton, benthic habitats, fish and shellfish, seabirds, and marine mammals. The EZI has few marine protected areas.

1.10.6 In the EZI, human activities are concentrated in the southern portion (as far as the Faroe Islands to the north). This includes shipping and navigation, oil and gas cables and pipelines, and commercial fishing (Drawings 10.4 – 10.6). There is occasional use of the area for military activities. Marine archaeology is poorly known and so assumed to be present. There is presence of oil and gas infrastructure, subsea cables and pipelines, marine renewable energy, dredge disposal sites, tourism, and marine archaeological features.

1.10.7 Launches have the potential to affect the aforementioned water quality, biodiversity and human activities. The pathways of effect have been identified: impacts from the presence of the RFA ONE NOM Launch Vehicle and associated materials, such as metals, microplastics, and hydrocarbons; impacts from direct strike and impact at the seabed from when the returning components come to rest.

1.10.8 The potential impacts on water quality, biodiversity, and human activities in the EZI have been assessed. All pathways have a negligible or minor risk of a likely significant effect on the receptors. No likely significant effect.

1.10.9 Because the risk is negligible or minor there is no requirement to apply mitigation in order to reduce the risk further. Accordingly, the residual effects to the receptors is also negligible or minor. No likely significant effect.

Volume II AEE Report

Chapter 1 Introduction

1. Introduction

1. Introduction

1.1 Introduction

1.1.1 ITPEnergised has prepared this Assessment of Environmental Effects Report (AEE Report) on behalf of Rocket Factory Augsburg ('the Applicant') regarding their application to the Civil Aviation Authority (the regulator) for a license under the Space Industry Act 2018.

1.1.2 The Applicant intends to launch the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland and as such is applying to the UK Civil Aviation Authority (CAA) for a launch operator licence as required by the Space Industry Act 2018.

1.1.3 For purposes of this AEE Report the proposed launch operations will be referred to as 'the Proposed Project'.

1.1.4 The location of the Proposed Project is shown on Drawing 3.1 in Volume III and a schematic of the RFA ONE NOM Launch Vehicle included as Figure 1.1. The Proposed Project is summarised in section 1.5 and described in full in Chapter 3.

Figure 1.1 RFA ONE NOM Launch Vehicle

1.2 The Applicant

1.2.1 The Applicant for the Proposed Project is Rocket Factory Augsburg AG (RFA).

1.2.2 RFA is a European commercial launch company established in 2018, with a vision to 'make space accessible for every business model'.

1.2.3 RFA is a company incorporated in Germany with its registered office at Berliner Allee 68, 86153 Augsburg, Germany.

1.3 Background

1.3.1 Growth in demand for meteorological, telecommunications, earth observation and Global Navigation Satellite Systems (GNSS) satellite services has led to rapid growth and diversification within the space industry and a marked shift from state to private provision. In the UK in 2018 the industry was worth more than £16 bn (annual growth exceeds three per cent) and comprised around 1,000 companies and organisations (UK Government, 2018). Glasgow produces more satellites than any other European city. However, currently, the "missing link" for the UK is launch capability.

1.3.2 As set out in the National Space Policy (UK Government 2018) and the later National Space Strategy (UK Government, 2021), the UK aims to become the European hub for commercial spaceflight and related sector technologies. The UK Government is committed to building one of the most innovative and attractive space economies in the world, supporting the growth of a robust and competitive commercial space sector growing the value of the UK Space Sector to £40 billion by 2030, representing approximately 10% of the global market.

1.3.3 The Applicant's mission is to 'build rockets just like cars' – transferring factory concepts and serial production strategies from classical machine construction to provide short-term leaps in production efficiency. At their production facilities in Augsburg, Germany, and Matosinhos, Portugal, the Applicant combines the highest design principles with extremely cost-effective manufacturing.

1.3.4 Engineered and manufactured in Germany, the RFA ONE NOM Launch Vehicle is a three stage, ground-launched rocket with a maximum capacity of 2,000 kg payload to polar, sun synchronous and low earth orbit. The RFA ONE NOM Launch Vehicle combines three key competitive advantages: precise in-orbit delivery, extremely cost-effective architecture, and superior propulsion technology.

1.4 Regulatory Requirements and Guidance Documents

Space Industry Act 2018

1.4.1 The Space Industry Act 2018 received Royal Assent on 15 March 2020 and provides a legal framework for the licensing of space activities, sub-orbital activities and associated activities carried out in the UK.

1.4.2 The Act requires that person or organisation wishing to undertake the following to obtain a relevant license:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities form the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

1.4.3 As the Applicant wishes to become a spaceflight operator and launch RFA ONE NOM Launch Vehicles from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

1.4.4 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence and the regulators licensing rules, which specify what information the CAA, the regulator, requires in support of an application.

Relevant Guidance

Guidance for the Assessment of Environmental Effects

1.4.5 The CAA, with the UK Space Agency, the Department for Business, Energy and Industrial Strategy and the Department for Transport, issued guidance note '*CAP2215 Guidance for the Assessment of Environmental Effects*' in July 2021. The guidance sets out what is required by the regulator regarding assessment of environmental effects as part of a licence application under the Act.

1.4.6 The guidance describes the licence required by the Applicant as follows:

- *A launch operator licence means an operator licence within section 3 of the Act which authorises a person or organisation to carry out spaceflight activities… A person or organisation holding a launch operator licence is referred to as a spaceflight operator, or in some circumstances, launch operator licensee. If a launch operator licensee wishes to return a launch vehicle launched from the UK or the UK's territorial waters to land in the UK, it can apply to do so under the launch operator licence and does not need to apply for a separate return operator licence.*

1.4.7 AEE is relevant to applications for launch operator licences and so this document has been prepared in support of the launch operator licence application.

Guidance to the regulator on environmental objectives relating to the exercise of its functions under the Space Industry Act 2018

1.4.8 The Department for Transport issued its document '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK:

The environmental objectives for spaceflight are to:

- *Minimise emissions contributing to climate change resulting from spaceflight activities;*
- *Protect human health and the environment from the impacts of emissions on local air quality arising from spaceflight activities;*
- *Protect people and wildlife from the impacts of noise from spaceflight activities;*
- *Protect the marine environment from the impact of spaceflight activities.*

1.4.9 The objectives presented in the guidance are noted to be consistent with the environmental topics that must be addressed in an AEE. Consideration of the environmental objectives has been included as relevant in the AEE technical assessment chapters.

1.5 The Proposed Project

1.5.1 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland.

1.5.2 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian. All launches will take place from Launch Pad 1 at the SaxaVord Spaceport.

1.5.3 The Proposed Project consists of the following, and where appropriate throughout, the term "Proposed Project" shall mean all of the following elements:

- Preparation of the RFA ONE NOM Launch Vehicle;
- Storage and Handling of RFA ONE NOM Launch Vehicle Propellant;
- Operation of Ground Segment and Launch Complex; and
- Launch of RFA ONE NOM Launch Vehicle (including discarded stage impact zones).

1.5.4 The Proposed Project will utilise the following existing SaxaVord Spaceport infrastructure:

- Launch Site: the most westerly of the three launch pads located on the Lamba Ness peninsula; Launch Pad 1. The Applicant will own all of Launch Pad 1 and will launch from Launch Pad 1 Area 1c. Launch Pad 1 incorporates ground services storage and control, lightning protection masts, liquid and compressed gas storage and water deluge tanks for launch operations;
- Satellite Tracking Station: an area of hardstanding housing satellite tracking and telemetry devices located on the Lamba Ness peninsula;
- Integration Hangars –
  - Launch Site Processing Facility (LSPF) hangar buildings (two): located on the Lamba Ness peninsula, the buildings where the RFA ONE NOM Launch Vehicles will be assembled and the payload(s) integrated in future years;
  - Administration Building and Hazardous Materials Store located adjacent to the LSPF on the Lamba Ness peninsula;
  - RFA AIT building: located on the Lamba Ness peninsula, a forward position building close to the launch pad for assembly, integration and testing (AIT) of launch vehicles. Prior to the LSPF being constructed, the RFA ONE NOM Launch Vehicles will be assembled, and the payload(s) integrated in this building. When the LSPF buildings are in place, assembly of the Launch Vehicles will move to the LSPF, and only final integration activities will take place in the RFA AIT building;
- Support Infrastructure: located on the Lamba Ness peninsula including access, an internal track system and a series of small temporary buildings.

1.5.5 A full description of the Proposed Project is provided in Chapter 3.

1.5.6 Subject to securing the appropriate permissions, consents and licences, the intention is to initiate first demonstration launch as soon as Q2 2024 and then increase cadence to 10 launches per year.

1.5.7 This AEE has been carried out assuming the maximum 10 launches of the RFA ONE NOM Launch Vehicle per year as a worst case scenario.

1.6 Environmental Budget

1.6.1 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 launches per year.

1.6.2 Whilst the Applicant has not yet determined a specific timeframe for launch operations, when required for the purposes of this AEE an operational period of 30 years (equating to 300 launches) has been assumed, aligning with the current land lease for the SaxaVord Spaceport. This applies in particular to the process of calculating total mass of returning components, required for the Marine and Transboundary assessment (Chapter 10).

1.6.3 For other technical disciplines the appropriate timeframe for assessment varies – for example for ecology/ornithology the appropriate timeframe is considered generally to be a year due to breeding seasonality, and similarly cumulative noise effects are assessed over the period of a year. Whereas for air quality, due to the fact that only one launch will occur at any given time and launches will be phased with time enough for the EZI to return fully to the baseline state for all environmental topics between launches (i.e., no more than one launch within a 24-hour period) the appropriate assessment period is considered to be a single launch. Due to this variance between technical disciplines, appropriate timescales for assessment are detailed in each technical chapter.

Launch Frequency

1.6.4 The Applicant's environmental budget is for a maximum of 10 launches per year. In terms of launch frequency, it is anticipated that there will be a maximum of two launches per month.

1.6.5 In line with the SaxaVord Spaceport commitment to a no-launch window between mid-May and the end of June in order to protect breeding birds, no static hotfire tests or launches of the RFA ONE NOM Launch Vehicle will be carried out during this period.

1.7 Site Description

1.7.1 The Proposed Project will operate at the SaxaVord Spaceport located at Lamba Ness in Unst, the most northerly of the Shetland Islands.

1.7.2 For the purposes of this AEE, the boundary of the Proposed Project has been assumed as the areas within SaxaVord Spaceport where the delivery, preparation and launch of the RFA ONE NOM Launch Vehicle will take place. The Proposed Project site boundary is shown on Drawing 3.1 in Volume III, centred on national grid reference 466470 E, 121550 N and occupies an area of approximately 28 hectares. It is approximately 2.5 km north-east of the settlement of Norwick.

1.7.3 There are no residential properties located within the boundary of Proposed Project or that of SaxaVord Spaceport, with the closest property, the Haa, located approximately 0.6 km away. The Haa is uninhabited and will remain so for the duration of operation of the Proposed Project as it is unfit for habitation. Accordingly, it has not been considered as a residential receptor and the closest residential receptors are therefore the properties in Norwick, located approximately 2.5 km south-west of the Proposed Project.

1.8 Designated Sites

1.8.1 A plan showing relevant designated sites within the vicinity of the Proposed Project is included as Drawing 1.1.

Ecological Designations

1.8.2 There are no statutorily designated sites relevant to ecology within the boundaries of the Proposed Project.

1.8.3 There are a number of national and international statutorily designated sites relevant to ecology in the vicinity of the Proposed Project, with 10 designated sites within 10 km as follows:

- Hermaness, Saxa Vord and Valla Field Special Protection Area (SPA) - Designated for breeding birds: fulmar (Fulmarus glacialis), gannet (Morus bassanus), great skua (Stercorarius skua), common guillemot (Uria aalge), kittiwake (Rissa tridactyla), puffin (Fratercula arctica), red-throated diver (Gavia stellata), shag (Phalacrocorax aristotelis) and breeding bird assemblages;
- Keen of Hamar Special Area of Conservation (SAC) - Designated for upland habitats: base rich scree, dry heath and grasslands on soils rich in heavy metals;
- Keen of Hamar Site of Special Scientific Interest (SSSI) - Designated for Calaminarian grassland and serpentine heath and vascular plant assemblages;

- Hill of Colvadale and Sobul SSSI - Designated for Arctic sandwort (Arenaria norvegica), breeding Arctic skua (Stercorarius parasiticus), whimbrel (Numenius phaeopus), calaminarian grassland and serpentine heath and breeding bird assemblages;
- Valla Field SSSI - Designated for breeding great skua and red-throated diver;
- Crussa Field and Heogs SSSI - Designated for breeding Arctic skua, whimbrel, vascular plant assemblages, Calaminarian grassland and serpentine heath and breeding bird assemblages;
- Hermaness SSSI - Designated for breeding gannet, great skua, guillemot, puffin and breeding seabird colony;
- Saxa Vord SSSI - Designated for breeding fulmar, guillemot and breeding seabird colony;
- Norwick Meadows SSSI - Designated for sand dune habitats and valley fen wetlands; and,
- Fetlar to Haroldswick Marine Protection Area - Designated for aggregation of breeding birds: black guillemot (Cepphus grylle), horse mussel beds, circalittoral sand and coarse sediment communities and kelp and seaweed communities on sublittoral sediment.

1.8.4 The Hermaness, Saxa Vord and Valla Field SPA lies approximately 1.5 km west of the Proposed Project along the northern Unst coastline. The SPA consists of 100-200 m high sea cliffs and adjoining areas of grassland, heath and blanket bog, and the seaward extension extends approximately 2 km into the marine environment to include the seabed, water column and surface. The boundary of the SPA is coincident with that of the Saxa Vord SSSI and Hermaness SSSI which are located approximately 3 km and 4 km north-west of the Proposed Project respectively.

1.8.5 The high cliffs and stacks of the Hermaness SSSI support large colonies of nesting seabirds, with some species individually reaching numbers of national importance. Inland from the cliffs, the bog and heath vegetation provide nesting habitat for one of the largest colonies of great skua in the world, representing over 3 % of the global population.

1.8.6 The Saxa Vord SSSI contains several skerries which, along with the sea cliffs, support a wide range of seabirds. This SSSI site is notified for its nationally and internationally important breeding fulmar and guillemot populations and for the seabird colony as a whole. The site supports a breeding colony of fulmar and guillemot contributing to 1.2% and 0.4% of the British population respectively.

1.9 Environmentally Sensitive Periods of Time

No-launch Window

1.9.1 Following consultation with NatureScot during the planning application stage for the Spaceport, SaxaVord committed to a no-launch window whereby no satellite launches, or static tests will be carried out between mid-May and the end of June so as to avoid disturbing birds during the critical incubation and early brooding period. The Applicant is aware of this operational constraint and will not schedule launches within the defined mid-May to end of June window.

Night-time Operations

1.9.2 Shetland has long hours of daylight in the summer months, but long hours of darkness in winter. In Shetland in winter at this latitude it can be dark from 3pm through to 9am.

1.9.3 However, for the purposes of this AEE night-time effects are relevant to the noise impact assessment and as such the night-time period has been assumed to be 23:00 – 07:00, as defined in Noise Guidance Document Planning Advice Note (PAN)1/2011 & Technical Advice Notes (TAN) and based on the period of time when the population is likely to be asleep or at rest.

1.9.4 Of the proposed 10 launches per year, when taking into account the no-launch window agreed between mid-May to the end of June, the Applicant anticipates that in any one month there will be a maximum of two launches of the RFA ONE NOM Launch Vehicle. Given the proposed frequency of launches and the short duration of the associated noise events adverse effects associated with sleep disturbance due to night-time launches are considered to be minimal.

1.10 Purpose of Assessment of Environmental Effects (AEE)

1.10.1 The AEE process is the systematic process of identifying, predicting and evaluating the environmental effects of a proposed project. This AEE Report sets out the conclusions of the AEE process undertaken in relation to the Proposed Project. Where appropriate, it also sets out mitigation measures designed to prevent, reduce and, if at all possible, offset significant effects. An assessment of residual effects, those expected to remain following implementation of mitigation measures, is also presented.

1.10.2 The main findings and conclusions of the AEE Report are summarised in a Non-Technical Summary (NTS) presented in Volume I.

1.11 AEE Project Team

1.11.1 The assessment has been undertaken by ITPEnergised supported by external consultants as shown in Table 1.1. CVs for the AEE team are included in Appendix 1.1.

Table 1.1 – AEE Team

Discipline	Lead Specialist	Qualifications	Accreditations	Professional Experience (years)
AEE co-ordination, introductory and concluding chapters	Ruth Fain, ITPEnergised	MGeol. (Hons) Environmental Geology	Chartered Scientist (CSci) Member of the Institution of Environmental Sciences (MIEnvSc) NEBOSH General Certificate	20+
Climate Change	Gavin Bollan, ITPEnergised	BSc (Hons) Environmental Science	Member of the Institution of Environmental Sciences, Fellow of the Institute of Air Quality Management, Chartered Scientist, Chartered Environmentalist	25+
Accidents				
Ornithology	Dr Peter Cosgrove, Alba Ecology Ltd	PhD Ornithology	FCIEEM	25+
Ecology	Dr Kate Massey, Alba Ecology Ltd	PhD Ecology	MCIEEM	13+
Air Quality	Annie Danskin, ITPEnergised	BEng (Hons) Environmental Engineering	Member of the Institution of Environmental Sciences (MIEnvSc)	20+
Noise and Vibration	Michael James, Blue Ridge Research and Consulting LLC	B.S., Mechanical Engineering, Virginia Tech M.S, Mechanical Engineering, Virginia Tech	BRRC founding member and principal. >50 military, civilian aviation, rockets, weaponry and blast noise studies including NASA and SpaceX	20+
	Simon Waddell, ITPEnergised	BSc (Hons) Environmental Geoscience, University of Edinburgh Post-graduate Diploma Acoustics and Noise Control, Institute of Acoustics	Member Institute of Acoustics (MIOA)	13+

Discipline	Lead Specialist	Qualifications	Accreditations	Professional Experience (years)
Marine Effects / Transboundary Considerations	Ian Reach, MarineSpace Ltd	BSc. (Hons) Marine Biology with Fish Biology	Professional Member of the Marine Biological Association UK	28+
	Dr Liam Dickson, MarineSpace Ltd	PhD Marine Biology	Member of the British Ecological Society	5+
Population and Human Health	Graeme Blackett, BiGGAR Economics	BA (Hons) Economics, University of Strathclyde	Member Economic Development Association Scotland Member Institute for Economic Development	30+
Landscape, Seascape and Visual Impact	Peter Dunmow, Hepla	BA (Hons) Landscape Architecture Dip LA, Landscape Architecture MA (Hons) Landscape Architecture	Chartered Member of the Landscape Institute	28+

1.12 Availability of the AEE Report

1.12.1 The CAA will undertake a formal public consultation process on this AEE. The CAA will provide the opportunity for representations to be made on the Proposed Project via the CAA consultation hub: https://consultations.caa.co.uk/. All representations will be taken into account before the CAA makes a decision on the application. Any representations on this AEE Report or other elements of the associated licence application should be made directly to the CAA.

1.13 References

Literature

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Chapter 2 Approach to AEE

2. Approach to AEE

2. Approach to AEE

2.1 Introduction

2.1.1 This AEE Report comprises a Non-Technical Summary (NTS), the main AEE Report text, accompanying drawings and technical appendices.

2.2 Legislation, Policy and Guidance

2.2.1 The Proposed Project comprises the preparation and vertical launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland. The project will be regulated under the Space Industry Act 2018 ('the Act').

2.2.2 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 3.3 m in diameter. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian.

2.2.3 The Applicant is applying for a maximum environmental budget of 10 launches per year, launching solely from Launch Pad 1 within the SaxaVord Spaceport.

2.2.4 The Proposed Project consists of the following elements:

- Preparation of RFA ONE NOM Launch Vehicle;

Storage and Handling of RFA ONE NOM Launch Vehicle Propellant;

- Operation of Ground Segment and Launch Complex; and
- Launch of RFA ONE NOM Launch Vehicle (including discarded stage impact zones).

2.2.5 Section 11 of the Act stipulates that all applicants for a launch operator licence are required to submit an assessment of environmental effects (AEE) as part of their licence application. The regulator, the Civil Aviation Authority (CAA), is required to take the AEE into account when deciding whether to grant a licence and what, if any, conditions should be attached to such a licence, and cannot grant a launch operator licence until the AEE has been submitted.

2.2.6 Under section 11(4) of the Act the regulator can permit applicants to submit an equivalent assessment, prepared previously, as part of the AEE.

2.2.7 Whilst this AEE Report is issued as a standalone AEE submission and all effects have been assessed in terms of Proposed Project, the assessment does refer to, and as relevant include as appendices, previous relevant assessments and documents submitted either to Shetland Islands Council as part of the planning application for the SaxaVord Spaceport (reference 2021/005/PPF) or to the CAA as part of the subsequent SaxaVord Spaceport operator licence application (reference SR-APP-001019) where operational phase elements of the reports relate directly to the AEE and it was considered disproportionate to duplicate these assessments as stand-alone AEE only assessments.

2.2.8 Appendices included in their original format (i.e., that which has already gone through the either planning process and been considered by Shetland Islands Council or to the CAA as part of the subsequent SaxaVord Spaceport operator licence application and can therefore be considered 'equivalent assessments') include:

- Appendix 1.1 – CVs. Included in SaxaVord Spaceport AEE as submitted previously to the CAA.
- Appendix 5.1a Shetland Space Centre Breeding Bird Survey, 2020. The document has been reviewed by Shetland Islands Council and relevant statutory consultees. Included in SaxaVord Spaceport AEE and submitted previously to the CAA. Document unchanged since then – equivalent assessment.

- Appendix 5.2 - Background Literature Review. Submitted to Shetland Islands Council with the planning application. Document unchanged since then – equivalent assessment.
- Appendix 5.3 - Detailed Habitat Management Plan, February 2022 – document produced subsequent to receipt of planning consent as part of pre-commencement conditions. The document has been reviewed by Shetland Islands Council and relevant statutory consultees. Included in SaxaVord Spaceport AEE as submitted previously to the CAA. Document unchanged since then – equivalent assessment.
- Appendix 6.1 – Natural Heritage Desk Study. Submitted to Shetland Islands Council with the planning application. Document unchanged since then – equivalent assessment.
- Appendix 6.2 – Phase 1 Habitat, NVC and GWDTE Survey Report. Submitted to Shetland Islands Council with the planning application. Document unchanged since then – equivalent assessment.
- Appendix 6.3a Otter Species Protection Plan, March 2022 - document produced subsequent to receipt of planning consent as part of pre-commencement conditions. The document has been reviewed by Shetland Islands Council and relevant statutory consultees. Included in SaxaVord Spaceport AEE as submitted previously to the CAA. Document unchanged since then – equivalent assessment.
- Appendix 6.3b Pre-construction Otter Survey Report, March 2022 - document produced subsequent to receipt of planning consent as part of pre-commencement conditions. The document has been reviewed by Shetland Islands Council and relevant statutory consultees. Included in SaxaVord Spaceport AEE as submitted previously to the CAA. Document unchanged since then – equivalent assessment.
- Appendix 6.4 – Freshwater Pearl Mussel Survey Report. Submitted to Shetland Islands Council with the planning application. Document unchanged since then – equivalent assessment.
- Appendix 6.5 – SaxaVord AEE Chapter 9 Water. Included in SaxaVord Spaceport AEE as submitted previously to the CAA. Document unchanged since then – equivalent assessment.
- Appendix 8.2 – Summary of Guidance - Included in SaxaVord Spaceport AEE as submitted previously to the CAA. Document unchanged since then – equivalent assessment.
- Appendix 8.3 – Noise Baseline Survey. Submitted to Shetland Islands Council with the planning application. Document unchanged since then – equivalent assessment.
- Appendix 8.4 – Noise Traffic Flow Data. Submitted to Shetland Islands Council with the planning application. Document unchanged since then – equivalent assessment.

2.2.9 The following appendices have been updated during the RFA SaxaVord AEE process:

- Appendix 2.1 LVIA Scoping Opinion Letter – document produced subsequent to receipt of planning consent as part of pre-application consultation with CAA. LVIA was discussed and scoped out of the AEE during the CAA teams meeting 14 October 2022.
- Appendix 2.3 Population and Human Health Precis – document produced subsequent to receipt of planning consent as part of pre-application consultation with CAA. Population and Human Health was discussed and scoped out of the AEE during the CAA teams meeting 14 October 2022.

- Appendix 4.1 GHG Calculations – document based on the calculations method included in the SaxaVord Spaceport AEE but updated to reflect RFA ONE NOM emissions.
- Appendix 7.1 Traffic Assessment - document based on the traffic flow data and method included in the SaxaVord Spaceport AEE but updated to reflect 2022 background data.
- Appendix 7.2 Launch Emissions Assessment – document based on the calculations method included in the SaxaVord Spaceport AEE but updated to reflect RFA ONE NOM emissions.
- Appendix 8.1 BRRC Noise Study – modelling and report document provided specifically for this RFA ONE NOM AEE.
- Appendix 10.1 – document based on the planning policy screening included in the SaxaVord Spaceport AEE but updated to reflect changes during the RFA ONE NOM AEE preparation period.
- Appendix 10.2 – document based on the baseline screening assessment included in the SaxaVord Spaceport AEE but updated to reflect RFA ONE NOM AEE EZI.
- Appendices 10.3, 10.4 and 10.5 Risk matrices – documents based on the risk assessment included in the SaxaVord Spaceport AEE but updated to reflect RFA ONE NOM operations.
- Appendix 10.6 – list of marine receptors specific to the RFA ONE NOM AEE.

2.2.10 In addition, Appendix 5.1b – 'Shetland Space Centre Breeding Bird Survey 2022' has also been updated during preparation of this AEE version. Whilst not specific to RFA ONE NOM operations; this update should be noted by the regulator.

2.2.11 Other than changes specific to the RFA ONE NOM Launch Vehicle, which are detailed in full in this AEE (with relevant changes made to appended documents as listed in 2.2.9 above), there have been no materially significant changes to the design of the Spaceport or the operational activities between submission of the Spaceport planning application/AEE and preparation and submission of this associated Launch Operator AEE and therefore the original appendix documents listed in 2.2.8 are considered valid for the purposes of this AEE.

2.2.12 There are no regulations for the AEE, however, under section 11(6) of the Act, the regulator is required to issue guidance. The AEE therefore follows the requirements set out in '*CAP2215 Guidance for the Assessment of Environmental Effects'* (CAA et. al. 2021). As applicable, reference is also made to guidance document *CAP1616: Airspace change: Guidance on the regulatory process for changing the notified airspace design and planned and permanent redistribution of air traffic, and on providing airspace information* (CAA, 2021).

2.2.13 In addition to the CAA guidance, in undertaking the AEE, the established framework for conducting environmental impact assessments, required by the Town and Country Planning (Environmental Impact Assessment) Regulations 2017 and Marine Works (Environmental Impact Assessment) Regulations 2017 have been considered. Within that framework, consideration has been given to the following:

- Guidelines for Environmental Impact Assessment, Institute of Environmental Management and Assessment (IEMA, 2006);
- A Handbook on Environmental Impact Assessment Version 5 (Scottish Natural Heritage, 2018); and
- Shetland Outdoor Access Strategy (Shetland Islands Council, 2019).

2.3 The AEE Process

2.3.1 The purpose of AEE is '*to ensure that applicants for launch operator licences have considered the potential environmental effects of their intended activities and, if necessary, taken appropriate and proportional steps to avoid, mitigate or offset the risks and their potential effects*' (CAA et. al. 2021).

2.3.2 AEE is the systematic process of identifying, quantifying, and evaluating the potential effects of the proposed activities on the environment. The key stages in the AEE process are presented in this chapter, with an overview of the specific methodology adopted for each technical study provided within the respective technical chapters (Chapters 4 to 12).

2.3.3 As stated in the CAA guidance document, the process of AEE can be broken down into four main phases as shown in Figure 2.1.

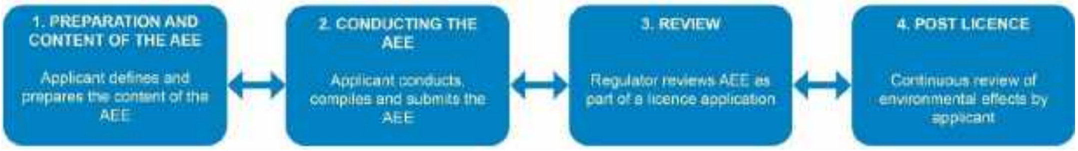

Figure 2.1 Overview of the AEE Process

2.4 Scope of the AEE

Environmental Zone of Influence

2.4.1 The environmental zone of influence (EZI) of the AEE, in other words the spatial scope or geographical coverage of the assessment, takes into account of a number of factors, in particular:

- the extent of the Proposed Project (refer to Drawing 3.1);
- the nature of the baseline environment, sensitive receptors and the likely impacts that could arise; and,
- the distance over which predicted effects are likely to remain significant and, particularly, the existence of pathways which could result in the transfer of effects to a wider geographical area than the extent of proposed physical works.

2.4.2 For the purposes of this AEE, the EZI is based on and comprises the proposed launch flight corridors (which extend in a northerly direction over the sea along azimuths of +/- 30 degrees around the meridian) and all study areas required for the technical disciplines included in the AEE.

2.4.3 The North Atlantic EZI and Pacific EZIs are presented as Drawings 3.3 and 3.4.

2.4.4 Within the EZI, the study area(s) required for each technical discipline assessed vary and as such the rationale for each study area has been included in relevant technical chapter. Individual study areas are shown in detail on Drawing 2.1.

Temporal Scope

2.4.5 The baseline year used for the assessment of effects has been taken as 2023, with the assumption that the SaxaVord Spaceport is fully constructed and operational. However, appropriate technical disciplines have carried out pre-assessment studies and/or literature reviews from wider timeframes, for example, ecology and ornithology surveys have been undertaken in 2018, 2019 and 2020 and the Climate, Heritage and Marine and Transboundary Effect chapters refer to datasets spanning the period 1970 – 2020 as relevant.

Environmental Budget

2.4.6 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 launches per year.

2.4.7 Whilst the Applicant has not yet determined a specific timeframe for operations, when required for the purposes of this AEE an operational period of 30 years (equating to 300 launches) has been assumed, aligning with the current land lease for the SaxaVord Spaceport. This applies in particular to the process of calculating total mass of returning components, required for the Marine and Transboundary assessment (Chapter 10).

2.4.8 For other technical disciplines the appropriate timeframe for assessment varies – for example for ecology/ornithology the appropriate timeframe is considered generally to be a year due to breeding seasonality, and similarly cumulative noise effects are assessed over the period of a year. Whereas for air quality, due to the fact that only one launch will occur at any given time and launches will be phased with time enough for the EZI to return fully to the baseline state for all environmental topics between launches (i.e., no more than one launch within 24 hour period) the appropriate assessment period is considered to be a single launch. Due to this variance between technical disciplines, appropriate timescales for assessment are detailed in each technical chapter.

2.5 AEE Preparation and Content

2.5.1 This AEE looks to identify, describe, and assess the potential direct and indirect significant effects of the Proposed Project.

2.5.2 A launch operator AEE is described in section 11(3)(b) of the Act:

'Assessment of environmental effects… In relation to an operator licence authorising launch of spacecraft, means an assessment that those launches are expected to have on the environment.'

2.5.3 As required by the CAA guidance, this launch operator AEE covers all operations and activities intended to be carried out that may have an environmental effect. Effects on the following environmental features have been considered:

- Population and human health;
- Biodiversity (ecology and ornithology);
- Air quality;
- Noise and vibration;
- Water;
- Climate;
- Marine environment;
- Land, Soils and Peat;
- Landscape, Seascape and Visual Impact;
- Material assets and cultural heritage; and
- Accidents and Disasters.

2.5.4 Of these, due to the temporary nature of each proposed launch and the fact that the delivery, assembly and launch of the RFA ONE NOM Launch Vehicle will not have significant effect on land condition due to the SaxaVord Spaceport infrastructure already in place, it is considered that the Proposed Project has no potential for significant effects on either the water environment or land, soils and peat. As such, these elements have not been considered further in this AEE.

2.5.5 As the RFA ONE NOM Launch Vehicle is only 10 m longer than the RepLV limiting case launch vehicle assessed for the SaxaVord Spaceport AEE, it is considered that no further assessment of landscape, seascape and visual impact is required on top of that previously submitted in the SaxaVord spaceport operator licence application AEE (reference SR-APP-001019). As discussed with the CAA om July 2023, the Applicant confirms that there have been no material changes to the SaxaVord Spaceport infrastructure required for the Proposed Project and therefore the original SaxaVord Spaceport assessment of landscape, seascape and visual impact can be considered an equivalent assessment for the purposes of this AEE. A letter further detailing the reasoning for this position is included as Appendix 2.1, and the SaxaVord Spaceport AEE Landscape, Seascape and Visual Impact Chapter has been included for reference as Appendix 2.2. Landscape and visual assessment has not been considered further in this AEE.

2.5.6 Similarly, it is considered that assessment of population effects is not required as, Launch Vehicle height aside, the Proposed Project is within the limiting case envelope assessed for the SaxaVord Spaceport - sub-orbital and orbital launches of small satellites into either polar or sun-synchronous, low-earth orbits. As such the assessment of population effects completed for the SaxaVord Spaceport AEE is considered appropriate to this AEE.

2.5.7 A precis of the SaxaVord Spaceport population effects chapter, updated to reflect how the Proposed Project sits within the wider SaxaVord Spaceport assessment, is included as Appendix 2.3. The SaxaVord Spaceport AEE Population and Human Health Chapter has been included for reference as Appendix 2.4. Whilst relevant effects on Human Health from the Proposed Project are discussed in detail in the relevant technical chapters of the AEE Report; population effects have otherwise not been considered further in this AEE.

2.5.8 Due to the small number of launches proposed by the Applicant (maximum 10 per year), the temporary nature of each proposed launch and the fact that the delivery, assembly and launch of the RFA ONE NOM Launch Vehicle will not have significant effect on material assets and cultural heritage due to the SaxaVord Spaceport infrastructure already in place, it is considered that the Proposed Project in isolation has no potential for significant effects on material assets and cultural heritage. As such, these elements have not been considered further in this AEE.

2.5.9 The likely significant cultural heritage effects of overall operation of the SaxaVord Spaceport (and within that, therefore, operation of the Proposed Project) are inherently associated with the land-take and infrastructure required for the construction of the Spaceport and were carried over into the SaxaVord Spaceport AEE for assessment only by nature of the continued operation of the Spaceport infrastructure. Cultural heritage effects of the Spaceport overall have been assessed by Shetland Islands Council and the relevant statutory consultees (including HES, NatureScot and SEPA) during the planning stage of the SaxaVord Spaceport and the Spaceport (and, by extension, associated future operations of Launch Operators) found to be suitable for development. Heritage plans and mitigation measures outlined within the Environmental Statement submitted with the Spaceport planning application have been included in the planning consent for the SaxaVord Spaceport as conditions and accepted as being appropriate from a planning perspective. No further assessment for the purposes of this AEE is required.

2.5.10 It is acknowledged that in relation to the wider spaceflight activities / environmental budget of the SaxaVord Spaceport, the SaxaVord Spaceport AEE includes a commitment to monitoring vibration during the operational phase; however, this is the responsibility of the Spaceport Operator, not of the Applicant or any other individual Launch Operator. Information on the monitoring program for the Spaceport is detailed in Chapter 14 of the SaxaVord Spaceport AEE, included for reference as Appendix 2.5. RFA is committed to complying with any related monitoring required by SaxaVord Spaceport.

2.5.11 A detailed programme for the conservation management and monitoring of cultural heritage assets in the vicinity of the Saxavord Spaceport has been supplied to Historic Environment Scotland and to Shetland Island Council to meet mitigation requirements of Scheduled Monument Consent and planning permission for the SaxaVord Spaceport respectively. This conservation management plan, which is the responsibility of SaxaVord Spaceport, sets out a programme for ongoing condition monitoring of heritage assets over the operational lifespan of the spaceport, in consultation with Historic Environments Scotland and Shetland Islands Council.

Consultation

2.5.12 Although there is no statutory requirement for applicants to undertake scoping, pre-application consultation with the CAA has been undertaken, with the scope of this AEE as outlined above discussed with the CAA on 12 October 2022.

2.5.13 Some of the consultation with statutory and non-statutory consultees in regard to operation of the SaxaVord Spaceport during the planning application phase for that development is considered relevant to this AEE and therefore, as applicable, details of consultation responses have been included in the technical chapters, alongside comments on subsequent additional post-planning consultations and any pertinent planning conditions arising from the SaxaVord Spaceport planning consent.

Conducting the AEE

2.5.14 The Applicant has engaged competence experts, as detailed in Chapter 1, to conduct the AEE.

2.5.15 The main steps in each of the technical impact assessments for the Proposed Project are as follows:

- Baseline surveys (where appropriate) to provide information on the existing baseline condition of the existing site and surrounding area.
- Consideration of the possible interactions between the Proposed Project and the existing and predicted future site conditions. These interactions or effects are assessed using stated criteria based on accepted guidance and best practice.
- Using robust design parameters for the Proposed Project, assessment of the likely significant effects, including direct effects and any indirect, secondary, short, medium, and long-term, permanent and temporary, positive and negative effects.
- Identification of any uncertainties inherent in the methods used, the predictions made, and the conclusions drawn during the assessment process.
- Identification of mitigation measures designed to avoid, reduce or off-set any significant adverse effects identified as well as enhancement measures that could result in beneficial effects.
- Assessment of the significance of any residual effects after mitigation, in relation to the sensitivity of the feature impacted upon and the magnitude of the effect predicted, in line with the relevant methodology.
- Reporting of the results of the AEE in this AEE Report.

Assessing Significance

2.5.16 Throughout the assessment, a distinction has been made between the term 'impact' and 'effect'. The Act refers to the requirement to report the significance of "effects". An impact is defined as the likely change to the characteristics/nature of the receiving environment as a result of the Proposed Project (e.g., noise from a launch), whereas the 'effect' relates to the significance of the impact (e.g., a significant residual noise effect on residential properties). These terms have been adopted throughout this AEE Report to present a consistent approach to the assessment and evaluation of effects and their significance.

2.5.17 To determine whether the potential effects of the Proposed Project are likely to be 'significant' a number of criteria are used. Criteria vary between topics but generally include:

- international, national, and local designations or standards;
- relationship with planning policy and guidance;
- sensitivity of the receiving environment;
- magnitude of impact;
- reversibility and duration of the effect; and,
- inter-relationship between effects.

2.5.18 Effects that are considered to be significant prior to mitigation but following the implementation of best practice are identified within this AEE Report. The significance attributed to the resultant effect is informed by an exercise of professional judgement in relation to the sensitivity of the affected receptor(s) and the nature, duration, frequency, and magnitude of the predicted changes/impacts. For example, a major adverse change/impact on a feature or site of low importance will have an effect of lesser significance than the same impact on a feature or site of high importance.

2.5.19 Table 2.1 is used as a guide to the relationship between the sensitivity of the identified receptor and the anticipated magnitude of an impact/change. Professional judgement is however equally important in establishing the suitability of this guiding 'formula' to the assessment of the significance of each individual effect.

Table 2.1 Inter-Relationship between Magnitude of Impact and Sensitivity of Receptor

		Sensitivity of Receptor / Receiving Environment to change			
		High	**Medium**	**Low**	**Negligible**
Magnitude of Impact / change	**High**	Major	Moderate to Major	Minor to Moderate	Minor to Negligible
	Medium	Moderate to Major	Moderate	Minor	Negligible
	Low	Minor to Moderate	Minor	Negligible to Minor	Negligible
	Negligible	Minor to Negligible	Negligible	Negligible	Negligible

2.5.20 The following terms are used in this AEE Report, unless otherwise stated, to determine the level of effects predicted to occur:

- **significant beneficial** or **adverse effect** – where the Proposed Project would result in a significant improvement (or deterioration) to the existing environment;
- **moderate beneficial** or **adverse** effect – where the Proposed Project would result in a noticeable improvement (or deterioration) to the existing environment;
- **minor beneficial** or **adverse** effect – where the Proposed Project would result in a small improvement (or deterioration) to the existing environment; and,
- **negligible** effect – where the Proposed Project would result in no discernible improvement (or deterioration) to the existing environment.

2.5.21 Using professional judgement and with reference to the Guidelines for Environmental Impact Assessment (IEMA, 2006), the majority of the assessments within this AEE Report consider effect levels of moderate or major to result in significant effects, and effect levels of minor or negligible to be non-significant. If there are deviations from this, these are clearly stated within the individual technical chapters.

2.5.22 Summary tables that outline the predicted pre-mitigation effects associated with an environmental issue, the mitigation measures proposed to address those, and the subsequent residual effect significance are provided in Chapter 11.

Assessing Cumulative Effects

2.5.23 Cumulative effects can be either inter-project or intra-project effects.

2.5.24 Inter-project cumulative effects are those where an environmental topic/receptor is affected by impacts from more than one project at the same time and the impacts act together.

2.5.25 Due to the location of the SaxaVord Spaceport, where the Proposed Project will operate from, on the north coast of Unst, the most northerly of the Shetland Islands; for all but one of the technical disciplines assessed there are no potential inter-project cumulative effects other than those from other SaxaVord Spaceport based launch operators as there are no other existing or proposed developments in the relevant EZIs. The exception to this is the marine and transboundary assessment (Chapter 10) wherein the EZI extends across a large area and therefore the Proposed Project has the potential to interact with offshore wind, marine renewables, oil and gas, other Scottish spaceports and subsea cable developments.

2.5.26 The potential for inter-project cumulative effects from separate launch service providers within the envelope of the SaxaVord Spaceport Operations and environmental budget is considered at length in the SaxaVord Spaceport AEE submitted to the Civil Aviation Authority (CAA) in 2022 (reference SR-APP-001019); the conclusion of which is *"that there are no significant operational effects of concern from the* [SaxaVord Spaceport] *Proposed Project* [i.e., launching of sub-orbital, sounding rockets and small satellites into either polar or sun-synchronous, low-earth orbits… by multiple launch service providers using a range of different launch vehicle types… up to 30 m in height] *and that the proposed activities will comply with statutory requirements and environmental policy objectives.*"

2.5.27 Intra-project cumulative effects are those where an environmental topic/receptor is affected by more than one impact from the same Proposed Project and the impacts act together.

2.5.28 Given that between environmental topics there is little overlap (for example, simultaneously occurring air quality and noise effects on a receptor have no combined cumulative effect together) and because only one launch will occur at any given time and launches will be phased with time enough for the EZI to return fully to the baseline state for all environmental topics between launches (i.e., no more than one launch within 24 hour period), for all but three of the technical disciplines assessed there are no potential intra-project cumulative effects. The exceptions to this are:

- the ornithology and ecology assessments (Chapters 5 and 6) wherein effects on birds and wildlife of noise impacts associated with satellite launches (Chapter 8) have been assessed; and
- the marine and transboundary assessment (Chapter 10) wherein the potential additive effects of multiple launches have been assessed through time.

2.5.29 Within this AEE Report, therefore, cumulative effects for each technical discipline are covered as required on a chapter by chapter basis.

Assessing Mitigation Measures

2.5.30 The AEE presents a description of the measures proposed to avoid, reduce and, if possible, offset significant adverse effects. Wherever reasonably practicable, mitigation measures have been proposed for each significant environmental effect predicted, taking various forms including:

- changes to Proposed Project design;
- physical measures applied; and,
- measures to control particular aspects of the operation of the Proposed Project.

2.5.31 Where none of the above have been deemed practicable, the Proposed Project design includes measures to offset any significant adverse effects.

2.5.32 Monitoring measures may also be proposed, where appropriate, to examine the mitigation measures to ensure that they have the desired outcomes.

2.5.33 Mitigation measures and monitoring requirements are committed to in order to ensure a level of certainty as to the environmental effects of the Proposed Project. For the avoidance of any doubt, the Applicant is committed to implementing all mitigation measures and monitoring requirements identified in this AEE Report.

Review of the AEE

2.5.34 Following submission of the AEE, the regulator will review the document to satisfy itself that the applicant's assessment is sufficiently robust and provides adequate protection of the environment.

2.5.35 As part of the review, the regulator will take into account comments received from the public or other organisations throughout the consultation process. The regulator can then:

- Determine that the environmental effects as set out in the AEE are acceptable and continue with its assessment of the licence application;
- Request that the applicant revisits some areas of the AEE and then resubmit it;
- Determine whether to impose licence conditions.

Post Licence

2.5.36 The licensee will be responsible for required monitoring of environmental effects across all environmental zones of influence throughout operation of the Proposed Project.

2.6 Assumptions, Limitations and Uncertainty

2.6.1 The AEE process is designed to enable informed decision-making based on the best available information about the environmental implications of a Proposed Project. However, it is acknowledged there will always be some uncertainty inherent in the scale and nature of the predicted environmental effects as a result of the level of detailed information available at the time of assessment, the potential for minor alterations to the Proposed Project following completion of the AEE Report and/or the limitations of the prediction processes.

2.6.2 Several assumptions have been made during the AEE process and are described below:

- The principal land uses adjacent to the Proposed Project will remain unchanged during the Proposed Project's lifetime.
- Information provided by third parties, including publicly available information and databases, are correct at the time of submission.

2.6.3 Specific assumptions may also be made with regard to the individual technical disciplines. As applicable, these are detailed within each chapter.

2.6.4 Any limitations to the AEE are summarised in each technical chapter, where relevant, together with the means proposed to mitigate these.

2.7 AEE Report

2.7.1 The AEE Report is comprised of four volumes:

- Volume I – Non-Technical Summary;
- Volume II – Main AEE Report;
- Volume III – Drawings; and
- Volume IV – Technical Appendices.

2.7.2 As suggested in the guidance document (CAA et.al. 2021), the AEE Report includes:

- a Non-Technical Summary (AEE Report Volume I);
- an Introduction (AEE Report Volume II, Chapter 1);
- Scope of the Assessment (this Chapter)
- description of the Proposed Project (AEE Report Volume II, Chapter 3);
- a description of the environmental baseline conditions, EZI, assessment methodology and conclusions on likely significant effects, including cumulative effects, of the Proposed Project on the environment (AEE Report Volume II, Chapters 4 to 10); and
- a description of the features of the Proposed Project and any measures envisaged to avoid, prevent, or reduce and, if possible, offset likely significant adverse effects (AEE Report Volume II, Chapters 4 to 10 and summarised in Chapter 11).

2.7.3 References are included within each Chapter in Volume II.

2.7.4 Volume III contains the associated drawings that inform the AEE Report.

2.7.5 Volume IV contains relevant supporting reports and information for each of the technical disciplines prepared to inform the AEE chapters in Volume II of the AEE Report.

2.8 References

Chartered Institute of Ecology and Environmental Management. (2018). *Ecological Impact Assessment Guidelines.*

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Chapter 3 Description of Proposed Project

3. Description of Proposed Project

3. Description of Proposed Project

3.1 Introduction

3.1.1 The Space Industry Act 2018 requires any organisation wishing to operate as a launch operator in the UK to obtain a relevant licence.

3.1.2 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland. The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 orbital launches per year, and as such is applying to the UK Civil Aviation Authority (CAA) for a launch operator licence as required by the Space Industry Act 2018.

3.1.3 Section 11 of the Act stipulates that all applicants for a launch operator licence are required to submit an assessment of environmental effects (AEE) as part of their licence application. The CAA is required to take the AEE into account when deciding whether to grant a licence and what, if any, conditions should be attached to such a licence.

3.2 Background

3.2.1 The Applicant's mission is to 'build rockets just like cars' – transferring factory concepts and serial production strategies from classical machine construction to provide short-term leaps in production efficiency. At their production facilities in Augsburg, Germany, and Matosinhos, Portugal, the Applicant combines the highest design principles with extremely cost-effective manufacturing.

3.2.2 Engineered and manufactured in Germany, the RFA ONE NOM Launch Vehicle is a three stage, ground-launched rocket with a maximum capacity of 2,000 kg payload to polar, sun synchronous and low earth orbit. The RFA ONE NOM Launch Vehicle combines three key competitive advantages: precise in-orbit delivery, extremely cost-effective architecture, and superior propulsion technology.

3.2.3 The Proposed Project will be operated to launch small satellites into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian. All launches will take place from Launch Pad 1 at the SaxaVord Spaceport. For safety reasons, the RFA ONE NOM Launch Vehicles will not fly over inhabited areas.

3.3 Proposed Project Location

3.3.1 The Proposed Project will operate at the SaxaVord Spaceport located at Lamba Ness in Unst, the most northerly of the Shetland Islands. The location of the Proposed Project is shown on Drawing 3.1 in Volume III.

3.3.2 For the purposes of this AEE, the boundary of the Proposed Project has been assumed as the areas within SaxaVord Spaceport where the delivery, preparation and launch of the RFA ONE NOM Launch Vehicles will take place. The Proposed Project site boundary is shown on Drawing 3.1 in Volume III. It is centred on national grid reference 466470 E, 121550 N and occupies an area of approximately 28 hectares. It is approximately 2.5 km north-east of the settlement of Norwick.

3.4 Proposed Project Infrastructure

3.4.1 The infrastructure required for the Proposed Project will be provided by SaxaVord Spaceport, which is subject to regulation under the Act itself and has completed an AEE as part of its own Spaceport Operator Licence application (document reference LP-004-SAXA, application SR-APP-001019). The Proposed Project site layout plan shows the infrastructure of the SaxaVord Spaceport and is included as Drawing 3.2 in Volume III.

3.4.2 The Proposed Project will utilise the following existing SaxaVord Spaceport infrastructure:

- Launch Site: the most westerly of the three launch pads located on the Lamba Ness peninsula; Launch Pad 1. The Applicant will own all of Launch Pad 1 and will launch from Launch Pad 1 Area 1c. Launch Pad 1 incorporates ground services storage and control, lightning protection masts, liquid and compressed gas storage and water deluge tanks for launch operations;
- Satellite Tracking Station: an area of hardstanding housing satellite tracking and telemetry devices located on the Lamba Ness peninsula;
- Integration Hangars –
  - Launch Site Processing Facility (LSPF) hangar buildings (two): located on the Lamba Ness peninsula, the buildings where the RFA ONE NOM Launch Vehicles will be assembled and the payload(s) integrated in future years;
  - Administration Building and Hazardous Materials Store located adjacent to the LSPF on the Lamba Ness peninsula;
  - RFA AIT building: located on the Lamba Ness peninsula, a forward position building close to the launch pads for assembly, integration and testing (AIT) of Launch Vehicles. Prior to the LSPF being constructed, the RFA ONE NOM Launch Vehicles will be assembled, and the payload(s) integrated in this building. When the LSPF buildings are in place, assembly of the Launch Vehicles will move to the LSPF and only final integration activities will take place in the RFA AIT building;
- Support Infrastructure: located on the Lamba Ness peninsula including access, an internal track system and a series of small temporary buildings.

3.4.3 The Applicant will use only Launch Pad 1 at the SaxaVord Spaceport. A layout plan showing Launch Pad 1 configuration for RFA launch campaigns is included for information as Drawing 3.5 in Volume III.

3.4.4 Subject to securing the appropriate permissions, consents and licences, the intention is to initiate first demonstration launch as soon as Q2 2024 and then increase cadence to 10 launches per year.

3.5 Environmental Zone of Influence

3.5.1 For the purposes of this AEE, the EZI is based on and comprises the proposed launch flight corridors (which extend in a northerly direction over the sea along azimuths of +/- 30 degrees around the meridian) and all study areas required for the technical disciplines included in the AEE.

3.5.2 The North Atlantic EZI and Pacific EZIs are presented on as drawings 3.3 and 3.4.

3.5.3 Within the EZI, the study area(s) required for each technical discipline assessed vary and as such the rationale for each study area has been included in relevant technical chapter. Individual study areas are shown in detail on Drawing 2.1.

3.6 Environmental Budget

3.6.1 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 launches per year.

3.6.2 Whilst the Applicant has not yet determined a specific timeframe for operations, when required for the purposes of this AEE an operational period of 30 years (equating to 300 launches) has been assumed, aligning with the current land lease for the SaxaVord Spaceport. This applies in particular to the process of calculating total mass of returning components, required for the Marine and Transboundary assessment (Chapter 10).

3.6.3 For other technical disciplines the appropriate timeframe for assessment varies – for example for ecology/ornithology the appropriate timeframe is considered generally to be a year due to breeding seasonality, and similarly cumulative noise effects are assessed over the period of a year. Whereas for air quality, due to the fact that only one launch will occur at any given time and launches will be phased with time enough for the EZI to return fully to the baseline state for all environmental topics between launches (i.e., no more than one launch within a 24-hour period) the appropriate assessment period is considered to be a single launch. Due to this variance between technical disciplines, appropriate timescales for assessment are detailed in each technical chapter.

3.7 Proposed Project Operations

Launch Frequency and Duration

3.7.1 The Applicant's environmental budget is for a maximum of 10 launches per year. In terms of launch frequency, it is anticipated that there will be no more than two launches per month, and no static tests or launches at all carried out between mid-May to end of June each year.

3.7.2 The duration of each RFA ONE NOM launch campaign is expected to run for around two weeks, starting with delivery of the RFA ONE NOM Launch Vehicle and ending with successful launch and demobilisation of equipment. Timings included in this section are based on current understanding of the process and may be subject to change; however, an assumption of two weeks operational campaign around each launch is considered appropriate.

3.7.3 The Applicant's launch timeline has them arriving at SaxaVord Spaceport three weeks prior to any proposed launch window with the component parts of the RFA ONE NOM Launch Vehicle and all associated commodities and payloads delivered in standard road containers. Propellants and fuels will be delivered by ISO tanker/container lorries by road.

Launch Preparation

3.7.4 The duration of each launch campaign is expected to run for around two weeks, starting with delivery of the RFA ONE NOMS Launch Vehicle and ending with successful launch and demobilisation of RFA Space Systems equipment. All operations by the Applicant will be required to align with the SaxaVord Spaceport Operational Environmental Management Plan to minimise environmental effects.

3.7.5 After arrival the RFA ONE NOM Launch Vehicle components will be unloaded in the RFA AIT hangar at SaxaVord Spaceport. Components will be unpacked and inspected to check for any damages after shipping.

3.7.6 The 13 Helix engines will be installed onto the first stage prior to it being sent out for acceptance testing at Launch Pad 1.

Static Hotfire Testing

3.7.7 The acceptance test will comprise a full-duration hotfire test event on the first stage engines and will be undertaken prior to each launch event. The hotfire test is completed as a dress rehearsal for actual launch, where all parts of the launch operation are simulated to ensure things go as planned on launch day. Static hotfire tests typically occur once in each launch mission; for example, the Applicant will carry out a static hotfire test prior to the launch window. However, if multiple launch attempts are programmed, additional tests may be required prior to each launch attempt.

3.7.8 Static engine testing outwith a launch event does not constitute a spaceflight activity and as such has not been considered within the AEE.

Integration and Transport to Launch Pad 1

3.7.9 Following successful hot fire testing, the payload will be integrated onto the third (orbital) stage in the RFA AIT hangar. The fairing and second stage will be integrated with the orbital stage and the whole assembly mounted together in the AIT hangar.

3.7.10 After integration the RFA ONE NOM Launch Vehicle will be rolled out of the RFA AIT hangar using an extendable trailer and driven to the Launch Pad 1. While in transit the RFA ONE NOM Launch Vehicle is connected to a portable HVAC system to keep it purged with dry air or nitrogen and power the vehicle. On the launch pad the RFA ONE NOM Launch Vehicle will be erected using a standard mobile crane and positioned onto the launch stool.

Launch Exclusion Zone

3.7.11 The public will be restricted from accessing the Proposed Project site during launches, and at all times the launch pads and integration buildings of the SaxaVord Spaceport will be fenced off from public access both to protect against livestock and for security reasons.

3.7.12 In order to provide public safety, measures to control a launch exclusion zone (LEZ) will be implemented by the Applicant and enforced by the Spaceport operator at specific periods of the launch, including the run-up to and during launch. The LEZ will include an area around Launch Pad 1, a downrange sea and overflight exclusion zone.

3.7.13 The dimensions of the LEZ for the RFA ONE NOM Launch Vehicle will be detailed fully in the updated RFA ONE NOM Flight Safety Case.

3.7.14 Figure 3.1 shows the intended LEZ .

Figure 3.1 LEZ schematic.

Launch Pad 1 Set Up

3.7.15 A Launch Pad 1 layout plan is provided as Drawing 3.5 in Volume III.

3.7.16 It should be noted that Drawing 3.5 differs from the Launch Pad 1 layout included in the earlier SaxaVord Spaceport AEE. This is because subsequent to that application being made, RFA has agreed a contract with SaxaVord Spaceport which affords them exclusivity on Launch Pad 1. A single launch stool has been erected at Launch Pad 1 in 2023 in the position shown on Drawing 3.5. RFA intends to use the remainder of the Launch Pad area for preparation and access activities only. There are no plans for additional launch stools to be added to Launch Pad 1.

3.7.17 Launch Pad 1 comprises a concrete slab with a launch pit sunk into it and a launch stool on which the RFA ONE NOM Launch Vehicle will sit for launch. This is a coated steel structure that forms the basis of the launch infrastructure, consisting of four 12 m high steel legs that provide support for a 120 m^3 water storage tank comprised of four standard ISO containers. The containers form the platform upon which the RFA ONE NOM will be mounted through the steel rocket adapter, which is translated to a square interface between the containers and to a round interface matching the RFA ONE NOM diameter.

3.7.18 The launch stool will be fitted out with access stairs and emergency ladders as well as handrailing around the platform. Adjacent to the launch pad is a water tank / pump house to deliver water inundation during launches. The water deluge system will be used during the launch and is designed to deliver a large quantity of water to dampen acoustic loading on the RFA ONE NOM Launch Vehicle and the launch pad during lift-off. The water also acts to reduce the temperature of exhaust gases, protecting the launch pad infrastructure.

3.7.19 The concrete slab is surrounded on three sides by a wall to contain any deluge water, if required. The slab falls towards the launch pit, such that any surface and deluge water will run-off into the launch pit. The launch pit is connected to a culvert via a manhole with a penstock valve permitting water to be diverted to an interceptor/storage tank (for collection and removal for off-site treatment) during fuelling and launch activities. When no launch activities are in operation, the penstock valve on the launch pit will be maintained open such that rainwater run-off from the launch pit will discharge into a filter trench prior to sea outfall.

3.7.20 Launch Pad 1 includes areas for storage of fuels and gases using standard ISO road containers, allowing the launch pad to be cleared between launches. The Launch Pad 1 fuel storage area has a contained concrete surface with run-off directed into a channel which discharges into a full retention alarmed interceptor, before discharging into a drainage ditch.

3.7.21 A lightning mast will be positioned at Launch Pad 1 and will comprise a telescopic tower which will be extended during a launch to an operational position of 2 m higher than the maximum Launch Vehicle / umbilical tower height. At all other times the lightning masts will be retracted to their un-extended configuration of 25 m.

RFA ONE NOM Launch Vehicle

3.7.22 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 2.1-3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three-stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits.

3.7.23 The RFA ONE NOM Launch Vehicle's primary structure is metallic, employing high-strength reliable stainless steel. The front end of the vehicle includes a custom-designed payload adapter fitting and a metallic fairing with acoustic protection.

3.7.24 The payload(s) is carried at the top of the RFA ONE NOM Launch Vehicle and is protected by fairings. Once the RFA ONE NOM Launch Vehicle is outside of the majority of the atmosphere these fairings are jettisoned to reduce weight.

Section	Length (m)
First stage	21
Second stage	5.2
Payload Fairing	8
Total Launch Vehicle	40.5
Launch Vehicle Diameter	3.3

Figure 3.2 RFA ONE NOM First Launch Specification Vehicle dimensions

3.7.25 The RFA ONE NOM Launch Vehicle uses 13 staged combustion kerolox engines with full thrust vector control (TVC) on the first stage, a single staged combustion kerolox vacuum optimised TVC-equipped engine on the second stage, and a third stage that doubles as an orbital transfer vehicle.

3.7.26 The RFA-designed engines are based on highly performing staged combustion RP1-LOx cycles, allowing for high combustion efficiencies and specific impulse. Identical engines are used in both the first stage and second stages, with minor changes for vacuum optimisation and TPU power/trimming being the only difference.

3.7.27 A fuel mix of Rocket Propellant-1 (RP-1) and liquid oxygen (LOx) is used as propellant on the Helix staged combustion engine in the first and second stages and with a nitromethane (LNM) nitrous oxide (LNO) mix in the third stage orbital engine.

3.7.28 Propellant Quantities for all three stages of the RFA ONE NOM Launch Vehicle are detailed in Table 3.1.

Table 3.1 RF1 ONE NOM Propellant Quantities

Stage	Fuel	Fuel Mass (kg)	Oxidiser	Oxidiser Mass (kg)	Ignition (kg)
First and second stages	RP1	Approximately (~) 25,000	LO_x	~60,000	TEA-TEB torch igniter (>1)
Third stage	LNM	~500	LNO	~700	Electronic (no mass)

First Stage

3.7.29 The first stage of the RFA ONE NOM Launch Vehicle is 21 m in length and 2.1 m in diameter and includes 13 Helix Staged Combustion engines providing a total thrust of 1,300 kilonewtons (kN). It primarily contains the first stage propellent tanks and engines and as such, may contain residual amounts of RP1-LOx on return to earth.

Second Stage

3.7.30 The second stage of the RFA ONE NOM Launch Vehicle is 5.2 m in length and 2.1 m in diameter and comprised of a single combustion kerolox vacuum optimized engine providing a total thrust of ~100 kN. When the 2nd stage is integrated into the vehicle it adds an additional 4.1 m of length to the RFA ONE NOM Launch Vehicle (the difference in length results from the engine being buried within the first stage during the whole integration of the launch vehicle).

3.7.31 The second stage will return to earth and may contain residual amounts of RP1-LOx.

Third Stage

3.7.32 The third stage of the RFA ONE NOM launch vehicle, also known as the orbital transfer vehicle (OTV), is propelled by a pressure fed bi-propellant engine (Nitromethane and Nitrous Oxide) which produces a total thrust of ~1.5 kN. The OTV also incorporates a standard payload adapter and is enclosed in a composite fairing.

3.7.33 The third stage Redshift OTV carries the customer payload into orbit. Following a period of time in orbit no longer than 25 years, the third stage will also re-enter the earth's atmosphere on a trajectory designed to comply with the then current regulations.

Fairings

3.7.34 The payload fairings consist of a protective shell to protect the payload from heating and atmospheric effects associated with launch. These items are constructed from composite layers, primarily carbon fibre reinforced polymers, and measure approximately 8 m in length with a maximum combined diameter of 3.3 m. The fairings will return to earth.

Launch Operations

3.7.35 Launches of RFA ONE NOM Launch Vehicle may occur at any time, with time of launch dependent on the orbital parameters required by the payload customer.

3.7.36 Full details of launch operations carried out during an RFA ONE NOM mission are contained within the RFA Space Systems Safety Operations Manual included separately as part of the launch operator licence application. The key steps in a representative typical mission are set out below.

Fuel and Propellant Transportation and Storage

3.7.37 Fuels and propellants will be transported to SaxaVord Spaceport in ISO road containers and stored in the Spaceport delivery holding area located at the Spaceport entrance prior to being taken to the Integration Hangars and Launch Pad 1. At Launch Pad 1 the containers will be stored in the designated protected areas as shown on Drawing 3.5.

3.7.38 Propellants and other substances to be stored at Launch Pad 1 to facilitate the launch of the RFA ONE NOM Launch vehicle include the following:

- RP1
- LOx
- LNM
- LNO
- Water
- GN2
- GHE
- LIN
- TEA / TEB (triethylaluminium / triethylborane)

3.7.39 RP1 will be stored at the launch pad containers located a safe distance from one another. This distance is calculated according to the Federal Aviation Administration (FAA)'s regulations for Launch Sites, specifically 14 CFR 420.

3.7.40 TEA/TEB is a pyrophoric substance which ignites on contact with atmospheric oxygen. Ampoules containing ~0.25 kg of the substance are used in each of the first two stage engines. The ampoules are filled on site in a dedicated container according to the RFA Space Systems Safety Operations Manual. TEA-TEB is stored in a sealed ampoule until use, the ampoule is breached once in position in the launch vehicle and spontaneously ignites on contact with atmospheric oxygen. The ampoule is designed to withstand mechanical and heat stress i.e., will not prematurely breach if dropped or overheated. Each ampoule will be in a casing resistant to extremes of temperatures and mechanical shock and installed as close to launch as is practicable.

Propellant Loading

3.7.41 Launch preparations will begin as soon as the RFA ONE NOM Launch Vehicle is erected on the stand and inspections completed. Firstly, umbilical's will be connected to the RFA ONE NOM Launch Vehicle, and a series of electrical and pneumatic checks performed to ensure all systems are working as intended. After the successful checkouts, the launch site will be evacuated and the RFA ONE NOM Launch Vehicle propellant tanks will be filled with RP1 and held under slight pressure. The stage 3 propellant tank will then be filled with nitromethane through the attached umbilicals. During the filling process all the instruments are continuously monitored.

3.7.42 The Lox lines will be chilled prior to Lox filling. During this filling process the high-pressure helium required for the launch will also be supplied to the RFA ONE NOM through the umbilicals on the first and second stages.

3.7.43 Once the RFA ONE NOM Launch Vehicle is fully fuelled final checks will be performed and, if passed, the RFA ONE NOM Launch Vehicle will be designated "go for launch".

Launch, Ascent, Payload Deployment and Jettisoning of Objects

3.7.44 A few minutes before launch, the RFA ONE NOM Launch Vehicle will transition to its internal power source and continue to perform an autonomous series of preparatory configurations and status checks. On successful completion, the engines will then be spin-started by supplying high pressure nitrogen through the umbilical with engine ignition occurring shortly thereafter. The umbilicals will be retracted just after ignition of the engines.

3.7.45 Approximately one second after ignition, the engines will fire-up and the signal is given by the RFA ONE NOM to the ground systems for lift-off. As soon as the ground services receives the "lift-off" command, the hold-down clamps and the umbilicals will be retracted giving way for lift-off of vehicle.

3.7.46 The RFA ONE NOM Launch Vehicle will then be launched.

3.7.47 The RFA ONE NOM Launch Vehicle is a single use launch vehicle which discards spent stages along its flight trajectory. Discarded items consist of:

- First stage
- Second stage
- Payload fairings
- Third stage (which eventually burns up in the atmosphere on re-entry from orbit)

3.7.48 The typical flight stages of the RFA ONE NOM Launch Vehicle are shown on Figure 3.3.

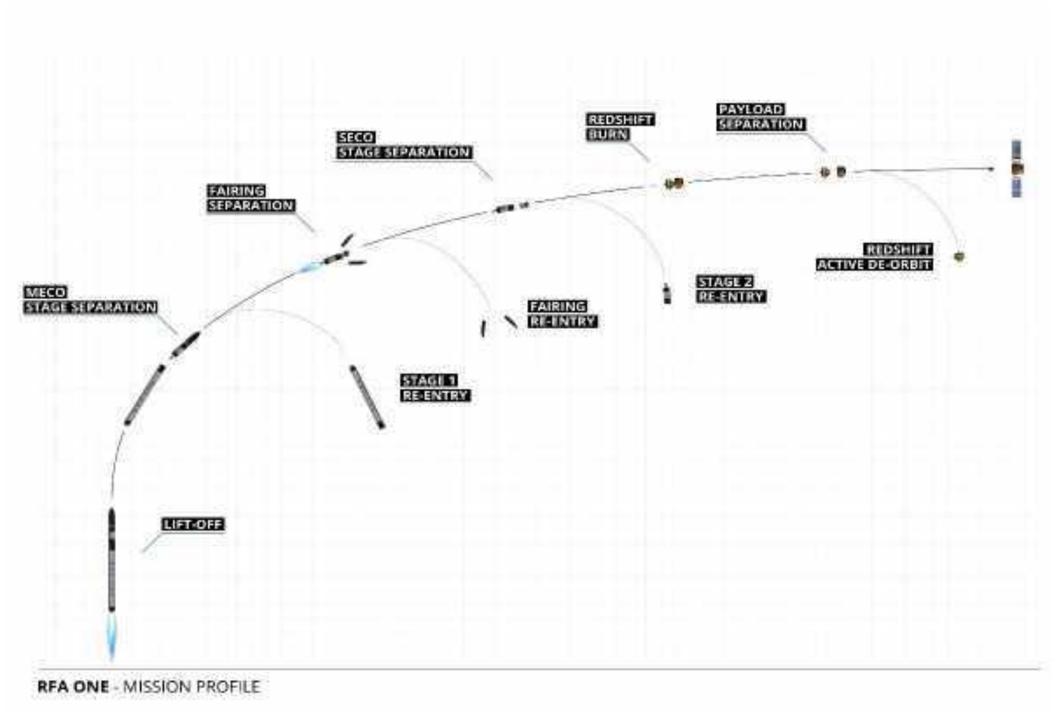

Figure 3.3 RFA ONE NOM typical flight stages

3.7.49 The EZI for the Proposed Project is contained between -30 and +30 degrees around the meridian.

3.7.50 The RFA ONE NOM Launch vehicle trajectory envelope has been provided to the CAA separately as it is considered to be commercially confidential.

3.7.51 All future launch campaigns will be aligned within the identified EZI. Each launch trajectory will be unique to the requirements of that launch campaign and the payload customers, but all launch campaigns will include contingency for modification as required due to meteorological or other aspects at the date/time of launch.

3.7.52 The RFA ONE NOM Launch vehicle is equipped with in-flight trajectory adjustment systems and a flight termination system to allow control of the Launch Vehicle during off-nominal launch scenarios.

Safety Clear Zones

3.7.53 An LEZ will be implemented at appropriate times to ensure the safety of the operation. The length of time restrictions that are in place will be kept to the practicable minimum.

Post Launch Operations

3.7.54 Post launch operations involve the inspection, demobilisation, and movement of all temporary RFA equipment into storage. The launch stool, storage tanks and line will remain in situ as the Applicant has agreed sole use of Launch Pad 1 with SaxaVord Spaceport.

Launch Trajectory and Recovery Operations

3.7.55 The proposed trajectories of the RFA ONE NOM Launch Vehicle will have an overall northerly direction from the SaxaVord Spaceport. Considering the impact zone for the payload fairings, up to three impact zones are expected per launch (first stage, the payload fairing, and second stage). The third stage carries the payload into orbit and will be on a trajectory that will result in burn-up upon re-entry into the atmosphere.

3.7.56 For the nominal trajectory, impact zones are expected to occur in marine locations between Scotland and Greenland.

3.7.57 The North Atlantic EZI for the Proposed Project (first stage and payload fairing) is indicated on Figure 3.4. The Pacific EZI for the Proposed Project (second stage) is indicated on Figure 3.5. For the purposes of this AEE, the Pacific EZI is split into zones a, b and c.

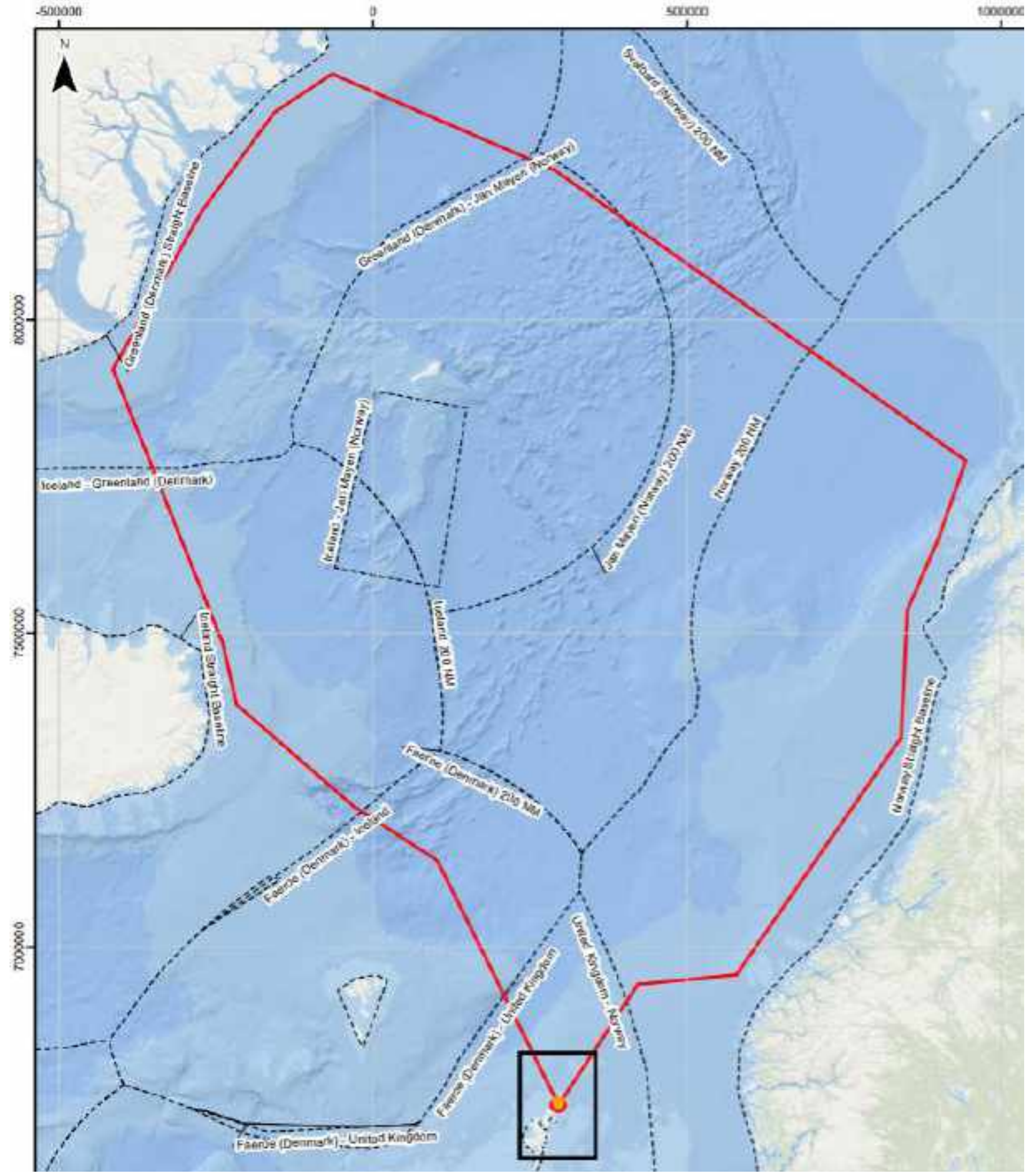

Figure 3.4 RFA ONE NOM EZI

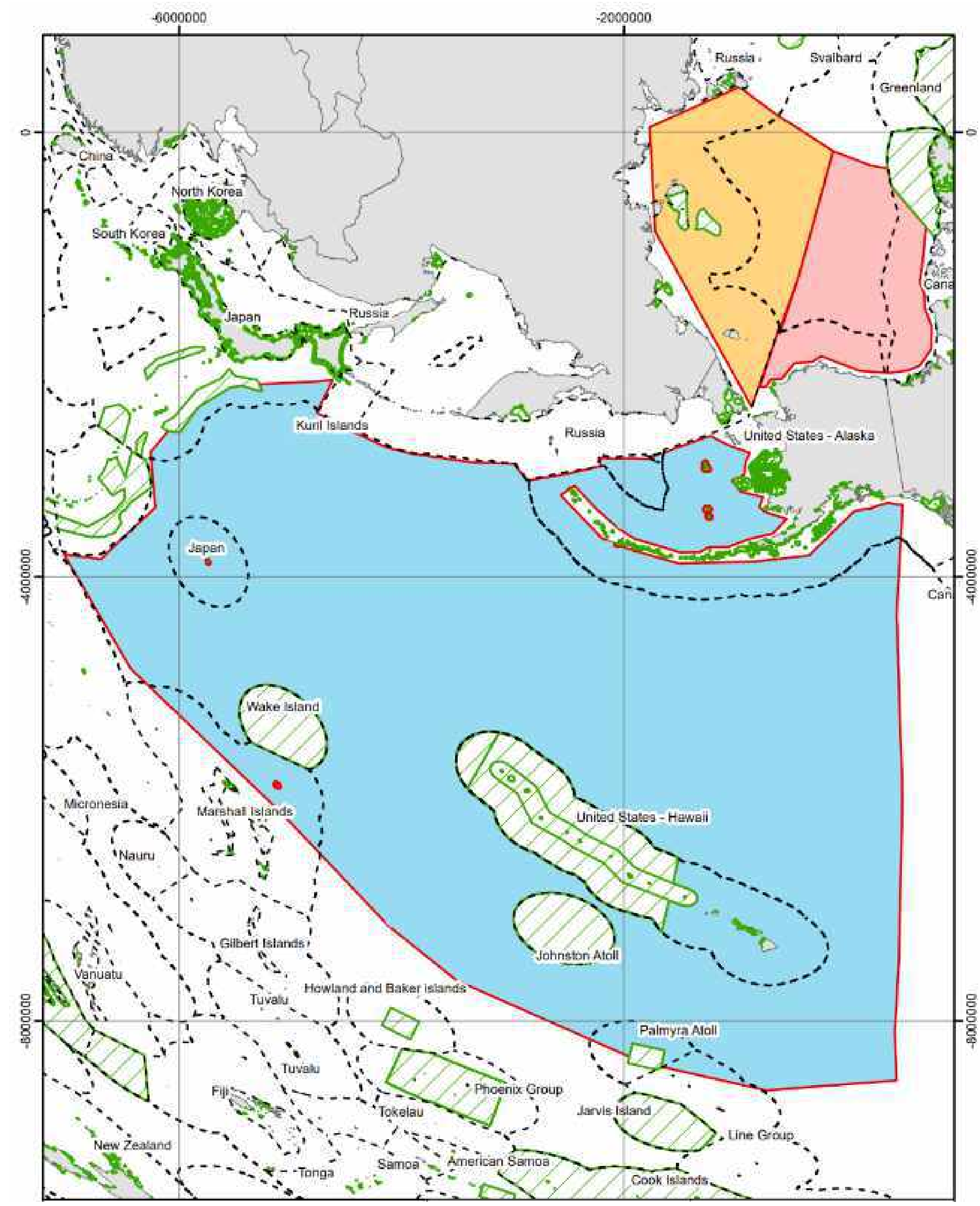

Figure 3.5 RFA ONE NOM Pacific EZI

3.7.58 The UK Government has consulted with the governments of countries where the stages or fairings are predicted to land to come to an agreement to allow stages to fall in their waters (SaxaVord Spaceport, 2020). The Pacific EZI of the RFA ONE NOM Launch Vehicle may overlap with the Exclusive Economic Zones (EEZs) of other countries; however, the second stage will not be released on any trajectory where it will fall within the EEZs of any of these nations, unless prior permission is obtained pertinent to the specific launch.

3.7.59 Noting the conditions of the Memoranda of Understanding currently in place between the UK Government and the Governments of The Faroe Islands and Iceland respectively, the Applicant will carry out the following activities:

- The Applicant will make all reasonable efforts to avoid RFA ONE NOM launch debris falling within the territory of Iceland.

- Prior to any launch activity, the Applicant will provide copies of any relevant Notices to Aviators or Notices to Mariners issued for the launch activity to the Government of The Faroe Islands and the Government of Iceland.
- On the day of launch, the Applicant will monitor the publicly available Automatic Identification Systems (AIS) information, to ensure that no fishing activity within the territories of the Faroes Islands is placed at risk by the Applicant's activities.

3.7.60 The Applicant is aware of the intergovernmental agreements with Jan Mayen and Norway that there should be no dropped debris within 12 nautical miles of the coasts of both Jan Mayen and Norway and confirms that planned trajectories and drop zones will be designed such that no debris falls either over land or within 12 nautical miles of the coast. This applies both to nominal and off-nominal launches. For off-nominal launch situations the RFA ONE NOM Launch Vehicle flight termination system would be activated prior to the RFA ONE NOM Launch Vehicle entering any area which could result in debris falling either over land or within 12 nautical miles of the coast.

3.7.61 With reference to the United Nations Convention on the Law of the Sea (UNCLOS) and associated directives to prevent, reduce and control anthropogenic input to the marine environment the Applicant will seek to minimise deposition of debris where possible, and in particular avoid MPAs/VMEs and other sensitive marine features.

3.7.62 There are currently no recovery operations planned to recover first or second stages or fairings from the RFA ONE NOM Launch Vehicle from the Icelandic EEZ or any other oceanic area. This is because recovery of stages is an expensive operation involving specialized equipment, aircraft and multiple sea craft, personnel, and logistics. The Applicant considers that:

- The window of operation is limited in time as the stages are designed to be passivated and sink after impact on sea.
- There are inherent risks associated with stage recovery. Factors such as unstable structures (the debris itself), adverse weather conditions and working far out at sea pose significant threats to the safety of the recovery team.
- Once at the bottom of the ocean, the stages, mainly constructed out of stainless steel, will start an artificial reef and serve as a habitat for marine life, contributing to biodiversity in the area as assessed in more detail in Chapter 10.
- The stages will be jettisoned at a minimum distance of 12 nautical miles from the nearest coastline, it is therefore very unlikely that there will be a justified demand from the public to remove it once the environmental benefits of such artificial reef have been communicated.

3.7.63 Therefore, it is considered that the cost and risk associated with recovery outweighs the potential benefits of removal of the debris.

Test Launches

3.7.64 For the purposes of this AEE, test launches (a test launch event that proceeds beyond ignition and lift off) have been considered as full launches within the Applicant's environmental budget.

Off-Nominal Launch Scenarios

3.7.65 Scrubbed launches (launch events where the Applicant calls off the attempted launch prior to ignition) inherently have no significant environmental effects and therefore are not considered further in the AEE.

3.7.66 Off-nominal launch events (when the launch event proceeds beyond ignition but does not perform within expected/acceptable limits) are considered further in Chapter 9 (Accidents) and Chapter 10 of this AEE Report.

3.7.67 Aborted launches (where the Applicant calls off the attempted launch following ignition – either resulting in the Launch Vehicle remaining on the pad, or the Applicant activating the flight termination system in flight) are considered interchangeable with off-nominal launch scenarios.

3.7.68 It is anticipated that the deflagration following ignition of propellant during any launch failure would create a short-lived initial fireball potentially extending several tens of metres from the pad, with the residual propellant rapidly burning off over several minutes.

3.7.69 The initial deflagration radius is not expected to extend beyond the boundary of the Proposed Project and the duration of any subsequent propellant burn-off would be minimal in the open air.

3.7.70 Peat depth and condition surveys have now completed at SaxaVord Spaceport. The NatureScot classification of peatland at the Spaceport is Class 5 (peat soil with areas of bare soil), which is consistent with data obtained during site surveys. The expectation is that the relative flammability of the substrate will be low, and that it will not be at risk of ignition following a propellant deflagration.

3.7.71 Firefighting water will be limited to damping / suppression and hence not of a volume sufficient to mobilise any combustion products. Foam is highly unlikely to be deployed given the rapid burnout of any fires.

Chapter 4 Climate Change and Resilience

4. Climate Change

4. Climate Change

4.1 Introduction

4.1.1 This chapter evaluates the potential impact of the Proposed Project on climate change due to its greenhouse gas emissions (GHG), as well as assessing the vulnerability of the Proposed Project to climate change and the need for adaptation measures where relevant.

4.1.2 The Proposed Project will have an impact on climate change due to GHG emissions resulting from transportation and fuel consumption. A reasonable worst-case scenario for carbon emissions associated with the Proposed Project has been quantified as part of a GHG assessment.

4.1.3 Following the identification of potential effects, suitable mitigation measures have been proposed, and an assessment of residual effects on environmental receptors sensitive to climate change has been undertaken.

4.2 Legislation, Policy and Guidelines

Space Industry Act

4.2.1 The Space Industry Act (2018) regulates all spaceflight activities carried out in the United Kingdom, and associated activities. The Act requires any person or organisation to obtain the relevant licence to:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities from the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

4.2.2 As the Applicant wishes to become a spaceflight operator and launch RFA ONE NOM Launch Vehicles from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

4.2.3 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence the Regulators Licensing rules, which specify what information the UK Civil Aviation Authority (CAA), the regulator, requires in support of an application.

Additional Legislation

4.2.4 Relevant legislation and guidance documents have been reviewed as part of this climate change assessment. Of particular relevance are:

- The Climate Change (Scotland) Act 2009 which required ministers to establish Scotland's programme for climate change adaptation (Scottish Government, 2009);
- The Paris Agreement 2015 which sets a target for net zero global carbon emissions in the second half of the 21st century to limit the global temperature increase to less than 2°C above pre-industrial levels. A key aim of this agreement is to strengthen national responses to combat climate change and adapt to its effects. The Paris Agreement was ratified by the UK in 2016 (UNFCCC, 2015);

- Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 which sets Scottish targets for the reduction of GHG emissions to deliver on the Paris Agreement, and makes provision about advice, plans and reports in relation to those targets. The Act sets an interim 56 % reduction target for 2020 and a Net Zero target for 2045 (Scottish Government, 2019); and,
- Scottish Government Climate Change Plan (CCP) (2018-2032) which is a roadmap for Scotland to transition to a low carbon economy. The plan sets out how Scotland will reduce emissions by 66 % over the period to 2032 (Scottish Government, 2018).

Planning Policy

4.2.5 The following policies have been taken into consideration:

- Scottish Government Climate Change Plan (CCP) (2018-2032) sets out how Scotland will continue to improve resilience to climate change and reduce emissions over the period to 2032 (Scottish Government, 2018);
- Shetland Islands Council Carbon Management Plan 2015-2020 (still extant) outlines a five-year implementation plan for achieving its desired carbon emissions reduction target of 42 % by 2020 (SIC, 2015); and
- Shetland Islands Local Development Plan 2014 policies GP1 (Sustainable Development) and GP2 (General Requirements for All Development).

Guidance

4.2.6 The following best practice guidance for assessing climate change effects has been taken into account:

- Guidance for the Assessment of Environmental Effects (CAA, 2021);
- 2015 IEMA guidance on Climate Resilience and Adaptation in EIA (amended in 2020) provides a framework for the effective consideration of climate change resilience and adaptation through EIA procedures. It includes case studies of EIAs which have considered climate adaptation and resilience issues, reflecting legislative developments and evolving practice (IEMA, 2015);
- Guidance to the Regulator on Environmental Objectives relating to the exercise of its functions under the Space Industry Act 2018 (Department for Transport, 2021); and
- Climate Change Allowance for Flood Risk Assessment in Land Use Planning (SEPA,2022).

Considerations noted in the DfT guidance for the regulator

4.2.7 The Department for Transport issued '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK.

4.2.8 The guidance notes several subject areas which are recommended for consideration by the regulator when assessing AEE reports. The CAA has not yet provided detailed guidance on the exact treatment of these areas; but for completeness, the provisional approaches taken in this AEE are summarised below.

Alternative fuels

4.2.9 Calculated emissions per launch of the RFA ONE NOM Launch Vehicle in this AEE assume that kerosene-based RP-1 is the fuel of choice in each case with liquid oxygen (LOx) acting as the oxidant. Greenhouse gas emissions per launch using other liquid or solid hydrocarbon fuels will be of a similar magnitude and other primary fossil hydrocarbon fuels would produce a similar quantity of GHGs.

4.2.10 Liquid hydrogen does have precedent as a fuel for much larger launch vehicles and can represent a low or zero GHG fuel depending on the means of production – green (renewably-powered electrolytic) hydrogen is still at a very early developmental stage in the UK as a commercial proposition. The hydrogen fuel used by NASA, for instance, is produced from steam methane reformation and uses a methane feedstock. The residual carbon dioxide is most likely emitted to air meaning that this option cannot be considered low carbon.

4.2.11 Liquid hydrogen fuel howsoever derived requires cryogenic cooling, which currently carries disproportionate weight and energy penalties for small launch vehicles. It is not considered a viable alternative to RP-1 for the Proposed Project at the time of writing.

Efficiency savings

4.2.12 There are not expected to be material opportunities for fuel savings (and hence GHG reductions) on a per-launch basis as fuel is inherently optimised to allow maximum payload per launch plus contingency. Incremental gains in efficiency through design iterations and use of more lightweight materials may be possible as the relevant technologies develop.

Ozone depletion

4.2.13 Stratospheric ozone depletion by the reaction with kerosene exhaust compounds is reported to be related to the action of black carbon caused by the incomplete combustion of hydrocarbons in the kerosene blend. Black carbon increases radiative forcing in the stratosphere, which leads in turn to warming in that atmospheric layer and an increase in the rate of reactions which contribute to ozone depletion.

4.2.14 This issue is most effectively mitigated in practice by optimising fuel mixing ratios during combustion; the desired outcome is for the maximum calorific value to be extracted from the fuel rather than wastage from incomplete combustion and black carbon formation.

4.2.15 The most effective mitigation against black carbon will be the sectoral transition to carbon-free fuels. Whilst it is possible that emissions from non-carbon fuels such as hydrogen and hydrazine will also lead to the formation of ozone-depleting chemical species, they are likely to be more reactive than black carbon and hence possess a shorter atmospheric residence time.

Meteorology

4.2.16 Local meteorological conditions are not considered a relevant consideration in the context of the climate effects of the Proposed Project but are considered by the air quality assessment (Chapter 7) in terms of their influence on dispersion of potential air pollutants formed by combustion.

Offsetting

4.2.17 Offsetting is not currently under consideration as a mitigation strategy. The Proposed Project has no scope for direct offsetting as it is a transient activity with no physical footprint where land use change could be explored. The purchase of third-party carbon credits is not considered to offer a guarantee of genuine additive GHG savings in the current market.

Other Considerations

4.2.18 Nitromethane and nitrous oxide are used as a bipropellant mixture to provide impulse for the third stage of the RFA ONE NOM Launch Vehicle. Reaction products are likely to be mixed but are assumed to be primarily composed of carbon dioxide, water and nitrogen. The RFA ONE NOM Launch Vehicle will have reached the thermosphere before third stage firing takes place, and this layer of the atmosphere is not associated with enhanced greenhouse effects from emitted gases such as carbon dioxide. However, it has been included in the overall GHG budget for a launch on a precautionary basis.

4.3 Assessment Methodology and Significance Criteria

4.3.1 The following assessments have been undertaken as part of this chapter:

- a GHG assessment to evaluate the potential effects of the Proposed Project on climate change;
- an assessment of potentially significant climate change variables on the Proposed Project; and,
- an assessment of the residual effects on environmental receptors sensitive to climate change.

Environmental Zone of Influence

4.3.2 The scope of the GHG assessment includes operational emissions of the Proposed Project which are predominated by emissions from launches.

4.3.3 The Environmental Zone of Influence (EZI) for the assessment of the potential adverse climate change effects on the Proposed Project is restricted to the Proposed Project boundary and the transport network utilised for the transport of materials and personnel.

Desk Study

4.3.4 An assessment has been undertaken of current and future climate trends in the EZI, including mean air temperature, wind speed and precipitation rate. The following sources were used to characterise existing or future baseline conditions:

- Met Office UK Climate Averages (Met Office, 2020a);
- UKCP18 Climate Projections (Met Office, 2020b); and,
- UK local authority and regional carbon dioxide emissions national statistics (BEIS, 2019).

Assessment of Potential Effect Significance

4.3.5 For the purposes of this chapter, two assessments of potential effect significance have been carried out, a GHG assessment to evaluate the potential effects of the Proposed Project on climate change and an assessment of potentially significant climate change impacts on the Proposed Project, both at the time of the first launch and at the further future years covered by the climatic modelling considered.

4.3.6 The sensitivity of the receptor has been evaluated, along with the significance of effect and the magnitude of the impact, based on the subjective judgement of the assessor. The terminology used has been defined below.

Sensitivity

4.3.7 An evaluation of the sensitivity of the Proposed Project in terms of climate change and the sensitivity of the global atmospheric environment as the receiving body for GHG emissions, was undertaken using the following terminology:

- High Sensitivity - Absolutely reliant on specific climate/global atmospheric conditions prevailing.
- Medium Sensitivity - Affected by changes in climate/global atmospheric conditions but not dependent on specific conditions.
- Low Sensitivity - Hardly influenced by climate/global atmospheric conditions at all.

Magnitude of impact

4.3.8 The magnitude of the impacts on baseline conditions has been assessed, and the following terminology has been used to define magnitude:

- High - A fundamental change (positive or negative) to the baseline condition of the receptor, leading to total loss or major alteration of character. An impact on regional GHG emissions which causes a large net increase;
- Medium - A material change (positive or negative) leading to partial loss or alteration of character. An impact on regional GHG emissions which causes an appreciable net increase;
- Low - A slight, detectable, alteration of the baseline condition which may be positive or negative. An impact on regional GHG emissions which causes a measurable net increase;
- Negligible - A barely distinguishable change from baseline conditions. Changes in GHG emissions so low as to not be practically measurable.

Significance of effect

4.3.9 Based on the sensitivity of receptors and magnitude of impact, the significance of effect has been professionally evaluated. Under environmental impact assessment legislation, major and moderate impacts are to be considered as significant:

- Major - A significant effect that is likely to be a material consideration in its own right. GHG emissions which represent a major proportion of regional totals;
- Moderate - A significant effect that may be a material consideration in combination with other significant effects but is unlikely to be a material consideration in its own right. GHG emissions which represent a recognisable change in regional totals;
- Minor - An effect that is not significant but may be of local concern. GHG emissions which though measurable do not materially affect regional totals; and
- Negligible - An effect that would result in no change to the existing environment.

Requirements for Mitigation

4.3.10 Standard mitigation measures must be implemented to lessen the impact of potentially significant climate effects on the Proposed Project, these have been outlined in Section 4.7.

4.3.11 IEMA best practice guidance considers all GHG emissions to be significant due to their contribution towards climate change; however, to assign any GHG emissions which are additive to the prevailing baseline as being of major significance is to ignore local context, which is why the magnitude and significance descriptors above have been developed.

4.3.12 To mitigate against potential significant effects, a baseline carbon footprint is calculated and then used as a basis to reduce emissions.

Limitations to Assessment

4.3.13 The principal sources of uncertainty are:

- Natural climate variability resulting from natural external influences on climate or changes in the energy received from the sun;
- Climate models represent an incomplete understanding of Earth system processes; and,
- Uncertainty in future GHG emission trends in transport vectors associated with the Proposed Project.

4.4 Baseline Conditions

Current baseline – climatic conditions

4.4.1 A local climate baseline is provided by Met Office Historic Climate Data which presents a set of 30-year averages, covering the period 1981-2010 for a range of parameters. The nearest meteorological Met Office data station to the site is Baltasound No. 2, which is located approximately 8 km to the south-west (60.749, -0.854). The data available for the Baltasound No. 2 data station comprises a representative baseline for the Proposed Project due to its close proximity, comparable altitude of 15 m above mean sea level, and the similar maritime setting on the east coast of Unst, Northern Shetland. The data is presented in Table 4.1 and summarised below:

- The Baltasound No. 2 data station recorded an average annual maximum temperature of 10.2°C, 0.5°C lower than the average annual minimum temperature for Scotland.
- The average annual minimum temperature of 5.4°C was 1.2°C warmer than the average annual minimum temperature for Scotland (4.2°C).
- An annual average of 1,108.1 mm of rain was recorded by the Baltasound No. 2 data station. This is significantly less than the average annual rainfall for Scotland between 1981-2010 which stands at 1,570.9 mm.
- The monthly mean wind speed at 10 m in Unst is 13.4 knots, with the highest average wind speed recorded in the month of January, an average of 16.7 knots.

Table 4.1 Climate averages 1981-2010 recorded by Baltasound No. 2 Station

Month	Maximum temperature (°C)	Minimum temperature (°C)	Days of air frost (days)	Rainfall (mm)	Days of rainfall ≥1 mm (days)	Monthly mean wind speed at 10 m (knots)
January	6.4	2	7.8	123	22	16.7
February	6	1.3	7.7	95.7	17.5	15.7
March	7.1	2.1	6.3	107.4	20.1	15.3
April	8.9	3.7	3.5	64.7	13.7	13.1
May	11	5.6	0.5	52.3	11.8	11.4
June	13.1	8	0	56.6	11	10.9
July	15	10.2	0	59.9	12	10.3
August	15.2	10.4	0	82.1	13.4	10.5
September	13.4	8.8	0.1	96	16.7	12.6
October	10.7	6.5	0.5	122.6	20.6	14.4
November	8.2	3.8	3.6	128	20.5	15
December	6.8	2.1	7.8	119.8	20.7	14.5
Annual	10.2	5.4	37.7	1108.1	200	13.4

Current baseline – GHG emissions

4.4.2 Local and regional CO_2 emissions data tables published by the UK Government contain historic emissions data for the period 2005 - 2019 for all UK local authorities and councils; at the time of writing in 2022 this is still the most recent dataset available. The total emissions and emissions per capita in the Shetland Islands for the reported period are reproduced in Table 4.2 and include all fossil fuel and land use / land use change factor (LULUCF) related GHG emissions. Between 2005 and 2019, CO_2 emissions per capita in the Shetland Islands have decreased consistently.

Table 4.2 Shetland Islands Local Authority CO2 emissions estimates 2005-2019 (kilotons CO2)

Year	Kilotons CO_2	Population ('000s)	Per Capita Emissions (tonnes)
2005	621.4	22.3	27.9
2006	618.4	22.2	27.8
2007	610.2	22.4	27.3
2008	594.3	22.5	26.4
2009	576.1	22.8	25.3
2010	581.2	23.1	25.2
2011	567.9	23.2	24.4
2012	564.0	23.2	24.3
2013	555.5	23.2	23.9
2014	545.8	23.2	23.5
2015	532.4	23.2	22.9
2016	516.0	23.2	22.2
2017	506.8	23.1	22.0
2018	502.2	23.0	21.8
2019	495.5	22.9	21.6

Future baseline

4.4.3 Climate projections for the periods 2020-2048 and 2050-2078 have been analysed to account for changing conditions over the proposed 50-year maximum design life of the built assets at the Proposed Project.

4.4.4 Representative Concentration Pathway 8.5 (RCP8.5) was utilised to capture the worst-case scenario future trends. RCP8.5 represents a pathway in which global population doubles to 12 billion, technology development and GDP growth is slow, and high fossil fuel consumption is sustained. This scenario assumes a culmination in radiative forcing levels of 8.5 W/m^2 by 2100.

4.4.5 The climate variables considered relevant to this assessment are mean air temperature, maximum air temperature, wind speed and precipitation.

4.4.6 The future baseline data is presented as a series of 12 thumbnail maps each representing a "member". Each member represents a plausible future climate scenario, with the ensemble members differing due to natural climate variability and uncertainty in global model physics. The 12 members therefore display the range of uncertainty in climate projections.

4.4.7 In general, the trends become more pronounced over time with more extreme trends arising by the late 2070s.

Mean Air Temperature

4.4.8 An increase in mean air temperature in Unst is expected in the 21st century. For the period 2020 - 2048, the annual mean air temperature at Unst is projected to be 1°C -2°C higher than the 1981-2010 average. This rises to 2-3°C above baseline levels for the 2050 - 2078 timescale, according to 75 % of member scenarios.

4.4.9 An identical trend is predicted for the maximum air temperature anomaly. However, there is greater uncertainty in predictions for the annual average minimum air temperature anomaly, this variable is projected to rise by between 1°C - 4°C above baseline levels under the RCP8.5 scenario.

4.4.10 The baseline maximum temperature recorded at Baltasound, Unst is 15.2°C for the month of August (see Table 4.1), and the highest temperature ever recorded by this weather station is 25°C in July 1958. The average maximum temperature in Unst over the baseline period is significantly lower than the UK average maximum temperature of 19.4°C for the month of July. As such, despite the projected warming, temperatures in Unst will remain comparatively low.

Wind Speed

4.4.11 In all member scenarios covering the 2020-2048 and 2050-78 periods, the annual average wind speed is predicted to be between 0-0.5 m/s lower than the 1981-2010 baseline levels. This minor decrease in wind speed applies to all seasons.

4.4.12 The baseline monthly mean wind speed at 10 m in Unst is 13.4 knots (6.9 m/s), which is higher than the UK average. Therefore, average wind speed in Unst will remain comparatively high, despite the projected reduction.

Precipitation rate

4.4.13 A slight increase in the annual average precipitation rate is expected over the climatic modelling period. Throughout both the 2020 - 2048 and 2050 - 2078 periods, two thirds of member scenarios predict a 0-10 % increase in the annual average precipitation rate in Unst compared to baseline levels.

4.4.14 Seasonal variation is predicted, with summer months expected to experience a slight decrease in the average precipitation rate, whilst winter months will see an increase.

4.5 Receptors Brought Forward for Assessment

4.5.1 The sensitive receptors in the instance of this climate change assessment are the RFA ONE NOM Launch Vehicles and attendant vehicles and personnel for the Proposed Project itself. In terms of climate vulnerability and the global atmospheric environment as the receiving body for GHG emissions. No individual receptors have been selected for assessment.

4.6 Standard Mitigation

4.6.1 A range of standard mitigation measures will be implemented to lessen the impact of potentially significant climate effects on the Proposed Project:

- Lamba Ness has localised areas at risk from pluvial surface water flooding, meaning the site is vulnerable to heavy rainfall. Within the SaxaVord Spaceport site there are small unnamed natural streams and watercourses, and drainage ditches have been cut in the flatter areas to aid drainage into these natural streams. A comprehensive drainage system will be implemented by SaxaVord Spaceport at the site and this will act to mitigate flood risk during operation of the Proposed Project. Drainage works will be the responsibility of SaxaVord Spaceport, but the Applicant will adhere to any associated management/operational plans required by SaxaVord Spaceport.

- Proposed Project activities will be suspended during extreme weather events to mitigate against health and safety risks for site personnel and potential damage to structures and equipment.

4.6.2 To mitigate against potential significant effects caused by the Proposed Project, the following measures will be applied to reduce resulting GHG emissions:

- Iterative increases in energy efficiency as data is collected from launches and used to inform the Launch Vehicle design process; and
- Surface and marine vehicle transport will similarly decarbonise over the later 2020s and 2030s reducing GHG emissions from these sources.

4.7 Potential Effects

Influence of the development on climate change

4.7.1 An assessment of the likely GHG emissions resulting from the Proposed Project has been undertaken in accordance with the methodology specified in Section 4.4.

4.7.2 A number of input parameters were required in order to quantify the carbon footprint, these are specified in Table 4.3.

4.7.3 A full overview of the emissions factors and calculation data is provided in Appendix 4.1.

Table 4.3 GHG Assessment Boundaries

Source of GHG Emissions	Input Data	Emissions Factor Source	Description
Transport	Distance travelled by HGV and ferry	UK Government GHG Conversion Factors for Company Reporting	GHG emissions from vehicles transporting Launch Vehicles and fuel to site
Launches	Mass of fuel consumed	UK Government GHG Conversion Factors for Company Reporting	GHG emissions resulting from fuel consumption during launches

4.7.4 The transportation of payloads to the SaxaVord Spaceport has been excluded from the assessment due to high levels of uncertainty around their source destinations. It can be assumed that this contribution would be very small for domestically produced payload items.

4.7.5 The emissions associated with a single launch of the RFA ONE NOM Launch Vehicle have been calculated and can be simply factored to represent the emissions from multiple launches.

Table 4.4 GHG Assessment (per launch)

Source of GHG Emissions	GHG Emissions (tCO_2e)
Launch	70.6
Transport of RFA ONE NOM Launch Vehicle	9.7
Total	**80.3**

4.7.6 The major contributor to GHG emissions will be the combustion of fuel during the actual launches.

4.7.7 The other major component of GHG emissions will be from the transportation of the RFA ONE NOM Launch Vehicles to the launch site. The fairings will be sourced from Porto, Portugal with the remainder of the componentry supplied from Augsburg in Germany. Emissions from the transportation of the RFA ONE NOM Launch Vehicle, fuel and oxidant are assumed to require a total of four shipping containers (one from Portugal and three from Germany) loaded onto articulated lorries, travelling the distance from the works at Porto and Augsburg by road to the nearest suitable port (Leixoes and Hamburg respectively) with onward transport by small container vessel to Aberdeen. A combination of ferry and road transport is assumed to deliver the loads from Aberdeen to Lerwick and thence to SaxaVord Spaceport.

4.7.8 Distance and emission factor assumptions are presented in Appendix 4.1.

4.7.9 GHG emissions are assessed as a low impact given that they are too large to be considered negligible but do not represent a significant proportion of regional emissions. As such they are considered to represent **no likely significant effect**.

4.7.10 The effects of the GHG emissions caused by the Proposed Project are theoretically reversible as natural processes and emerging technologies such as Direct Air Capture can fix atmospheric carbon dioxide on a temporary or permanent basis. However, the Precautionary Principle suggests that these removal vectors should not be assumed and that the effects be considered permanent.

Vulnerability of the development to climate change

High wind speeds

4.7.11 Damage to the RFA ONE NOM Launch Vehicle may occur as a result of high wind loading. Launches may be delayed due to the suspension of ferry routes and flights. The Proposed Project is considered moderately sensitive to the effects of high wind speeds.

4.7.12 Met Office climate models anticipate that there will be a barely distinguishable change from baseline wind speed conditions between 2020 - 2078.

4.7.13 The annual average wind speed is predicted to be between 0-0.5 ms^{-1} lower than the 1981 - 2010 baseline levels. This minor decrease in wind speed can be considered a negligible impact of climate change. Although climate change is likely to result in a negligible decrease in wind speed for the northern Shetland Islands, extreme wind events will remain a risk to the Proposed Project site as the baseline annual mean wind speed for Unst is amongst the highest in the UK at 13.4 knots. Consequently, wind speed can be considered to pose a moderate adverse effect to the Proposed Project.

4.7.14 To mitigate against launch failure during extreme wind conditions, the weather needs to be closely monitored in the days preceding a launch and the launch delayed if wind speeds are deemed high enough to potentially cause damage to the RFA ONE NOM Launch Vehicle, payload or on-site structures. Furthermore, to minimise the effect that transport route suspensions may have on launches, goods and services will be sourced as close to the Proposed Project site as practicable. Following the implementation of these mitigation measures, the effect of strong winds on the Proposed Project can be considered minor adverse with **no likely significant effect**.

Heavy precipitation

4.7.15 Extreme rainfall events could cause pluvial surface water flooding which may impact upon operation of the Proposed Project. On-site roads and off-site access routes may experience erosion through scour caused by surface water flooding events. This may result in access restrictions for equipment and staff critical to the launch. In addition, electrical equipment may fail due to water ingress. Due to the potential for delay to launches, the receptors are deemed to be moderately sensitive to heavy rainfall.

4.7.16 A slight increase in the annual average precipitation rate is expected from first launch until the late 2070s. Throughout both the 2020-2048 and 2050- 2078 periods, two thirds of scenarios predict a 0-10 % increase in the annual average precipitation rate in Unst, compared to baseline levels. The projected slight increase in precipitation can be considered a minor adverse impact of climate change due to the low magnitude of change above baseline levels.

4.7.17 Due to the above factors, prior to the implementation of mitigation, pluvial flooding caused by heavy rainfall has the potential to have a moderate adverse impact on the Proposed Project.

4.7.18 SEPA's Climate Change Allowance for Flood Risk Assessment in Land Use Planning guidance advises that a 40 % increase in rainwater drainage provision be applied to activities taking place in Shetland.

4.7.19 A drainage strategy and system has been designed by SaxaVord Spaceport to mitigate against localised surface water pooling and flooding, and the implementation of this strategy will reduce the potential effect of heavy rainfall on the operation of the Proposed Project to minor adverse with **no likely significant effect**.

High temperatures

4.7.20 High temperatures may result in heatwaves and droughts, which could cause personnel welfare impacts (for example, heat stress), damage to machinery through overheating, and an increased risk of fire.

4.7.21 Throughout the climatic modelling window examined at the Proposed Project site, an increase in mean air temperature in northern Shetland is predicted. For the period 2020-2048, the annual mean air temperature in Unst is projected to be 1-2°C higher than the 1981-2010 average. This rises to 2-3°C above baseline levels for the 2050-2078 timescale, according to 75 % of member scenarios.

4.7.22 Based on Met Office climate data from 1981 - 2001, temperatures in Unst are consistently low; the baseline maximum temperature is 15.2°C for August, compared to an average of 19.1°C across the UK. Furthermore, extreme hot weather events occur infrequently and are of a low magnitude; the hottest temperature ever recorded at Baltasound was 25°C in July 1958. The predicted trend towards rising temperatures may increase the frequency of heatwaves and droughts in Unst. However, extreme temperatures are unlikely to be of a high enough magnitude to have a significant impact on the Proposed Project site, so this constitutes a minor climate change impact.

4.7.23 Considering the sensitivity of the receptor of human health and the potential for the magnitude of impact to rise throughout the design life of the Proposed Project, high temperatures have the potential to have a minor effect.

4.7.24 Appropriate standard mitigation measures will be applied in the event of high temperature conditions. Personnel will be provided with appropriate personal protective equipment (PPE) to mitigate against the health and safety risks posed by heat and the availability of drinking water confirmed. Following the implementation of these measures, heat will pose a negligible risk to the Proposed Project and therefore result in **no likely significant effect**.

4.8 Residual Effects

4.8.1 No significant residual effects have been identified following the implementation of mitigation measures.

4.9 Cumulative Assessment

4.9.1 The climate resilience risks identified are limited in their spatial extent to the Proposed Project and therefore no cumulative effect with other committed developments is considered in this climate change impact assessment.

4.10 Summary

4.10.1 An assessment of the potential effects of GHG emissions associated with the Proposed Project on climate change has been undertaken.

4.10.2 The assessment considered emissions arising from the operation of the Proposed Project including transportation and combustion of RFA ONE NOM Launch Vehicle fuel.

4.10.3 A climate resilience assessment has been carried out to assess the vulnerability of the Proposed Project to climate change.

4.10.4 The assessment evaluated the impact of climatic variables such as wind speed, precipitation and temperature on sensitive receptors associated with the Proposed Project.

4.10.5 The climate baseline has been characterised using Met Office climate data for the period 1981-2010.

4.10.6 GHG emissions in the context of overall annual emissions by the Shetland Islands are considered of minor significance.

4.10.7 Mitigation measures including the development of low carbon kerosene substitutes and the continued decarbonisation of passenger and freight transport will contribute to reducing GHG emissions.

4.10.8 Climate resilience impacts on the Proposed Project associated with high temperatures are considered to be of negligible significance.

4.10.9 High wind speeds are predicted to have an effect of minor significance on the Proposed Project.

4.10.10 The effects of heavy precipitation on the Proposed Project are considered to be minor.

4.10.11 Standard mitigation has been considered in the inference of effect significance. Committed mitigation measures include suspending activities during extreme weather events and providing personnel with appropriate Personal Protective Equipment (PPE).

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Chapter 5 Ornithology

5. Ornithology

5. Ornithology

5.1 Introduction

5.1.1 This chapter considers the likely significant effects of the Proposed Project on birds, both on-site and in the surrounding ornithological environmental zone of influence (study area). The assessment is based upon comprehensive baseline data, comprising specifically targeted ornithological surveys of potentially important and legally protected bird species identified during a desk study and consultation feedback. It draws on pre-existing information, where appropriate, from other studies, survey data sources and relevant Chartered Institute for Ecology and Environmental Management (CIEEM) and NatureScot (previously Scottish Natural Heritage, SNH) guidance. The scope of the ornithological assessment excludes potential impacts on habitats, flora and other fauna, which are considered separately in Chapter 6: Ecology.

5.1.2 Alba Ecology Limited led on all aspects of the ornithological fieldwork and assessment in association with the Proposed Project. Alba Ecology is a Scottish-based multi-disciplinary ecological consultancy that has worked in the north of Scotland, and Shetland specifically, for many years. Alba Ecology's staff have led on and contributed to all aspects of Ecological Impact Assessment (EcIA) on several large-scale development projects, including the management of Ecological Clerks of Work (ECoW) teams, principal ornithological/ecological surveyors and advisors on planning applications, expert witness advice at Public Local Inquiry and the production of Environmental Statements, Habitat Regulations Assessments and Habitat Management Plans.

5.1.3 The ornithological surveyors used between 2018 and 2022 were Mr David Cooper, Mr Brydon Thomason and Dr Peter Cosgrove. These surveyors have extensive ornithological field experience of Shetland and Unst specifically. Surveyors carried out bird surveys in a systematic and objective manner, following recognised standardised methods. Those surveyors working near breeding birds listed in Schedule 1 of the Wildlife and Countryside Act 1981 (and as amended) were covered by relevant SNH Schedule 1 Bird Licences.

5.1.4 This chapter is supported by ornithological drawings in Chapter 6 from the 2021 Shetland Space Centre EIAR and the following Appendices in Volume IV:

- Appendix 5.1: Shetland Space Centre Breeding Birds Survey Report; and its addendum update 'SaxaVord UK Spaceport Breeding Bird Survey, 2022'.
- Appendix 5.2: Background literature review of noise impacts on birds for the Shetland Space Centre (now SaxaVord Spaceport).
- Appendix 5.3 SaxaVord Spaceport Habitat Management Plan.

5.1.5 Confidential bird species information, where information would have appeared in the relevant sections of this AEE Report chapter were it not for the fact that this information could endanger rare and legally protected species from wildlife crime, has been submitted to and assessed previously by the local planning authority, as part of the EIA process for the SaxaVord Spaceport facility. This information is not included in the AEE submission as it does not make any material difference to the assessment findings; but, as required, has been shared with relevant statutory authorities during the planning process for the SaxaVord Spaceport.

5.1.6 The assessment involved the following key phases:

- Reference to relevant legislation, policy and guidance.
- Identification of the likely environmental zone of influence of the Proposed Project.
- Identification of potentially important ornithological receptors (baseline conditions) likely to be affected by the Proposed Project.

- Evaluation of important ornithological receptors and features likely to be affected by the Proposed Project.
- Identification of likely impacts and magnitude of the Proposed Project on important ornithological receptors.
- Assessment of the likely significant effects of the Proposed Project, including any mitigation and enhancement measures and any residual significant effects.

5.1.7 The term '*receptor*' is used throughout the AEE process and is defined as the element in the environment affected by a development (e.g., a bird in the case of ornithology). The term '*impact*' is also used commonly throughout the AEE process and is defined as a change experienced by a receptor (this can be beneficial, neutral or adverse). The term '*effect*' is defined as the consequences for the receptor of an impact.

5.2 Legislation, Policy and Guidelines

Legislation

Space Industry Act

5.2.1 The Space Industry Act (2018) regulates all spaceflight activities carried out in the United Kingdom, and associated activities. The Act requires any person or organisation to obtain the relevant licence to:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities from the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

5.2.2 As the Applicant wishes to become a spaceflight operator and launch RFA ONE NOM Launch Vehicles from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

5.2.3 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence and the Regulators Licensing rules, which specify what information the UK Civil Aviation Authority (CAA) – the regulator - requires in support of an application.

Policy Context

5.2.4 Further relevant legislation and best practice guidance documents have been reviewed and taken into account as part of this ornithological assessment. The approach used to assess the significance of likely effects of the Proposed Project upon ornithological receptors is set in the context of:

- The Wildlife and Countryside Act 1981 (as amended);
- European Commission (EC) (2011) European Biodiversity Strategy;
- EC Directive 2009/147/EC on the conservation of wild birds (codified version). The so-called 'Birds Directive';
- EC Directive 1992/43/EEC on the conservation of natural habitats and of wild fauna and flora. The so-called 'Habitats Directive';

- The Conservation (Natural Habitats) Regulations 1994. The so-called 'Habitats Regulations';
- The Conservation of Habitats and Species Regulations 2010;
- The Nature Conservation (Scotland) Act 2004 (as amended);
- Scottish Government PAN 1/2013;
- Scottish Government Planning Circular 1 2017: The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations 2017;
- National Planning Framework 4 (NPF 4), 2022;
- Guidelines for Ecological Impact Assessment in the UK and Ireland (CIEEM, 2016; 2018; 2019 as amended);
- Regional Population Estimates of Selected Scottish Breeding Birds (SNH, now NatureScot);
- Natural Heritage Zones Bird Population Estimates. SWBSG (Scottish Windfarm Bird Steering Group) Commissioned Report: 150413;
- Scottish Government. The Scottish Biodiversity List (SBL);
- Scottish Government 2020. The Environment Strategy for Scotland: vision and outcomes;
- Biodiversity Net Gain: Good practice principles for development: A practical guide. (CIRIA, CIEEM and IEMA 2019);
- Biodiversity Net Gain in Scotland, CIEEM Scotland Policy Group, 2019;
- Strategic Plan for Biodiversity 2011-2020. Convention on Biological Diversity;
- 'Living Shetland' – the Shetland Local Biodiversity Action Plan (LBAP);
- The Shetland Local Development Plan (2014); and
- The Shetland Local Development Plan – Natural Heritage Supplementary Guidance (2012).

5.2.5 There is no Scottish or UK specific ornithological guidance on satellite launch operations.

5.2.6 Scottish Planning Policy (Scottish Government, 2014) sets out the Scottish Government's national planning policies for the protection of biodiversity through the planning system. This seeks to ensure that projects provide biodiversity benefits where possible, not simply to avoid significant adverse effects. These policies are incorporated into development plans and are a material consideration in the determination of development proposals. NPF4 (2022) is designed to support Scotland's commitment of reaching net zero emissions by 2045 and thereby tackling the climate change emergency.

5.2.7 The UK Biodiversity Action Plan (BAP) was the UK Government's 2004 response to the Convention on Biological Diversity, to which the UK was a signatory. Action plans for the most threatened species and habitats (called 'UK BAP species and habitats') were set out to aid recovery. Following the publication of the Convention on Biological Diversity's 'Strategic Plan for Biodiversity 2011–2020' (Convention on Biological Diversity, 2010), its commitment to 20 'Aichi targets', agreed at Nagoya Japan in October 2010, and the launch of the European Biodiversity Strategy in May 2011, the UK Government has changed its strategic thinking.

5.2.8 The Scottish Biodiversity List (SBL) is a list of animals, plants and habitats that Scottish Ministers consider to be of principal importance for biodiversity conservation in Scotland, under the Nature Conservation (Scotland) Act 2004. The SBL therefore supersedes the UK BAP list of species and habitats. Nevertheless, since most existing planning policy and guidance requires consideration of, and makes explicit reference to, UK BAP species and habitats, these are still referred to where necessary.

5.2.9 The Shetland Local Development Plan (2014) contains policies and objectives to conserve and enhance the habitats and species that contribute to the unique character and heritage of Shetland. It has links to Supplementary Guidance on Local Nature Conservation Sites in Shetland and Supplementary Guidance on Natural Heritage. This guidance is provided to aid planning applicants and their agents when considering development in relation to their biodiversity responsibilities.

5.2.10 It is recognised that the term '*Favourable Conservation Status'* (FCS) as articulated within the EC Habitats Directive is not used in the EC Birds Directive, but SNH (now NatureScot) advises on its use and context in relation to consideration of birds. Conservation status is considered favourable where:

- Population dynamics indicate that the species is maintaining itself on a long-term basis as a viable component of its habitat.
- The natural range of the species is not being reduced, nor is it likely to be reduced in the foreseeable future.
- There is (and will continue to be) a sufficiently large habitat area to maintain its populations on a long-term basis.

5.2.11 Whilst considering a range of potential outcomes that could arise from the Proposed Project, the assessment reports the effects that are considered likely to be significant on the basis of evidence, standard guidance and professional judgement. It is these *likely significant effects* that the applicant is obliged to report, and that the decision maker is obliged to consider.

Relevant Guidance

Guidance for the Assessment of Environmental Effects

5.2.12 The CAA, with the UK Space Agency, the Department for Business, Energy and Industrial Strategy and the Department for Transport, issued guidance note '*CAP 2215 Guidance for the Assessment of Environmental Effects*' in July 2021. The guidance sets out what is required by the regulator regarding assessment of environmental effects as part of a licence application under the Act.

5.2.13 The AEE Guidance requires that potential direct and indirect significant effects of proposed spaceflight activities on environmental features, including noise and vibration, are considered. The guidance further requires that:

- Specific potential effects are identified and, where possible, quantified;
- The focus of the AEE should be on significant effects arising from the proposed activities;
- Applicants set an environmental budget, comprising a maximum number of launches per launch vehicle type which can take place over the course of a year that can be carried out in an environmentally sustainable manner, taking into account the cumulative effect of all launches; and
- The AEE must address a range of environmental topics, including ecology and biodiversity.

Guidance to the regulator on environmental objectives relating to the exercise of its functions under the Space Industry Act 2018

5.2.14 The Department for Transport issued its document '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK:

The environmental objective for spaceflight is to:

- *Minimise emissions contributing to climate change resulting from spaceflight activities;*
- *Protect human health and the environment from the impacts of emissions on local air quality arising from spaceflight activities;*
- *Protect people and wildlife from the impacts of noise from spaceflight activities; and*
- *Protect the marine environment from the impact of spaceflight activities.*

5.2.15 The objectives presented in the guidance are noted to be consistent with the environmental topics that must be addressed in an AEE.

5.3 Consultation

5.3.1 Extensive statutory consultation on ornithological matters was carried out during preparation and determination of the planning application for the SaxaVord Spaceport, from where the Proposed Project will operate. Where directly relevant to this AEE, consultation responses received during the SaxaVord Spaceport planning application period have been summarised in Table 5.1.

Table 5.1 SaxaVord Spaceport Consultation Responses directly relevant to this AEE

Consultee	Summary ornithology response	Where and how addressed
SNH (now NatureScot) - Jonathan Swale 16/02/18	Following an approach on 06/02/20 by Alan Farningham of Farningham Planning Ltd into the scope and scale of ornithological surveys, Jonathan Swale of SNH responded on 16/02/18 as follows: "*The environmental assessment should consider the impacts on breeding birds of operation of the launch site, as well as its construction, so surveys should cover the area likely to be affected. Rocket launches could cause disturbance over a large area, but without information on the expected noise levels we aren't able to advise on the likely extent of disturbance nor on the area that should be surveyed to carry out the impact assessment. It may be necessary to assess possible impacts on seabirds within Hermaness, Saxa Vord and Valla Field SPA but this will not require additional survey work as we have recent data that can be used*". Consideration of whimbrel within the Hill of Colvadale and Sobul SSSI was also recommended for potential works near that designated site.	The nature and scale of the ornithological study area (environmental zone of influence) is discussed within this chapter and also Appendix 5.1. Breeding bird survey data collected by Alba Ecology is presented in Volume IV Appendix 5.1. Consideration of potential noise impacts on birds is presented in Volume IV Appendix 5.2. Consideration of sensitive Schedule 1 species breeding information has been submitted to and assessed previously by the local planning authority, as part of the EIA process and is therefore not included in this AEE for reasons of confidentiality.

Consultee	Summary ornithology response	Where and how addressed
	However, this area did not feature in the final planning Application Boundary, therefore is not reported on. SNH also advised that the cliffs around Lamba Ness were likely to support nesting fulmar, shag, black guillemot and possibly gulls and that these species should therefore be surveyed too.	
SNH - Glenn Tyler 24/05/20	Agreement on the proposed seabird (boat-based) survey methods and personnel was sought and agreed with Glenn Tyler at SNH (in a phone call on 24/05/18). Glen Tyler agreed that this approach was suitable and that three separate boat-based surveys spread across the first three weeks of June during suitable weather conditions was standard and 'sounded ideal', given the information available at the time. Surveys were undertaken in 2018 as per agreement with SNH.	Seabird survey data collected by Alba Ecology is presented in Appendix 5.1.
SNH – 28/05/20	Alba Ecology provided SNH with a draft version of Appendix 5.1.	Provided as part of a verbal agreement to share information/data ahead of the planning application submission.
SNH – 29/05/20 and 02/06/20	During data sharing with SNH it became apparent that SNH's existing bird data for the SPA (Special Protection Area) did not exist for the whole of the Hermaness, Saxa Vord and Valla Field SPA area. The SPA extends to Virdik but only the marine extension – it does not include the cliffs, which was the only section SNH monitors. Consequently, a gap in nesting seabird data for the area between Virdik and Ura was identified. On 02/06/20 SNH provided what up-to- date breeding bird data they had for the relevant designated sites.	Boat-based seabird surveys were conducted for the relevant 'gap' section of cliff in June 2020, which also coincided with the relaxation of COVID-19 restrictions for outdoor work. The same surveyors who undertook the 2018 boat-based seabird surveys conducted three boat-based seabird surveys between Virdik and Ura in June 2020.
SNH – 18/08/20	Alba Ecology provided SNH with a brief update on the 2020 survey results and a draft of Appendix 5.2.	Information provided as part of a verbal agreement to share information/data ahead of the planning application submission.

Consultee	Summary ornithology response	Where and how addressed
Royal Society for the Protection of Birds (RSPB) Scotland – 28/05/20	Alba Ecology provided RSPB Scotland with a draft version of Appendix 5.1.	Provided as part of a verbal agreement to share information/data ahead of the planning application submission.
RSPB Scotland – 18/08/20	Alba Ecology provided RSPB Scotland with a brief update on the 2020 surveys and a draft of Appendix 5.2.	Information provided as part of a verbal agreement to share information/data.

5.3.2 Following consultation with NatureScot subsequent to submission of the planning application SaxaVord Spaceport, it has been confirmed by planning condition that no satellite launches, or static tests will be carried out between mid-May and the end of June in order to avoid disturbance to breeding birds during the critical incubation and early brooding period. The Applicant is aware of this operational constraint and will not schedule launches within the defined mid-May to end of June window.

5.3.3 The following potential impacts have been assessed in full in relation to the operation of the Proposed Project:

- Loss of foraging or breeding habitat due to displacement or avoidance.
- Death or injury of birds (including eggs and dependent young) through noise impacts associated with launches.

5.3.4 Collision risk with birds striking the RFA ONE NOM Launch Vehicle during take-off is not considered likely. Given the noise generated at launch, it is not considered likely that many birds would remain in the vicinity of the launch pads. At some satellite launch facilities, very occasional bird strikes have occurred e.g., vultures at the Kennedy Space Centre in Florida (Appendix 5.2) which do not occur in Unst.

5.4 Assessment Methodology and Significance Criteria

Consultation

5.4.1 In accordance with CIEEM best practice guidance, consultation with SNH/NatureScot was undertaken throughout the planning process for SaxaVord Spaceport. As the Proposed Project environmental budget makes up approximately one third of that of the wider Spaceport; it was not considered necessary to undertake further consultation for this AEE.

Environmental Zone of Influence (EZI)

5.4.2 The main elements of the Proposed Project which have the potential to impact on ornithological receptors during operation are described in Chapter 3 and include:

- Preparation of RFA ONE NOM Launch Vehicle;
- Storage and Handling of Launch Vehicle Propellant;
- Operation of Ground Segment and Launch Complex; and
- Launch of RFA ONE NOM Launch Vehicle.

5.4.3 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland.

5.4.4 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian. All launches will take place from Launch Pad 1 at the SaxaVord Spaceport.

5.4.5 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of SaxaVord Spaceport's own assessed environmental budget of 30 launches per year.

5.4.6 Assessing the potential effects of disturbance on bird species is a complex issue which will vary depending on the type of disturbance (e.g., routine/predictable verses unusual/unexpected), topography, vegetation and the behaviour/tolerance of the bird species and even different individuals within species. Therefore, identifying a one-size-fits-all ornithological study area over which potentially affected breeding bird species should be surveyed is challenging. Consequently, this was considered in a number of different ways, which are outlined below.

5.4.7 In Scotland, all wild birds are legally protected, but some species are considered more sensitive to human related disturbance than others and they are specially protected under European, UK and Scottish legislation. Disturbance can have adverse effects on birds' breeding success, e.g., through chilling, overheating and desiccation of eggs or chicks, predation and starvation of chicks and ultimately the abandonment of a breeding territory. Therefore, the distance over which disturbance might potentially occur was considered particularly important when determining the ornithological study area.

5.4.8 Limited work has taken place on the impact of disturbance on most of the bird species potentially present within habitats in Unst. However, for two of the important species which breed in Unst, some guidance has been published on the distances at which they are likely to be affected by human-related disturbance. In Ruddock and Whitfield (2007), 80 % of experts canvased estimated static disturbance occurred at 500 m to 750 m for nesting and chick-rearing red-throated divers (*Gavia stellata*) and expert opinion suggested 'safe working distances' could exceed 500 m. Ruddock and Whitfield (2007) suggested that breeding red-throated divers are sensitive to human activity, visual disturbance and sudden noise events over relatively large distances (e.g., up to 500 m). Evidence from Viking Wind Farm studies in Shetland indicated that some individual red-throated divers (perhaps habituated) appear to tolerate moderate levels of disturbance in some situations. The size of waterbodies also has an impact; breeding divers are more easily disturbed and fly from smaller nesting lochans (where they presumably feel more vulnerable) than larger nesting lochs, where they have the ability to swim away and dive underwater without taking flight.

5.4.9 Similarly, breeding merlins (*Falco columbarius*) are considered sensitive to human activity, visual disturbance and sudden noise events over large distances (e.g., up to 500 m) (Ruddock and Whitfield, 2007), particularly prior to egg laying and during incubation in Shetland (the late Mark Chapman, *pers comm*.). However, individual merlin pairs appear to tolerate moderate levels of disturbance in some situations. For example, merlins appear to be able to nest relatively close to public roads in Shetland, where regular (mostly predictable) disturbance occurs.

5.4.10 Based on Ruddock and Whitfield (2007), there is some limited evidence and expert opinion that sudden noise events up to 500 m to 750 m away from the two potentially affected bird species could be detrimental. Based on this, it might have been possible to recommend a one-kilometre survey buffer around the launch pads. However, none of the potentially affected target species had been monitored in relation to short-duration loud noise events of the magnitude of a launch. Furthermore, at the time of Pre-application consultation with SNH (2018) and determination of the ornithological study area, there was no information on predicted noise levels available. Consequently, this nominal one-kilometre survey buffer was not considered an adequate basis on which to determine the size of the ornithological study area.

5.4.11 During initial survey planning, there was only an indicative boundary area for the SaxaVord Spaceport. As a result, an arbitrary, but very large precautionary initial study area, was selected for breeding bird surveys, based on bird species likely to be present from existing data sources e.g., Pennington *et al*. 2004 and the habitats present. According to expert opinion (Ruddock and Whitfield, 2007), the greatest distance any UK species was predicted to be affected by human induced disturbance was 1.5 km - 2 km (for breeding golden eagle – which does not occur in Unst), and this was even considered by Ruddock and Whitfield to be overly precautious. Nevertheless, given the lack of any empirical evidence or guidance, it was decided that doubling the greatest possible disturbance distance for any UK breeding bird, i.e., a 4 km buffer from the Proposed Project, was a legitimate precautionary basis on which to proceed with breeding bird surveys to cover the potential zone of influence. Consequently, the size of the breeding bird study area (Drawing 5.1) was much larger than the final site boundary of the SaxaVord Spaceport, and it was centred on indicative launch site locations provided by SaxaVord Spaceport during initial discussions in early 2018.

5.4.12 A plan of the breeding birds study area is included as Drawing 5.1.

Desk Study

5.4.13 An initial desk study was conducted in 2018 using the SNH's SiteLink website and Shetland Biological Records Centre data held for the study area. This was supplemented by existing knowledge of the breeding birds of Unst and consultation with SNH on the nature and scope of bird surveys. Given the time gap between 2018 and the current planning submission, the exercise was undertaken again from the same data providers, alongside up to date information from the National Biodiversity Network (NBN); a collaborative UK partnership created to exchange biodiversity information. This information was compiled into a report and is presented in Appendix 5.1.

5.4.14 The desk study identified several Annex 1, Schedule 1, UK BAP and SBL species previously recorded within the study area. Based on the results of the desk study, initial site-walkover, size/quality/importance of habitats present, EIA Scoping comments and feedback from the regulators, legal protection, the site and the exercise of professional judgement, the following potentially important ornithological receptors have been identified for further consideration:

- Nearby designated site species.
- Breeding red-throated diver.
- Breeding raptors, in particular merlin.
- Breeding waders, in particular whimbrel (*Numenius phaeopus*), curlew (*Numenius arquata*), ringed plover (*Charadrius hiaticula*), golden plover (*Pluvialis apricaria*) and dunlin (*Calidris alpina*).
- Breeding terns and skuas, in particular Arctic tern (*Sterna paradisaea*) and Arctic skua (*Stercorarius parasiticus*).
- Cliff nesting seabirds, in particular black guillemot (*Cepphus grylle*), common guillemot (*Uria aalge*), razorbill (*Alca torda*), puffin (*Fratercula arctica*), shag (*Phalacrocorax aristotelis*), fulmar (*Fulmarus glacialis*) and gulls.
- Potentially rare species, including confidential breeding Schedule 1 species.

5.4.15 There was no evidence from the desk study of the study area being especially important for non-breeding birds and SNH did not request non-breeding bird surveys. Consequently, surveys focussed on breeding birds.

Site Visit

5.4.16 A reconnaissance site visit by Dr Peter Cosgrove in late autumn 2017 determined that the Proposed Project area was predominantly open coastal/upland habitat characterised by peatland, grassland and sea cliffs. The principal land use was sheep grazing through crofting and common grazing. There was potential for several specially protected bird species to be present, so breeding bird surveys were conducted under a SNH Schedule 1 licence.

Breeding Bird Surveys

5.4.17 Breeding bird surveys were undertaken monthly between April and July 2018 and 2019 within the ornithological study area (Appendix 5.1). In 2020, additional Schedule 1 surveys were undertaken within the Proposed Project site boundary, to inform other surveyors working there of the potential avian sensitivities present through the production of an up-to-date Breeding Birds Protection Plan (BBPP) and associated on-site Ecological Clerk of Works (ECoW) support.

5.4.18 Updated and repeat breeding bird surveys (moorland, raptor, diver, black guillemot and cliff nesting seabirds) were undertaken in 2022 and are provided as an addendum to the previous breeding bird survey report and provide an update on the ornithological baseline (Appendix 5.1). The existing 2018-2020 survey data and assessment is considered robust in light of the updated 2022 survey data which demonstrates no substantial changes in the baseline conditions, potentially aside from one. In common with many parts of Shetland and Unst, surveys in 2022 recorded several dead species which were presumed to have died from birdflu (H5N1 is the strain of avian flu in Scotland). According to the RSPB, the virus has killed tens of thousands of seabirds, including many in key Shetland colonies of gannets and great skuas in 2022 (How together we can protect wild birds from Avian Flu | The RSPB).

Moorland Breeding Bird Surveys

5.4.19 The modified Brown and Shepherd (1993) Moorland Breeding Bird survey is the standard survey technique for moorland/upland breeding birds (Gilbert *et al.,* 1998) and is described in the SNH online guidance (e.g., SNH 2005; and subsequent updates). The main habitat was open moorland/grassland and so this survey technique was used across all parts of the study area. However, there were some wetter/marshy areas in the study area which were observed from the nearest edge. Further details are provided in Appendix 5.1.

5.4.20 Population estimates of terrestrial birds in the study area were derived by comparing the summary maps for each of the breeding survey visits. Registrations/territories plotted during each period were considered to be separate from one another if more than approximately 500 m apart for larger species, 300 m in the case of smaller species. If there was any doubt about whether more than one pair of birds was present in an area, the surveyor would sit quietly nearby and observe the behaviour, gender and number of birds present as per Brown and Shepherd's (1993) survey methodology. When compiling figures of breeding birds, the approximate central location of all registrations recorded from different survey visits is used to identify a notional territory centre (the species 'dot' on the relevant drawing) where a nest was not discovered. Surveys were undertaken in 2018 and 2019 as per agreement with SNH across the study area and additionally in 2020 and 2022 for Schedule 1 species within the SaxaVord Spaceport boundary.

Breeding Raptor Surveys

5.4.21 SNH provides clear guidance in relation to raptor sensitivities and survey effort (2005; and subsequent updates). Breeding raptor surveys were undertaken to determine the location of any breeding merlins within the study area using standardised merlin survey methods (e.g., Hardey *et al*., 2013). These surveys also covered potential breeding habitats of kestrel and peregrine, were they to be present. Surveys were undertaken in 2018 and 2019 as per agreement with SNH across the study area and additionally in 2020 and 2022 for Schedule 1 species within the SaxaVord Spaceport boundary. Further details are provided in Appendix 5.1.

Breeding Red-throated Diver Surveys

5.4.22 Following SNH standard guidance, searches for nesting red-throated divers were undertaken on all potentially suitable waterbodies within the study area. The waterbodies were visited at least twice during the breeding season if nothing was present. However, if the water body was occupied, sites were revisited later in the breeding season to determine nest locations and breeding success. Surveys were undertaken in 2018 and 2019 as per agreement with SNH across the study area and additionally in 2020 and 2022 within the SaxaVord Spaceport boundary Further details are provided in Appendix 5.1.

Black Guillemot

5.4.23 Counts of individual adult black guillemots provide the most accurate survey method for this species (Gilbert *et al*., 1998). Two survey visits, a week or more apart during the first three weeks of April were undertaken. The surveys were conducted from first light until particular defined potential black guillemot cliff reaches were surveyed, during suitable, calm and clear weather conditions (as per Gilbert *et al*., 1998). The surveyor, who was familiar with the study area, moved along the coast counting all black guillemots on the sea, within about 300 m of the shore and any that were on land. Repeat counts were also undertaken in the afternoon for some reaches for comparative purposes. Surveys were undertaken in 2018 and 2019 (and also 2022) as per agreement with SNH across the study area.

Cliff Nesting Seabirds

5.4.24 The standard method for surveying cliff nesting seabirds requires the number of individual adult birds per visit recorded or Apparently Occupied Nests (AON), which can either be summed and a mean produced over different survey visits undertaken or simply use the highest count to provide a maximum population estimate. The standard survey guidance recommends between two and five survey visits. Given the nature of the study area, with no low tide beach below the steep cliffs, boat-based counts were undertaken between the eastern edge of the Hermaness, Saxa Vord and Valla Field SPA (approximately Virdik) and The Nev (south-east of Hill of Clibberswick), as per agreement with SNH. No climbing down cliffs to count breeding seabirds was undertaken.

5.4.25 The razorbill, common guillemot and shag standard survey methods recommend surveys in the first three weeks of June in the north of Scotland in 'normal years' (June or July for gannets (*Morus bassanus*), June for fulmar, early-mid June for kittiwake (*Rissa tridactyla*). Consequently, boat-based surveys were scheduled for and undertaken during the first three weeks of June given the main species likely to be present on the cliffs (and where possible due to weather constraints, well-spaced across these 3 weeks). The two main sources of seabird survey guidance were followed: Gilbert *et al*., (1998) and JNCC Seabird Monitoring Handbook (Walsh *et al*., 2011).

5.4.26 Puffins are difficult to census due to their use of burrows, often in inaccessible locations. The most reliable way in which they are monitored is by long-term monitoring of Apparently Occupied Burrows (AOB) from sample areas, rarely possible in Shetland due to the steep and inaccessible nature of much of the terrain (Mitchell *et al.,* 2004). When these burrows cannot be accessed, as was the case within the study area, the standard survey methodology is to count individual birds on land, which provides a rough estimate of numbers present. However, in Shetland such previous counts have mostly taken place at the same time as the optimal count for other cliff nesting seabirds in June, when it is known that nonbreeding puffins also attend colonies and so can inflate numbers of presumed breeders present. This is a recognised limitation of the survey method in Shetland and needs to be recognised when comparing puffin data from other/previous surveys.

5.4.27 Further methodological detail on how each seabird species was counted is provided within the JNCC Seabird Monitoring Handbook (Walsh *et al*., 2011). These survey methods and proposed personnel were discussed and agreed with Glenn Tyler at SNH (in a phone call on 24/05/18; Table 5.1). Surveys were undertaken as per agreement with SNH. Further details are provided in Appendix 5.1.

5.4.28 During data sharing with SNH in 2020 it became apparent that existing bird data for the SPA did not exist for the whole of the Hermaness, Saxa Vord and Valla Field SPA area. The SPA extends to Virdik but only the marine extension – it does not include the cliffs, which is the only section SNH monitors. Consequently, a gap in cliff nesting seabird data for the area between Virdik and Ura was identified. Fortuitously, this data gap was identified in May 2020, allowing boat-based seabird surveys to be organised for the relevant section of cliff in June 2020, which also coincided with the relaxation of COVID-19 restrictions for (socially distanced) outdoor work. The same experienced surveyors who undertook the 2018 boat-based seabird surveys conducted the 2020 (and also 2022) boat-based seabird surveys between Virdik and Ura, providing consistency of experienced observers.

Assessment of Potential Effect Significance

5.4.29 This section defines the criteria used to evaluate the likely significance of predicted effects on important ornithological receptors due to the Proposed Project. A level of confidence (whether the predicted effect is certain, likely, possible or unlikely) is attached to the predicted effect.

Evaluating Conservation Importance

5.4.30 The ornithological receptors identified in the baseline studies have been evaluated following best practice guidelines (e.g., CIEEM, 2018 and SNH/NatureScot guidance). Identifying the importance of potential ornithological receptors was the first step of the process, and those considered potentially important, and present were then subject to detailed survey and assessment. Those considered sufficiently widespread, unthreatened, and resilient to the project impacts have been scoped out of further assessment as per best practice EcIA guidance (e.g., CIEEM, 2018).

5.4.31 Ornithological receptors can be important for a variety of reasons and the rationale used to define their importance has been explained to demonstrate a robust selection and evaluation process. Importance may relate, for example, to a designated site, to species rarity, to the extent to which they are threatened throughout their range, or to their rate of decline. Various characteristics contribute to the potential importance of ornithological receptors within a study area. Examples include:

- Naturalness of a bird population.
- Species, sub-species or varieties that are rare or uncommon, either internationally, nationally or more locally, including those that may be seasonally transient.
- Ecosystems and their component parts, which provide the habitats required by important bird species, populations and/or assemblages.
- Endemic bird species or locally distinct sub-populations of a species.
- Size of a bird population.
- Bird species in decline.
- Large populations of bird species or concentrations of species considered uncommon or threatened in a wider context.
- Bird species on the edge of their range, particularly where their distribution is changing as a result of global trends and climate change.

5.4.32 Guidance on EcIA sets out categories of ornithological or nature conservation importance that relate to a geographical framework (e.g., international through to local) together with criteria and examples of how to place a site or study area (defined by its ornithological attributes) into these categories. It is generally straightforward to evaluate sites or species populations designated for their international or national importance (as criteria for defining these exist e.g., SPA and SSSI), but for sites or populations of regional or local importance, criteria may not be easily defined.

5.4.33 According to CIEEM EcIA guidance (2018) the importance of an ecological feature should be considered within a defined geographical context, and these should be adapted to suit local circumstances, as outlined in Table 5.2.

Table 5.2 Summary of Geographic Population Importance Criteria Used

Term	Use
International	For example, >1 % of European Community (EC) population, internationally designed site feature.
National	For example, >1 % of United Kingdom (UK) or Scottish population, nationally designated site feature.
Regional	For example, >1 % of the relevant Natural Heritage Zone (NHZ) population, regionally designed site feature.
Local	For example, within local area (<1 % of relevant NHZ population), local wildlife sites.

5.4.34 There is no fundamental biological reason to take 1 % of a population as the threshold level for establishing the level of geographic importance of a site. Nevertheless, this percentage is widely considered to be of value in developing measures that give an appropriate level of protection to populations and has gained acceptance on this basis throughout the world. The criterion was, for example, adopted by parties involved in the Ramsar Convention 1971. Thereafter, the 1 % level of national species totals has been taken as the basis of assessment in various countries, including Britain (Stroud *et al*. 1990).

5.4.35 For breeding bird species, SNH/NatureScot uses the NHZ (Natural Heritage Zone) as the appropriate regional biogeographical unit of assessment. Twenty-one zones covering Scotland have been drawn to reflect biogeographical differences between zones, with a high level of coherence within each zone. According to SNH guidance "*the question as to whether there is an impact on a [bird] species regionally therefore may be translated into the question as to whether there is an impact within the relevant NHZ*". The Proposed Project is wholly within the Shetland NHZ and so this biogeographical unit is used for the regional population assessment.

5.4.36 The Scottish Wind Farm Bird Steering Group published a systematic review of NHZ bird populations across Scotland, including Shetland (Wilson *et al*., 2015), which is helpful in the context of determining regional bird population estimates. The Viking Wind Farm Environmental Statement also examined existing data sources and estimated relevant Shetland bird populations (Viking Energy Partnership, 2009), and provides useful additional information on Shetland priority bird population estimates. The regional population metrics reported in this chapter are mostly derived from the Scottish Wind Farm Bird Steering Group report and those used in the Viking Wind Farm ES and have been updated where more up to date population data/information was available.

5.4.37 The importance attached to an ecological receptor can also be determined according to legislative status. Some ecological receptors are subject to a general level of legal protection through e.g., the Wildlife and Countryside Act 1981 (as amended), or The Nature Conservation (Scotland) Act 2004 (as amended) and others under the Birds Directive. There is no clear guidance for conservation importance of ecological receptors other than those of European Protected Species and designated sites. The importance of other species and habitats is based on professional judgement using the characteristics outlined above. The status of potentially important receptors, such as being on the SBL, is also taken into consideration.

5.4.38 Nevertheless, and for the avoidance of doubt, CIEEM EcIA guidance (2018) makes it clear that species which appear on national lists e.g., Schedule 1 of the Wildlife and Countryside Act (1981 as amended) and SBL are not necessarily evaluated as of national importance simply by appearing on such a 'national' list. Importance evaluation must consider the number of individuals of species or area of habitat within a geographical context/scale, i.e., how many of a particular species are likely to be affected by the Proposed Project and what proportion of the local/regional/national population does this constitute. Legal listing/protection is a separate but important consideration.

Extent

5.4.39 According to CIEEM (2018) EcIA guidance, extent is the spatial or geographical area over which the predicted impact/effect may occur under a suitably representative range of conditions.

Magnitude

5.4.40 According to CIEEM (2018) EcIA guidance, magnitude refers to size, amount, intensity and volume. It should be quantified if possible and expressed in absolute or relative terms e.g., the amount of habitat lost, number of pairs lost, percentage decline in a species population. For consistency across all the topics within the AEE, magnitude terms are required and are clearly defined (Table 5.3), along with metrics in absolute and relative terms. There are a number of approaches for determining the significance of effects on ecological features. This includes methods for scoring and ranking impacts on the basis of subjective criteria. Results are often presented in the form of a matrix in which ecological value/importance and magnitude of impact are combined into a significance score. A matrix approach is commonly used in EIA by disciplines other than ecology to assign significant residual effects to categories (e.g., major, moderate, minor). CIEEM (2018) guidance discourages use of the matrix approach and artificial significance scores. Spurious assessment should be avoided in which artificial numerical scores, or significance rankings/categories are used without a clear definition of the criteria and thresholds that underpin them.

Table 5.3 Summary of Magnitude Criteria Used

Term	Definition
Major	Total/near total loss of a population due to mortality or displacement. Total/near total loss of breeding productivity in a population due to disturbance. e.g., ≥50 % of population affected.
Moderate	Moderate reduction in the status or productivity of a population due to mortality or displacement or disturbance. e.g., 10-49 % of population affected.
Minor	Small but discernible reduction in the status or productivity of a population due to mortality or displacement or disturbance. e.g., 1-9 % of population affected.
Negligible	Very slight reduction in the status or productivity of a population due to mortality or displacement or disturbance. Reduction barely discernible, approximating to the ‘no change’ situation. e.g., <1 % population affected.

Duration

5.4.41 According to CIEEM (2018) EcIA guidance, duration should be defined in relation to ornithological characteristics (such as the life cycle of a species). The duration of an activity may differ from the duration of the resulting effect caused by the activity. Impacts and effects may be described as short, medium or long-term and permanent or temporary and should be defined. In this assessment three timeframes are used: short-term (up to two years), medium-term (two-five years) and long-term (between five years and the lifetime of the Proposed Project).

Frequency and Timing

5.4.42 According to CIEEM (2018) EcIA guidance, the number of times an activity occurs will influence the resulting effect. For example, a single person walking a dog will likely have very limited impact on nearby wader utilisation of a wetland, but numerous dog walkers will subject the waders to frequent disturbance and could affect feeding success, leading to displacement of the birds and knock-on effects on their ability to survive. The timing of an activity may result in an impact if it coincides with critical life-stages or seasons e.g., bird nesting season.

Reversibility

5.4.43 According to CIEEM (2018) EcIA guidance, an irreversible effect is one from which recovery is not possible within a reasonable timescale or there is no reasonable chance of action being taken to reverse it. A reversible effect is one from which spontaneous recovery is possible or which may be counteracted by mitigation. In some cases, the same activity can cause both reversible and irreversible effects.

Sensitivity

5.4.44 Another factor when assessing potential impacts is the sensitivity of the ornithological receptor under consideration (e.g., high, medium or low), which can vary in space and time. Different receptors respond differently to stimuli, making some particularly sensitive to development activities and others less so. Professional judgement is used when assigning a sensitivity value to an ornithological receptor and this is recorded in a clear and transparent way.

5.4.45 By way of example, sensitivity is determined according to species behaviour, using broad criteria set out in Table 5.4. Behavioural sensitivity can differ between species and between individuals of the same species. Therefore, sensitivity is likely to vary with both the nature and context of the disturbance activity as well as the experience and even personality of the individual bird. Sensitivity also depends on the activity the species is undertaking. For example, a species is likely to be less tolerant of disturbance close to its nest during the breeding season than at other times of year. Furthermore, breeding birds are widely considered to be more likely to abandon eggs rather than dependent young, which they may have developed familial ties to. Thus, sensitivity changes with both space and time.

Table 5.4 Summary of Sensitivity Criteria Used

Term	Definition
High	Species occupying remote areas away from human activities and exhibiting strong and long-lasting reactions to disturbance events.
Medium	Species that appear to be warily tolerant of human activities and exhibiting short-term reactions to disturbance events.
Low	Species occupying areas subject to frequent human activity and exhibiting mild and brief reaction to disturbance events.

Ecosystem Services

5.4.46 Ecosystem services are the benefits that people derive from the natural environment. The natural environment can be considered a stock of 'natural capital' from which many benefits flows e.g., social, health-related, cultural or economic (CIEEM, 2018).

Criteria for Evaluating Significance

5.4.47 Significance is a concept related to the weight that should be attached to predicted effects when decisions are made. A '*significant effect*' is an effect that either supports or undermines biodiversity conservation objectives for important receptors (CIEEM, 2018). There could be any number of possible impacts on important ornithological features arising from a development. However, it is only necessary to describe in detail the impacts that are considered likely to be significant. Impacts that are either unlikely to occur, or if they did occur are unlikely to be significant, can be scoped out.

5.4.48 In this assessment, a significant effect is defined as "*an impact on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a defined geographical area*". Thus, the geographical terms of reference at which a predicted effect may be considered significant must also be defined (e.g., an effect on a species population evaluated to be of regional importance at a given site is likely to be either significant or not at the regional level). Effects can be considered significant at a wide range of scales from international to local.

5.4.49 There is sometimes confusion over geographical context, potentially important receptors and quantifying predicted effects and EcIA best practice guidance has struggled to articulate this clearly. For example, if a potentially important species appears on a conservation list e.g., the SBL and there is a predicted impact, the geographical context in which the receptor is found must be considered (CIEEM, 2018). Therefore, the simple presence of a species on the SBL within an area does not mean that likely effects are significant at the national (Scottish) level. For that to occur a Proposed Project must have likely significant effects on its national (Scottish) population.

Requirements for Mitigation

5.4.50 Best practice guidance e.g., CIEEM (2018) identifies a hierarchy of mitigation for potential impacts that seeks to:

- Avoid and prevent adverse ecological impacts, especially those that would likely be significant to important receptors.
- Minimise and reduce adverse impacts that cannot be avoided.
- Compensate and offset for any remaining likely significant residual impacts.

5.4.51 CIEEM EcIA guidance (2018) states that "*Avoiding and/or minimising negative impacts is best achieved through consideration of potential impacts of a project from the earliest stages of scheme design and throughout its development*". This approach to avoiding potential adverse impacts within a design layout is sometimes described as embedded mitigation or mitigation by design. "*Mitigation by design is particularly beneficial as there is greater certainty that it will be delivered*" (CIEEM 2018).

5.4.52 This AEE Report chapter considers mitigation in the context of CIEEM guidance and also in relation to local planning authority guidance for protected species. The embedded mitigation is considered in the design layout and because of this, it is guaranteed through planning conditions for the Proposed Project. Where likely significant effects are predicted regardless of design layout, further mitigation is separately identified as per CIEEM best practice guidance.

Assessment of Residual Effect Significance

5.4.53 After assessing the potential impacts of the Proposed Project (incorporating embedded mitigation), all feasible attempts have been made to further avoid and mitigate predicted adverse ornithological impacts. Once measures to avoid and mitigate predicted ornithological impacts had been incorporated, assessment of the residual impacts was undertaken to determine the likely significance of their effects on important ornithological features.

Limitations to Assessment

5.4.54 Where assumptions within the assessment are made, these are explicitly identified and explained. Similarly, limitations in methods and knowledge of species' ecology are also identified and discussed, particularly where this is likely to affect the outcome of the assessment. As with any environmental assessment there will be elements of uncertainty. Where there is uncertainty, this is identified and reported transparently, along, where possible, with the measures taken to reduce it, assumptions made, and an explanation as to the likely extent that any uncertainties are likely to affect the assessment conclusions. In circumstances where there is uncertainty; evidence, expert opinion, best practice guidance and professional judgement have been used to evaluate what is considered biologically likely to occur if the Proposed Project is operational.

5.4.55 The level of certainty of impact prediction varies depending upon a range of parameters discussed already. For some elements e.g., land-take it is relatively straightforward to assess and quantify the area of habitat that is likely to be lost to development infrastructure and therefore quantify potential impacts of land-take on the habitats and species present. The main limitations in this assessment are common to most ornithological assessments because:

- Baseline surveys undertaken are based on sampling techniques, not absolute censuses. Results give an indication of the numbers of ornithological receptors recorded at the particular times that surveys were carried out (e.g., 2018, 2019, 2020 and 2022 for breeding bird surveys). Species occurrence changes over time and therefore the results presented in this AEE Report are snapshots in time.
- Putting ornithological survey results into a wider geographical context is sometimes challenging because some species have not been systematically surveyed beyond the study area. Thus, defining a receptor population as locally or regionally important is potentially difficult because local or regional population estimates do not exist for many taxa. Whenever such uncertainty exists, professional judgement and published evidence is used and populations in the study area or site have been assumed to be at their highest potential level of geographical/ornithological importance.

5.5 Baseline Conditions

Designated Sites

5.5.1 The 2020 desk study identified three designated sites (which overlap) where birds were a qualifying feature within the 4 km ornithological study area (taken to be the EZI for this technical discipine) in Unst (Drawing 5.2) as detailed below.

Hermaness, Saxa Vord and Valla Field SPA (6,833 ha)

5.5.2 According to SNH/NatureScot (https://sitelink.nature.scot/site/8512) "The Hermaness, Saxa Vord and Valla Field SPA lies in the north-west corner of the island of Unst, Shetland, at the northernmost tip of Britain. It consists of 100-200 m high sea cliffs and adjoining areas of grassland, heath and blanket bog. The boundary of the SPA is coincident with that of the Hermaness SSSI, Saxa Vord SSSI, and Valla Field SSSI. The seaward extension extends approximately 2 km into the marine environment to include the seabed, water column and surface.

5.5.3 Hermaness, Saxa Vord and Valla Field SPA qualifies under Article 4.1 by regularly supporting populations of European importance of the Annex I species red-throated diver (average of 26 proven breeding pairs for 1994 - 1999, 3 % of the British breeding population). It also qualifies under Article 4.2 by regularly supporting populations of European importance of the migratory species; gannet (16,400 pairs in 1999, 8 % of the British and 6 % of the world population), great skua (788 pairs in 1997, 9 % of the British and 6 % of the world population) and puffin (55,000 individuals in 1999, 6 % of the British and 3 % of the total population of the sub-species F. a. grabae).

5.5.4 The Hermaness, Saxa Vord and Valla Field SPA qualifies further under Article 4.2 by regularly supporting in excess of 20,000 individual seabirds. It regularly supports 157,500 seabirds including nationally important populations of the following species: fulmar (19,539 pairs in 1999; 4 % of the GB population), shag (450 pairs in censuses in 1995 and 1999; 1 % of the GB population), common guillemot (25,000 individuals over two surveys carried out in 1996 and 1999; 2 % of the GB population) and kittiwake (922 pairs in 1999; 0.2 % of the GB population)".

Hermaness SSSI (978 ha)

5.5.5 According to SNH/NatureScot (https://sitelink.nature.scot/site/776; Accessed July 2020) "The high cliffs and stacks of the west and north support large colonies of nesting seabirds. A range of species occur in various nesting habitats including kittiwake on bare cliff ledges, herring gull and great black-backed gull on the summits of stacks and on sloping coastal rocks, shag and razorbill among cliff-foot boulders and black guillemot in rock crevices.

5.5.6 Some species individually reach numbers of national importance. These include gannet at 6 % of the British population, puffin (4 %), fulmar (3 %) and guillemot (1 %). Inland from the cliffs, the bog and heath vegetation provide nesting habitat for one of the largest colonies of great skua in the world, representing over 3 % of the global population". Hermaness SSSI is part of Hermaness, Saxa Vord and Valla Field SPA.

Saxa Vord SSSI (55.47 ha)

5.5.7 According to SNH/NatureScot (https://sitelink.nature.scot/site/475; Accessed July 2020) "The site is located on the coastline to the east of Saxa Vord hill overlooking Burra Firth and extends from Grisa Lee in the south to The Noup in the north. At the Noup the site boundary includes both sides of the headland and extends down the east coast to Ura. The site also contains several skerries which along with the sea cliffs support a wide range of seabirds. The site is notified for its nationally and internationally important breeding fulmar and guillemot populations and for the seabird colony as a whole.

5.5.8 The site supports a breeding colony of fulmar and guillemot contributing to 1.2% and 0.4% of the British population respectively".

5.5.9 Beyond the 4 km Ornithological Study Area (Volume III Drawing 5.2) there are other designated sites, some with ornithological features. Table 6.6 within AEE Report Chapter 6, Ecology, outlines biological designated sites within 10 km of the Proposed Project and includes the recently designated Fetlar to Haroldswick Marine Protection Area.

Ornithological Receptors

5.5.10 A summary of the principal findings from three years of targeted ornithological surveys (2018-2020) are provided below. Repeat breeding bird surveys were undertaken in 2022 and are provided as an addendum to the previous breeding bird survey report and provide an update on the ornithological baseline (Appendix 5.1). No new breeding bird species were recorded in 2022.

5.5.11 The study area was surveyed under SNH Schedule 1 licence for breeding birds in 2018 and 2019 by Mr David Cooper. Mr David Cooper and Mr Brydon Thomason undertook boat-based seabird counts. In 2020 Mr David Cooper surveyed the SaxaVord Spaceport site during the breeding season to inform summer survey visits by staff and other non-ornithological surveyors e.g., archaeologists. Both Mr David Cooper and Mr Brydon Thomason are highly experienced and competent, locally based ornithologists and used the relevant standard breeding bird survey methods during suitable weather conditions.

5.5.12 A total of 135 bird species were recorded in the study area during targeted breeding bird surveys. For full list of species recorded see Appendix 5.1. There is direct evidence from the study area surveys of potentially sensitive and specially protected bird species breeding within, and adjacent to, the Proposed Project and so these need to be considered further. These birds were considered '*wider countryside species*' for the purposes of evaluation and do not form part of any designated site feature.

5.5.13 The accompanying drawings provided for important ornithological receptors have been drawn showing distance bands away from the most westerly pad (Pad 1) with the following increments illustrated: 0-0.5 km; 0.5-1 km; 1-2 km; 2-3 km and 3-4 km.

Red-throated Diver

5.5.14 Evidence of breeding from three lochans within the study area (Confidential Drawing 1). Two breeding attempts in study area in 2018 – one failed and one presumed failed. Two breeding attempts in study area in 2019, both presumed successful as near-fledged juveniles seen at both sites.

Black Guillemot

5.5.15 The maximum count in 2018 was 84 black guillemots with 101 in 2019. The black guillemot surveys counted individual adult birds. The locations of breeding black guillemots are presented in Drawing 5.3.

Shag

5.5.16 The maximum boat-based count was 55 shag AON in 2018. The addition of a maximum 26 AON in the area between Virdik and Ura in 2020, provides an overall total of 81 shag AON within the 4 km study area (between Ura and The Nev). The locations of breeding shags are presented in Drawing 5.4.

Gannet

5.5.17 For clarity, no breeding gannets were recorded on boat-based surveys in 2018 and 2020.

Fulmar

5.5.18 The maximum boat-based count was 4,300 fulmar AON in 2018. The addition of 2,657 AON in the area between Virdik and Ura in 2020, provides an overall total of 6,987 fulmar AON within the 4 km study area (between Ura and The Nev). The locations of breeding fulmars are presented in Drawing 5.5.

Kittiwake

5.5.19 The maximum boat-based count was 55 kittiwake AON in 2018. The addition of no kittiwake AON in the area between Virdik and Ura in 2020, provides an overall total of 55 kittiwake AON within the 4 km study area (between Ura and The Nev). The locations of breeding kittiwake are presented in Drawing 5.6.

Black-headed Gull

5.5.20 A small black-headed gull (*Chroicocephalus ridibundus*) colony consisting of 11 pairs (2018) and 13 pairs (2019) was present at the Norwick Meadows (Drawing 5.6).

Common Gull

5.5.21 A moderate number of common gulls (*Larus canus*) bred, consisting of 22 pairs (2018) and 30 pairs (2019) at Braefield in a mixed gull colony (Drawing 5.6).

Lesser Black-backed Gull

5.5.22 A small number of lesser black-backed gulls (*Larus fuscus*) bred, consisting of 12 pairs (2018) and 10 pairs (2019) at Braefield in a mixed gull colony (Drawing 5.6).

Great Black-backed Gull

5.5.23 The maximum boat-based count was two great black-backed gull (*Larus marinus*) AON in 2018. The addition of a maximum six AON in the area between Virdik and Ura in 2020, provides an overall total of eight great black-backed gull AON within the 4 km study area (between Ura and The Nev). The locations of breeding great black-backed gulls are presented in Drawing 5.6.

Herring Gull

5.5.24 There was no herring gull (*Larus argentatus*) AON recorded in 2018. The addition of five AON in the area between Virdik and Ura in 2020, provides an overall total of five herring gull AON within the 4 km study area (between Ura and The Nev). Up to 16 pairs also bred in land at Braefield in a mixed gull colony, within the 3-4 km distance band. The locations of breeding herring gulls are presented in Drawing 5.6.

Common Guillemot

5.5.25 The maximum boat-based count was 80 individual common guillemots in 2018. The addition 20 individuals in the area between Virdik and Ura in 2020 provides an overall total of 100 individual common guillemots within the 4 km study area (between Ura and The Nev). The locations of breeding common guillemots are presented in Drawing 5.7.

Razorbill

5.5.26 The maximum boat-based count was 11 individual razorbills in 2018. The addition of four individuals in the area between Virdik and Ura in 2020, provides an overall total of 15 individual razorbills within the 4 km study area (between Ura and The Nev). The locations of breeding razorbills are presented in Drawing 5.8.

Puffin

5.5.27 The maximum boat-based count was 49 individual puffins in 2018. The addition of 76 individuals in the area between Virdik and Ura in 2020, provides an overall total of 125 individual puffins. The locations of puffins recorded on potentially suitable nesting habitat during the breeding season are presented in Drawing 5.9.

Merlin

5.5.28 Evidence of successful breeding near to, but not within the study area. One nearby successful breeding attempt in 2018 - a brood of three fledged merlin recorded around Northdale. Despite searching, no merlin nest was recorded within the study area, and it is not known where the fledged brood came from. One nearby successful breeding attempt in 2019. A female with fledged juveniles was recorded around between Skaw and Inner Skaw. Despite careful searching, no merlin nest was recorded within the study area, and it is not known where the fledged brood came from. Whilst it is assumed, they came from close to the study area boundary, it is possible they may have come from further away.

Ringed Plover

5.5.29 Evidence of multiple pairs breeding in study area. Nine breeding pairs were recorded in 2018 and 10 breeding pairs recorded in 2019 (Drawing 5.10). Most of the pairs were found at Skaw, Lamba Ness and Norwick, including pairs within the Proposed Project boundary (Drawing 5.11).

Golden Plover

5.5.30 Evidence of multiple pairs breeding in study area. Seven breeding pairs were recorded in 2018 and 13 pairs in 2019 in the study area (Drawing 6.12). Breeding pairs were distributed throughout the study area including at Saxa Vord, Sothers Field, Northdale, Housi Field, Hill of Clibberswick and Swartling, including one pair within the Proposed Project boundary (Drawing 5.13).

Whimbrel

5.5.31 Evidence of multiple pairs breeding in study area. There were five breeding territories in 2018 and four in 2019. Further confidential details have been provided to the local planning authority for assessment during the planning application phase of the SaxaVord Spaceport in accordance with SNH (2016) guidance.

Curlew

5.5.32 Evidence of multiple pairs breeding in study area. There were ca. 16 breeding territories in 2018 and ca. 13 in 2019 (Drawing 5.14). Given the distances breeding curlews can move, it is possible that some territories have been double-counted and without colour ringing it is not possible to be certain. Nevertheless, in areas where multiple curlew territories have been plotted close together e.g., Norwick Meadows, there was direct evidence of multiple pairs being present within a relatively small area, including pairs within the SaxaVord Spaceport Planning Application boundary (Drawing 5.15).

Dunlin

5.5.33 Evidence of multiple pairs breeding in study area (Drawing 5.16). Five breeding territories were recorded in 2018 and four breeding territories recorded in 2019. Breeding territories were located in areas including Saxa Vord hill, Southers Field, Skaw, Lamba Ness and Housi Field, including one pair within the Proposed Project boundary (Drawing 5.17).

Arctic Tern

5.5.34 Evidence of multiple pairs breeding in study area (Drawing 5.18). A few small breeding colonies were present within the study area, with one pair on Hill of Clibberswick in 2018, two pairs in 2018 and three pairs in 2019 on Norwick beach and six pairs in 2018 and 10 pairs in 2019 at Skaw.

Arctic Skua

5.5.35 Evidence of multiple pairs breeding in study area. Five pairs of Arctic skua recorded breeding in the study area in 2018 and 2019 (Drawing 5.19). Pairs occupied territories both years in areas such as Hill of Clibberswick, Ward of Norwick and Inner Skaw, including territories very close to the Proposed Project boundary (Drawing 5.20).

Great Skua

5.5.36 Highly variable numbers of great skua (*Stercorarius skua*) were recorded during surveys, reflecting the social nature of this species. Large numbers of non-breeding great skuas can hold territory in apparently suitable breeding habitats, making accurate estimates of actual number breeding difficult and with a high degree of uncertainty. It is considered the numbers of breeding pairs within the study area likely to be in the low tens, with breeding birds mainly concentrated over three kilometres away from the nearest launch pad. Great skua numbers were concentrated around Saxa Vord hill e.g., with minimum 17 nests recorded in June 2018 and groups of presumed non-breeders numbering up to 90 individuals. Additionally, within the 3 km to 4 km buffer, smaller numbers of great skua were recorded at Sothers Field and Housi Field (Drawing 5.21).

Confidential Schedule 1 species

5.5.37 Confidential species information, where information would have appeared in the relevant sections of this AEE Report chapter were it not for the fact that this information could endanger rare and legally protected species from wildlife crime, has been submitted to and assessed previously by the local planning authority, as part of the EIA process for the SaxaVord Spaceport facility. For confidentiality reasons, this information is not included in the AEE submission.

Natural Capital

5.5.38 The most easterly headland on Lamba Ness, where the Proposed Project will be operated, is regularly used by local people and visitors for bird watching and whale watching.

5.6 Receptors Brought Forward for Assessment

5.6.1 Ornithological designated site interests on the Hermaness, Saxa Vord and Valla Field SPA (and overlapping Hermaness SSSI and Saxa Vord SSSI) and the following non-designated wider countryside ornithological receptors are taken forward for assessment: red-throated diver, merlin, black guillemot, common guillemot, puffin, razorbill, shag, kittiwake, fulmar, ringed plover, golden plover, whimbrel, curlew, dunlin, Arctic tern, Arctic skua and a confidential Schedule 1 species. The numbers of most gull species (with the exception of kittiwake) were considered small and trivial in relation to their overall regional population size and so have been scoped out of further consideration, as was gannet.

Potentially Important Ornithological Receptors

5.6.2 The conservation/legal importance of potentially important ornithological receptors was determined using criteria set out in Table 5.5. The importance of a species from a legal perspective in this listing does not equate to the importance of population at a site. The conservation importance of the birds using a site is evaluated by considering the number of individuals of species present in the context of geographical populations. A site can hold a protected species of importance, but the population present may not be regionally, nationally or internationally important. Thus, the occurrence of a legally protected species listed in Table 5.5 does not mean a site is necessarily important for that species.

Table 5.5 Conservation Listing of Potentially Important Ornithological Receptors

Species	Conservation listing of target species
Red-throated diver	S1, A1
Gannet	Amber L
Black guillemot	Amber L
Common guillemot	Amber L
Puffin	Red L
Razorbill	Amber L
Shag	Red L
Kittiwake	Red L
Fulmar	-
Merlin	A1, S1, Red L
Ringed plover	Red L
Golden plover	A1
Dunlin	A1 (*schinz*), Amber L
Whimbrel	S1, Red L
Curlew	Red L
Arctic tern	Amber L
Arctic skua	Red L
Great skua	Amber L
Key: A1 = EC Birds Directive Annex I species, S1 = UK Wildlife and Countryside Act Schedule 1 species, Amber L = UK Birds of Conservation Concern Amber List Species, Red L = UK Birds of Conservation Concern Red List species.	

5.6.3 Geographical population estimates for potentially important bird species within the study area are provided in Table 5.6.

Table 5.6 Geographical Population Estimates for Potentially Important Study Area Bird Species (breeding pairs unless stated)

Species	Shetland (Regional) population	Scotland population	UK (National) population	Europe population (International status)
Red-throated diver	407*	935-1,500	1,250	42,100-93,000 (Least Concern)
Gannet	42,183 AOS**	243,505 AOS**	295,000	683,000 (Least Concern)
Black guillemot	15,739 individuals***	18,750	19,500	304,000-742,000 individuals (Least Concern)
Common guillemot	172,681 individuals***	780,000	950,000	2,350,000-3,060,000 individuals (Least Concern)

Species	Shetland (Regional) population	Scotland population	UK (National) population	Europe population (International status)
Puffin	107,676 AOBs*	493,000	580,000	4,770,000-5,780,000 (Vulnerable)
Razorbill	9,492 individuals***	93,300	165,000	979,000-1,020,000 individuals (Near Threatened)
Shag	6,147 AON***	21,500-30,000	17,500	76,300-78,500 (Least Concern)
Kittiwake	16,732 AON***	282,200	205,000	1,730,000-2,200,000 (Vulnerable)
Fulmar	188,544 AOS***	486,000 AOS	350,000	3,380,000-3,500,000 (Least Concern)
Merlin	30*	800	1,150	32,000-51,600 (Least Concern)
Ringed plover	800-1,000*	4,900-6,700	5,300	140,000-213,000 (Least Concern)
Golden plover	5,665*	15,000	32,500-50,500	630,000-860,000 (Least Concern)
Dunlin	2,054*	8,000-10,000	8,600-10,500	426,000-562,000 (Least Concern)
Whimbrel	290*	400-500	310	343,000-402,000 (Least Concern)
Curlew	4,227*	58,800	58,500	212,000-292,000 (Near Threatened)
Arctic tern	24,716 AON***	47,300 AON	53,500	564,000-906,000 (Least Concern)
Arctic skua	516*	2,100	785	39,900-56,200 (Least Concern)
Great skua	6,846	9,650	9,650	16,300-17,200 (Least Concern)
Population estimate reference	*Wilson *et al.* 2015 **Murray *et al.* 2015 ***Mitchell *et al.* 2004	Wilson *et al.* 2015	Woodward *et al.* 2020	Birdlife International, 2015

AOB = Apparently Occupied Burrow, AOS = Apparently Occupied Site, AON = Apparently Occupied Nest. Quoting the most recent published estimate for geographical populations sometimes results anomalies, such as the apparently larger Scottish than UK population estimate for whimbrel. The UK population estimate of 310 pairs is more up to date than the older Scottish population estimate of 400-500 pairs. For whimbrel the 290 Shetland metric comes from work Dr Digger Jackson conducted in 2009 on the Viking Wind Farm and he reported that subsequent monitoring across west and central Shetland shows the population has not substantially changed since then. Furthermore, the 290 pairs metric originally quoted was based on a single survey visit and subsequent detailed whimbrel population monitoring work has shown that if two-three site visits are undertaken, then surveyors record ca. 10 % more pairs. Consequently, the actual Shetland whimbrel population size is probably around ca. 320 pairs (D. Jackson, *pers com.*).

5.6.4 The behavioural sensitivity of the potentially important ornithological receptors is described using criteria set out in Table 5.7. When available, the assumed distance thresholds and hence sensitivity for disturbance in Table 5.7 was predominantly based on expert opinion examined by Ruddock and Whitfield (2007), Gilbert *et al.*, (1998), Scottish Government (2012) and field experience. The assessment of behavioural sensitivity is primarily based on disturbance to breeding birds at the nest, not general disturbance of birds undertaking other activities. However, note that the Scottish Government (2012) assessment of sensitivity was largely based around disturbance at sea foraging and not at the nest and each species was given a 'Disturbance Score' out of 5, where scoring categories were: 1 (hardly any escape behaviour and a very short flight distance when approached), to 5 (strong escape behaviour, at a large response distance).

5.6.5 A potentially useful and recognised method used to describe potential disturbance to birds involves two basic measures of receptor response (Ruddock and Whitfield, 2007):

- 'Alert Distance' (AD) – the distance between the disturbance source and the bird; at the point where the bird changes its behaviour in response to the approaching disturbance event.
- 'Flight Initiation Distance' (FID) – the point at which the bird flushes or flies away from the approaching disturbance event.

5.6.6 Where known, the difference between AD and FID in potentially important ornithological receptors is described based on published and unpublished research sources. However, few studies have looked in enough detail at AD and FID to differentiate these with any degree of rigour or confidence and often simply describe a 'flushed at' distance instead (equivalent to FID).

5.6.7 To understand potential impacts of short duration loud noise events, a background literature review of noise impacts on birds for the Proposed Project (Appendix 5.2) was undertaken. This literature review looked at how impulsive noise (from various sources including aircraft, fireworks, military ranges and rocket launches) impacts on both bird populations and individual behaviour and breeding success in order to help assess the potential noise impacts of the launches. To do this, the review focussed on identifying impulsive noise studies for the species of interest in Unst and specifically within the ornithological study area. A variety of freely available databases have been searched including ResearchGate and Google Scholar. References considered included both peer-reviewed published scientific papers and 'grey literature' reports. However, relevant literature was limited and so a wider literature search was conducted looking at other species including where possible analogous birds to those present in the ornithological study area.

5.6.8 Taking into account evidence from the literature review (Appendix 5.2), it is apparent that loud infrequent noise associated with RFA ONE NOM Launch Vehicle launches could be expected to impact on birds in close proximity to operational launch pads. Less clear, are the ecological effects and consequences of the short duration loud disturbance impacts on these birds. Most studies consider potential impacts (e.g., startled response, increased vigilance etc.) and do not show or demonstrate long-term population level consequences or effects. Nevertheless, space centres can hold good breeding populations of birds, many of them declining species and conservation priorities. For example, the land immediately adjacent to the Kennedy Space Centre in Florida, USA, is home to large breeding populations of wading birds (Smith and Breininger, 1995), despite being exposed to irregular loud impulsive noise events.

Table 5.7 Behavioural Sensitivity of Potentially Important Species

Species	Nature of sensitivity	Sensitivity level
Red-throated diver	Breeding birds are sensitive to human activity, visual disturbance and sudden noise events over large distances (up to 500 m). However, evidence from the Shetland Viking Wind Farm studies indicates that some individuals (perhaps habituated) appear to tolerate moderate levels of disturbance in some situations. The size of waterbodies also has an impact on FID; breeding birds are more easily disturbed and fly from small nesting lochans than large lochs, where they have the ability to swim away and/or dive without taking flight.	High at nest.
Gannet	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity (1 = hardly any escape behaviour and a very short flight distance when approached, to 5 = strong escape behaviour, at a large response distance). Gannet scored 2. Gannets are highly traditional in where they breed (Mitchell *et al.,* 2004) and have increased at locations such as Sula Sgeir, where they are regularly disturbed and still exploited for food, with ca. 2,000 well-grown chicks harvested every year (Murray *et al.,* 2015).	Low at sea and nest.
Black guillemot	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Black guillemot scored 3, sometimes flying from approaching boats hundreds of metres away (FID). Elsewhere, e.g., Lerwick Harbour, the species nests in harbour wall holes in very close proximity to regular, but also unexpected human disturbance (both visual and noise) on water and land.	Moderate at sea. Low at nest.
Common guillemot	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Common guillemot scored 3, sometimes flying from approaching boats hundreds of metres away. Nest sensitivity considered to be moderate, with for example guillemots sometimes being flushed from ledges if boats get too close.	Moderate at sea and nest.
Puffin	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Puffin scored 2. Nest sensitivity considered low, with puffins able to tolerate large numbers of humans within a few metres of nesting burrows e.g., Sumburgh Head RSPB Reserve.	Low at sea and nest.
Razorbill	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Razorbill scored 3, sometimes flying from approaching boats hundreds of metres away. Nest sensitivity considered moderate.	Moderate at sea and nest.

Species	Nature of sensitivity	Sensitivity level
Shag	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Shag scored 3. Nest sensitivity considered to be moderate, with for example shag sometimes being flushed from ledges if boats get too close.	Moderate at sea and nest.
Kittiwake	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Kittiwake scored 2. Nest sensitivity considered to be low.	Low at sea and nest.
Fulmar	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Fulmar scored 1. Nest sensitivity also considered to be low.	Low at sea and nest
Merlin	Breeding merlin are particularly sensitive to human activity, visual disturbance, and sudden noise events over large distances (up to 500 m). However, some individual merlins appear to tolerate moderate levels of disturbance in some situations. For example, some merlins appear to be able to nest relatively close to public roads, where regular disturbance occurs, including on Shetland.	High at nest
Ringed plover	Breeding ringed plovers have relatively small territories and regularly select to nest on man-made habitats in Shetland, such as road verges and quarries and so is not considered particularly susceptible or sensitive to human disturbance.	Low at nest
Golden plover	Breeding golden plovers have relatively small territories are sensitive to human activity, visual disturbance, and sudden noise events over moderate distances (~250 m).	Moderate at nest
Dunlin	Breeding dunlin have very small territories, are sensitive to human activity, visual disturbance and sudden noise events over moderate distances (~250 m).	Moderate at nest
Whimbrel	Breeding birds are usually considered sensitive to human activity, visual disturbance and sudden noise events. However, in Shetland whimbrel nest in short, grazed vegetation, periodically visited by crofters. Adult whimbrel on their breeding territories show disturbance responses to the presence of a moving or static person up to 250 m away (Massey *et al.,* 2016).	Moderate at nest
Curlew	Breeding birds are usually considered sensitive to human activity, visual disturbance and sudden noise events over moderate distances (~250 m). However, in Shetland curlews often nest and feed close to or on in-bye fields, which are regularly used by crofters, often on a daily basis.	Moderate at nest

Species	Nature of sensitivity	Sensitivity level
Arctic tern	Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Arctic tern scored 2. Tern colonies are considered moderately sensitive; with total colony abandonment possible under some (poorly understood) circumstances.	Low at sea, moderate at nest
Arctic skua	Arctic skuas have relatively small nesting territories (sometimes within discrete colonies). Although birds aggressively defend territories, care needs to be taken around nests, especially not to flush young skuas which are vulnerable to predation by neighbouring adult Arctic and great skuas. Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Arctic skua scored 1.	Low at sea, low-moderate at nest
Great skua	Great skua colonies are relatively robust to human disturbance e.g., consider the 9,000 people who walk through the great skua colony at Hermaness annually [1]. Scottish Government advice (2012) on disturbance by wind farm structures, ship and helicopter traffic conducted a literature search focused on disturbance sensitivity of seabirds, and allocated scores by experts on sensitivity. Great skua scored 1.	Low at sea, low-at nest

5.6.9 The typical breeding calendar of the potentially important ornithological receptors within the study area is provided in Table 5.8. There is obviously overlap between the main egg laying/incubation period and the main period dependent young present. However, for simplicity, these main periods are separated out in Table 5.8.

Table 5.8 Typical Breeding Calendar of Potentially Important Species

Species	April		May		June		July		August		Sept		Reference
Red-throated diver			red	red	yellow	yellow	yellow	yellow	yellow	yellow			Incubation 27 days; Fledging 43 days[1,2,3]
Gannet	red	red	red	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow		Incubation 43 days; Fledging 90 days[1,2,3]
Black guillemot				red	red	red	yellow	yellow	yellow	yellow			Incubation 23-40 days; Fledging 40 days[1,2,3]
Common guillemot		red	red	red	yellow	yellow	yellow						Incubation 34 days; Fledging 20 days[1,2,3]
Puffin	red	red	red	yellow	yellow	yellow	yellow	yellow					Incubation 42 days; Fledging 50 days[1,2,3]
Razorbill		red	red	red	red	red	yellow	yellow					Incubation 34 days; Fledging 20 days[1,2,3]
Shag	red	red	red	red	yellow	yellow	yellow	yellow					Incubation 31 days; Fledging 53 days[1,2,3]

[1] Jonathan Swale (SNH) reported in the press that visitor numbers to Hermaness had gone up by 50 % over the previous four years to 9,000 in 2019. https://www.shetnews.co.uk/2019/06/06/hermaness-path-to-be-upgraded-to-cope-with-rising-visitor-numbers/

Species	April		May		June		July		August		Sept		Reference
Kittiwake				Red	Red	Red	Yellow	Yellow	Yellow				Incubation 29 days; Fledging 43 days[1,2,3]
Fulmar			Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow			Incubation 51 days; Fledging 49 days[3]
Merlin		Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow				Incubation 30 days; Fledging 30 days[4]
Ringed plover	Red	Red	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Yellow			Incubation 24 days; Fledging 24 days[1,2,3]
Golden plover	Red	Red	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow				Incubation 29 days; Fledging 30 days[1,2,3]
Dunlin		Red	Red	Red	Red	Yellow	Yellow	Yellow					Incubation 22 days; Fledging 20 days[1,2,3]
Whimbrel				Red	Red	Red	Yellow	Yellow	Yellow				Incubation 28 days; Fledging 30 days[1,2,3]
Curlew		Red	Red	Red	Red	Red	Yellow	Yellow					Incubation 28 days; Fledging 34 days[1,2,3]
Arctic tern				Red	Red	Red	Yellow	Yellow	Yellow				Incubation 22 days; Fledging 23 days[1,2,3]
Arctic skua				Red	Red	Red	Yellow	Yellow					Incubation 27 days; Fledging 28 days[1,2,3]
Great skua				Red	Red	Red	Yellow	Yellow	Yellow				Incubation 29 days; Fledging 44 days[1,2,3]

Red = typical main egg laying/incubation period, Yellow = typical main period dependent young present. Note, table does not include relay or 2nd brood dates. 1 = Gilbert *et al.,* 1998 (reprinted 2011); 2 = Forrester and Andrews, 2007; 3 = Snow and Perrins, 1998; 4 = Hardey *et al.,* 2013.

5.6.10 A summary of the population size and percentage of geographical population estimates for potentially important bird species is provided in Table 5.9.

5.6.11 Whilst considering the potential consequences of loud impulsive noise events on important and sensitive bird species, consideration has also been given to SNH's ornithological comments and advice on the recent 2020 Sutherland Space Hub planning application. The Caithness and Sutherland Peatlands SPA and the Ben Hutig and A'Mhoine SSSI are 31 m away from the nearest access road and 109 m away from the launch pad of that Project. Thus, that Project is very close to the designated sites and their breeding birds, which include dunlin, greenshank, golden plover and red-throated diver; three of which breed within the study area.

5.6.12 In SNH's consultation response on the Sutherland Space Hub of 12/03/20 it stated that "*Disturbance through noise from launches has been evaluated in the EIAR and although the noise events are extremely loud, they will be very short-lived. From our own experience of blasting for construction and from military jets, it appears that sudden, loud noise events have short-term effects and do not appear to result in the permanent displacement of breeding birds. Therefore, our advice is that there is no basis for concluding adverse impact from the launches themselves*".

Table 5.9 Summary Population Size and Percentage of Geographical Population Estimates for Potentially Important Bird Species (breeding pairs unless stated). **Species in bold match or exceed nominal 1 % threshold of either the Regional or National population levels.**

Species	Shetland (Regional) population	Scotland population	UK (National) population	Europe population	Population and % of Regional (and where relevant National) population within 4 km of launch pads (max est.)	Population and % of Regional population (and where relevant National) within 2 km of launch pads (max est.)	Population and % of Regional population within 1 km of launch pads (max est.)
Red-t diver	407	935-1,500	1,250	42,100-93,000	2 (0.5 % of Regional pop)	0 (0 %)	0 (0 %)
Gannet	42,183 AOS	243,505 AOS	295,000	683,000	0 (0 %)	0 (0 %)	0 (0 %)
Black guillemot	15,739 individuals	18,750	19,500	304,000-742,000 individuals	101 ind (0.64 % of Regional pop)	50 ind (0.32 % of Regional pop)	25 ind (0.16 % of Regional pop)
Common guillemot	172,681 individuals	780,000	950,000	2,350,000-3,060,000 individuals	100 ind (0.0 6% of Regional pop)	27 ind (0.02 % of Regional pop)	0 ind (0 %)
Puffin	107,676 AOB	493,000	580,000	4,770,000-5,780,000	125 ind (0.06 % of Regional pop*)	35 (0.02 % of Regional pop*)	8 (0.004 % of Regional pop*)
Razorbill	9,492 individuals	93,300	165,000	979,000-1,020,000 individuals	15 (0.16 % of Regional pop)	0 (0 %)	0 (0 %)
Shag	**6,147 AON**	**21,500-30,000**	**17,500**	**76,300-78,500**	**81 (1.32 % of Regional pop)**	**6 (0.1 % of Regional pop)**	**1 (0.02 % of Regional pop)**
Kittiwake	16,732 AON	282,200	205,000	1,730,000-2,200,000	55 (0.32 % of Regional pop)	50 (0.3 % of Regional pop)	0 (0 %)
Fulmar	**188,544 AOS**	**486,000 AOS**	**350,000**	**3,380,000-3,500,000**	**6,987 (3.7 % of Regional and 1.99 % of National pop)**	**2,635 (1.4 % of Regional pop)**	**1,170 (0.62 %)**

Species	Shetland (Regional) population	Scotland population	UK (National) population	Europe population	Population and % of Regional (and where relevant National) population within 4 km of launch pads (max est.)	Population and % of Regional population (and where relevant National) within 2 km of launch pads (max est.)	Population and % of Regional population within 1 km of launch pads (max est.)
Merlin	30	800	1,150	32,000-51,600 (Least Concern)	0 (0 %), although one fledged brood recorded	0 (0 %)	0 (0 %)
Ringed plover	**800-1,000**	**4,900-6,700**	**5,300**	**140,000-213,000**	**10 (1.0-1.25 % of Regional pop)**	**8 (0.8-1.0 % of Regional pop)**	**3 (0.3-0.38 % of Regional pop)**
Golden plover	5,665	15,000	32,500-50,500	630,000-860,000	13 (0.23 % of Regional pop)	4 (0.07 % of Regional pop)	1 (0.02 % of Regional pop)
Dunlin	2,054	8,000-10,000	8,600-10,500	426,000-562,000	5 (0.24 % of Regional pop)	3 (0.15 % of Regional pop)	1 (0.05 % of Regional pop)
Whimbrel	**[290] D. Jackson pop est. ca. 320**	**400-500**	**310**	**343,000-402,000**	**5 (1.7 % of Regional and 1.6 % of National pop). 1.6 % of Regional pop using Jackson pop est**	**3 (1.04 % of Regional pop). 0.9 % of Regional pop using Jackson pop est**	**2 (0.69 % of Regional pop). 0.63 % of Regional pop using Jackson pop est**
Curlew	4,227	58,800	58,500	212,000-292,000	16 (0.4 % of Regional pop)	3 (0.07 % of Regional pop)	1 (0.02 % of Regional pop)
Arctic tern	24,716 AON	47,300 AON	53,500	564,000-906,000	13(0.05 % of Regional pop)	13 (0.05 % of Regional pop)	0 (0 %)
Arctic skua	516	2,100	785	39,900-56,200	5 (0.97 % of Regional pop)	3 (0.58 % of Regional pop)	1 (0.19 % of Regional pop)
Great skua	6,846	9,650	9,650	16,300-17,200	Low tens (<1 % of Regional pop)	0 (0 %)	0 (0 %)

AOB = Apparently Occupied Burrow, AOS = Apparently Occupied Site, AON = Apparently Occupied Nest. *metric assumes all individuals counted were breeding birds and AOB converted from number of individuals for comparative purposes.

5.7 Standard Mitigation

5.7.1 Following CIEEM (2018) guidance, the assessment process assumes the application of standard mitigation measures. A range of mitigation measures have already been in-built as part of the iterative design process for the SaxaVord Spaceport, to avoid the higher value species and their habitats. As a Launch Operator working within the boundary of the SaxaVord Spaceport, the Applicant is committed to adhering to the following standard mitigation measures:

- A detailed Breeding Birds Protection Plan, required as a planning condition for the SaxaVord Spaceport, has been produced and will be updated regularly through targeted breeding bird surveys. The Applicant will adhere to any recommendations set out in this document.
- Following the NatureScot consultation response dated 11 March 2021, SaxaVord Spaceport has made a commitment to a 'no-launch window' whereby no satellite launches, or static tests will be carried out between mid-May and the end of June (subject to ongoing monitoring and appraisal). The Applicant is aware of this operational constraint and will not schedule launches within the defined mid-May to end of June window.
- As applicable, compliance with the SaxaVord Spaceport Habitat Management Plan, required as a planning condition for the SaxaVord Spaceport (Appendix 5.3).

5.8 Potential Effects

Designated Sites

5.8.1 Internationally important populations of birds are present within the Hermaness, Saxa Vord and Valla Field SPA, including red-throated diver (3 % of British population), gannet (8 % of British and 6 % of world population), great skua (9 % of British and 6 % of world population) and puffin (6 % of British population). The SPA also regularly supports over 150,000 breeding seabirds which include 4 % of the British fulmar population, 1 % of the British shag population, 2 % of the British common guillemot population and 2 % of the British kittiwake population (https://sitelink.nature.scot/site/8512; Accessed July 2020).

5.8.2 SNH provided Alba Ecology with the designated sites' breeding bird data on 02/06/20 (Table 5.10).

Table 5.10 Designed Site Breeding Bird Data (courtesy of SNH)

Species	Saxa Vord SSSI	Hermaness SSSI/NNR	Valla Field
Red-throated diver		5 pairs (2015-2016), 6 pairs (2018-2019)	12 pairs (2012-2013), average 18 pairs in past
Common guillemot	1,948 ind. (2017)	5,808 ind. (2016)	
Puffin	217 ind. (2017)	11,455 AOB (2017)*	82 ind. (2016)
Razorbill	42 ind. (2017)	139 ind. (2016)	
Shag	32 AON (2017)		
Kittiwake	95 AON (2017)	171 AON (2016)	
Fulmar	8,057 AOS (2016)	11,786 AOS (2016)	1,146 AOS (2016)
Gannet		25,580 AON (2014)*	
Merlin		1 pair (2018)	

Species	Saxa Vord SSSI	Hermaness SSSI/NNR	Valla Field
Arctic skua		2 AON (2016, 2018, 2019), 1 AON (2017)	
Great skua		955 AON (2018)	198 AOT (2013)

*Puffin estimate calculated from counts of loafing birds and so has a wide margin of error (Jonathan Swale, *pers comm.*).
**Following the 2022 birdflu (H5N1) outbreak, the virus has killed tens of thousands of seabirds, including many in key Shetland colonies of gannets and great skuas. Consequently, published population estimates (which are based on pre birdflu estimates) are unlikely to reflect actual numbers, which may be substantially lower than these quoted metrics.

5.8.3 The distance between the nearest land part of the Hermaness, Saxa Vord and Valla Field SPA (at the Noup) and Launch Pad 1 is 3.79 km.

5.8.4 Based on the Applicant's maximum monthly launch program, up to six launches could in theory take place annually between April and June, the main incubation period for the SPA birds. However, it should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.5 In the context of the Sutherland Space Hub, the launch pad of which was 109 m from the nearest part of the Caithness and Sutherland Peatlands SPA, SNH considers "*loud noise events have short-term effects and do not appear to result in the permanent displacement of breeding birds. Therefore, our advice is that there is no basis for concluding adverse impact from the launches themselves*" and so it seems unlikely that Hermaness, Saxa Vord and Valla Field SPA birds, the nearest of which are approximate 3.79 km away from Pad 1, would be adversely affected by the predicted maximum noise levels at launch.

5.8.6 Under this scenario, the potential magnitude of adverse impacts of operational (noise) disturbance on designated site bird species would likely be negligible, with **no likely significant effects** predicted.

Red-throated Diver

5.8.7 Red-throated diver is an Annex 1 and Schedule 1 species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be high (Table 5.7). The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ red-throated diver population estimate is 407 pairs and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.8 The species nests on the edge of freshwater lochs and lochans, often within blanket bog/peatland. The adults usually forage away from the breeding lochs, feeding in the sea, or occasionally large freshwater lochs and carry fish back to the chicks (Forrester and Andrews, 2007). Consequently, the breeding sites are a relatively predictable 'fixed constraint' insofar as they always nest within 1 m of a loch/lochan shore, can only use certain types of waterbody (whose characteristics are well known) and regularly use the same lochs and lochans over time.

5.8.9 Details of potential operational impacts on red-throated diver have been provided in a confidential appendix previously to the local planning authority in accordance with SNH (2016) guidance.

5.8.10 The potential magnitude of adverse impacts of operational disturbance combined on red-throated diver would likely be negligible, with **no likely significant effects** predicted. Although red-throated diver is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates, that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Red-throated diver is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.

- The natural range of red-throated diver in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the red-throated diver population on a long-term basis should the Proposed Project operate.

Black Guillemot

5.8.11 Black guillemot is an Amber listed species and therefore of moderate conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be low at the nest (Table 5.7). The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ black guillemot population estimate is 15,739 individuals and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.12 The species typically nests on predator-free islands with suitable boulder beaches in loose colonies, or at lower densities on cliffs inaccessible to mammalian predators (Forrester and Andrews, 2007). The adults feed at sea and carry fish back to the chicks. Consequently, the breeding sites are a relatively predictable 'fixed constraint' insofar as they nest within the same boulder beach and cliff habitats over time.

5.8.13 With a maximum of 101 black guillemots breeding within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project. Noise modelling of a RFA ONE NOM launch has been completed by BRRC and is described in detail in Chapter 8. Data relevant to ecology has been summarised and assessed below.

5.8.14 Table 5.12 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting black guillemot. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.12 Maximum Predicted Decibel Levels at Black Guillemot Nesting Locations around Launch Pad 1

Individuals	Launch LAmax	Static LAmax
13-14 ind, 0-0.5km	120-130dB	110-130dB
8-12 ind, 0.5-1km	110-120dB	100-110dB
25-27 ind, 1-2km	100-110dB	90-100dB
25-26 ind, 2-3km	90-100dB	90-100dB
10-25 ind, 3-4km	90-100dB	80-90dB

5.8.15 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding black guillemot within the study area and there is also no threshold noise metric against which to compare potential effects on black guillemot. However, pigeon guillemot (*Cepphus columba*), a similar analogous Pacific species has shown adverse responses to fireworks near nesting sites in California (Appendix 5.2).

5.8.16 Breeding black guillemot are not considered particularly sensitive to human activity, visual disturbance and sudden noise events at the nest, as evidenced by the range of nesting sites provided by Forrester and Andrews (2007). Nevertheless, whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds (in the underground nest) to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 23-40 day incubation period for black guillemot (Table 5.8). It should be noted that following the NatureScot consultation response to the

Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.17 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding black guillemot directly related to a launch) then this would constitute an adverse impact on 101 individuals out of Shetland's 15,739 individual black guillemots, i.e., 0.64 % of the regional population (Table 5.9). If no such adverse response took place, then 0 % of the regional population would be adversely affected. Under both of these scenarios, a significant operational impact on the regional black guillemot population in Shetland is considered unlikely.

5.8.18 Under either of these scenarios, the potential magnitude of adverse impacts of operational disturbance on black guillemot would likely be negligible, with **no likely significant effects** predicted. Although black guillemot is a species of moderate conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operated, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Black guillemot is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of black guillemot in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the black guillemot population on a long-term basis should the Proposed Project be operated.

Common Guillemot

5.8.19 Common guillemot is an abundant Amber listed species and therefore of moderate conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be moderate at the nest (Table 5.7). The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ common guillemot population estimate is 172,681 individuals and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.20 The species typically nests in colonies, often containing many thousands of pairs, in locations inaccessible to mammalian predators e.g., ledges on sheer cliffs, tops of stacks and among boulders and flat ground on offshore islands (Forrester and Andrews, 2007). The adults feed at sea and carry fish back to the chicks. Consequently, the breeding sites are a relatively predictable 'fixed constraint' insofar as they nest within the same sheer cliff habitats over time.

5.8.21 With a maximum of 100 common guillemots breeding within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.22 Table 5.13 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting common guillemot. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.13 RFA Modelling Study - Maximum Predicted Decibel Levels at Common Guillemot Nesting Locations around Launch Pad 1

Individuals	Launch LAmax	Static LAmax
27 ind, 1-2km	100-110dB	90-100dB
20 ind, 2-3km	95-105dB	90-100dB
53 ind, 3-4km	90-105dB	80-90dB

5.8.23 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding common guillemot within the study area and there is also no threshold noise metric against which compare potential effects on common guillemot.

5.8.24 A study (Dunnet, 1977) to explore the possibility that an increase in air traffic associated with oilfields off the north-east of Scotland was impacting on breeding seabirds recorded the reactions of a mixed seabird colony, including common guillemots, on the Buchan cliffs in relation to aircraft flying within 100 m. Virtually no behavioural reaction was reported as a result of the flyovers to within 100 m of the colony which was conducted during early egg laying and early nestling periods (Appendix 5.2).

5.8.25 Breeding common guillemots are considered moderately sensitive to human activity, visual disturbance, and sudden noise events at the nest. Based on the literature available (Appendix 5.2) on common guillemot (called common murre in the USA publications) on disturbance from planes/helicopters suggests that this species is most sensitive to flushing in the pre-egg laying/early egg laying period. Flushing in this species occasionally causes eggs/chicks to be dislodged. However, it is not known if such dislodging of eggs/chicks is additive in terms of overall mortality, as sub-optimal nest locations regularly lose eggs/chicks naturally in the breeding season regardless. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Such activity would likely to be most severe during pre-egg laying and early incubation period. Based on the likely launch schedule, launches could take place during the typical 34-day incubation period for common guillemot (Table 5.8). It should be noted that following the NatureScot consultation response to the Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.26 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding common guillemots directly related to a launch) then this would constitute an adverse impact on 100 individuals out of Shetland's 172,681 individual common guillemots, i.e., 0.06 % of the regional population (Table 5.9). If no such adverse response took place, then 0 % of the regional population would be adversely affected. Under both of these scenarios, a significant operational impact on the regional common guillemot population in Shetland is considered unlikely.

5.8.27 Under either of these scenarios, the potential magnitude of adverse impacts of operational disturbance on common guillemot would likely be negligible, with **no likely significant effects** predicted. Although common guillemot is a species of moderate conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Common guillemot is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of common guillemot in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the common guillemot population on a long-term basis should the Proposed Project be operated.

Puffin

5.8.28 Puffin is a common Red listed species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be low at the nest (Table 5.7). The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ puffin population estimate is 107,676 AOB and with recent evidence of an apparent decline the species in Shetland (e.g., Owen *et al.,* 2018), puffin is not likely to be in FCS within Shetland.

5.8.29 The species typically nests within burrows (dug in soil and less commonly among boulders) in colonies, in locations inaccessible to mammalian predators (Forrester and Andrews, 2007). The adults feed at sea and carry fish back to the chicks. Consequently, the breeding sites are a relatively predictable 'fixed constraint' insofar as they nest within the same burrow habitats over time.

5.8.30 With a maximum of 125 individuals breeding within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.31 Table 5.14 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting puffin. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.14 RFA Modelling Study - Maximum Predicted Decibel Levels at Puffin Nesting Locations around Launch Pad 1

Individuals	Launch LAmax	Static LAmax
2 ind, 0-0.5 km	120-130dB	110-130dB
6 ind, 0.5-1 km	110-120dB	100-110dB
27 ind, 1-2 km	100-110dB	90-100dB
23 ind, 2-3 km	95-105dB	90-100dB
67 ind, 3-4 km	90-105dB	80-90dB

5.8.32 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding puffin within the study area and there is also no threshold noise metric against which compare potential effects on puffin.

5.8.33 A study (Dunnet, 1977) to explore the possibility that an increase in air traffic associated with oilfields off the north-east of Scotland was impacting breeding seabirds recorded the reactions of a mixed seabird colony, including puffins, on the Buchan cliffs in relation to aircraft flying within 100 m. Virtually no behavioural reaction was reported as a result of the flyovers to within 100 m of the colony which was conducted during early egg laying and early nestling periods (Appendix 5.2).

5.8.34 Breeding puffins are considered tolerant of human activity, visual disturbance, and sudden noise events at the nest. Based on the literature available, puffins hearing range is between 500h hz to 6,000 hz (Appendix 5.2) so they would certainly hear the noise at launch. The presence of puffin nests in underground burrows will substantially reduce the potential noise at nests. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Such activity would probably be most severe during pre-egg laying and the incubation period (early April to the end of May). Based on the likely launch schedule, launches could take place during the typical 42 day incubation period for puffin (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.35 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding puffins directly related to a launch) then this would constitute an adverse impact on 125 individuals (assuming they were all breeders, which is unlikely) out of Shetland's 107,676 AOB (215,352 individuals), i.e., 0.06 % of the regional population (Table 5.9). If no such adverse response took place, then 0 % of the regional population would be adversely affected. Under both of these scenarios, a significant operational impact on the regional puffin population in Shetland is considered unlikely.

5.8.36 Under either of these scenarios, the potential magnitude of adverse impacts of operational disturbance on puffin would likely be negligible, with **no likely significant effects** predicted. Although puffin is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Puffin is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of puffin in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the puffin population on a long-term basis should the Proposed Project be operated.

Razorbill

5.8.37 Razorbill is an Amber listed species and therefore of moderate conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be moderate at the nest (Table 5.7). The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ razorbill population estimate is 9,492 individuals and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.38 The species typically nests on open rocky coastlines, low cliffs and boulder scree slopes, particularly on offshore islands to high precipitous cliffs. Razorbills can nest individually or within loose groups (Forrester and Andrews, 2007). The adults feed at sea and carry fish back to the chicks. Consequently, the breeding sites are a relatively predictable ‘fixed constraint’ insofar as they nest within the same cliff habitats over time.

5.8.39 With a maximum of 15 razorbills breeding within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.40 Table 5.15 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting razorbill. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.15 RFA Modelling Study - Maximum Predicted Decibel Levels at Razorbill Nesting Locations around Launch Pad 1

Individual	Launch LAmax	Static LAmax
2 ind, 2-3 km	95-105dB	90-100dB
13 ind, 3-4 km	90-105dB	80-90dB

5.8.41 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding razorbill within the study area and there is also no threshold noise metric against which compare potential effects on razorbill.

5.8.42 A study (Dunnet, 1977) to explore the possibility that an increase in air traffic associated with oilfields off the north-east of Scotland was impacting breeding seabirds recorded the reactions of a mixed seabird colony, including razorbills, on the Buchan cliffs in relation to aircraft flying within 100 m. Virtually no behavioural reaction was reported as a result of the flyovers to within 100 m of the colony which was conducted during early egg laying and early nestling periods (Appendix 5.2).

5.8.43 Breeding razorbills are considered low-moderately sensitive to human activity, visual disturbance and sudden noise events at the nest. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Such activity would probably be most severe during pre-egg laying and early incubation period (early April to the end of May). Based on the likely launch schedule, launches could take place during the typical 34-day incubation period for razorbill (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.44 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding razorbill directly related to a launch) then this would constitute an adverse impact on 15 individuals out of Shetland's 9,492 individual razorbills, i.e., 0.16 % of the regional population (Table 5.9). If no such adverse response took place, then 0 % of the regional population would be adversely affected. Under both of these scenarios, a significant operational impact on the regional razorbill population in Shetland is considered unlikely.

5.8.45 Under both of these scenarios, the potential magnitude of adverse impacts of operational disturbance on razorbill would likely be negligible, with **no likely significant effects** predicted. Although razorbill is a species of moderate conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Razorbill is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of razorbill in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the razorbill population on a long-term basis should the Proposed Project be operational.

Shag

5.8.46 Despite being a common and widespread resident breeding species throughout Scotland (Forrester and Andrews, 2007), shag is a Red listed species and therefore of high conservation importance (Table 5.5). Relatively recent surveys of shags have revealed mixed fortunes across colonies from severe decline e.g., Foula (Heubeck *et al.,* 2014), relatively stable populations in the Outer Hebrides (Taylor *et al.,* 2018) to increases elsewhere such as Argyll and north-east Scotland (Forrester and Andrews, 2007). Nevertheless, whilst still numerous, when assessed in 1998-2002, the Britain and Ireland shag population revealed a widespread decline since the mid-1980s, for poorly understood reasons (Mitchell *et al.,* 2004).

5.8.47 The behavioural sensitivity of the species is considered to be low at the nest (Table 5.7). A study (Dunnet, 1977) to explore the possibility that an increase in air traffic associated with oilfields off the north-east of Scotland was impacting breeding seabirds recorded the reactions of a mixed seabird colony, including shags, on the Buchan cliffs in relation to aircraft flying within 100 m. Virtually no behavioural reaction was reported as a result of the flyovers to within 100 m of the colony which was conducted during early egg laying and early nestling periods (Appendix 5.2).

5.8.48 The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ shag population estimate is 6,147 individuals and without evidence to the contrary the species is likely to be in FCS within Shetland, Foula notwithstanding.

5.8.49 The species typically nests among boulders on small islands and at the bases of cliffs, in caves, crevices and less commonly on flat open ledges and high sea cliffs (Forrester and Andrews, 2007). The adults feed at sea and carry fish back to the chicks. Consequently, the breeding sites are a relatively predictable ‘fixed constraint’ insofar as they nest within the same boulder and cliff habitats over time.

5.8.50 With a maximum of 81 shag AON within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.51 Table 5.16 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting shag. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.16 RFA Modelling Study - Maximum Predicted Decibel Levels at Shag Nesting Locations around Launch Pad 1

AON	Launch LAmax	Static LAmax
1 AON, 0-0.5 km	120-130dB	110-130dB
5 AON, 1-2 km	100-110dB	90-100dB
24 AON, 2-3 km	95-105dB	90-100dB
51 AON, 3-4 km	90-105dB	80-90dB

5.8.52 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding shag within the study area and there is also no threshold noise metric against which compare potential effects on shag. Dunnet’s (1977) research suggests that shag may have a tolerance for unexpected loud noises. However, the volume of a launch will exceed that of an aircraft flying within 100 m of nesting shags.

5.8.53 Breeding shags are considered to have low sensitive to human activity, visual disturbance and sudden noise events at the nest. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 31 day incubation period for shag (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.54 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding shag directly related to a launch) then this would constitute an adverse impact on 81 AON out of Shetland’s 6,147 AON, i.e., 1.32 % of the regional shag population (Table 5.9). If no such adverse response took place, then 0 % of the regional population would be adversely affected. The former worst-case scenario would constitute a minor impact on the regional shag population in Shetland. The question therefore follows, how likely is this worst-case complete breeding failure to occur? Based on Dunnet’s (1977) work, it is apparent that shags can tolerate unexpected loud noises and with the vast majority of shag AON in the study area (75 out of the 81) greater than two kilometres away from launch sites, it seems highly unlikely that such a worst-case scenario would occur. Therefore, were any adverse effect to occur (and there is no direct evidence that it would) it would most likely occur on the six AON within two kilometres of the launch pad site (ca. 0.1 % of the regional population).

5.8.55 Consequently, the potential magnitude of adverse impacts of operational disturbance on shag would likely be negligible, with **no likely significant effects** predicted. Although shag is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Shag is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of shag in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the shag population on a long-term basis should the Proposed Project be operated.

Kittiwake

5.8.56 Despite being a common and widespread breeding species throughout coastal Scotland (Forrester and Andrews, 2007) and the most numerous gull species in the world (Mitchell *et al.,* 2004), kittiwake is a Red listed species in the UK and therefore of high conservation importance (Table 5.5). The national censuses suggested that the Scottish population increased by 4 % between 1969-70 and 1985-88, but then declined by 21 % by 1998-2002, with the greatest declines in Shetland (Mitchell *et al.,* 2004; Forrester and Andrews, 2007). Although this decline occurred throughout most of the British Isles, there was substantial regional variation in trends. Oceanographic changes (resulting in reduction of their food) and predation of kittiwakes by an expanding great skua population in Shetland are believed to have contributed significantly to the overall decline in kittiwakes in Shetland (Mitchell *et al.,* 2004).

5.8.57 The behavioural sensitivity of the species is considered to be low at the nest (Table 5.7). A study (Dunnet, 1977) to explore the possibility that an increase in air traffic associated with oilfields off the north-east of Scotland was impacting breeding seabirds recorded the reactions of a mixed seabird colony, including kittiwakes, on the Buchan cliffs in relation to aircraft flying within 100 m. Virtually no behavioural reaction was reported as a result of the flyovers to within 100 m of the colony which was conducted during early egg laying and early nestling periods (Appendix 5.2).

5.8.58 The regional, national, and international population estimates of this species are known (Table 5.6). The Shetland NHZ kittiwake population estimate is 16,732 AON and based on successive seabird surveys the species is unlikely to be in FCS within Shetland.

5.8.59 The species typically nests colonially on vertical rock cliffs, offshore stacks and, occasionally, on man-made structures (Forrester and Andrews, 2007). The adults feed at sea and carry fish back to the chicks. Consequently, the breeding sites are a relatively predictable ‘fixed constraint’ insofar as they nest within the same cliff habitats over time.

5.8.60 With a maximum of 55 kittiwake AON within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.61 Table 5. outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting kittiwake. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.17 RFA Modelling Study - Maximum Predicted Decibel Levels at Kittiwake Nesting Locations around Launch Pad 1

AON	Launch LAmax	Static LAmax
50 AON 1-2 km	100-110dB	90-100dB
5 AON 3-4 km	90-105dB	80-90dB

5.8.62 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding kittiwake within the and there is also no threshold noise metric against which compare potential effects on kittiwake. Dunnet's (1977) research suggests that kittiwake may have a tolerance for unexpected loud noises. However, the volume of a launch will exceed that of an aircraft flying within 100 m of nesting kittiwake.

5.8.63 Breeding kittiwakes are considered to have low sensitive to human activity (for example, they have bred on buildings and structures along the quayside at the busy Newcastle-Gateshead Quayside on the River Tyne in Northeast England since the 1960s), visual disturbance and sudden noise events at the nest. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 29-day incubation period for kittiwake (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.64 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding kittiwake directly related to a launch) then this would constitute an adverse impact on 55 AON out of Shetland's 16,732 AON, i.e., 0.32 % of the regional kittiwake population (Table 5.9). If no such adverse response took place, then 0 % of the regional kittiwake population would be adversely affected. How likely is this worst-case complete breeding failure to occur? Based on Dunnet's (1977) work, it is apparent that kittiwakes can tolerate unexpected loud noises and with none within one kilometre of the launch site and 50 AON within two kilometres, it seems unlikely that such a worst-case scenario would occur. Therefore, were any adverse effect to occur (and there is no direct evidence that it would) it would most likely occur on the 50 AON within two kilometres of the launch sites (ca. 0.3 % of the regional population).

5.8.65 Consequently, the potential magnitude of adverse impacts of operational disturbance on kittiwake would likely be negligible, with **no likely significant effects** predicted. Although kittiwake a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Kittiwake is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of kittiwake in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the kittiwake population on a long-term basis should the Proposed Project be operated.

Fulmar

5.8.66 Fulmar is one of the commonest seabirds around Britain (Mitchell *et al.,* 2004) particularly in the Northern Isles and Outer Hebrides, but also breeding in coastal areas throughout Scotland (Forrester and Andrews, 2007). The spectacular growth in fulmar numbers across Britain in the 20th Century is one of the best documented for any bird species (Mitchell *et al.,* 2004). It is the only bird species taken forward for assessment within this EIA Report chapter that is not conservation listed or specially protected, i.e., it is not Amber or Red listed and does not appear on Schedule 1 of the 1981 Wildlife and Countryside Act or Annex 1 of the Birds Directive (Table 5.5) and is therefore of low conservation importance. Nevertheless, it was taken forward in this assessment based on the relatively large number of AOS recorded within the study area and because SNH specifically mentioned the species during EIA Scoping (Table 5.1).

5.8.67 The behavioural sensitivity of the species is considered to be low at the nest (Table 5.7). A study (Dunnet, 1977) to explore the possibility that an increase in air traffic associated with oilfields off the north-east of Scotland was impacting breeding seabirds recorded the reactions of a mixed seabird colony, including fulmars, on the Buchan cliffs in relation to aircraft flying within 100 m. Virtually no behavioural reaction was reported as a result of the flyovers to within 100 m of the colony which was conducted during early egg laying and early nestling periods (Appendix 5.2).

5.8.68 The regional, national and international population estimates of this species are known (Table 5.6). The Shetland NHZ fulmar population estimate is 188,544 AOS and the species is likely to be in FCS within Shetland. The species typically nests on cliffs on islands and open coasts, both on vegetated and bare ledges. It can also nest in dunes and on shorelines on low, mammalian predator free, islands. Occasionally it nests on man-made structures such as bridges and quarries (Forrester and Andrews, 2007). The adults feed at sea and bring food back to the chicks. Consequently, the breeding sites are a relatively predictable 'fixed constraint' insofar as they nest within the same cliff and open coast habitats over time.

5.8.69 With a maximum of 6,987 fulmar AOS within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.70 Table 5.18 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting fulmar. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.18 RFA Modelling Study - Maximum Predicted Decibel Levels at Fulmar Nesting Locations around Launch Pad 1

AON	Launch LAmax	Static LAmax
430 AON 0-0.5 km	120-130dB	110-130dB
740 AON 0.5-1 km	110-120dB	100-110dB
1,465 AON 1-2 km	100-110dB	90-100dB
2,645 AON 2-3 km	95-105dB	90-100dB
1,707 AON 3-4 km	90-105dB	80-90dB

5.8.71 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, breeding fulmar within the study area and there is also no threshold noise metric against which compare potential effects on fulmar. Dunnet's (1977) research suggests that fulmar may have a tolerance for unexpected loud noises. However, the volume of a launch will exceed that of an aircraft flying within 100 m of nesting fulmar.

5.8.72 Breeding fulmars are considered to have low sensitivity (high tolerance) to human activity, visual disturbance and sudden noise events at the nest. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 51-day incubation period for fulmar (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.73 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding fulmar directly related to a launch) then this would constitute an adverse impact on 6,987 AOS out of Shetland's 188,544 AOS, i.e., 3.7 % of the regional fulmar population (Table 5.9). Based on Dunnet's (1977) work, it is apparent that fulmars can tolerate unexpected loud noises and so it seems highly unlikely that such a worst-case scenario would occur. If no such adverse response took place, then 0 % of the regional fulmar population would be adversely affected. However, this is also considered unlikely given the large number of AOS widely spread throughout the study area, and with 1,170 AOS within one kilometre of launch facilities (ca. 0.6% of regional population), it is considered likely that some of these fulmars will be adverse affected and some breeding attempts may fail, but it is not known how many, but possibly some of the 430 AON within 0.5 km of the launch pads.

5.8.74 Consequently, the potential magnitude of adverse impacts of operational disturbance on fulmar would likely be negligible on the regional population, with **no likely significant effects** predicted. Fulmar is not a species of conservation importance, and the likely effects are judged to be not significant, i.e., there would be little/no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Fulmar is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of fulmar in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the fulmar population on a long-term basis should the Proposed Project be operated.

Merlin

5.8.75 Merlin is scarce upland breeding raptor that predominantly nests in heather moorland, usually on sloping ground on hillsides (Forrester and Andrews, 2007). Merlin is an Annex 1, Schedule 1 and Red listed species and therefore is considered to be of High conservation importance (Table 5.5). The behavioural sensitivity of the species is considered High (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ merlin population estimate is ca. 30 pairs and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.76 The favoured merlin breeding territories tend to be used year after year. Consequently, the breeding sites are relatively predictable, but new sites can and are used in different years. Nesting sites are relatively difficult to find and consequently the species is somewhat under-recorded.

5.8.77 As there is no evidence that merlins nest within the study area, the species is unlikely to be susceptible to disturbance from operation of the Proposed Project and no likely significant effects are predicted.

5.8.78 Consequently, the potential magnitude of adverse impacts of operational disturbance on merlin would equate to no effect on the regional population, with **no likely significant effects** predicted. Although merlin is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Merlin is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of merlin in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.

- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the merlin population on a long-term basis should the Proposed Project be operated.

Ringed Plover

5.8.79 Ringed plover is a largely coastal wader species, nesting on or above the strandline on open sand and shingle beaches, but can also use sand dunes, grass hinterlands, rocky headlands, maritime heath, small storm beaches and artificial habitats (Forrester and Andrews, 2007). Ringed plover is a Red listed species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered low (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ ringed plover population estimate is 800-1,000 pairs and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.80 The favoured breeding sites tend to be used year after year and evidence from 2018 and 2019 surveys shows a high degree of overlap in terms of ringed plover territories. Consequently, the breeding sites are a relatively predictable ‘fixed constraint’, but new sites can and are used in different years.

5.8.81 With a maximum of 10 pairs of ringed plover within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.82 Table 5.19 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting ringed plover. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.19 RFA Modelling Study - Maximum Predicted Decibel Levels at Ringed Plover Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
3 pairs, 0-0.5 km	120-130dB	110-130dB
4-5 pairs, 1-2 km	100-110dB	90-100dB
1-2 pairs, 2-3 km	95-105dB	90-100dB
0-1 pair, 3-4 km	90-105dB	80-90dB

5.8.83 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding ringed plover within the study area and there is also no threshold noise metric against which compare potential effects on ringed plover. The literature review (Appendix 5.3) identified studies on two potentially analogous coastal wader species: Wilson’s plover (*Charadrius wilsonia*) and snowy plover (*Charadrius nivosus*). The Wilson’s plover study reported military flights increased bird’s alertness and scanning behaviour, but with no evidence of effect on heart rate or incubation, or direct evidence of this behavioural response reducing reproductive success. The snowy plover study was focused on Titan IV rocket launches (130 dBA) and the birds did not exhibit any adverse reactions to a launch, and monitoring during the breeding season recorded no injury or mortality to adults, young, or eggs following smaller launches and concluded behaviour was not adversely affected by launch noise.

5.8.84 The lack of an adverse response of the analogous snowy plover to rocket launches up to 130 dBA suggests that *Charadrius* plovers maybe relatively robust/tolerant of sudden, very loud noise events and so worst-case scenarios (where all 10 breeding pairs fail) within the study area are considered unlikely to occur. Nevertheless, one-two pairs are particularly close (<250 m) to the launch pads and so are potentially most likely to be adversely affected by operational disturbance. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 24-day incubation period for ringed plover (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.85 If a worst-case (*not likely*) scenario is assumed (a failure for all breeding ringed plover directly related to a launch) then this would constitute an adverse impact on 10 pairs out of Shetland's 800-1,000 pairs, i.e., approximately 1 % of the regional ringed plover population (Table 5.9). However, based on the responses of analogous *Charadrius* plovers to rocket launches in the USA, this seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional ringed plover population would be adversely affected. However, this is also considered unlikely given that the territories of one-two pairs in 2018-2019 were located close enough to launch pads (<250 m) to assume that they would likely be adversely affected and possibly fail.

5.8.86 Consequently, the potential magnitude of adverse impacts from operational disturbance on ringed plover would likely be negligible on the regional population, with **no likely significant effects** predicted. Although ringed plover is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Ringed plover is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of ringed plover in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the ringed plover population on a long-term basis should the Proposed Project be operated.

Golden Plover

5.8.87 Golden plover breeds in semi-natural moorland, dwarf shrub, peatland and arctic alpine heath (Forrester and Andrews, 2007). Golden plover is an Annex 1 wader species and therefore of high conservation importance (Table 5.5), although it is still a quarry species that can legally be shot in season in the UK. The behavioural sensitivity of the species is considered moderate (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ golden plover population estimate is 5,665 pairs and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.88 There is high annual variation in terms of site occupancy (e.g., with seven breeding pairs recorded in the study area in 2018 and 13 pairs in 2019) and is a feature of many upland golden plover populations Alba Ecology has worked on. Consequently, the breeding sites are considered relatively unpredictable in terms of annual occupancy, although some favoured territories appear to be regularly used.

5.8.89 With a maximum of 13 pairs of golden plover within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.90 Table 5.20 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting golden plover. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.20 RFA Modelling Study - Maximum Predicted Decibel Levels at Golden Plover Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
0-1 pair, 0-0.5 km	120-130dB	110-130dB
2-3 pairs, 1-2 km	100-110dB	90-100dB
1-5 pairs, 2-3 km	95-105dB	90-100dB
4 pairs, 3-4 km	90-105dB	80-90dB

5.8.91 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding golden plover within the study area and there is also no threshold noise metric against which compare potential effects on golden plover. The literature review (Appendix 5.2) identified studies on two potentially analogous *Charadrius* species: Wilson's plover and snowy plover. The Wilson's plover study reported military flights increased birds' alertness and scanning behaviour, but with no evidence of effect on heart rate or incubation, or direct evidence of this behavioural response reducing reproductive success. The snowy plover study was focused on Titan IV rocket launches (130 dBA) and the birds did not exhibit any adverse reactions to a launch, and monitoring during the breeding season recorded no injury or mortality to adults, young, or eggs following smaller launches and concluded behaviour was not adversely affected by launch noise or vibrations. Furthermore, studies of golden plover breeding on the Otterburn firing range in northern England showed an apparent population increase from 25 pairs in 1994 to 34 pairs in 1998 despite regular loud noise disturbance from live firing and explosions (Appendix 5.2).

5.8.92 The lack of an adverse response of the analogous snowy plover to rocket launches up to 130 dBA and population increases of golden plover in an English live fire range despite explosive noise disturbance suggests that *Charadrius* plovers are relatively robust/tolerant of sudden, very loud noise events and so worst-case scenarios (where all 13 breeding pairs fail) within the study area are considered unlikely to occur. Nevertheless, one pair in 2019 was particularly close <250 m) to the launch pads and so would potentially be most likely to be adversely affected by operational disturbance. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 29-day incubation period for golden plover (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.93 If a worst-case scenario (*not likely*) is assumed (a failure for all breeding golden plover directly related to a launch) then this would constitute an adverse impact on a maximum of 13 pairs out of Shetland's 5,665 pairs, i.e., 0.23 % of the regional golden plover population (Table 5.9). However, based on the responses of analogous *Charadrius* plovers to rocket launches in the USA and golden plover breeding success at an English live firing range, this seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional golden plover population would be adversely affected. However, this is also considered unlikely given that one territory (if subsequently used) is located close enough to launch pads to assume that they would likely be adversely affected and possibly fail.

5.8.94 Consequently, the potential magnitude of adverse impacts of operational disturbance on golden plover would likely be negligible on the regional population, with **no likely significant effects** predicted. Although golden plover is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH use to consider FCS):

- Golden plover is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of golden plover in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the golden plover population on a long-term basis should the Proposed Project be operated.

Dunlin

5.8.95 Dunlin breeds on wet upland and montane heath, especially where bog pool systems occur, but also on machair and rarely on salt marsh (Forrester and Andrews, 2007). Dunlin (sub-species *schinzii*, which breeds in Shetland) is an Annex 1 wader species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered moderate (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ dunlin population estimate is 2,054 pairs and without evidence to the contrary the species is likely to be in FCS within Shetland.

5.8.96 There is high annual variation in terms of site occupancy (e.g., with five breeding pairs recorded in the study area in 2018 and four pairs in 2019, mostly in different locations). Consequently, the breeding sites are considered relatively unpredictable in terms of annual occupancy, although some favoured territories appear to be regularly used.

5.8.97 With a maximum of five pairs of dunlin within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.98 Table 5.21 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting dunlin. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.21 RFA Modelling Study - Maximum Predicted Decibel Levels at Dunlin Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
0-1 pair, 0-0.5 km	120-130dB	110-130dB
2 pairs, 1-2 km	100-110dB	90-100dB
0-1 pair, 2-3 km	95-105dB	90-100dB
1-2 pairs, 3-4 km	90-105dB	80-90dB

5.8.99 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding dunlin within the study area and there is also no threshold noise metric against which compare potential effects on dunlin. The literature review (Appendix 5.2) did not identify any directly relevant studies on dunlin or potentially analogous wader species. Based on current information it is not possible to predict likely responses of all breeding dunlin to the noise caused by the launches, but it is considered that one territory occupied in 2019 would likely be adversely affected (were it to be subsequently occupied) by operational noise during launches. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 22-day incubation period for dunlin (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord

Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.100 If a worst-case scenario (*not likely*) is assumed (a failure for all breeding dunlin directly related to a launch) then this would constitute an adverse impact on a maximum of five pairs out of Shetland's 2,054 pairs, i.e., 0.24 % of the regional dunlin population (Table 5.9). However, based on the predicted responses of other waders, this worst-case scenario seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional dunlin population would be adversely affected. However, this is also considered unlikely given that one territory (in 2019) was located close enough to launch pads to assume that they would likely be adversely affected were it to be subsequently occupied.

5.8.101 Consequently, the potential magnitude of adverse impacts of operational disturbance combined on dunlin would likely be negligible on the regional population, with **no likely significant effects predicted**. Although dunlin is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Dunlin is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of dunlin in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the dunlin population on a long-term basis should the Proposed Project be operated.

Whimbrel

5.8.102 Within Shetland, whimbrel breed in short vegetation on wet heath, blanket bog and serpentine heath (Grant 1991; Massey *et al.,* 2016). Whimbrel is a Schedule 1 and Red listed wader species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be moderate (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The published Shetland NHZ whimbrel population estimate is 290 pairs, but should be increased by 10 % (Digger Jackson, *pers comm.*) to ca. 320 pairs. The current status of the Shetland population is unknown, but detailed monitoring across west and central Shetland suggests it has not substantially changed over the last decade and consequently the species is probably in FCS within Shetland, especially with great skua, believed to be the main culprit in the species' decline (at least in the Northern Isles), now apparently in decline itself. It should be noted that the RSPB quote that the Shetland and Orkney breeding population has been slowly increasing and the UK population estimate to be 400-500 pairs (https://www.rspb.org.uk/birds-and-wildlife/wildlife-guides/bird-a-z/whimbrel/ - accessed August 2020). It is not clear on what the much higher RSPB population data is based, but it is considered potentially misleading and so has not been used within this assessment.

5.8.103 There is a relatively low variation in terms of site occupancy (with five breeding pairs recorded in the study area in 2018 and four pairs in 2019, mostly in similar locations). Consequently, the breeding sites are considered relatively predictable in terms of annual occupancy.

5.8.104 Details of potential impacts on whimbrel have been provided previously in a confidential appendix to the local planning authority in accordance with SNH (2016) guidance.

5.8.105 The potential magnitude of adverse impacts of operational disturbance on whimbrel would likely be negligible on the regional (which also is almost all the national) population, with **no likely significant effects** predicted, as discussed below. Although whimbrel is a species of high conservation importance and probably in FCS, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Whimbrel is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of whimbrel in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the whimbrel population on a long-term basis should the Proposed Project operate.

Curlew

5.8.106 Curlew is a widespread but declining Scottish breeding bird on farmland and uplands (Forrester and Andrews, 2007). Curlew is a Red listed wader species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be moderate (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ curlew population estimate is 4,227 pairs and without evidence to the contrary, the species is likely to be in FCS within Shetland.

5.8.107 There is relatively low variation in terms of site occupancy, with many territories occupied in both years of survey (e.g., there were ca. 16 breeding territories in 2018 and ca. 13 in 2019). Consequently, the breeding sites are considered relatively predictable in terms of annual occupancy.

5.8.108 With a maximum of 16 pairs of curlew within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.109 Table 5.23 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting curlew. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.23 RFA Modelling Study - Maximum Predicted Decibel Levels at Curlew Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
0-1 pair, 0-0.5 km	120-130dB	110-130dB
2-3 pairs, 1-2 km	100-110dB	90-100dB
5 pairs, 2-3 km	95-105dB	90-100dB
5-8 pairs, 3-4 km	90-105dB	80-90dB

5.8.110 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding curlew within the study area and there is also no threshold noise metric against which compare potential effects on curlew. The literature review (Appendix 5.2) did not identify any directly relevant noise studies on breeding curlew or potentially analogous wader species (although it did note some evidence of noise disturbance impacts on wintering curlew). Based on current information it is not possible to predict likely responses of all breeding curlew to the noise caused by the launches, but it is considered that one-two regularly occupied territories would likely be adversely affected by operational noise during launches. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 28-day incubation period for curlew (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.111 If a worst-case scenario (*not likely*) is assumed (a failure for all breeding curlew directly related to a launch) then this would constitute an adverse impact on a maximum of 16 pairs out of Shetland's 4,227 pairs, i.e.,0.4 % of the regional curlew population (Table 5.9). However, based on the distribution of curlew territories and predicted responses of other waders, this worst-case scenario seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional curlew population would be adversely affected. However, this is also considered unlikely given that one-two territories are located close enough to launch pads to assume that they would likely be adversely affected. Were that scenario to take place, this would constitute an adverse effect (loss) of 0.02-0.05 % of the regional curlew population.

5.8.112 Consequently, the potential magnitude of adverse impacts of operational disturbance on curlew would likely be negligible on the regional population, with **no likely significant effects** predicted. Although curlew is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Curlew is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of curlew in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the curlew population on a long-term basis should the Proposed Project be operated.

Arctic Tern

5.8.113 Arctic tern is a widespread coastal breeding summer visitor, with strongholds in Orkney and Shetland (Forrester and Andrews, 2007). Arctic tern is an Amber listed species and therefore of moderate conservation importance (Table 5.5). The behavioural sensitivity of the species at the nest is considered to be moderate (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ population estimate is 24,716 AON and without evidence to the contrary, the species is likely to be in FCS within Shetland.

5.8.114 There is some variation in terms of site occupancy, with a few small breeding colonies present within the study area, which fluctuate annually in terms of occupancy.

5.8.115 With a maximum of 13 Arctic tern AON within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.116 Table 5.24 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting Arctic tern. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.24 RFA Modelling Study - Maximum Predicted Decibel Levels at Arctic Tern Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
8-13 pairs, 1-2 km	100-110dB	90-100dB
0-1 pair, 2-3 km	95-105dB	90-100dB

5.8.117 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding Arctic tern within the study area and there is also no threshold noise metric against which compare potential adverse effects on Arctic tern. The literature review (Appendix 5.2) found that Arctic tern incubating behaviour is impacted by both fixed-wing aircraft and helicopters, with helicopters causing more disturbance to birds than fixed-wing aircraft, however human presence had a larger effect than aircraft disturbance. Based on current information it is not possible to predict likely responses of all breeding Arctic tern to the noise caused by the launches. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 22-day incubation period for Arctic tern (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.118 If a worst-case scenario (*not likely*) is assumed (a failure for all breeding Arctic tern directly related to a launch) then this would constitute an adverse impact on a maximum of 13 AON out of Shetland's 24,716 AON, i.e., 0.05 % of the regional Arctic tern population (Table 5.9). However, given the distance between the small Arctic tern colonies and the launch sites, this worst-case scenario seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional Arctic tern population would be adversely affected and this seems most likely.

5.8.119 Consequently, the potential magnitude of adverse impacts of operational disturbance on Arctic tern would likely be negligible on the regional populations, with **no likely significant effects** predicted. Although Arctic tern is a species of moderate conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Arctic tern is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of Arctic tern in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the Arctic tern population on a long-term basis should the Proposed Project be operated.

Arctic Skua

5.8.120 Arctic skua is a localised and apparently declining breeding species in Scotland (Forrester and Andrews, 2007). Arctic skua is a Red listed species and therefore of high conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be moderate at the nest (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ population estimate is 516 pairs and without evidence to the contrary, the species is unlikely to be in FCS within Shetland.

5.8.121 There is annual variation in terms of site occupancy, but some territories were occupied in both years of survey (there were five breeding territories in 2018 and 2019). Consequently, some of the breeding sites are relatively predictable in terms of annual occupancy.

5.8.122 With a maximum of five pairs of Arctic skua within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.123 Table 5.25 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting Arctic skuas.

Table 5.25 RFA Modelling Study - Maximum Predicted Decibel Levels at Arctic Skua Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
1 pair, 0.5-1 km	110-120dB	100-110dB
1-2 pairs, 1-2 km	100-110dB	90-100dB
2-3 pairs, 2-3 km	95-105dB	90-100dB

5.8.124 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding Arctic skua within the study area and there is also no threshold noise metric against which compare potential effects on Arctic skua. The literature review (Appendix 5.2) did not identify any directly relevant noise studies on breeding Arctic skua or potentially analogous species. Based on current information it is not possible to predict likely responses of all breeding Arctic skua to the noise caused by the launches, but it is considered that one regularly occupied territory (approximately 600 m away from Launch Pad 1) would likely be adversely affected by operational noise during launches. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based on the likely launch schedule, launches could take place during the typical 27-day incubation period for Arctic skua (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.125 If a worst-case scenario (*not likely*) is assumed (a failure for all breeding Arctic skua directly related to a launch) then this would constitute an adverse impact on a maximum of five pairs out of Shetland's 516 pairs, i.e., 0.97 % of the regional Arctic skua population (Table 5.9). However, given the distance away of some territories, this worst-case scenario seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional Arctic skua population would be adversely affected. However, this is also considered unlikely given that one territory is located close enough to launch pads to assume that they would likely be adversely affected. Were that scenario to take place, this one pair would constitute an adverse effect (loss) on 0.19 % of the regional Arctic skua population.

5.8.126 Consequently, the potential magnitude of adverse impacts of operational disturbance on Arctic skua would likely be negligible on the regional population, with **no likely significant effects** predicted. Although Arctic skua is a species of high conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates, that the conservation status would not likely be affected because (as articulated using three tests SNH (2006) use to consider FCS):

- Arctic skua is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.

- The natural range of Arctic skua in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the Arctic skua population on a long-term basis should the Proposed Project be operated.

Great Skua

5.8.127 Great skua is a localised breeding species in Scotland (Forrester and Andrews, 2007). Great skua is an Amber listed species and therefore of moderate conservation importance (Table 5.5). The behavioural sensitivity of the species is considered to be low at the nest (Table 5.7). The national and international population estimates of this species are known (Table 5.6). The Shetland NHZ population estimate is 6,846 pairs and without evidence to the contrary, the species is likely (in the long-term) to be in FCS within Shetland[2]. A study of abundance data in Scotland from 1992 to 2015 indicated that great skuas increased at most sites, with some very large increases at smaller colonies. However, declines at the two largest colonies (Foula and Hoy) resulted in little overall change in AOTs across all colonies combined (https://jncc.gov.uk/our-work/great-skua-stercorarius-skua/#conservation-status: Accessed August 2020).

5.8.128 The difficulties in distinguishing between non-breeding and breeding pairs holding territory, makes estimates of annual site occupancy challenging (unless undertaken as part of detailed single species monitoring). Consequently, the surveys do not provide sufficient information to comment on annual site occupancy in any detail. At best, the surveys provide evidence of breeding pairs in the low tens, with breeding mainly concentrated over three kilometres away from the Proposed Project around Saxa Vord hill.

5.8.129 With tens of pairs of great skua within the study area, all will be within the range of elevated noise levels predicted for operation of the Proposed Project.

5.8.130 Table 5.26 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on nesting great skuas. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 5.26 RFA Modelling Study - Maximum Predicted Decibel Levels at Great Skua Nesting Locations around Launch Pad 1

Pairs	Launch LAmax	Static LAmax
Low tens of pairs, 3-4 km	90-105dB	80-90dB

5.8.131 There is no direct evidence to suggest that the noise at launch would impact on, and adversely affect the success of, all the breeding great skua within the study area and there is also no threshold noise metric against which compare potential effects on great skua. The literature review (Appendix 5.2) did not identify any directly relevant noise studies on great skua or potentially analogous species. Based on current information it is not possible to predict likely responses of all breeding great skua to the noise caused by the launches. Nevertheless, with most of the tens of pairs 3-4 km away from the launch site, few if any breeding pairs would likely be adversely affected by operational noise during launches. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle, building to a maximum, followed by a rapid decrease back to baseline will be sufficient to allow the birds to cope with the noise is currently speculative. Based

[2] In common with many parts of Shetland, Unst breeding bird surveys in 2022 recorded several dead species which were presumed to have died from birdflu (H5N1 is the strain of avian flu in Scotland). According to the RSPB, the virus has killed tens of thousands of seabirds, including many in key Shetland colonies of gannets and great skuas in 2022 (How together we can protect wild birds from Avian Flu | The RSPB). The conservation status of great skua (and other affected birds such as gannet) is likely to be re-evaluated in the near future.

on the likely launch schedule, launches could take place during the typical 29-day incubation period for great skua (Table 5.8). It should be noted that following the NatureScot consultation response to the SaxaVord Spaceport planning application (11 March 2021), commitment to a no-launch window, whereby no satellite launches, or static tests will be carried out between mid-May and the end of June, has subsequently been made by SaxaVord Spaceport and will be adhered to by the Applicant.

5.8.132 If a worst-case scenario (*not likely*) is assumed (a failure for all breeding great skua directly related to a launch) then this would constitute an adverse impact on a maximum of low tens of pairs out of Shetland's 6,846 pairs, i.e., <1 % of the regional great skua population (Table 5.9). However, given the large distance away of most breeding territories, this worst-case scenario seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional great skua population would be adversely affected and this seems most likely.

5.8.133 Consequently, the potential magnitude of adverse impacts of operational disturbance on great skua would likely be negligible on the regional population, with **no likely significant effects** predicted. Although great skua is a species of moderate conservation importance, the likely effects are judged to be not significant, i.e., there would be no detectable regional population level impacts and so the Shetland NHZ would not be adversely affected. Therefore, if the Proposed Project was operational, the available information indicates that conservation status would not likely be affected because (as articulated using three tests SNH use to consider FCS):

- Great skua is likely to maintain itself on a long-term basis as a viable component of its habitat in the Shetland NHZ.
- The natural range of great skua in the Shetland NHZ would not be reduced by the Proposed Project, nor would it become likely to be reduced in the foreseeable future.
- There would be (and would continue to be) a sufficiently large habitat area in the Shetland NHZ to maintain the great skua population on a long-term basis should the Proposed Project be operated.

Natural Capital

5.8.134 Informal discussions with local birdwatchers and whale watchers raised a concern that access to the favoured tip of Lamba Ness might be curtailed by the Proposed Project. As a consequence of this, a new dedicated wildlife watching hide and path too it will be built. Details of the wildlife watching hide are provided in Appendix 5.3 Habitat Management Plan.

5.9 Additional Mitigation

5.9.1 The Habitat Management Plan for the SaxaVord Spaceport identifies seven objectives, three of which are focussed on breeding Schedule 1 bird species and therefore relevant to this chapter.

5.9.2 Two of the objectives, creation of breeding pools and protection/restoration of existing pools, target mitigation for species likely to be adversely affected by the Spaceport and hence the Proposed Project. The third objective, habitat creation, is better described as enhancement as the objective is for a receptor where no adverse or likely significant effects are predicted. All objectives are the responsibility of SaxaVord Spaceport but will be adhered to by the Applicant as applicable.

5.9.3 After mitigation, **no significant residual effects** are predicted.

5.10 Residual Effects

5.10.1 No likely significant residual effects are predicted.

5.11 Cumulative Assessment

5.11.1 Cumulative effects can result from individually insignificant but collectively significant actions taking place over a period of time or concentrated in a location (CIEEM, 2018). This guidance goes on to say that "*developments to be included in the cumulative impact assessment should be in accordance with national guidance*".

5.11.2 NatureScot provides no advice or guidance in relation to the cumulative impacts of a spaceport. CIEEM (2018) state in relation to cumulative assessment that "*Information about developments within the zone(s) of influence may be available in other EcIAs, Local Plan documents, Marine Spatial Plans, Strategic Environmental Assessments (SEAs), Sustainability Appraisals (SAs), Water Framework Directive Assessments (WFDAs), and Habitats Regulations Assessments/Appraisals (HRAs), including 'Natura Impact Statements' (NISs) / 'Natura Impact Reports' (NIRs), 'Information / 'Reports to Inform an Appropriate Assessment', 'Shadow Habitats Regulations Assessments' and, for Nationally Significant Infrastructure Projects, 'Reports on the Implications for European Sites' (RIES)*".

5.11.3 Shetland Islands Council confirmed during the planning application for SaxaVord Spaceport that there were no other committed development or infrastructure projects which needed to be considered in that assessment and there has been no change subsequent to planning consent. As such, as far as the Applicant is aware, there are no like for like or similar projects within the ecological study area and therefore, no significant issues are likely to arise from developments other than the SaxaVord Spaceport.

5.11.4 The SaxaVord Spaceport has a proposed capacity for 30 launches per annum. The Proposed Project will account for 10 of those launches.

5.11.5 As detailed in Chapter 8, noise from launches of the RFA ONE NOM Launch Vehicle is not anticipated to be significantly greater than that from the SaxaVord Spaceport AEE RepLV and therefore it is no more likely that birds in close proximity to Launch Pad 1 will be disturbed any more from the RFA ONE NOM Launch Vehicle than that from the SaxaVord Spaceport AEE RepLV. In addition, the RFA ONE NOM specific launch vehicle dimensions, propellants used, stage weights, and payload weight(s) by comparison to the SaxaVord Spaceport AEE RepLV do not make any material difference to the significance of cumulative environmental effects on ornithology. Therefore, assuming operators are identified for the remaining capacity, the cumulative ornithological effects of all 30 launches would be expected to be as documented in the SaxaVord Spaceport AEE:

"The ornithological study area (out to four kilometres from the Proposed Project) is an equivalent to the potential 'zone of influence' and as there are no existing or proposed developments within that area, no significant issues are considered likely to arise from inter-project additive or cumulative effects.

Intra-project cumulative effects are those where an environmental topic/receptor is affected by more than one impact from the same Proposed Project and the impacts act together. The interactions between noise and ornithology have been identified and assessed within this chapter, and no other environmental topic are considered likely to give rise to potential intra-project cumulative effects."

5.12 Summary

5.12.1 Targeted and licensed breeding bird surveys were undertaken following agreed standardised survey methods between 2018 and 2020 within the ornithological study area. A total of 135 bird species were recorded during breeding bird surveys. There was direct evidence of potentially sensitive and specially protected bird species breeding within, and adjacent to, the Proposed Project boundary.

5.12.2 Ornithological designated site interests on the Hermaness, Saxa Vord and Valla Field SPA (and overlapping Hermaness SSSI and Saxa Vord SSSI) and the following non-designated wider countryside ornithological birds are taken forward for assessment: red-throated diver, merlin, black guillemot, common guillemot, puffin, razorbill, shag, kittiwake, fulmar, ringed plover, golden plover, whimbrel, curlew, dunlin, Arctic tern, Arctic skua, great skua and a confidential Schedule 1 species.

5.12.3 To understand potential impacts of loud, short duration noise events, a background literature review of noise impacts on relevant bird species was undertaken. This literature review looked at how impulsive noise (from various sources including aircraft, fireworks, military ranges and rocket launches) impacted on birds in order to help assess the potential noise impacts of the launches.

5.12.4 Potential impacts from the Proposed Project (preparation and launch of the RFA ONE NOM Launch Vehicle) have been assessed. The magnitude of predicted operational effects is either 'no effect' or 'negligible' for all bird species considered except one. Minor operational impacts are predicted for a confidential Schedule 1 breeding species (although there was no evidence of this species recorded during breeding bird surveys in 2022).

5.12.5 Confidential bird species information has been submitted to and assessed previously by the local planning authority, as part of the planning process for the Proposed Project.

5.12.6 All likely effects are assessed as non-significant, apart from a confidential Schedule 1 species, where minor magnitude operational effects are considered likely to be significant in the absence of mitigation.

5.12.7 Confidential bird species information has been submitted to and assessed previously by the local planning authority, as part of the planning process for the Proposed Project.

5.12.8 Mitigation measures inherent to operation of the Proposed Project, as confirmed and implemented through planning conditions for the SaxaVord Spaceport, are outlined in Appendix 5.3: Habitat Management Plan and comprise of the following elements that will benefit ornithological receptors: large-scale peatland restoration, creation of native broadleaved riparian woodland, coastal grassland management, offsite red-throated diver lochan habitat restoration/protection, habitat creation for a Schedule 1 breeding bird and whimbrel chick habitat creation.

5.12.9 A summary of the magnitude of predicted residual effects on target bird species is provided in Table 5.27.

Table 5.27 Magnitude of Predicted Operational Effects on Target Species

Species	Magnitude of predicted operational effects?
Red-throated diver	No likely significant effect
Black guillemot	No likely significant effect
Common guillemot	No likely significant effect
Puffin	No likely significant effect
Razorbill	No likely significant effect
Shag	No likely significant effect
Kittiwake	No likely significant effect
Fulmar	No likely significant effect
Merlin	No likely significant effect
Ringed plover	No likely significant effect
Golden plover	No likely significant effect
Dunlin	No likely significant effect

Species	Magnitude of predicted operational effects?
Whimbrel	No likely significant effect
Curlew	No likely significant effect
Schedule 1 species*	No likely significant effect
Arctic tern	No likely significant effect
Arctic skua	No likely significant effect
Great skua	No likely significant effect

*Minor magnitude operational effects were considered likely to be significant before mitigation. After mitigation applied, effects are predicted likely to be not significant.

5.12.10 After mitigation, all residual effects are predicted likely to be not significant.

5.13 References

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Chapter 6 Ecology and Biodiversity

6. Ecology and Biodiversity

6. Ecology and Biodiversity

6.1 Introduction

6.1.1 This chapter considers the likely effects of the Proposed Project on ecological receptors on-site and in the surrounding ecological environmental zone of influence (study area). This assessment is based upon comprehensive baseline data, comprising specifically targeted ecological surveys of potentially important and legally protected ecological receptors identified during the desk study and consultation feedback. It draws on pre-existing information, where appropriate, survey data and Chartered Institute for Ecology and Environmental Management (CIEEM) best practice guidance. The scope of the ecological assessment excludes potential impacts on birds, which are considered separately in Chapter 5: Ornithology.

6.1.2 Alba Ecology Limited led on all aspects of the ecological fieldwork and assessment of the Proposed Project. Alba Ecology is a Scottish-based multi-disciplinary ecological consultancy that has worked in the north of Scotland, and Shetland specifically, for many years. Alba Ecology's staff have led on and contributed to all aspects of Ecological Impact Assessment (EcIA) on many large-scale development projects, including the management of Ecological Clerks of Work teams, principal ornithological/ecological surveyors and advisors on planning applications, expert witness advice at Public Local Inquiry and production of EcIA Reports, Habitat Regulations Assessments and Habitat Management Plans.

6.1.3 The ecological surveyors used between 2018 and 2020 were Dr Peter Cosgrove, Mr Brydon Thomason, Dr Fergus Massey and Dr Kate Massey. The ecological surveyors have extensive ecological field experience of Shetland, and Unst specifically, and have attended regular training events led by experts, covering areas such as species identification, recording data concisely and accurately, navigation techniques and health and safety. Surveyors were trained to carry out surveying and mapping work in a systematic manner, following recognised standardised survey methods. When ecological surveys required working near birds listed in Schedule 1 of the Wildlife and Countryside Act 1981 (and as amended) in the breeding season they were covered by relevant Scottish Natural Heritage (now NatureScot) Schedule 1 Bird Licences.

6.1.4 This chapter is supported by the following documents:

- Appendix 5.3: SaxaVord Spaceport Habitat Management Plan.
- Appendix 6.1: Natural Heritage Desk Study.
- Appendix 6.2: Phase 1 Habitat, National Vegetation Classification (NVC) and Potential Groundwater dependent Terrestrial Ecosystem (GWDTE) Survey Report.
- Appendix 6.3a: Otter Survey Report and Otter Protection Plan.
- Appendix 6.3b: SaxaVord Spaceport Pre-construction Otter Survey Report (2022).
- Appendix 6.4: Freshwater Pearl Mussel Survey Report.
- Appendix 6.5: SaxaVord Spaceport AEE Chapter 9: Water.

6.1.5 This chapter should be read alongside other chapters within the AEE Report, in particular Chapters 2, 3, 4, 5, and 10.

6.1.6 The assessment involved the following key phases:

- Reference to relevant legislation, policy and guidance.
- Identification of likely environmental zone of influence (study area) of the Proposed Project.

- Identification of potentially important ecological receptors likely to be affected (baseline conditions) by the Proposed Project.
- Evaluation of important ecological receptors and features likely to be affected by the Proposed Project.
- Identification of likely impacts and magnitude of the Proposed Project works on important ecological receptors.
- Assessment of the likely significant effects of the Proposed Project, including any mitigation and enhancement measures and definition of any residual significant effects.

6.1.7 The term '*receptor*' is used throughout this AEE and is defined as the element in the environment affected by a Project (e.g., a species or habitat in the case of ecology). The term '*impact'* is also used commonly throughout the AEE and is defined as a change experienced by a receptor (this can be beneficial, neutral or adverse). The term '*effect'* is defined as the consequences for the receptor of an impact.

6.2 Legislation, Policy and Guidelines

Legislation

Space Industry Act

6.2.1 The Space Industry Act (2018) regulates all spaceflight activities carried out in the United Kingdom, and associated activities. The Act requires any person or organisation to obtain the relevant licence to:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities from the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

6.2.2 As the Applicant wishes to become a spaceflight operator and launch RFA ONE NOM Launch Vehicles from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

6.2.3 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence the Regulators Licensing rules, which specify what information the UK Civil Aviation Authority (CAA), the regulator, requires in support of an application.

Policy Context

6.2.4 Further relevant legislation and best practice guidance documents have been reviewed and taken into account as part of this ecological assessment. The approach used to assess the significance of likely effects of the Proposed Project upon ecological receptors is set in the context of:

- The Wildlife and Countryside Act 1981 (as amended);
- European Commission (EC) (2011) European Biodiversity Strategy;
- European Commission (EC) (2020). European Biodiversity Strategy;

- EC Directive 1992/43/EEC on the conservation of natural habitats and of wild fauna and flora. The so-called 'Habitats Directive';
- The Conservation (Natural Habitats) Regulations 1994. The so-called Habitats Regulations;
- The Conservation of Habitats and Species Regulations 2010;
- The Nature Conservation (Scotland) Act 2004 (as amended);
- Scottish Government PAN 1/2013;
- Guidelines for Ecological Impact Assessment in the UK and Ireland (CIEEM, 2016; 2018);
- Scottish Government. The Scottish Biodiversity List (SBL);
- Scottish Government 2014. Scottish Planning Policy;
- Scottish Government 2020. The Environment Strategy for Scotland: vision and outcomes;
- Biodiversity Net Gain: Good practice principles for development: A practical guide. (CIRIA, CIEEM and IEMA 2019);
- Biodiversity New Gain in Scotland, CIEEM Scotland Policy Group, 2019;
- Strategic Plan for Biodiversity 2011-2020. Convention on Biological Diversity;
- Land-use planning system Scottish Environment Protection Agency (SEPA) Guidance Note 31: Guidance on Assessing the Impacts of Development Proposals on Groundwater Abstractions and Groundwater Dependent Terrestrial Ecosystems. LUPG-GU31 Version 3 (SEPA, 2017);
- The Fourth National Planning Framework – Revised Draft (NPF4) (2022); and
- Living Shetland Local Biodiversity Action Plan (LBAP) documents.

6.2.5 There is no Scottish or UK specific ecological guidance on satellite launch operations.

6.2.6 Scottish Planning Policy (Scottish Government, 2014) sets out the Scottish Government's national planning policies for the protection of biodiversity through the planning system. This seeks to ensure that projects provide biodiversity benefits where possible, not simply to avoid significant adverse effects. These policies are incorporated into development plans and are a material consideration in the determination of development proposals. The revised draft of NPF4 includes a range of policies that will contribute to delivering Scotland's commitment to net zero emissions by 2045 and tackling the climate emergency. The draft was approved by the Scottish Parliament on 11th January 2023 and will be adopted by the Scottish Ministers in its current form imminently (expected February 2023).

6.2.7 The UK Biodiversity Action Plan (BAP) was the UK Government's 2004 response to the Convention on Biological Diversity, to which the UK was a signatory. Action plans for the most threatened species and habitats (called 'UK BAP species and habitats') were set out to aid recovery. Following the publication of the Convention on Biological Diversity's 'Strategic Plan for Biodiversity 2011–2020' (Convention on Biological Diversity, 2010), its commitment to 20 'Aichi targets', agreed at Nagoya Japan in October 2010, and the launch of the European Biodiversity Strategy in May 2011 the UK Government has changed its strategic thinking.

6.2.8 The Scottish Biodiversity List (SBL) is a list of animals, plants and habitats that Scottish Ministers consider to be of principal importance for biodiversity conservation in Scotland, under the Nature Conservation (Scotland) Act 2004. The SBL therefore supersedes the UK BAP list of species and habitats (CIEEM, 2017). Nevertheless, since most current planning policy and SNH guidance requires consideration of, and makes explicit reference to, UK BAP species and habitats and the definitions of SBL habitats are largely based on UK BAP definitions, these are still referred to where necessary.

6.2.9 The Shetland Local Development Plan (2014) contains policies and objectives to conserve and enhance the habitats and species that contribute to the unique character and heritage of Shetland. It has links to Supplementary Guidance on Local Nature Conservation Sites in Shetland and Supplementary Guidance on Natural Heritage. This guidance is provided to aid planning applicants and their agents when considering development in relation to their biodiversity responsibilities.

6.2.10 Whilst considering a range of potential outcomes that could arise from the Proposed Project, the assessment reports the effects that are considered likely to be significant on the basis of evidence, standard guidance and professional judgement. It is these *likely significant effects* that the Applicant is obliged to report, and that the decision maker is obliged to consider.

Relevant Guidance

Guidance for the Assessment of Environmental Effects

6.2.11 The CAA, with the UK Space Agency, the Department for Business, Energy and Industrial Strategy and the Department for Transport, issued guidance note '*CAP2215 Guidance for the Assessment of Environmental Effects*' in July 2021. The guidance sets out what is required by the regulator regarding assessment of environmental effects as part of a licence application under the Act.

6.2.12 The AEE Guidance requires that potential direct and indirect significant effects of proposed spaceflight activities on environmental features, including noise and vibration, are considered. The guidance further requires that:

- Specific potential effects are identified and, where possible, quantified;
- The focus of the AEE should be on significant effects arising from the proposed activities;
- Applicants set an environmental budget, comprising a maximum number of launches per launch vehicle type which can take place over the course of a year that can be carried out in an environmentally sustainable manner, taking into account the cumulative effect of all launches; and
- The AEE must address a range of environmental topics, including ecology and biodiversity.

Guidance to the regulator on environmental objectives relating to the exercise of its functions under the Space Industry Act 2018

6.2.13 The Department for Transport issued its document '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK:

The environmental objective for spaceflight are to:

- *Minimise emissions contributing to climate change resulting from spaceflight activities;*
- *Protect human health and the environment from the impacts of emissions on local air quality arising from spaceflight activities;*
- *Protect people and wildlife from the impacts of noise from spaceflight activities; and*
- *Protect the marine environment from the impact of spaceflight activities.*

6.2.14 The objectives presented in the guidance are noted to be consistent with the environmental topics that must be addressed in an AEE.

6.3 Consultation

6.3.1 Extensive statutory consultation on ecological matters was carried out during preparation and determination of the planning application for the SaxaVord Spaceport, where the Proposed Project will be operated. Where directly relevant to this AEE, consultation responses received during the SaxaVord Spaceport planning application period have been summarised in Table 6.1. In addition, notes on relevant planning conditions received from Shetland Islands Council are also included for information.

Table 6.1 Record of Consultation and relevant Planning Conditions

Consultee	Summary Ecological Response	Where and How Addressed
Scottish Natural Heritage (SNH; now NatureScot) 16/02/18	Otters "*Otters are protected by law, making it an offence to disturb one in a holt or whilst it is caring for its young, or to destroy, damage or obstruct access to a holt*" SNH provided a link to SNH's standing advice on otters (in May 2020 this was superseded by NatureScot standing advice on otters, which is essentially the same as the previous SNH standing advice). SNH provided standing advice for planning consultation with regard to otter. It states that "*this is standing advice to help planning applicants seeking permission for development that could affect otters, and to assist planning officers and other regulators in their assessment of these applications. It avoids the need for us to advise on individual planning consultations in relation to otters. We will only provide further advice in exceptional circumstances that are not covered by this standing advice*". SNH went on to say that "*in Shetland, otters are predominantly coastal animals, however natal holts (places of shelter where cubs are born and reared) are usually hidden inland and away from watercourses...If a holt is found it may be necessary to submit a species protection plan with your planning application and consider whether a licence might be required for the development*".	Otter surveys are reported in Appendix 6.3 and are considered throughout this chapter.
SNH (NatureScot) 16/02/18	Plants "*The key plant species, referred to in the Alba Ecology report, are the Shetland endemic Edmondston's chickweed (Cerastium nigrescens) and serpentine dandelion (Taraxacum serpenticola),*	The airport is not included in the Planning Application; therefore, no specific rare plant surveys were reported in the EIA Report. A detailed Phase 1 Habitat and NVC survey was conducted during

Consultee	Summary Ecological Response	Where and How Addressed
	nationally rare Norwegian sandwort (Arenaria norvegica) and nationally scarce northern rock-cress (Arabis petraea), all of which have very limited distributions in areas with ultrabasic "serpentine" bedrock with natural or semi-natural vegetation. Only the former RAF camp and Baltasound airport are in serpentine areas, and on the first of these the vegetation has been highly modified so none of these species is likely to be present. Consequently, the proposed rare plant survey can be restricted to the airport".	the standard field season. Although this does not constitute a formal floristic or rare plant survey, plant species were recorded where they were encountered. Plants species records are listed in Appendix 6.2 and are considered in Sections 6.4 and 6.5. Habitats and, associated plant species are reported in Appendix 6.2 and considered in Sections 6.4, 6.5, 6.6 and 6.8. Following 2022 survey updates, these baseline surveys are considered robust.
SNH (NatureScot) 16/02/18	Marine mammals "*Noise and vibration from onshore activity close to the coast, such as drilling and blasting (and potentially rocket launching) can affect cetaceans so should not be scoped out at this stage, however there is no need for a survey of marine mammals as the assessment of potential impacts and any necessary mitigation can be generic in nature*."	Marine mammals are considered in Chapter 10.
Shetland Islands Council Conditions document (1/4/2022).	NatureScot: *Scottish Natural Heritage (SNH) – SNH are content that the proposal can be progressed with appropriate mitigation... They also identified that mitigation measures identified in the EIAR will reduce to some extent the impact on otters, a European Protected Species, and any licence required from them would be granted.*	Otter surveys are reported in Appendix 6.3 and are considered throughout this chapter.
Shetland Islands Council Conditions document (1/4/2022).	Condition 17 Otter Protection Plan *No development shall commence unless and until:* *(a) i) a pre-construction otter survey is conducted and a report produced;* *ii) based on the results from the pre-construction otter survey apply for an otter licence, if necessary, from NatureScot; and* *iii) until such otter licence (if necessary) is issued, not carry out any works on any otter holts.; and*	Otter surveys, including the pre-construction otter survey are reported in Appendix 6.3. The Otter Protection Plan is also provided as part of Appendix 6.3a (note that this is a 'live document' and so regularly updated). Otters are considered throughout this chapter.

Consultee	Summary Ecological Response	Where and How Addressed
	(b) an Otter Protection Plan (OPP) has been submitted to and approved in writing by the Planning Authority following consultation with NatureScot, which shall provide for a programme of future monitoring for otters on the site to allow the adaptation of management under the approved OPP as may be agreed to in writing by the Planning Authority.	

6.3.2 Given the geographical location and habitats present, and in consultation with SNH (now NatureScot), the protected mammal survey focussed on determining the potential presence of otter (*Lutra lutra*). All terrestrial mammal species in Shetland are non-native having been introduced by humans over time (Johnston, 1999). Neither NatureScot nor CIEEM provides guidance on determining the value of non-native species, so professional judgement and general guidance from the Invasive Non-native Species Framework Strategy for Great Britain has been used (DEFRA, 2015). This suggests that non-native species should not be considered as valuable or important ecological receptors. This approach was also used at the Viking Wind Farm, Beaw Field Wind Farm and Mossy Hill Wind Farm. SNH and Shetland Islands Council agreed with the intention to scope out non–native terrestrial mammal species within a Shetland context, with the exception of otter, which is a European Protected Species (EPS).

6.3.3 Marine mammals are considered separately in Chapter 10.

6.3.4 Consultation and best practice guidance identified key ecological surveys required to consider the potential impacts of the Proposed Project on ecology. These studies included:

- a natural heritage desk study;
- a Phase 1 Habitat survey;
- a National Vegetation Classification (NVC) survey;
- a Groundwater Dependent Terrestrial Ecosystem (GWDTE) survey;
- an otter survey; and,
- a freshwater pearl mussel survey.

6.3.5 Full details of ecological survey methodologies and results can be found in Appendices 6.1 to 6.4 inclusive.

6.4 Assessment Methodology and Significance Criteria

Consultation

6.4.1 In accordance with CIEEM best practice guidance, consultation was undertaken with SNH on the nature and scale of surveys as part of the preparation for environmental impact assessment of the SaxaVord Spaceport in February 2018. These surveys remain pertinent to the Proposed Project and have therefore been included in the AEE.

Environmental Zone of Influence

6.4.2 The following geographic definitions are used in this chapter and associated Appendices (Drawings 6.1 and 6.2 and Table 6.2).

Table 6.2 Site and Environmental Zone of Influence Definitions

Term	Definition
The site	This refers to all of the land within the Proposed Project boundary.
The Development Footprint	This refers to the footprint of the infrastructure within the SaxaVord Spaceport boundary.
The study area	The study area equates to the land within the Proposed Project footprint, plus an appropriate survey buffer. This can be variable depending on the ecological receptor and is described in the relevant appendices. As surveys were conducted as part of the SaxaVord Spaceport planning application works, the habitats study area equates to the SaxaVord Spaceport site plus a ca. 100 meters (m) or 250 m buffer, excluding private properties and gardens. For otters the study area was the site plus a 500 m buffer. In this Chapter two study areas are referred to: ➢ The Habitats study area, which is the SaxaVord Spaceport site at Lamba Ness plus a 250 m buffer, for habitats and vegetation communities. ➢ The Otter study area, which is the SaxaVord Spaceport site at Lamba Ness plus a 500 m buffer, for otters. These are shown in Drawing 6.1.

6.4.3 These geographic areas combined are generally considered to be the ecological study area for the Proposed Project.

6.4.4 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland.

6.4.5 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian. All launches will take place from Launch Pad 1 at the SaxaVord Spaceport.

6.4.6 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of SaxaVord Spaceport's own assessed environmental budget of 30 launches per year.

6.4.7 The main elements of the Proposed Project which have the potential to impact on ecological receptors during operation are described in Chapter 3 and comprise:

- Preparation of the RFA ONE NOM Launch Vehicle;
- Storage and Handling of RFA ONE NOM Launch Vehicle Propellant;
- Operation of Ground Segment and Launch Complex; and
- Launch of RFA ONE NOM Launch Vehicle (including discarded stage impact zones).

6.4.8 The environmental zone of influence (EZI) for a project is the area over which ecological receptors may be affected by biophysical changes as a result of the Proposed Project. The EZI or study area will vary for different ecological receptors depending on their sensitivity to, and nature of, an environmental change. The study area can extend beyond the site and the study areas, particularly in the context of hydrological connectivity and potential pollution events. However, the study area for each receptor is considered an appropriate zone of influence for the vast majority of ecological receptors.

6.4.9 For habitats, the study area is considered to be straight forward and is defined as the Proposed Project site plus a buffer, which equates to the study area. The Proposed Project Site Habitats study area has a 250 m buffer in accordance with SEPA's guidance for GWDTE assessments (SEPA, 2017).

6.4.10 Assessing the potential effects of disturbance on other ecological receptors, such as otters, is a more complex issue which will vary depending on the type of disturbance (e.g., routine/predictable verses unusual/unexpected), topography, vegetation and the behaviour/tolerance of the receptor species and even different individuals within species.

6.4.11 For the previous SaxaVord Spaceport planning application, SNH's standing guidance on otter surveying (no date) stated that "*otters could be affected by a development proposal anywhere in Scotland close to a water course, wetland, coastline or estuary. An otter survey should be carried out for any proposal within 200 m of these habitats*". The updated NatureScot standing guidance issued subsequently (no date) provides the same advice. Whilst this is in accordance with best practice guidance e.g., Chanin (2003), the potential noise and vibration from the satellite launches could be considerable. Consequently, this 200 m survey buffer was not necessarily considered an adequate basis on which to determine the size of the Otter study area.

6.4.12 There is no standard guidance on potential disturbance (and so survey) distances for satellite launches and so in the planning application, and followed through into this AEE, a precautionary approach to determining the size of the study area has been adopted in line with CIEEM (2018) best practice guidance.

6.4.13 Given the lack of any empirical evidence or guidance on the potential impact of satellite launches on otters, it was decided that at least doubling the standing guidance for determining survey area, from a 200 m to a 500 m buffer was a legitimate precautionary basis on which to proceed with otter surveys. Consequently, the size of the Otter study area (Drawing 6.1) is considerably larger than the Proposed Project boundary area and is centred on indicative launch site locations assessed during the SaxaVord Spaceport planning pre-application consultation discussions in 2018.

6.4.14 Surveys have continued where, in the professional judgement of the surveyor, otter signs may have occurred just outwith the survey buffer in potentially suitable and contiguous habitats e.g., along watercourses.

Survey Approach

6.4.15 A reconnaissance site visit by Dr Peter Cosgrove in late autumn 2017 determined that the Proposed Project area was predominantly open coastal/upland habitat characterised by peatland, grassland and sea cliffs (plus some buildings and associated hard standings). The principal land use was sheep grazing through crofting and common grazing.

6.4.16 The ecological surveys included a desk study of historical information sources and a series of targeted field surveys of potentially important and/or legally protected ecological receptors. All the ecology field surveys were undertaken by experienced ecological surveyors using recognised survey methods, during suitable times of year and under suitable weather conditions for the habitats and species concerned. Any departures from standard guidance are explicitly stated and reasons for the departure given.

Desk Study

6.4.17 An initial desk study was conducted in 2017 using the SNH's SiteLink website and Shetland Biological Records Centre data held for the Search Area. This was supplemented by existing knowledge of Unst. Given the time gap between 2017 and the current planning submission, the exercise was repeated from the same data providers, alongside up to date information from the National Biodiversity Network (NBN) Atlas; a collaborative partnership created to exchange biodiversity information. This information was then compiled into a technical report in August 2020 (Appendix 6.1).

6.4.18 All known records of potentially important ecological receptors within at least a one kilometre (km) radius of the Proposed Project were identified. All designated sites with ecological qualifying features within a 10 km radius of the Proposed Project were also identified.

Field Surveys

Phase 1 Habitat Survey

6.4.19 A Phase 1 Habitat survey was conducted in July 2018 and updated in July 2020. The vegetation was described and mapped following the methods described in the Joint Nature Conservation Committee (JNCC) Handbook for Phase 1 Habitat surveys (JNCC, 2010), the revised field manual (JNCC, 2012). Details of the survey methodology and results are provided in Appendix 6.2. Whilst no systematic Phase 1 Habitat survey was undertaken in 2022, in line with best practice guidance, the Habitats study area was walked over during summer months by the same experienced habitat surveyor and no substantive changes were recorded other than the construction works commencing and so the 2018-2020 baseline survey and assessment is considered robust.

National Vegetation Classification (NVC) Survey

6.4.20 A NVC survey was conducted in July 2018 and updated in July 2020. The vegetation was classified and mapped following the methods described in the JNCC National Vegetation Classification User's Handbook (Rodwell, 2006). Details of the survey methodology and results are provided in Appendix 6.2. Whilst no systematic NVC survey was undertaken in 2022, in line with best practice guidance, the Habitats study area was walked over during summer months by the same experienced habitat surveyor and no substantive changes were recorded other than the construction works commencing and so the 2018-2020 baseline survey and assessment is considered robust.

Potential Groundwater Dependent Terrestrial Ecosystem (GWDTE) Survey

6.4.21 Wetland habitats were identified in July 2018 and updated in July 2020 as part of the Phase 1 Habitats and NVC vegetation surveys, in accordance with the Functional Wetland Typology (SNIFFER, 2009a, 2009b). Where wetlands were identified, an assessment was made as to whether they were likely to be potential GWDTEs as defined by SEPA (SEPA, 2017). Details of the survey methodology and results are provided in Appendix 6.2. Whilst no systematic GWDTE survey was undertaken in 2022, in line with best practice guidance, the Habitats study area was walked over during summer months by the same experienced habitat surveyor and no substantive changes were recorded other than the construction works commencing and so the 2018-2020 baseline survey and assessment is considered robust.

Peatland Condition Assessment (PCA)

6.4.22 A PCA was undertaken in July 2018 and updated in July 2020 as part of the Phase 1 Habitats and NVC vegetation surveys, in accordance with the Peatland Action Guidance (Peatland Action, 2016). Details of the assessment methodology and results are provided in Appendix 6.2. Whilst no systematic PCA was undertaken in 2022, in line with best practice guidance, the Habitats study area was walked over during summer months by the same experienced habitat surveyor and no substantive changes were recorded other than the construction works commencing and so the 2018-2020 baseline survey and assessment is considered robust.

Otter Survey

6.4.23 The Otter study area was surveyed under SNH licence for otters in 2018 and 2020 by Brydon Thomason, a highly experienced and locally based otter surveyor, with unparalleled practical experience of working on otters in Unst (Appendix 6.a).

6.4.24 A typical/standard otter survey often involves a single survey visit. However, otters are known to be seasonal in their use of certain habitats and so single visits can underestimate occupancy or seasonal use of an area. To ensure that a robust assessment of otter activity was undertaken and the use by otters understood, the Otter study area was surveyed during June and October 2018 and again in July 2020. A pre-construction otter survey (Appendix 6.3b) was undertaken in March 2022 by Donald Shields MCIEEM, a highly experienced mammal surveyor and ecologist. Surveys were undertaken around the Development Footprint and in suitable habitat within a 200 m buffer.

6.4.25 The survey methods involve a systematic survey of terrestrial, aquatic and riparian habitats within the study areas looking for places' otters use for shelter, resting and protection (such as couches, lying-up sites and holts), or for signs of activity (such as spraints, feeding remains or footprints). The otter surveys took place during suitable weather conditions, so that otter field signs (spraints, slides, sheltering or resting places etc.) would have had time to build up, be relatively visible and would not have been degraded/washed away e.g., after heavy rain. Details of the survey methodology and results are provided in Appendix 6.3a. The pre-construction surveys undertaken in 2022 are provided as an addendum to the previous otter survey report (Appendix 6.3b) and provide an update on the otter European Protected Species baseline (Appendix 6.3a). The existing 2018-2020 survey data and assessment is considered robust in light of the updated 2022 survey data which demonstrates no substantial changes in the baseline conditions.

Freshwater Pearl Mussel Survey

6.4.26 The Burn of Norwick was surveyed by Dr Peter Cosgrove, an experienced and licensed freshwater pearl mussel surveyor in September 2018. Details of the survey methodology and results are provided in Appendix 6.4.

Assessment of Potential Effect Significance

6.4.27 This section defines the criteria that were used to evaluate the significance of predicted likely effects on important ecological receptors due to the Proposed Project. A level of confidence or likelihood (whether the predicted effect is certain, likely, possible or unlikely) is attached to the predicted effect.

Evaluating Conservation Importance

6.4.28 The ecological receptors identified in the baseline studies were evaluated following best practice guidelines (e.g., CIEEM, 2018). Identifying the importance of potential ecological receptors was the first step of the process, and those considered potentially important, and present were then subject to detailed survey and assessment. Those considered sufficiently widespread, unthreatened and resilient to the project impacts were scoped out of further assessment as per best practice EcIA guidance (e.g., CIEEM, 2018).

6.4.29 Ecological receptors can be important for a variety of reasons and the rationale used to define their importance has been explained to demonstrate a robust selection and evaluation process. Importance may relate, for example, to a designated site, to species rarity, to the extent to which they are threatened throughout their range, or to their rate of decline. Various characteristics contribute to the potential importance of ornithological receptors within an area. Examples include:

- naturalness;
- animal or plant species, sub-species or varieties that are rare or uncommon, either internationally, nationally or more locally, including those that may be seasonally transient;
- ecosystems and their component parts, which provide the habitats required by important species, populations and/or assemblages;
- endemic species or locally distinct sub-populations of a species;
- habitats that are rare or uncommon;
- habitats that are effectively irreplaceable;
- habitat diversity;
- size of habitat or species population;
- habitat connectivity and/or synergistic associations;
- habitats and species in decline;
- rich assemblages of plants and animals;
- large populations of species or concentrations of species considered uncommon or threatened in a wider context;

- plant communities (and their associated animals) that are considered to be typical of valued natural/semi-natural vegetation types, including examples of naturally species-poor communities; and,
- species or habitats on the edge of their range, particularly where their distribution is changing as a result of global trends and climate change.

6.4.30 Guidance on EcIA also sets out categories of ecological or nature conservation importance that relate to a geographical framework (e.g., international through to local) together with criteria and examples of how to place a site or study area (defined by its ecological attributes) into these categories. It is generally straightforward to evaluate sites or species populations designated for their international or national importance (as criteria for defining these exist e.g., SAC and SSSI), but for sites or populations of regional or local importance, criteria may not be easily defined. Where possible, the potential importance of an ecological receptor in the site/study area has been determined within a defined geographical context using criteria outlined in Table 6.3.

Table 6.3 Summary of Geographic Population Importance Criteria Used

Term	Definition
International	For example, >1 % of European Community (EC) population/area of habitat
National	For example, >1 % of United Kingdom (UK/Scotland) population/area of habitat
Regional	For example, <1 % of United Kingdom (UK/Scotland) population/area of habitat, but >1 % of regional resource (Shetland) population/area of habitat
Local	For example, within local area

6.4.31 It should be noted that there is no fundamental biological reason to take 1 % of a population as the threshold level for establishing the level of geographical importance of a site. Nevertheless, this percentage is widely considered to be of value in developing measures that give an appropriate level of protection to populations and has gained acceptance on this basis throughout the world. The criterion was, for example, adopted by parties involved in the Ramsar Convention 1971. Thereafter, the 1 % level of national species totals has been taken as the basis of assessment in various countries, including Britain (Stroud *et al*., 1990).

6.4.32 To be clear, the ecological importance afforded to a habitat or species within a site or study area is determined by both the geographical context, as well as the range of ecological characteristics of the habitat or species exhibit (listed above). For example, a habitat in any condition, which is >1 % of the national total could be considered nationally important, whereas a habitat smaller than this, but considered to be of particular high quality (for example, meeting SSSI selection criteria) and/or are connected to/are a stepping-stone between designated sites may also be considered nationally important.

6.4.33 The importance attached to an ecological receptor can also be determined according to legislative status. Some ecological receptors are subject to a general level of legal protection through e.g., the Wildlife and Countryside Act 1981 (as amended), or The Nature Conservation (Scotland) Act 2004 (as amended) and others under Council Directive 1992/43/EEC of 21 May 1992 on the Conservation of Natural Habitats and of Wild Fauna and Flora (the so-called Habitats Directive). There is no clear guidance for conservation importance of ecological receptors other than those of European Protected Species and nationally designated site species and habitats. The importance of other species and habitats is based on professional judgement using the characteristics outlined above. The status of potentially important receptors, such as being on the SBL, is also taken into consideration.

6.4.34 Nevertheless, for the avoidance of doubt, CIEEM EcIA guidance (2018) makes it clear that species which appear on national lists e.g., Schedule 1 of the Wildlife and Countryside Act (1981 as amended) and SBL are not necessarily evaluated as of national importance simply by appearing on such a 'national' list. Importance evaluation must consider the number of individuals of species or area of habitat within a geographical context/scale, i.e., how many of a particular species are likely to be affected by the Proposed Project and what proportion of the local/regional/national population does this constitute. Legal listing/protection is a separate but important consideration.

6.4.35 Once the importance of an ecological receptor has been determined, the potential impacts on that receptor are considered in terms of magnitude, extent, duration, frequency and timing, reversibility, sensitivity and whether the impact would likely be beneficial, adverse or neutral.

Beneficial or Adverse

6.4.36 According to CIEEM (2018) beneficial (positive) and adverse (negative) impacts and effects should be determined according to whether the change is in accordance with nature conservation objectives and policy. In the CIEEM Guidance, the terms positive and negative are used, but in this chapter the equivalent terms beneficial and adverse are used, as synonyms, for consistency between Chapters. These terms are defined as:

- Beneficial – a change that improves the quality of the environment e.g., by increasing species diversity, extending habitat or improving water quality. This may also include halting or slowing an existing decline in the quality of the environment.
- Adverse – a change which reduces the quality of the environment e.g., destruction of habitat, habitat fragmentation, pollution.
- Impacts and effects can also be assessed as neutral.

Extent

6.4.37 According to CIEEM EcIA guidance (2018), extent is the spatial or geographical area over which the predicted impact/effect may occur under a suitably representative range of conditions.

Magnitude

6.4.38 According to CIEEM EcIA guidance (2018), magnitude refers to size, amount, intensity and volume. It should be quantified if possible and expressed in absolute or relative terms e.g., the amount of habitat lost, percentage change to habitat area, percentage decline in a species population. In this assessment there are considered to be four levels of magnitude of impact (Table 6.4) and it is assumed these are adverse, unless otherwise stated.

Table 6.4 Summary of Magnitude Criteria Used

Term	Definition
Major	Total/near total loss of a population/habitat due to mortality or displacement. Total/near total loss of breeding productivity in a population due to disturbance. e.g., ≥50 % of population/habitat affected.
Moderate	Moderate reduction in the status or productivity of a population/habitat due to mortality or displacement or disturbance. e.g., 10 % to 49 % of population/ habitat affected.
Minor	Small but discernible reduction in the status or productivity of a population/habitat due to mortality or displacement or disturbance. e.g., 1 % to 9 % of population/habitat affected.
Negligible	Very slight reduction in the status or productivity of a population/habitat due to mortality or displacement or disturbance. Reduction barely discernible, approximating to the 'no change' situation. e.g., <1 % population/habitat affected.

Duration

6.4.39 According to CIEEM EcIA guidance (2018), duration should be defined in relation to ecological characteristics (such as the life cycle of a species). The duration of an activity may differ from the duration of the resulting effect caused by the activity. Impacts and effects may be described as short, medium or long-term and permanent or temporary and should be defined. In this assessment three timeframes are used: short-term (up to two years), medium-term (two-five years) and long-term (between five years and the lifetime of the Proposed Project).

Frequency and Timing

6.4.40 According to CIEEM EcIA guidance (2018), the number of times an activity occurs may influence the resulting effect. For example, a single person walking a dog will have very limited impact on nearby otters using wetland habitat, but numerous dog walkers will subject the otters to frequent disturbance and could affect breeding/feeding success, leading to displacement and knock-on effects on their ability to survive. The timing of an activity or change may result in an impact if it coincides with critical life-stages or seasons.

Reversibility

6.4.41 According to CIEEM EcIA guidance (2018), an irreversible effect is one from which recovery is not possible within a reasonable timescale or there is no reasonable chance of action being taken to reverse it. A reversible effect is one from which spontaneous recovery is possible or which may be counteracted by mitigation. In some cases, the same activity can cause both reversible and irreversible effects.

Sensitivity

6.4.42 Another factor when assessing potential impacts is the behavioural sensitivity of the ecological receptor under consideration (e.g., high, medium or low) and the zone of influence. Different receptors respond differently to stimuli, making some particularly sensitive to development activities and others less so. Professional judgement is used when assigning sensitivity to an ecological receptor and this is recorded here in a clear and transparent way. Sensitivity criteria vary across the wide range of taxonomic groups considered in an ecological impact assessment and are therefore provided in the receptor descriptions of this chapter.

6.4.43 By way of example, sensitivity is determined according to species' behaviour, using broad criteria set out in Table 6.5. Behavioural sensitivity can differ between species and between individuals of the same species. Therefore, sensitivity is likely to vary with both the nature and context of the disturbance activity as well as the experience and even 'personality' of the species, in the case of mammals. Sensitivity also depends on the activity the species is undertaking and when it is doing it. For example, a species is likely to be less tolerant of disturbance during the breeding season than at other times of year. Thus, sensitivity changes with both space and time.

Table 6.5 Summary of Sensitivity Criteria Used

Term	Definition
High	Species occupying remote areas away from human activities or exhibiting strong and long-lasting reactions to disturbance events. Habitats that are considered to have a slow recovery time to disturbance.
Medium	Species that appear to be warily tolerant of human activities or exhibiting short-term reactions to disturbance events. Habitats that are considered to have a moderate recovery time to disturbance.
Low	Species occupying areas subject to frequent human activity and exhibiting mild and brief reaction to disturbance events. Habitats that are considered to have a quick recovery time from disturbance.

Likelihood

6.4.44 Finally, a level of confidence (whether the predicted impact is certain, likely, possible or unlikely) can be attached to a predicted effect.

Criteria for Evaluating Significance

6.4.45 Significance is a concept related to the weight that should be attached to predicted effects when decisions are made. A "*significant effect"*" is an effect that either supports or undermines biodiversity conservation objectives for important receptors (CIEEM, 2018). There could be any number of possible impacts on important ecological features arising from a development. However, it is only necessary to describe in detail the impacts that are likely to be significant. Impacts that are either unlikely to occur, or if they did occur are unlikely to be significant, can be scoped out.

6.4.46 In the context of AEE, each likely effect is evaluated and classified as either significant or not significant, using professional judgement, evidence and best practice guidance. In this assessment, a significant effect is defined as "*an impact on the integrity of a defined site or ecosystem and/or the conservation status of habitats or species within a defined geographical area*". Thus, the geographical terms of reference at which a predicted effect may be considered significant must also be defined (e.g., an effect on a species population evaluated to be of regional importance at a given site is likely to be either significant or not at the regional level). Effects can be considered significant at a wide range of scales from international to local.

6.4.47 There is sometimes confusion over geographical context, potentially important receptors and quantifying predicted effects and EcIA best practice guidance has often struggled to articulate this clearly. For example, if a potentially important species appears on a conservation list e.g., the SBL and there is a predicted impact, the geographical context in which the receptor is found must be considered. Therefore, the simple presence of a species on the SBL within an area does not mean that likely effects are significant at the national (Scottish) level. For that to occur, the Proposed Project must have significant effects on its national (Scottish) population.

Requirements for Mitigation

6.4.48 Best practice guidance e.g., CIEEM (2018) identifies a hierarchy of mitigation for potential impacts that seeks to:

- Avoid adverse ecological impacts, especially those that could be significant to important receptors.
- Minimise adverse impacts that could not be avoided.
- Compensate for any remaining significant residual impacts.

6.4.49 CIEEM EcIA guidance (2018) states that "*Avoiding and/or minimising negative impacts is best achieved through consideration of potential impacts of a project from the earliest stages of scheme design and throughout its development*". This approach to avoiding potential adverse impacts within a design layout is sometimes described as embedded mitigation or mitigation by design. "*Mitigation by design is particularly beneficial as there is greater certainty that it will be delivered*" (CIEEM 2018).

6.4.50 There is a growing body of policy and guidance that development plans should not just try to avoid causing likely significant effects. Best practice guidance recommends seeking to provide enhancement for important biodiversity over and above design requirements for avoidance, minimisation or compensation (e.g., CIEEM, 2018; NPF4, 2022).

6.4.50 This chapter considers mitigation in the context of CIEEM guidance and also in relation to local planning authority guidance for protected species. The embedded mitigation has been considered in the design layout of the SaxaVord Spaceport and because of this, has been guaranteed through planning conditions for the same. Where likely significant effects are predicted regardless of design layout, further mitigation is separately identified as per CIEEM best practice guidance.

Assessment of Residual Effect Significance

6.4.51 After assessing the potential impacts of the Proposed Project (incorporating embedded mitigation), all attempts were made to further avoid and mitigate predicted adverse ecological impacts. Once measures to avoid and mitigate predicted ecological impacts had been incorporated, assessment of the residual impacts was undertaken to determine the likely significance of their effects on important ecological features.

Limitations to Assessment

6.4.52 Where assumptions within the assessment are made, these are explicitly identified and explained. Similarly, limitations in methods and knowledge of species' ecology are also identified and discussed, particularly where this is likely to affect the outcome of the assessment. As with any environmental assessment there will be elements of uncertainty. Where there is uncertainty, this is identified and reported transparently, along with the measures taken to reduce it, assumptions made, and an explanation as to the likely extent that any uncertainties are likely to affect the conclusions. In circumstances where there is uncertainty; evidence, expert opinion, best practice guidance and professional judgement have been used to evaluate what is biologically likely to occur if the Proposed Project is constructed.

6.4.53 The level of certainty of impact prediction varies depending upon a range of parameters discussed already. For some elements e.g., land-take it is relatively straightforward to assess and quantify the area of habitat that is likely to be lost to development infrastructure and therefore quantify potential impacts of land-take on the habitats present. However, other impacts are less certain because there can be a range of possible scenarios. The main limitations in this assessment are common to most ecological assessments because:

- Baseline surveys undertaken are based on sampling techniques, not absolute censuses. Results give an indication of the numbers of ecological receptors recorded at the particular times that surveys were carried out e.g., summer 2018. Species occurrence changes over time and therefore the results presented in this AEE Report are snapshots in time. Importantly, no information gaps were identified in the baseline survey data that would prevent assessments in line with the requirements of the AEE to be undertaken.
- Putting ecology survey results into a wider geographical context is sometimes challenging because most species and habitats have not been systematically surveyed beyond the study area. Thus, defining a receptor population as locally or regionally important is potentially difficult because local or regional population estimates do not exist for most taxa and habitats. Whenever such uncertainty exists, professional judgement and published evidence is used and populations in the study area or site have been assumed to be at their highest potential level of geographical/ecological importance.

6.5 Baseline Conditions

Desk Study – Designated Sites

6.5.1 A total of 10 designated sites with ecological qualifying features within a 10 km radius of the Proposed Project have been identified (Table 6.6; Drawing 6.2). There are a number of Local Nature Conservation Sites in Unst and these are listed in Table 6.7.

Table 6.6 Biological Designated Sites within 10 km of the Proposed Project.

Designated Site	Designation Type	Area (ha)	Distance (km) and Direction from Proposed Project	Biological Qualifying Features
Hermaness, Saxa Vord and Valla Field	SPA	6,832 ha	1.5 km, northwest	Breeding birds: • Fulmar (*Fulmarus glacialis*) • Gannet (*Morus bassanus*) • Great skua (*Stercorarius skua*) • Guillemot (*Uria aalge*) • Kittiwake (*Rissa tridactyla*) • Puffin (*Fratercula arctica*) • Red-throated diver (*Gavia stellata*) • Shag (*Phalacrocorax aristotelis*) Breeding bird assemblages
Keen of Hamar	SAC	40 ha	4.9 km, south	Upland habitats: • Base rich scree • Dry heath Grasslands on soils rich in heavy metals
Keen of Hamar	SSSI	50 ha	4.7 km, south	Calaminarian grassland and serpentine heath Vascular plant assemblages
Hill of Colvadale and Sobul	SSSI	809 ha	7.9 km, south	Arctic sandwort (*Arenaria norvegica*) Breeding birds: • Arctic skua (*Stercorarius parasiticus*) • Whimbrel (*Numenius phaeopus*) Breeding bird assemblages Calaminarian grassland and serpentine heath
Valla Field	SSSI	629 ha	6.0 km, southwest	Breeding birds: • Great skua Red-throated diver
Crussa Field and Heogs	SSSI	469 ha	4.5 km, south	Breeding birds: • Arctic skua • Whimbrel Breeding bird assemblages Vascular plant assemblages Calaminarian grassland and serpentine heath

Designated Site	Designation Type	Area (ha)	Distance (km) and Direction from Proposed Project	Biological Qualifying Features
Hermaness	SSSI	978 ha	3.9 km, west	Breeding birds: • Fulmar • Gannet • Great skua • Guillemot • Puffin Breeding seabird colony
Saxa Vord	SSSI	56 ha	3.0 km, west	Breeding birds: • Fulmar • Guillemot Breeding seabird colony
Norwick Meadows	SSSI	25 ha	0.75 km, southwest	Sand dune habitats Valley fen wetlands
Fetlar to Haroldswick	MPA	216,000 ha	3.0 km, south	Aggregation of breeding birds: • Black guillemot (*Cepphus grylle*) Horse mussel beds Circalittoral sand and coarse sediment communities Kelp and seaweed communities on sublittoral sediment

Table 6.7 Local Nature Conservation Sites in Unst (Shetland Islands Council, 2015).

Local Conservation Sites in Unst	Primary Interest	Justification for Local Conservation Site
Baltasound	Species	Glasswort (*Salicornia europea*) and annual sea-blite (*Suaeda maritima*).
Burn of Mailand	Species	Rare plants. Lesser tussock sedge (*Carex diandra*) and small bur-reed (*Sparganium natans*) are found nowhere else in Shetland. Rich bryophyte flora.
Haroldswick mires	Species	Schedule 1 bird species. The pool at Haroldswick is attractive to migrant birds. The base-rich mire vegetation is unusual in Shetland.
Lochs of Bordastubble and Stourhoull	Species	These water bodies are on the Unst serpentine; they are nutrient rich and support a variety of aquatic species. Breeding Schedule 1 bird species.
Skeo Taing	Species	The herb-rich turf with base-rich shell sand provides habitat for a diverse range of plants. The nationally rare autumn gentian (*Gentianella amarelle septentrionalis*) is found on site, and it is one of only a few sites in Shetland where harebell (*Campanula rotundifolia*) has been recorded.

Local Conservation Sites in Unst	Primary Interest	Justification for Local Conservation Site
Wick of Skaw	Geology	Easily identifiable exposure of a granite intrusion contact zone.
Belmont Quarry	Geology	Rock exposures across a major shear zone/ophiolite thrust. Part of the Shetland Ophiolite Suite.
Clibberswick Cross Geo	Geology	Part of the Shetland Ophiolite suite.
Hill of Clibberswick	Species	Two nationally scarce plant species are present on-site, Norwegian sandwort (*Arenaria norvegica*) and northern rock cress (*Arabis petraea*)

Desk Study – Species

6.5.2 Full details of the of the desk study are provided in Appendix 6.1. The desk study demonstrated that there are a large number of records of species of potential interest within vicinity of the site, including legally protected species, SBL species and locally important/rare species. Table 6.8 summaries the results of the desk study for species with potential ecological importance for the site.

Table 6.8 Species Identified as EPS, SBL Species or having Local Importance in the Desk Study

Species name	Common name	Taxa	Listing	Closest Record to the Proposed Project	Year of Record
Lutra	Otter	Mammal	EPS, SBL	>700 m, Norwick	2002-2011
Celaena haworthii	Haworth's minor	Lepidoptera	SBL	One in Saxa Vord, one 150 m away, Houlanbrindy	2017
Eugnorisma glareosa	Autumnal rustic	Lepidoptera	SBL	Within Saxa Vord	2017
Hepialus humuli	Ghost moth	Lepidoptera	SBL	Near Northdale Road	2017
Xanthorhoe decoloraria	Red carpet	Lepidoptera	SBL	Within Saxa Vord	2017
Caloplaca britannica	A lichen	Lichen	SBL	Lamba Ness	2015
Leptogium britannicum	A lichen	Lichen	SBL	Lamba Ness	2015
Opegrapha areniseda	A lichen	Lichen	SBL	Lamba Ness	2015
Thelenella muscorum var. octospora	A lichen	Lichen	SBL	Lamba Ness	2015
Spergula arvensis	Corn spurry	Vascular plant	Nationally vulnerable	Northdale and near Saxa Vord	2012-2015

Species name	Common name	Taxa	Listing	Closest Record to the Proposed Project	Year of Record
Mertensia maritima	Oyster plant	Vascular plant	LBAP. Near Threatened and Nationally Scarce and scarce in Shetland	Inner Skaw	2019

Field Surveys

Habitat Surveys

6.5.3 Full details of the methods and results of the Phase 1 Habitat and NVC surveys can be found in Appendix 6.2 and Drawings 6.3 and 6.4. The results are summarised here. It should be noted that the results of these surveys are based on the Habitats study area prior to construction of SaxaVord Spaceport, and whilst the survey data are relevant beyond the Development Footprint, the habitats within the Development Footprint, as described in these surveys, has subsequently been stripped of all vegetation during pre-construction works for the SaxaVord Spaceport (Photo 1).

Photo 1: Vegetation stripping at Lamba Ness, March 2022

6.5.4 The Habitats study area included distinctive maritime grasslands in the east, on Lamba Ness, which had a range of pools. This transitioned into an area of wet modified bog dominated by purple moor-grass (*Molinia caerulea*). More westerly in the Habitats study area the habitats were made up of wet modified bog/wet heath, which was dominated by heather (*Calluna vulgaris*) and common cottongrass (*Eriophorum angustifolium*), and acid grasslands. To the north-west side of the Habitats study area transitioned into blanket bog habitats.

6.5.5 There were small areas of other habitats, including standing water, marginal vegetation at the edge of pools and saltmarsh perched within the coastal vegetation. The old military buildings and roads and other infrastructure were also mapped across the Habitats study area and often had distinct vegetation around them, enriched from the sheep that sheltered in them.

6.5.6 All the habitats within the Habitats study area had clearly been subject to modification through current and historic management practices including sheep grazing and drainage. Sheep were evident across the Habitats study area and the impacts of fertilisation, grazing and sheep lay-down areas were recorded. Drainage ditches, both very recently cut, and older, were also recorded in wet modified bog and wet modified bog/wet heath habitats. There were areas of naturally occurring haggs, within the blanket bog, which were likely to be exacerbated by sheep and subsequently wind erosion.

6.5.7 The list of Phase 1 habitats mapped and described in the Proposed Project site Habitats study area along with the total area and the percentage of the study area are displayed in Table 6.9.

Table 6.9 Phase 1 Habitats Described in the Habitats Study Area

Phase 1 Habitats	Area (ha)	% of Habitats Study Area
Wet modified bog/wet heath	30.5	26.1
Wet modified bog	28.2	24.2
Coastal grassland	19.7	16.8
Semi-improved acid grassland	16.3	14.0
Unimproved acid grassland	7.3	6.2
Wet modified bog/wet heath/dry heath	6.5	5.6
Buildings and roads	1.8	1.5
Fen	1.5	1.3
Blanket bog/bare peat	1.5	1.3
Blanket bog	1.1	1.0
Dry dwarf shrub heath	0.7	0.6
Saltmarsh	0.4	0.3
Wet modified bog/wet heath/bare peat	0.3	0.2
Sand dunes	0.3	0.2
Marginal and inundation	0.2	0.2
Wet modified bog/wet heath/acid flush	0.2	0.2
Bare ground	0.1	<0.1
Acid flush	0.1	<0.1
Bare peat	0.1	<0.1
Neutral grassland	0.1	<0.1
Standing water	<0.1	<0.1
Open vegetation	Too small to map separately	N/A
Water courses and drains	Mapped as lines	N/A

6.5.8 The NVC communities found within the Habitats study area were:

- Coastal grasslands
  - MC8d *Festuca rubra – Holcus lanatus* maritime grassland, *Holcus lanatus* sub-community
  - MC10a *Festuca rubra - Plantago spp.* maritime grassland, *Armeria maritima* sub-community
  - MC10b *Festuca rubra - Plantago spp.* maritime grassland, *Carex panacea* sub-community
  - MG11 *Festuca rubra – Agrostis stolonifera – Potentilla anserine* grassland community;
- Saltmarsh
  - SM16b *Festuca rubra* salt-marsh community, *Juncus gerardii* dominant sub-community;
- Sand dunes
  - SD4 *Elytrigia juncea* fore-dune community
  - SD8d *Festuca rubra – Galium verum* fixed dune grassland *Bellis perennis - Ranunculus acris* sub-community;
- Wet modified bog
  - M25b *Molinia caerulea – Potentilla erecta* mire, *Anthoxanthum odoratum* sub-community
  - Mxd *Carex nigra* provisional fen, *Molinia caerulea* sub-community
  - M3x *Eriophorum angustifolium* community;
- Fen
  - Mxd *Carex nigra* provisional fen, *Molinia caerulea* sub-community;
- Semi-improved acid grassland
  - U4b *Festuca ovina – Agrostis capillaris – Galium saxatile* grassland, *Holcus lanatus – Trifolium repens* sub-community;
- Unimproved acid grassland
  - U5a *Nardus stricta – Galium saxatile* grassland, species poor sub-community
  - U5b *Nardus stricta – Galium saxatile* grassland, *Agrostis canina – Polytrichum commune* sub-community
  - U6 *Juncus squarrosus – Festuca ovina* grassland community;
- Neutral grassland
  - MG10a *Holcus lanatus – Juncus effusus* rush-pasture, typical sub-community;
- Wet dwarf shrub heath
  - M15d *Trichophorum cespitosum – Erica tetralix* wet heath, *Vaccinium myrtillus* sub-community
  - M15 *Trichophorum cespitosum – Erica tetralix* wet heath community;
- Blanket bog
  - M2b *Sphagnum cuspidatum/fallax* bog pool, *Sphagnum fallax* sub-community
  - M19 *Calluna vulgaris – Eriophorum vaginatum* blanket mire community;

- Bare peat
  - M3 *Eriophorum angustifolium* bog pool community;
- Dry dwarf shrub heath
  - H10b *Calluna vulgaris – Erica cinerea* heath, *Racomitrium lanuginosum* sub-community;
- Acid flush
  - M6b *Carex echinata – Sphagnum fallax* mire, *Carex nigra – Nardus stricta* sub-community;
- Open vegetation
  - OV25 *Urtica dioica – Cirsium arvense* community; and
- Standing water, water margins and inundation vegetation
  - S19a *Eleocharis palustris swamp, Eleocharis palustris* sub-community;
  - A22a *Littorella uniflora - Lobelia dortmanna* community, *Littorella uniflora* sub-community
  - A24 *Juncus bulbosus* community
  - OV28 *Agrostis stolonifera – Ranunculus repens* community.

GWDTE

6.5.9 Full details of the GWDTE survey and assessment can be found in Appendix 6.2 and Drawing 6.5. NVC communities recorded in the Habitats study areas that are considered in the guidance (SEPA, 2017) to be potentially groundwater dependent include:

- M6 *Carex echinata – Sphagnum fallax* mire;
- M15 *Trichophorum cespitosum – Erica tetralix* wet dwarf shrub heath;
- M25 *Molinia caerulea – Potentilla erecta* mire;
- MG9 *Holcus lanatus – Deschampsia cespitosa* grassland;
- MG10 *Holcus lanatus – Juncus effusus* rush-pasture;
- MG11 *Festuca rubra – Agrostis stolonifera – Potentilla anserine* grassland community; and
- U6 *Juncus squarrosus – Festuca ovina* grassland.

6.5.10 Those not in the guidance, that are considered potentially GWDTE (due to their association with similar/related communities that are listed as potentially GWDTE), are:

- Mxd *Carex nigra* provisional fen, *Molinia caerulea* sub-community; and
- M3x *Eriophorum angustifolium* community.

6.5.11 Of these, only M6 is considered to be potentially highly groundwater dependent, depending on the hydrological setting (SEPA, 2017). All the other communities are considered potentially moderately groundwater dependent, depending on the hydrological setting (SEPA, 2017). All mosaics of habitat were allocated their GWDTE category according to the NVC community with the highest potential GWDTE.

6.5.12 The bedrock for the majority of the Habitats study area was the Skaw Intrusion which was describe as a "*Low productivity aquifer*" with "*small amounts of groundwater in near surface weathered zone and secondary fractures; rare springs*" (BGS, 2020). To the far west of the Habitats study area the bedrock is Hevda Phyllite Formation which was also described a "*Low productivity aquifer*" with "*small amounts of groundwater in near surface weathered zone and secondary fractures*" (BGS, 2020). Therefore, the majority of the potentially GWDTE are considered most likely to be present due to waterlogged conditions sustained by high rainfall in the region, rather than groundwater for their maintenance.

6.5.13 The M6 community was located at the transition between the two bedrock types in the Habitats study area. This can be a source location for GWDTE, where groundwater is released at a spring or seepage line (McMullen, 2020). It is therefore considered that the M6 community may be an actual GWDTE.

6.5.14 Detailed geological and hydrological analysis of the SaxaVord Spaceport site determined that the potential GWDTE were either assessed as not being actual GWDTE or were >250 m from the Proposed Project (Appendix 6.5).

Peatland Condition

6.5.14 Full details of the PCA can be found in Appendix 6.2. The PCA bases the condition of blanket bog on indicators such as bog-moss cover, extent of bare peat and evidence of grazing and burning (Peatland Action, 2016). Given that the small area of bog habitat within the Habitats study area was clearly grazed and drained and there were patches of bare peat, using PCA terminology, the blanket bog was considered to be modified and some areas drained. Using the PCA Support Tool, the blanket bog would be considered of intermediate condition.

Vascular Plants

6.5.15 Oyster plant, which was recorded in the fore-dune community within the Habitats study area, is an LBAP species and considered Near Threatened and Nationally Scarce and scarce in Shetland.

6.5.16 No other species recorded during field surveys in 2018 were identified as being on the SBL, an LBAP species or in the lists of rare and scarce species for Shetland (Scott *et al*., 2002).

6.5.17 There was no evidence of any notifiable non-native invasive species within the Habitats study area during walkover surveys.

Lower Plants

6.5.18 No lower plant surveys were requested by SNH or conducted as part of this EcIA. Lichen and bryophyte records identified as part of the desk study have been considered. Full details of the desk study are provided in Appendix 6.1. Table 6.8 summaries the results of the desk study and includes four lichen species which are on the SBL and are within the Proposed Project boundary.

Otters

6.5.19 Numerous otter field signs were recorded during targeted surveys in June and October 2018. Based on 2018 survey data, there were eight-ten otter holts within the Otter study area, with six-seven of these within the site (Drawing 6.6).

6.5.20 In 2020, additional otter surveys were undertaken at the Proposed Project Site. Numerous otter signs were recorded (Drawing 6.7). This included eight holts, located in boulder scree and on the boulder beaches, above the high tide mark. The holts were in inaccessible locations, between boulder or going into caves/crevices and were viewed from the cliff tops with binoculars. Scats and regularly used runs were recorded at the holt sites, and otters occasionally seen/heard. One particular holt on Lamba Ness, which had a large build-up of scats, was clearly being used by a female and her young in July 2020. Three otter holts were recorded in the 2022 pre-construction surveys.

6.5.21 Scats and footprints, including those of adults and young, were also recorded in the abandoned buildings across Lamba Ness. It was considered likely that some of the buildings were used as lay-ups during poor weather conditions and the predated remains of several fulmars (*Fulmarus glacialis*) were also noted within the buildings. Similar evidence of otter use was recorded in the 2022 pre-construction surveys.

6.5.22 Otter use of an underpass at HP 671 154 was particularly noticeable. It was considered likely that otters use this underpass as a regular route to cross from the north to south side of Lamba Ness. The route was well delineated on the grassland and rocks showing a well-established run, and so was functionally important to otter use of the Lamba Ness area.

6.5.23 The data from 2020 indicated that there was one female with young using Lamba Ness as their home territory. Regular sightings of a male indicated that Lamba Ness also formed part of at least one, if not two, dog otter territories. Evidence of otter activity was also recorded in the 2022 pre-construction surveys.

Freshwater Pearl Mussels

6.5.24 The Burn of Norwick was surveyed, under licence, for freshwater pearl mussels in September 2018. No evidence of freshwater pearl mussels was found in the Burn of Norwick survey reach. No patches of suitable or potentially suitable substrate habitat were recorded in the Burn of Norwick survey reach. There was no evidence of freshwater pearl mussel presence within the Burn of Norwick survey reach. Consequently, the survey evidence suggests that there are no special freshwater pearl mussel sensitivities that need to be considered.

6.6 Receptors Brought Forward for Assessment

Potentially Important Ecological Receptors

6.6.1 Ecological features/receptors can be important for a variety of reasons and the rationale used in evaluation should be explained to demonstrate a robust and transparent selection process (CIEEM, 2018). Based on the results of the desk study, initial site walkover, field surveys, consultation and feedback from the regulators, legal protection and professional judgement, the following potentially important receptors were identified for further consideration:

- designated sites;
- semi-natural habitats; and
- otter.

6.6.2 No other potentially important ecological receptors on which potentially significant effects were likely to occur were identified for further consideration. Other species (such as those identified in the desk study, cited as part of nearby designated areas with similar habitats to the study area or present in the LBAP), were mainly scoped out of further consideration on the basis of:

- recent survey results;
- habitats within the study area (e.g., coastal grassland) compared to the species' preferred habitat; and
- the population size of the potentially important species on a geographical basis.

6.6.3 Table 6.10 summarises the evaluation of potentially important receptor population/feature within the Proposed Project ecological study area/EZI.

Table 6.10 Summary Evaluation of Potentially Important Ecological Receptors

Potentially Important Receptor	Evaluation of Potentially Important Receptor Population/Feature within Study Area
Designated sites	Nationally important designated sites <750 m from the study area. Norwick Meadows, is taken forward for assessment.
Otter	Legally protected species. Evidence of regular and frequent use of the study area, with numerus field signs and multiple holts around the Otter study area. Otter's use is likely to include at least one male and one female, sometimes with young, around the Otter study area.

Potentially Important Receptor	Evaluation of Potentially Important Receptor Population/Feature within Study Area
	Otters are considered to have moderate sensitivity to human activities, with resting places and holts considered highly sensitive. However, in Shetland, otters tolerate and utilise a wide variety of human-built features, such as buildings, ferry terminals and fish farms. Status: Stable in Scotland. GB population estimate unknown (Mammal Society, 2020). Scottish population considered to be flourishing, with an estimate of ca. 8,000 individuals (JNCC, 2019; SNH, 2020). Shetland population estimate 700-900 (Kruuk *et al.,* 1989) – but note the age of this population estimate data and subsequent national population increase (30 years +). The study area is estimated to hold ca. 0.5 % of the Shetland population. The site population is therefore considered locally important. The ecological receptor, otter, is taken forward for assessment.
Semi-natural habitats Semi-natural habitats (continued)	Local, regionally, nationally and internationally important habitats present in Shetland. Some of the habitats described within the study area are similar to, or approaching descriptions for, Annex 1 habitats and/or SBL habitats. These include: ➢ coastal grasslands; ➢ saltmarsh; ➢ sand dunes; ➢ wet modified bog; ➢ wet modified bog/blanket bog; ➢ blanket bog; ➢ dry dwarf shrub heath; ➢ acid flush; and ➢ water margin vegetation. Within the study area, the quantity/quality of semi-natural habitats evaluated as locally important, except for some of the water margin vegetation and the sand dune vegetation. For full details of these evaluation refer to Appendix 6.2. These habitats are taken forward for assessment.
GWDTE	Potentially important GWDTE habitats present in the vicinity of the study area. All the potential GWDTE were assessed as not being actual GWDTE and/or were >250 m from the Proposed Project (Appendix 6.5). Therefore, GWDTE have been scoped out of further consideration.
Freshwater pearl mussels	Legally protected species. Status: Listed as Critically Endangered in Europe by IUCN. Scotland population declining; extinct in 73 rivers, not recruiting in 44 rivers and recruiting in 71 rivers (Cosgrove *et al.,* 2016).

Potentially Important Receptor	Evaluation of Potentially Important Receptor Population/Feature within Study Area
	Although present in Shetland (Cosgrove and Harvey, 2005), there was no evidence of freshwater pearl mussels, or potentially suitable habitat, in the Burn of Norwick during targeted surveys in 2018. Furthermore, all extant pearl mussel populations in Scotland have headwater lochs/lochan, Burn of Norwick does not have a headwater loch/lochan. Therefore, freshwater pearl mussels have been scoped out of further assessment.
Plants	<u>Oysterplant</u> LBAP species. Considered Near Threatened and Nationally Scarce and scarce in Shetland. Distributed around the coast of northern Britain. Population increased in north, but declined in south (Preston *et al.,* 2002). Only found on gravelly beaches and shingle, and sometimes sand. This species was located on the fore-shore community at Inner Skaw. The dunes and fore-shore community at Inner Skaw are being avoided by the design layout. Therefore, this species has been scoped out of further assessment.
Lichens	The desk study identified four species of lichen, which have been recorded within close vicinity of the Proposed Project, that are SBL species ("*watching brief only*" category). *<u>Caloplaca britannica</u>* is considered rare in the UK (SBL, 2013). It is distributed widely around the coast of the UK and is of Least Concern according to the GB Red List (NBN Atlas, 2020) This species "*is found on coastal rocks, in the spray zone and is undoubtedly under-recorded*" (Images of British Lichens, 2013). In Shetland it is known to be located in "*sheltered crevices in landward-facing rock face*"(Dalby and Dalby, 2005). *<u>Leptogium britannicum</u>* is found on coastal rocks (Images of British Lichens, 2013). It is distributed widely on the west coast of the UK and on Shetland and Orkney and is of Least Concern according to the GB Red List (NBN Atlas, 2020). In Shetland it is known to be located within amongst mosses in salt marshes and on cliffs (Dalby and Dalby, 2005). *<u>Opegrapha areniseda</u>* is considered rare in the UK. It is found on "*slightly acid or neutral soft rocks near the seashore (schists) and mainly on old walls, notably of chapels*" (Maritime Lichens, 2020). It is distributed widely around the coast of the UK and is of Least Concern according to the GB Red List (NBN Atlas, 2020). This lichen species was not included in the Lichens of Shetland reference (Dalby and Dalby, 2005). *<u>Thelenella muscorum var. octospora</u>* is considered rare in the UK (SBL, 2013). No information was found on the UK habitat requirements for this lichen and it has limited records in the UK with only 20 records on the NBN Atlas, although these are spread across England, Wales, Ireland and Scotland. This species is considered circumboreal, and is found across western United States, western Canada, UK, Ireland, Scandinavia, Europe and Russia (Christy *et al.*, 2010). The habitat requirements that are reported in the United States are not consistent with the habitats found on Lamba Ness. It is considered that it is an obscure, under recorded and under researched species. The record on Lamba Ness describes the habitat it was found in as "*Coastal rocks, mainly granite, turf*

Potentially Important Receptor	Evaluation of Potentially Important Receptor Population/Feature within Study Area
Lichens (continued)	*edge on cliff top*". This species is not legally protected and is has not been evaluated by the GB Red List (NBN Atlas, 2020). The closely related lichen species *Thelenella muscorum* is distributed widely across the UK. This lichen species was not included in the Lichens of Shetland reference (Dalby and Dalby, 2005). It is considered unlikely that the three common species, which are of Least Concern, are widely distributed in the UK and were not mentioned by SNH in consultation, would be significantly impacted though the Proposed Project because: ➢ the relatively small number of records compared to the wide distribution of their under-recorded UK population; ➢ the study area is not designated or specially protected for these species, or habitats which support these species; ➢ they are located in habitat(s) which appear to be largely or wholly avoided by the design layout (e.g., namely coastal cliffs); and, ➢ ambient sulphur dioxide levels (the air pollutant which lichens are generally sensitive to) will not be impacted by the operation of the Proposed Project (Chapter 7). Therefore, these species have been scoped out of further assessment. These assessments are likely to also be relevant to the more obscure species *Thelenella muscorum var. octospora*. Additionally, the edge of the cliff, where this species was reported as being situated, is avoided by design. Therefore, it has also been scoped out of further assessment. Nevertheless, it is recognised that the ecological requirements of these poorly known species are not well understood. It should also be recognised that the distribution of some species can be poorly understood, particularly those in less widely known taxonomic groups, such as lichens. Where systematic surveys have not been widely undertaken know distributions may not fully reflect actual distribution and may be associated to where these species have been visited by specialist observers. This is a well know limitation of species distribution data.
Lepidoptera	Four species of Lepidoptera identified as part of the Desk Study which are all SBL species ("*watching brief only*" category). The four species were recorded within the vicinity of the Proposed Project. Haworth's minor (*Celaena haworthii*) is "*mainly a moorland species, occurring most commonly in northern England, Wales and Scotland… Cotton-grass* (Eriphorium spp.) *is the main foodplant, the larvae feeding internally on the stems*" (UK Moths, 2020). Distributed widely across the UK, more common in the north (Hill *et al.,* 2010; Butterfly Conservation, 2020). Considered local (only found in some areas) (Butterfly Conservation, 2020). Resident in Shetland (Nature in Shetland, 2020). Autumnal rustic (*Eugnorisma glareosa*) inhabits "*woodland fringes, moorland and sandy or chalky soils, it is widely distributed, though not always common, throughout Britain. The adults fly in August and September, and the*

Potentially Important Receptor	Evaluation of Potentially Important Receptor Population/Feature within Study Area
Lepidoptera (continued)	*caterpillars are polyphagous, living on a wide variety of plants and grasses"* (UK Moths, 2020). Distributed widely across the UK (Hill *et al.,* 2010). Considered common (NatureSpot, 2020). Resident in Shetland (Nature in Shetland, 2020). Ghost moth (*Hepialus humuli*) is considered a "*common species over much of Britain… The adults fly during June and July. The larvae feed underground on the roots of grasses and small plants"* (UK Moths, 2020) including nettles (*Urtica dioica*) and dock (*Rumex* spp) (Butterfly conservation, 2020). Distributed widely across the UK (Hill *et al.,* 2010; Butterfly conservation, 2020). Considered common (Butterfly Conservation, 2020). Resident in Shetland (Nature in Shetland, 2020). Red carpet (*Xanthorhoe decoloraria*) "*A locally common species in northern Britain, occurring from Shropshire and Staffordshire northwards, into Scotland, where a local subspecies hethlandica occurs on the Shetland Isles… The favoured habitat is rocky moorland, where the larvae feed on lady's mantle Alchemilla spp., possibly also on other low plants"* (UK Moths, 2020). Distributed across northern Britain (Hill *et al.,* 2010). Considered common (Butterfly Conservation, 2020). Resident in Shetland (Nature in Shetland, 2020). It is considered unlikely that these, generally common and widespread species, which were not mentioned by SNH in consultation, would be significantly adversely impacted though the Proposed Project because: ➢ the relatively small number of records compared to the wide distribution of their under-recorded UK population; ➢ the study area is not specially designated for these species, or habitats which support these species; and ➢ other than a potentially small (negligible) land-take of possible habitat, no significant impacts are considered likely from the Proposed Project on these species. Therefore, these species have been scoped out of further assessment.

6.7 Standard Mitigation

6.7.1 In line with best practice guidance (CIEEM, 2018), an iterative design approach has been taken and the design of the SaxaVord Spaceport, and within that context the Proposed Project, has been amended to avoid or minimise impacts on ecological receptors as far as possible. As such, mitigation has been embedded within the design and layout of the infrastructure needed to carry out operation of the Proposed Project since Alba Ecology's first involvement in the project in 2017.

6.7.2 The three key mitigation hierarchy principles of EcIA (CIEEM, 2018; CAA et. al., 2021), namely avoidance first, followed by minimisation and finally by compensation, along with enhancement have all been considered.

Avoidance

6.7.3 According to CIEEM best practice guidance, adverse effects should be avoided or minimised through mitigation measures, either through the design of the project or subsequent measures that can be guaranteed. For example, through a planning condition. The baseline habitat surveys influenced the project design, avoiding, wherever possible areas of higher ecological sensitivities.

6.7.4 Avoidance of ecological receptors has been achieved by the Proposed Project because there will be no direct impact on any habitat type from the Proposed Project as all works will take place within the existing design footprint of the SaxaVord Spaceport.

Minimisation

6.7.5 There will be no direct impact on any habitat type from the Proposed Project as all works will take place within the existing design footprint of the SaxaVord Spaceport, and as such no minimisation of effects is required.

Compensation and Enhancement

6.7.6 Where there are significant residual adverse ecological effects despite the mitigation proposed, these should, under EcIA guidelines, be offset by appropriate compensatory measures. This is not the case for the Proposed Project, and so no compensatory measures are proposed.

6.7.7 The SaxaVord Spaceport Habitat Management Plan (Appendix 5.3) identifies eight main objectives, six of which will have direct ecological benefits to the Proposed Project site and surrounding area. These include peatland restoration, creation of riparian broadleaf tree/scrub cover, coastal grassland management, wetland creation including creating new pools and the creation of artificial otter holts. Whilst the pools and wetland areas are under the auspices of ornithology mitigation, they will none the less have ecological benefits increasing the biodiversity and providing additional habitat for non-avian species e.g., invertebrates.

6.8 Potential Effects

Impacts to be Assessed

6.8.1 The main elements of the Proposed Project which have the potential to impact on ecological receptors are assessed within this section. For full details of the Proposed Project refer to Chapter 3.

6.8.2 The potential impacts of the Proposed Project are outlined in Table 6.11. It should be noted that potential impacts in this table do not imply that they would occur, or that any resultant effects would be significant.

Table 6.11 Summary of Potential Impacts on Ecology

Activity	Potential Ecological Impact
Launch pad operation	Noise and vibrations resulting in disturbance.
Tracks and road	Pollution and/or sediment release into watercourses. Mortality/disturbance from vehicles.

Effects on Designated Sites

6.8.3 There are 10 designated ecological sites within 10 km of the Proposed Project, as identified in Table 6.6. This is reduced to six when ornithological designations, which are addressed separately in Chapter 5, are excluded. It is further reduced to five designated sites if Marine Protected Areas, addressed in Chapter 10, are excluded.

6.8.4 The closest designated ecological site is Norwick Meadows SSSI supporting important sand dune and valley fen habitats. The flora in this designated site is considered "*floristically rich*" with several rare and scares species (NatureScot, 2020). The valley fen is "*one of the best and most extensive examples of mesotrophic (moderately nutrient-rich) marsh in Shetland*" (NatureScot, 2020). Norwick Meadows SSSI is considered nationally important with high sensitivity. No land-take would take place within this designated site, so no direct habitat loss of the designated site would occur.

6.8.5 When assessing impacts on designated sites it is important to consider whether the Proposed Project is likely to undermine the conservation objectives of the site, the condition of the site, or the conservation status of the species or habitats for which the site is designated (CIEEM, 2018). Consideration should also be given to whether any process or key characteristic will be removed or changed, whether there will be an effect on the nature, extent, structure and function of component habitats and if there is an effect on the average population size and viability of species (CIEEM, 2018).

6.8.6 The conservation objectives for the Norwick Meadows SSSI (taken from Norwick Meadows SSSI Site Management Statement, 2011) are:

- To maintain and enhance the extent and condition of fen and swamp communities.
- To maintain and enhance the extent and condition of open dune and dune grassland habitats.
- To ensure populations of nationally scarce and locally rare species are protected.

6.8.7 As there will be no land-take from the Norwick Meadows designated site, there will be no direct loss to the fen and swamp communities, open dune, or dune grassland and the nationally scarce and locally rare species will not be directly impacted. Therefore, **no likely significant effects** are predicted for Norwick Meadows SSSI.

6.8.8 Potential indirect impacts on Norwick Meadows could arise from pollution events, although it should be noted that Norwick Meadows is ca. 750 m away from the Proposed Project. Pollution prevention measures required by all launch operators using the SaxaVord Spaceport are outlined in Appendix 6.5 which takes into account standard mitigation, in particular implementation of a suitable OEMP and appropriate storage and management of fuels and chemicals. Therefore, with the embedded mitigation inherent to the SaxaVord Spaceport accounted for, the magnitude of change on designated site as a consequence of pollution form the Proposed Project is assessed as negligible. With the embedded mitigation, the indirect impact on designated as a consequence of pollution is considered to be unlikely, intermittent, temporary and short-term (event) to medium term (recovery) and **no likely significant effects** are predicted.

6.8.9 All the other terrestrial designated sites are >1.5 km away from the Proposed Project. Therefore, no land-take or changes to hydrology would take place within these designated sites, so no direct or indirect habitat loss would occur. No other route to impact on designated sites or their features are predicted. Consequently, **no likely significant effects** on designated sites are predicted.

Effects on Otters

6.8.10 This section describes the predicted effects on otters that could arise from the Proposed Project. Embedded mitigation, including avoidance and minimisation to reduce potential effects are described.

6.8.11 The Proposed Project has the potential to adversely affect otter directly or indirectly in a number of ways:

- damage to watercourses by runoff, pollution and blocking of streams;
- mortality caused by vehicle traffic during launch activities; and
- disturbance/damage to hearing caused by noise during launch activities.

6.8.12 Otters are legally protected species, considered to have moderate sensitivity to human activities, with resting places and holts considered highly sensitive. The population of otters using the Proposed Project site is considered of local importance.

6.8.13 Baseline otter surveys were completed on multiple occasions during the planning preparation stage for SaxaVord Spaceport, in different seasons and years, and were conducted in a larger study area than is usual for surveys of this nature. Consequently, otter use of the Proposed Project site is relatively well understood.

6.8.14 Numerous otter field signs were recorded including scats, holts, footprints and lay-ups. In the most recent 2022 pre-construction surveys, three holts were located in inaccessible boulder scree areas, caves and on the boulder beaches around Lamba Ness. Scats and footprints were also recorded in the abandoned military buildings across the Proposed Project site.

6.8.15 The survey data collected indicated that there was one female with young regularly using Lamba Ness as their (main) home territory. Regular sightings of a male indicated that Lamba Ness also formed part of at least one dog otter territory. This constitutes ca. 0.5 % of the Shetland otter population.

6.8.16 The Proposed Project will not result in any land-take and so there will be no mechanism for physical damage or loss of holts, feeding and resting places. Likewise, there will be no mechanism for severance or loss of connectivity as a result of the Proposed Project as there will be no land-take or construction of any kind (see Chapter 3 for details). Therefore, the physical damage or loss of holts, feeding and resting places, severance and loss of connectivity have been scoped out of the assessment.

Damage to watercourses by runoff, pollution and blocking of streams

6.8.17 In the unlikely event that a serious pollution incident occurred, leading to a sudden pulse of pollutant that was not readily contained, it might enter the aquatic environment and could affect otters directly e.g., by coating fur with oil or indirectly through damage to their prey species. However, taking into account the implementation of best practice pollution prevention measures required by all launch vehicle operators at SaxaVord Spaceport (Appendix 6.5), it is considered highly unlikely that a serious pollution incident would occur. Therefore, it is considered highly unlikely that pollution would substantially affect otter foraging. The magnitude of potential impact caused by a pollution event for otter is assessed as negligible. With the embedded mitigation designed into the SaxaVord Spaceport, the impact caused by a pollution event from the Proposed Project is considered to be unlikely, intermittent, reversible and short-term (event), with a medium-term recovery and **no likely significant effects** are predicted (Table 6.13).

Mortality caused by vehicle traffic

6.8.18 Vehicular traffic across the SaxaVord Spaceport site will be regular during the Proposed Project, meaning that individual otters would have a possibility (albeit very small) of being injured or killed. However, the existence of inbuilt mitigation measures such as the enforced low vehicle speed limits (10 mph) would greatly reduce the likelihood of injury or death occurring during operation. Otter crossing road signs will be located at the entrance to the SaxaVord Spaceport site and at the frequently used otter run to further help prevent vehicle traffic mortality during operation. Consequently, the magnitude of impact of direct mortality from operation of the Proposed Project is assessed as negligible. With the embedded mitigation, impact of direct mortality from operation of the Proposed Project is considered to be unlikely, intermittent, irreversible and short-term and **no likely significant effects** are predicted (Table 6.13).

Disturbance caused by noise

6.8.19 At the time of the survey, there were at least one dog otter and one female otter (sometimes with young), within the range of elevated noise levels predicted for the Proposed Project.

6.8.20 Table 6.12 outlines the modelled maximum predicted dB levels from launch of RFA ONE NOM on otter. The holts on Lamba Ness are in the 0 km to 0.5 km range, the holts located at Saxa's Kettle and Vadna Taing are in the 0.5 km to 1 km range. From launch, the noise would rapidly (i.e., a matter of a small number of seconds) build from baseline to maximum, followed by a fairly rapid decrease back to baseline (tens of seconds).

Table 6.12 SaxaVord Spaceport Modelling Study - Maximum Predicted Decibel (dB) Levels at Otter Holts around Launch Pad 1

Individuals	Launch LAmax	Static LAmax
0-0.5 km	120-130dB	110-130dB
0.5-1 km	110-120dB	100-110dB

6.8.22 Otters are considered moderately sensitive to human disturbance. Otters use acoustic communication in both antagonistic (blows, mewing and cries) and social (murmurs and two types of whistles) situations, with new-borns using "*twitters*" to demand care (Gnoli and Prigioni, 1995). Therefore, it can be concluded that hearing is an important sense for otters. A study of otter hearing range demonstrated that at 80 dB, in air hearing ranged from 200 hertz (Hz) to 32 kilohertz (kHz) (Voigt *et al.*, 2019). As the RFA ONE NOM Launch Vehicle noise will be concentrated in the low frequencies, the frequencies will be audible to otters in the vicinity to the Proposed Project. Exposure to loud sounds can result in hearing impairment or loss. Mammals are unable to regenerate damaged auditory (cochlear) hair cells following damage from high levels of noise. Therefore, any potential damage to hearing as a result of the Proposed Project would be considered permanent and non-reversible.

6.8.23 A literature search conducted using freely available sources (e.g., google scholar, researchgate), returned few relevant results regarding the impact of loud noise on otter. Areas of high human disturbance (i.e., not loud noise) has been shown to adversely impact on otter populations (e.g., Cortés *et al.*, 1998). This does not necessarily translate to infrequent very loud noises, and otters in Shetland are known to deliberately inhabit areas around ferry terminals and fish farms which have moderate-high levels of human disturbance and noise.

6.8.24 Anecdotal accounts described in the literature suggest loud noise can impact on otter behaviour. Sharp and sudden noises have been reported to cause instant flight to the nearest water. These effects on behaviour may continue after the noise that caused the reaction has ceased (e.g., Jeffries 1985).

6.8.25 There is no direct evidence to suggest that the short-lived noise caused by the launch of the RFA ONE NOM Launch Vehicle would impact on, and adversely affect the success of, otters within the study area and there is also no threshold noise metric against which to compare potential effects on otters. The literature search did not identify any directly relevant noise studies on otters or potentially analogous species. Whether the pre-launch warning siren, followed by the low frequency rumble of the RFA ONE NOM Launch Vehicle followed by a rapid decrease back to baseline will be sufficient to allow otters to cope with the noise is currently speculative. Nevertheless, it is considered likely that this warning would give otters warning to swim underwater or find refuge in a holt or shelter where noise levels experienced are likely to be reduced.

6.8.26 As part of the SaxaVord Spaceport ecological mitigation commitments a total of 10 artificial otter holts/shelters will have been provided to supply many suitable refuge locations for otters.

6.8.27 If a worst-case scenario is assumed, i.e., mortality of all the otters in the study area, this would constitute an adverse impact on a maximum of two to three otters out of the Shetland population of ca. 700 to 900 individuals, i.e., 0.3 % to 0.4 % of the regional population and 0.04 % of the Scottish population. However, based on the likelihood that the pre-launch warning siren would allow otters to find refuge, with a reduction in noise in holts or shelters, this worst-case scenario seems an unlikely scenario. If no such adverse response took place, then 0 % of the regional and Scottish otter population would be adversely affected.

6.8.28 The magnitude of potential impact, in the worst-case scenario, caused by mortality/loss of territory from noise disturbance, is negligible. In the worst-case scenario, the potential impact to otters caused by mortality/loss of territory from noise disturbance is considered to be possible, intermittent, irreversible and short-term and **no likely significant effects** are predicted (Table 6.13).

Table 6.13. Summary of Likely Predicted Impacts on Otter

Parameter	Pollution	Mortality from Traffic/Activities	Operational Disturbance
Beneficial/adverse/neutral	Adverse	Adverse	Adverse
Extent	Watercourse and coastal region around Lamba Ness	Site-wide	Site-wide
Duration	Event = short-term Recovery = medium-term	N/A	Short-term noise level, potential for long term hearing damage
Reversibility	Reversible – pollution prevention measures and incident kits will be used.	Irreversible	Irreversible
Frequency	Intermittent	Intermittent	Intermittent
Probability	Unlikely	Unlikely	Possible
Magnitude	Negligible	Negligible	Negligible

6.8.29 In summary, with the implementation of the mitigation measures already undertaken by the SaxaVord Spaceport, **no likely significant effects** are predicted for otters in relation to the Proposed Project (Table 6.13). To ensure up-to-date information with regard to otters on and around the wider SaxaVord Spaceport site, an Otter Protection Plan will be ongoing during the license period of the Proposed Project.

Effects on Semi-natural Habitats

6.8.30 The Proposed Project has the potential to adversely impact indirectly through pollution.

6.8.31 Direct impacts from land-take of habitats severance and indirect impacts through changes in hydrology are scoped out as there will be no change in the SaxaVord Spaceport design footprint and no additional land-take associated with the Proposed Project.

6.8.32 Potential indirect impacts on the habitats could arise from pollution events. Pollution prevention measures required by all launch operators using the SaxaVord Spaceport are outlined in Appendix 6.5 which takes into account standard mitigation, in particular implementation of a suitable OEMP and appropriate storage and management of fuels and chemicals. Therefore, with the embedded mitigation inherent to the SaxaVord Spaceport accounted for, the magnitude of change on habitats as a consequence of pollution form the Proposed Project is assessed as negligible. With the embedded mitigation, the indirect impact on habitats as a consequence of pollution is considered to be unlikely, intermittent, temporary and short-term (event) to medium term (recovery) and **no likely significant effects** are predicted (Table 6.14).

Table 6.14. Summary of Predicted Impacts on Habitats for the Proposed Project

Parameter	Pollution
Adverse/ beneficial/ neutral	Adverse
Extent	Around the Design Footprint on Lamba Ness and into watercourses and the sea.
Duration	Short-term (event) – medium-term (recovery).
Reversibility	Temporary.
Frequency	Intermittent.
Probability	Unlikely.
Magnitude	Negligible.

6.8.33 The SaxaVord Spaceport Habitat Management Plan (Appendix 5.3) identifies eight main objectives, six of which will have direct ecological benefits to the Proposed Project site and surrounding area. These include peatland restoration, creation of riparian broadleaf tree/scrub cover, coastal grassland management, wetland creation including creating new pools and the creation of artificial otter holts. Whilst the pools and wetland areas are under the auspices of ornithology mitigation, they will none the less have ecological benefits increasing the biodiversity and providing additional habitat for non-avian species e.g., invertebrates.

6.9 Residual Effects

6.9.1 No likely significant effects are predicted on habitats or otters in relation to the Proposed Project and therefore no mitigation is proposed. As a result of this the residual effects are identical to the pre-mitigation effects predicted.

6.10 Cumulative Assessment

6.10.1 Cumulative effects can result from individually insignificant but collectively significant actions taking place over a period of time or concentrated in a location (CIEEM, 2018). This guidance goes on to say that "*developments to be included in the cumulative impact assessment should be in accordance with national guidance*". SNH/NatureScot provide no advice or guidance in relation to the cumulative impacts of a spaceport.

6.10.2 CIEEM (2018) also states in relation to cumulative assessment that "*Information about developments within the zone(s) of influence may be available in other EcIAs, Local Plan documents, Marine Spatial Plans, Strategic Environmental Assessments (SEAs), Sustainability Appraisals (SAs), Water Framework Directive Assessments (WFDAs), and Habitats Regulations Assessments/Appraisals (HRAs), including 'Natura Impact Statements' (NISs) / 'Natura Impact Reports' (NIRs), 'Information / 'Reports to Inform an Appropriate Assessment', 'Shadow Habitats Regulations Assessments' and, for Nationally Significant Infrastructure Projects, 'Reports on the Implications for European Sites' (RIES)*".

6.10.3 Shetland Islands Council confirmed during the planning application for SaxaVord Spaceport that there were no other committed development or infrastructure projects which needed to be considered in that assessment and there has been no change subsequent to planning consent. As such, as far as the Applicant is aware, there are no like for like or similar projects within the ecological study area and therefore, no significant issues are likely to arise from developments other than the SaxaVord Spaceport.

6.10.4 The SaxaVord Spaceport has a proposed capacity for 30 launches per annum. The Proposed Project will account for 10 of those launches.

6.10.5 As detailed in Chapter 8, noise from launches of the RFA ONE NOM Launch Vehicle is not anticipated to be significantly greater than that from the SaxaVord Spaceport AEE RepLV and therefore it is no more likely that animals in close proximity to Launch Pad 1 will be disturbed any more from the RFA ONE NOM Launch Vehicle than that from the SaxaVord Spaceport AEE RepLV. In addition, the RFA ONE NOM specific launch vehicle dimensions, propellants used, stage weights, and payload weight(s) by comparison to the SaxaVord Spaceport AEE RepLV do not make any material difference to the significance of cumulative environmental effects on ecology. Therefore, assuming operators are identified for the remaining capacity, the cumulative ecological effects of all 30 launches would be expected to be as documented in the SaxaVord Spaceport AEE:

"Cumulative effects can result from individually insignificant but collectively significant actions taking place over a period of time or concentrated in a location (CIEEM, 2018). This guidance goes on to say that "developments to be included in the cumulative impact assessment should be in accordance with national guidance". SNH/NatureScot provide no advice or guidance in relation to the cumulative impacts of a spaceport.

CIEEM (2018) also states in relation to cumulative assessment that "Information about developments within the zone(s) of influence may be available in other EcIAs, Local Plan documents, Marine Spatial Plans, Strategic Environmental Assessments (SEAs), Sustainability Appraisals (SAs), Water Framework Directive Assessments (WFDAs), and Habitats Regulations Assessments/Appraisals (HRAs), including 'Natura Impact Statements' (NISs) / 'Natura Impact Reports' (NIRs), 'Information / 'Reports to Inform an Appropriate Assessment', 'Shadow Habitats Regulations Assessments' and, for Nationally Significant Infrastructure Projects, 'Reports on the Implications for European Sites' (RIES)".

The ecological study area is an equivalent to the potential 'environmental zone of influence' and as there are no existing or proposed developments within that area, no significant issues are considered likely to arise from inter-project additive or cumulative effects.

Intra-project cumulative effects are those where an environmental topic/receptor is affected by more than one impact from the same Proposed Project and the impacts act together. The interactions between noise and ecology have been identified and assessed within this chapter, and no other environmental topic are considered likely to give rise to potential intra-project cumulative effects."

6.11 Summary

6.11.1 This chapter has:

- Established the baseline ecological conditions of the site using a desk-study and targeted ecological surveys (Phase 1 Habitat survey, NVC survey, GWDTE survey, otter survey and freshwater pearl mussel survey).
- Identified the potentially important ecological receptors likely to be affected by the Proposed Project namely designated sites, otters and semi-natural habitats.
- Assessed the ecological importance and sensitivity of designated sites, otters and semi-natural habitats.
- Evaluated the likely magnitude of predicted impact on these ecological receptors from the operation of the Proposed Project.
- Identified mitigation, including avoidance and minimisation of impacts on sensitive ecological receptors.

6.11.2 The assessment does not predict any likely significant ecological effects associated with the Proposed Project.

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Chapter 7 Air Quality

7. Air Quality

7. Air Quality

7.1 Introduction

7.1.0 This chapter considers the potential effects of the Proposed Project on local air quality. The Proposed Project is described in full detail in Chapter 3; however, the elements with the potential to affect local air quality can be summarised as follows:

- Preparation of RFA ONE NOM Launch Vehicle;
- Storage and Handling of RFA ONE NOM Launch Vehicle propellant;
- Operation of Ground Segment and Launch Complex; and
- Launch of RFA ONE NOM Launch Vehicle.

7.1.1 This chapter examines the potential effects of the following:

- potential for emissions from traffic associated with operation of each RFA ONE NOM launch to cause significant effects at ecological sites and receptors relevant for human health; and
- potential for emissions from each RFA ONE NOM Launch Vehicle to cause significant effects at receptors relevant for human health. There are no airborne pollutants associated with ancillary launch activities considered likely to have any significant adverse effects on important local ecology.

7.1.2 The pollutants considered in this assessment are:

- Vehicle exhaust emissions of oxides of nitrogen (NO_x) and particulate matter (PM_{10} and $PM_{2.5}$); and,
- Carbon monoxide (CO) emissions from launches.

7.1.3 This chapter has been prepared by ITPEnergised and should be read in conjunction with Drawings 7.1 to 7.9 and Technical Appendices 7.1-7.2 in Volumes III and IV respectively.

7.2 Legislation, Policy and Guidelines

Space Industry Act

7.2.0 The Space Industry Act (2018) regulates all spaceflight activities carried out in the United Kingdom, and associated activities. The Act requires any person or organisation to obtain the relevant licence to:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities from the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

7.2.1 As the Applicant wishes to become a spaceflight operator and launch RFA ONE NOM Launch Vehicles from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

7.2.2 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence the Regulators Licensing rules, which specify what information the UK Civil Aviation Authority (CAA), the regulator, requires in support of an application.

Air Quality Legislation

7.2.3 The UK's legislation and regulatory regime, along with national, regional and local planning policy play a key role in the prevention, control and minimisation of atmospheric emissions that are potentially harmful to human health and the environment. Air Quality Objectives (AQOs) are quality standards for clean air that are used as assessment criteria for determining the significance of any potential changes in local air quality resulting from development proposals. Relevant legislation and guidance documents have been reviewed and taken into account as part of this Air Quality Impact Assessment (AQIA).

European Legislation

7.2.4 The EU has published a Directive on Ambient Air Quality Assessment and Management which came into force in September 1996 (Directive 96/62/EC). This Directive is intended as a strategic framework for tackling air quality consistently, through setting European wide air quality limit values in a series of daughter directives, superseding and extending existing European legislation. The first four daughter directives were placed into national legislation. A new EU air quality directive (Directive 2008/50/EC) came into force in June 2008 and was transposed into The Air Quality Standards Regulations in England, Wales, Scotland and Northern Ireland in June 2010 (H.M Government, 2010). The Directive merged the four daughter directives and one Council decision into a single national directive on air quality.

National Legislation

7.2.5 The Environment Act 1995 (H.M. Government, 1995) required the preparation of a National Air Quality Strategy (NAQS) setting air quality standards and objectives for specified pollutants and outlining measures to be taken by local authorities through the system of Local Air Quality Management (LAQM) and by others to work in pursuit of the achievement of these objectives. The NAQS was published in 1997 and subsequently reviewed and revised in 2000, and an addendum to the Strategy published in 2002. The current Strategy was published in July 2007; (Defra, 2007).

7.2.6 The objectives which are relevant to local air quality management have been set into Regulations namely Air Quality (Scotland) Regulations 2000, Air Quality (Scotland) Amendment Regulations 2002 and Air Quality (Scotland) Amendment Regulations 2016 (Scottish Government, 2016), the latter of which introduces an additional statutory obligation for Scottish Local Authorities to comply with an annual mean objective for $PM_{2.5}$ to align with the World Health Organisation Guideline Value (WHO).

7.2.7 The air quality standards (AQSs) are set for the purpose of protecting human health, vegetation and ecosystems from certain harmful atmospheric pollutants. The Scottish AQSs take account of the EU limit values and are either effectively identical, or more stringent. The AQSs applicable to the pollutants considered in this assessment are shown in Table 7.1.

Table 7.1 Air Quality Standards

Pollutant	Air Quality Standard	
	Concentration (µg/m³)	Averaging Period
For the Protection of Human Health (Scotland)		
NO_2	200	1-hour mean; not to be exceeded more than 18 times a year
	40	Annual mean

Pollutant	Air Quality Standard	
	Concentration (µg/m³)	Averaging Period
PM_{10}	50	24-hour mean; not to be exceeded more than seven times a year
	18	Annual mean
$PM_{2.5}$	10	Annual mean
CO	10 mg/m³	Running 8-hour mean
For the Protection of Vegetation and Ecosystems (UK)		
NO_x	30	Annual mean

Local Air Quality Management

7.2.8 Under Section 82 of the Environment Act (1995) (Part IV) Local Authorities (LAs) are required to periodically review and assess air quality within their area of administration under the system LAQM. This review and assessment of air quality involves considering present and likely future air quality against the objectives and reporting to the Scottish Government by means of an Annual Progress Report (Shetland Islands Council, 2020). If it is predicted that levels at sensitive locations where members of the public are regularly present for the relevant averaging period are likely to be exceeded, the LA is required to declare an Air Quality Management Area (AQMA). For each AQMA the LA is required to produce an Air Quality Action Plan (AQAP), the objective of which is to reduce pollutant concentrations in pursuit of the objectives.

7.2.9 There are currently no AQMAs within the Shetland Islands.

Guidance

Guidance to the regulator on environmental objectives relating to the exercise of its functions under the Space Industry Act 2018

7.2.10 The Department for Transport issued its document '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK:

The environmental objective for spaceflight are to:

- *Minimise emissions contributing to climate change resulting from spaceflight activities*
- *Protect human health and the environment from the impacts of emissions on local air quality arising from spaceflight activities*
- *Protect people and wildlife from the impacts of noise from spaceflight activities*
- *Protect the marine environment from the impact of spaceflight activities.*

Guidance for the Assessment of Environmental Effects

7.2.11 The CAA, with the UK Space Agency, the Department for Business, Energy and Industrial Strategy and the Department for Transport, issued guidance note '*CAP2215 Guidance for the Assessment of Environmental Effects*' in July 2021. The guidance sets out what is required by the regulator regarding assessment of environmental effects as part of a licence application under the Act.

7.2.12 The guidance requires that potential direct and indirect significant effects of proposed spaceflight activities on environmental features, including population and human health, are considered. The guidance further requires that:

- Specific potential effects are identified and, where possible, quantified;
- The focus of the AEE should be on significant effects arising from the proposed activities;
- The AEE should explain what other environmental assessments have been conducted in relation to the proposed activities and whether they are being used in support of the AEE;
- Applicants for a launch operator licence set an environmental budget, comprising a maximum number of launches per launch vehicle type which can take place over the course of a year that can be carried out in an environmentally sustainable manner, taking into account the cumulative effect of all launches; and
- The AEE must address a range of environmental topics, including air quality.

Air Quality Guidance

7.2.13 The assessment also uses the guidance documents listed below:

- The Technical Guidance LAQM.TG (16) for Local Air Quality Management, (Defra 2021);
- The Environmental Protection UK (EPUK) and Institute of Air Quality Management (IAQM), Land-Use and Development Control: Planning for Air Quality (Moorcroft and Barrowcliffe et al, 2017);
- IAQM, A Guide to the Assessment of Air Quality Impacts on Designated Nature Conservation Sites, (Holman et al, 2017);
- The Environmental Protection Scotland (EPS) and Royal Town Planning Institute (RTPI) Scotland Delivering Cleaner Air for Scotland guidance (EPS and RTPI, 2017); and,
- CAA Airspace Change guidance CAP 1616 (CAA, 2000).

7.3 Consultation

7.3.0 Extensive statutory consultation on air quality was carried out during preparation and determination of the planning application for the SaxaVord Spaceport, where the Proposed Project will be operated. Where directly relevant to this AEE, consultation responses received during the SaxaVord Spaceport planning application period have been summarised in Table 7.2.

Table 7.2 Consultation

Consultee	Summary of Response	Where addressed
Air Quality / Ian Taylor assistant EHO, Shetland Islands Council / 26/06/2020	Agreement with the parameters and methodology of the AQIA however reservations about scoping out the potential impacts from vehicular movements during the operational phase together.	Appendix 7.1
Air Quality / Ian Taylor assistant EHO, Shetland Islands Council / 14/07/2020	Agreement on method to assess impacts of Launch Vehicle emissions from launch pad 1, closest to a residential receptor. Agreement on screening approach for transport emissions.	Section 7.4 and Appendix 7.2
Air Quality/Peter Cosgrove/Director/Alba Ecology 12/06/2020	Confirmation that there are no airborne pollutants associated with launch emissions considered likely to have any significant adverse effects on important local ecology.	Appendix 7.2

7.4 Assessment Methodology and Significance Criteria

Scope of the Assessment

7.4.0 The scope of the assessment has included the following:

- Application of the method of assessment agreed in consultation with Shetland Islands Council during preparation and determination of the planning application for the SaxaVord Spaceport, where the Proposed Project will be operated;
- Identification of study area and air quality sensitive receptors;
- Collection of baseline CO concentrations at the Proposed Project;
- Collection of emissions data from the Applicant for the launch emissions from an approximately 40.5 m long RFA ONE NOM Launch Vehicle;
- Development of representative modelled scenario from Launch Pad 1 (closest to receptors);
- Development of a time-dependant puff model (duration up to 18s) of a jet release using ADMS 5 in a range of meteorological conditions and wind directions in typical UK and Shetland-specific wind speeds;
- Development of a time-integrated dose model to predict total concentration at the closest residential receptor during the lifetime of the puff release (calculated at 1-minute intervals) using ADMS 5 in a range of meteorological conditions and wind directions;
- Conversion of total dose concentrations to 8-hour running mean concentrations and comparison with the relevant air quality standard (AQS) for CO for the protection of human health, presented in tables;
- Contour maps demonstrating the puff concentration at 1-minute after the launch, followed by 2-minute intervals for the worst case Unst meteorological condition; and
- Mitigation measures required where necessary; and,
- Residual summary of effects.

Effects Scoped Out of the Assessment

7.4.1 There are no airborne pollutants associated with launches considered likely to have any significant adverse effects on ecological receptors. Therefore, the effect of emissions from launches on ecological sites has not been considered further in the assessment.

Environmental Zones of Influence

7.4.2 Maps and aerial images of the Proposed Project and the surrounding area have informed the selection of an appropriate environmental zone of influence (air quality study area) for the assessment.

7.4.3 For the potential effects of operational phase vehicle exhaust emissions, a study area of 50 m from affected roads was considered. This is in accordance with IAQM Guidance (Holman et al, 2014) and EPUK & IAQM guidance (Moorcroft and Barrowcliffe et al, 2017).

The closest air quality sensitive receptors in each direction from Launch Pad 1 were identified, and a study area of 5 km was defined to track the concentration of the puff release from launch until concentrations returned to normal ambient background levels under a range of meteorological conditions. The closest occupied sensitive receptor is Banks Cottage at Norwick which is 1840 m from Launch Pad 1. This is shown as R1 on Drawing 7.1 in Volume III.

Method of Assessment

7.4.4 Due to the remote location of the Proposed Project, the low baseline traffic movements and a lack of industrial activity in the surrounding area, it was agreed with Shetland Islands Council that no ambient baseline air quality monitoring was required to support the SaxaVord Spaceport planning application. Instead, background air quality concentrations from published Government data were used and have subsequently been used in the SaxaVord Spaceport AEE and are considered fit for purpose for this assessment.

7.4.5 The potential impacts of emissions to atmosphere from the Proposed Project have been calculated using screening tools and modelling which inherently include a number of robust assumptions.

7.4.6 The emission rate of exhaust gases from RFA ONE NOM Launch Vehicle will vary with height during the launch. However, they have been modelled as short-term puff releases from ground level for the duration it takes the RFA ONE NOM Launch Vehicle to reach an altitude of 1000 ft as required by the Civil Aviation Authority. This is considered to represent the maximum potential impact of emissions for identified receptors.

Vehicle Emissions

7.4.7 There is the potential for changes to long-term and short-term mean concentrations of fine particulates (PM_{10}, $PM_{2.5}$) and NO_2 to occur because of predicted changes in road traffic movements on the local road network as a result of the Proposed Project.

7.4.8 The maximum daily values during a launch are predicted to be 70 light goods vehicles and 11 heavy goods vehicles; significantly below the EPUK and IAQM screening thresholds for detailed assessment. However, in order to mirror the assessment undertaken for SaxaVord Spaceport AEE, an assessment of the potential magnitude of change in air quality due to operational traffic per launch has been assessed.

7.4.9 The magnitude of change at a sensitive roadside receptor has been calculated using the atmospheric dispersion model software ADMS Roads Version 5.0.0.1 (CERC, 2022) with built-in emissions factors, equivalent to those within the Defra emissions factors toolkit EfT 10.0 (2VC) (Defra, 2020).

7.4.10 The potential magnitude of change in air quality has been assessed by defining an affected road link which all of the maximum daily operational phase traffic is assumed to travel through. This assessment has used a section of the B9087 through Saxa Vord and Norwick where it is considered that maximum exposure to operational phase vehicle emissions is likely due to the number of residential settlements and a SSSI (Norwick Meadows) adjacent to the roadside as shown in Drawing 7.3.

7.4.11 A summary of the modelled road links, traffic speeds and development-generated traffic is shown in Tables 1 and 2 in Appendix 7.1.

7.4.12 Pollutant concentrations of NO_x, NO_2, PM_{10} and $PM_{2.5}$ have been predicted at selected receptors using development-generated traffic combined with existing baseline background concentrations in order to compare the total predicted concentration with the relevant AQSs.

7.4.13 The assessment has been undertaken using hourly meteorological data from 2019 for Baltasound Airport in Unst.

7.4.14 Details of general model conditions used in the dispersion model are provided in Table 7.3.

Table 7.3- General ADMS Roads Model Conditions

Variables	ADMS Roads Model Input
Surface roughness at source/meteorological site	0.02 m / 0.02 m (Open Grassland)

Variables	ADMS Roads Model Input
Minimum Monin-Obukhov length for stable conditions at source/meteorological site	Model-calculated per hourly meteorological condition
Terrain types	Flat Terrain
Receptor location	x, y coordinates determined by Geographic Information System (GIS) z = 1.5 m for ground floor human receptors z=0 m for ecological receptor
Pollutants	NO_x, PM_{10}, $PM_{2.5}$
Traffic Emissions Factors	Defra EfT10.0 (2 VC) emission factor dataset for 2022
Meteorological data	One year (2019) hourly sequential data from Baltasound Airport meteorological station.
Emission profiles traffic	None
Receptors	Selected existing receptors (residential) and SSSI
Model output	Long-term annual mean NO_x concentrations Long-term annual mean PM_{10} concentrations Long-term annual mean $PM_{2.5}$ concentrations

Launch Emissions

7.4.15 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness in Unst, Shetland.

7.4.16 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian. All launches will take place from Launch Pad 1 at the SaxaVord Spaceport.

7.4.17 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of SaxaVord Spaceport's own assessed environmental budget of 30 launches per year.

7.4.18 The RFA ONE NOM Launch Vehicles will use a propellent mixture of Rocket Propellant-1 and liquid oxygen (RP1-LOx). The majority of emissions from burning this propellent are water vapour (H_20) alongside much smaller quantities of carbon dioxide (CO_2) and CO. Emissions are via thirteen identical nozzles directed towards a flame deflector.

7.4.19 Launch greenhouse gas emissions (including CO_2) are quantified in Chapter 4.

7.4.20 The only pollutant that requires assessment with respect to air quality for potential effects on human health is CO.

7.4.21 There are no airborne pollutants considered likely to have any significant adverse effects on important local ecology.

7.4.22 In order to determine the maximum potential effects of emission from a launch at a sensitive receptor, the assessment considers the effects of emissions from Launch Pad 1 at receptor R1, Banks Cottage, the closest emission-receptor relationship.

7.4.23 CAA guidance document CAP1616 "Airspace Change – Guidance on the regulatory process for changing the notified airspace design and planned and permanent redistribution of air traffic, and on providing airspace information", states that assessment of emissions on local air quality is required for any airspace change less than 1000 feet in altitude. It is therefore only necessary for the AQIA to consider emissions from the RFA ONE NOM Launch Vehicles during the first stage as subsequent stages occur at significantly higher altitudes. This has been estimated to take a maximum of 16 seconds for the RFA ONE NOM Launch Vehicle.

7.4.24 The "Puff" model in ADMS 5 (CERC, 2022) enables releases of up to one-hour duration to be modelled and concentrations at chosen downwind distances to be predicted at different timesteps (time in seconds after the start of the emission). It is therefore possible to track the concentration at any point during the whole lifetime of that puff release, for any given meteorological condition, and calculate the total "dose" at each location i.e., the total concentration that a person would be exposed to if they stayed at the same location for the whole time the puff passed overhead. When considering the potential exposure for a human receptor during a launch, the total dose concentration is the most appropriate.

7.4.25 The assessment is provided in detail in Appendix 7.2.

Vehicle Exhaust Emissions and Launch Emissions

7.4.26 The change in pollutant concentrations with respect to future baseline concentrations has been described at identified sensitive receptors. The absolute magnitude of pollutant concentrations in the "future with Proposed Project" scenario is described, and this is used to consider the risk of the AQSs being exceeded.

7.4.27 The IAQM has published recommendations for describing the magnitude of impacts and determining the significance of such impacts at individual receptors (Moorcroft & Barrowcliffe et al., 2017). The impact descriptors are summarised in Table 7.4**.** A change of less than 0.5 % of the Air Quality Assessment Level (AQAL) is described as Negligible.

Table 7.4 – Impact Magnitude Descriptors for Individual Receptors

Long Term Average Concentration at Receptor	% Change in concentration relative to Air Quality Assessment Level (AQAL)			
	1 %	2-5 %	6-10 %	>10 %
75 % or less of AQAL	negligible	negligible	slight	moderate
76-94 % of AQAL	negligible	slight	moderate	moderate
95-102 % of AQAL	slight	moderate	moderate	substantial
103-109 % of AQAL	moderate	moderate	substantial	substantial
110 % or more of AQAL	moderate	substantial	substantial	substantial

Overall Assessment of Significance

7.4.28 The reported magnitude impacts for each receptor have been considered for the Proposed Project in overall terms. In addition, the potential for the Proposed Project to contribute to or hinder the successful implementation of policies and strategies for the management of local air quality has been considered. The descriptors used to characterise the overall significance of effects at sensitive receptors are summarised in Table 7.5.

Table 7.5 - Descriptors used for the Overall Assessment of Significance at Sensitive Receptors

Effect Descriptor	Significance
Major	A significant effect that is likely to be a material consideration in its own right.
Moderate	A significant effect that may be a material consideration in combination with other significant effects but is unlikely to be a material consideration in its own right.
Minor	An effect that is not significant but that may be of local concern.
Negligible	An effect that is not significant change.

Requirements for Mitigation

7.4.29 Proposed mitigation measures are presented in Section 7.7.

Assessment of Residual Effect

7.4.30 An assessment of predicted significant residual effects, taking account of committed mitigation measures, is presented in Section 7.9.

7.5 Baseline Conditions

7.5.0 Background concentrations for NO_x, NO_2, PM_{10} and $PM_{2.5}$ have been taken from the 2018-based Scottish Air Quality Database (Air Quality in Scotland, 2022) and Defra LAQM background maps (Defra, 2022). The maximum 2022 annual background concentrations in the study area are predicted to be 2.1 µg/m^3 1.7 µg/m^3, 5.8 µg/m^3, 3.8 µg/m^3 and 0.05 mg/m^3 for NO_x, NO_2, PM_{10}, $PM_{2.5}$ and CO respectively. These are all significantly below the relevant AQSs outlined in Table 7.1.

7.6 Receptors Brought Forward for Assessment

7.6.0 The receptors brought forward for assessment are:

- Norwick Meadows SSSI adjacent to the B9087 (shown on Drawing 7.1);
- The closest residential receptor to Launch Pad 1 (shown on Drawing 7.1); and,
- Two residential properties closest to the roadside along the B9087 road (Saxa Vord Residential and Norwick Residential on Drawing 7.3).

7.7 Standard Mitigation

Vehicle Emissions

7.7.0 Improvements to the existing public road network and the construction of the New Section of Access Road at Northdale required by the planning conditions for the SaxaVord Spaceport will act to mitigate against congestion pinch points that could lead to an increase in vehicle emissions due to reduced speed and stop-start behaviour during operation of the Proposed Project.

7.7.1 The SaxaVord Spaceport will use electric vehicles to collect and transport launch operator staff and visitors and as such this will mitigate emissions from the Proposed Project.

7.7.2 A Spectator Traffic Management Plan has been developed for the SaxaVord Spaceport to avoid congestion and encourage sustainable transport choices.

7.7.3 Consideration of activities related to spectators/visitors to SaxaVord Spaceport and their associated potential impact on the environment falls under the remit of SaxaVord Spaceport, rather than individual launch operators.

- SaxaVord Spaceport has the responsibility of managing spectators/visitors to launch events. All operations by the Applicant will be required to align with the SaxaVord Spaceport Spectator Traffic Management Plan.

7.8 Potential Effects

Operational Traffic

7.8.0 The assessment of traffic emissions in Appendix 7.1 concludes that:

- The magnitude of change in concentration of each pollutant is significantly below 0.5 % of the relevant annual mean AQS at all receptors.
- The maximum predicted total concentration of NO_2 at a sensitive receptor is less than 4.5 % of the annual mean AQS.
- The maximum predicted concentration of PM_{10} at a sensitive receptor is less than 28.5 % of the annual mean AQS.
- The maximum predicted concentration of $PM_{2.5}$ at a sensitive receptor is less than 30 % of the annual mean AQS.
- There is no predicted risk of exceedance of the annual mean or short-term AQSs at any residential receptor due to the emissions from the forecast peak number of operational vehicles during a launch.
- The magnitude of change in concentration of each NO_x is significantly below 1 % of the relevant annual mean AQS for the protection of vegetation and ecosystems.
- The maximum predicted annual mean NO_x concentration at the Norwick Meadows SSSI is 7.2 % of the annual mean AQS (or critical level).
- There is no predicted risk of exceedance of the critical level threshold at a roadside ecological receptor.

7.8.1 The effect of operational phase vehicle emissions at all identified receptors is therefore predicted to be of negligible significance**,** therefore resulting in **no likely significant effect**.

Launch Emissions

7.8.2 The assessment of the potential effects of emissions from launches in Appendix 7.2 predicted ambient CO concentrations at short term (1-minute) intervals after release. Modelling identifies that the downwind concentration was detectible above background levels following launch for a period of up to 4 minutes after which time, concentrations reverted to background levels. The maximum predicted dose at R1 was 291.35 mg/m^3 CO over 4 minutes. This is equivalent to a concentration dose over the lifetime of the jet release of 254.3 parts per million (ppm). There are no health effects of this level of exposure to CO over periods of 4 minutes. A person would have to be exposed to this dose for two to three hours of constant exposure to experience headache or dizziness (Goldstein, 2008).

7.8.3 The maximum predicted 8-hour concentration at R1 was 0.07 mg/m^3, 0.66 % of the AQS, when modelled using UK average convective (Stability A) meteorological conditions with wind from the north east (45°). This reduced to 0.61% of the AQS when average Unst wind speed conditions were modelled for this direction.

7.8.4 On analysis of meteorological data, a north east (45°) wind only occurs for approximately 9 % of the year in Unst. There is therefore a high probability that launches will take place under the local prevailing wind condition which, over the period 2015-2019, was southerly to westerly. Under prevailing conditions, there is no detectible impact at the closest receptor R1.

7.8.5 The assessment has demonstrated that there is no risk of exceedance of the 8-hour AQS for CO at any sensitive receptor in the vicinity of the Proposed Project irrespective of the prevailing weather conditions during a launch and there are no health effects associated with the maximum predicted exposure over 4 minutes.

7.8.6 The effect of launch emissions on all identified receptors is concluded to be of negligible significance**,** therefore resulting in **no likely significant effect**.

7.9 Cumulative Assessment

7.9.0 There are no intra-project cumulative effects that have the potential to result in significant effects and so no intra-project cumulative assessment is required.

7.9.1 Shetland Islands Council confirmed during the planning application for SaxaVord Spaceport that there were no other committed development or infrastructure projects which needed to be considered in that assessment and there has been no change subsequent to planning consent. As such, as far as the Applicant is aware, there are no like for like or similar projects within the air quality study areal and therefore, no significant issues are likely to arise from developments other than the SaxaVord Spaceport.

7.9.2 The SaxaVord Spaceport has a proposed capacity for 30 launches per annum. The Proposed Project will account for 10 of those launches. As detailed in this chapter, emissions from propellants used to launch the RFA ONE NOM Launch Vehicle are not anticipated to result in significant effects at identified receptors and are similar in scale to those from the SaxaVord Spaceport AEE RepLV. In addition, the RFA ONE NOM specific launch vehicle dimensions, stage weights, and payload weight(s) by comparison to the SaxaVord Spaceport AEE RepLV do not make any material difference to the significance of cumulative effects on air quality.

7.9.3 Therefore, assuming operators are identified for the remaining capacity, the cumulative air quality effects of all 30 launches would be expected to be as documented in the SaxaVord Spaceport AEE:

"Inter-project cumulative effects are those where an environmental topic/receptor is affected by impacts from more than one project at the same time and the impacts act together. Due to the location of the Proposed Project on the north coast of Unst, the most northerly of the Shetland Islands, it is considered that there are no potential inter-project cumulative effects as there are no other existing or proposed developments in the EZIs for air quality.

Shetland Islands Council was contacted during the planning application stage of the Proposed Project and confirmed that there are no committed development or infrastructure projects on the Island which should be considered in the assessment.

Intra-project cumulative effects are those where an environmental topic/receptor is affected by more than one impact from the same Proposed Project and the impacts act together. Given that none of the other environmental topics considered impact directly on air quality, and the fact that only one launch will occur at any given time and launches will be phased with time enough for the EZI to return fully to its baseline state between launches, it is considered that there is no potential for additive or intra-project cumulative effects."

7.10 Residual Effects

7.10.0 The residual effects on air quality from the Proposed Project are concluded to be of negligible significance, therefore resulting in **no likely significant effect**.

7.11 Summary

7.11.0 An assessment of the potential effects of emissions from the Proposed Project on local air quality has been undertaken. The assessment has considered the operational phase of the Proposed Project.

7.11.1 Proposed project-generated traffic is predicted to have an effect of negligible significance on air quality, therefore resulting in **no likely significant effect**.

7.11.2 Launch emissions are predicted to have no perceptible impact at any identified receptors under prevailing wind directions. The maximum predicted impact at a sensitive receptor is predicted to occur with north-easterly winds which occur typically for less than 10 % of the year. The maximum predicted 8-hour concentration of CO is 0.61% of the AQS. Emissions from launches are therefore considered to have an effect of negligible significance on air quality**,** therefore resulting in **no likely significant effect**.

7.12 References

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Chapter 8 Noise and Vibration

8. Noise and Vibration

8. Noise and Vibration

8.1 Introduction

8.1.1 This chapter considers the potential noise and vibration effects associated with the Proposed Project.

8.1.2 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness on Unst, Shetland.

8.1.3 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits. The environmental zone of interest (EZI) for the Proposed Project is contained between -30 and +30 degrees around the meridian.

8.1.4 The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of SaxaVord Spaceport's own assessed environmental budget of 30 launches per year.

8.1.5 The Applicant has not determined a specific timeframe for the Launch Operator Licence and as such the effect over any given year period is considered to be the most appropriate for the AEE.

8.1.6 The characteristics of the RFA ONE NOM Launch Vehicle are larger than the RepLV limiting case Launch Vehicle considered in the planning application EIA works for the SaxaVord Spaceport. As such, and due to the fact that in terms of noise impact it is best practice to assess cumulative impact, updated predictions have been undertaken for this AEE, considering the potential increase in noise and vibration impacts above those previously considered.

Scope of Assessment

8.1.7 The scope of the noise impact assessment comprised the following:

- Baseline noise survey at the SaxaVord Spaceport site (2018);
- Evaluation of predicted road traffic noise for the SaxaVord Spaceport operation;
- Modelling of engine testing and launch noise from 30 orbital launches per year from the SaxaVord Spaceport (undertaken by BRRC);
- Updated predictions to consider larger RFA launch vehicle (undertaken by BRRC);
- Evaluation and interpretation of modelling results; and
- Specification of appropriate mitigation.

8.1.8 Ground-borne vibration effects associated with launches and engine testing will be highly localised and are considered to be negligible at human receptor locations. The evaluation of ground-borne vibration effects has therefore been scoped out of this assessment. No significant vibration impacts to cultural heritage receptors are expected, however, precautionary mitigation to protect these receptors has been specified, and is detailed in Section 8.7.

8.1.9 Airborne vibration can be evaluated using metrics predicted as part of the noise assessment; this AEE therefore makes comment on likely airborne vibration effects where such data exists, for completeness only and to provide supplementary justification for the scoping out of detailed vibration assessment.

8.1.10 Prediction of noise associated with launch vehicles, including static engine tests and launches, has been undertaken by Blue Ridge Research and Consulting LLC (BRRC). BRRC is an acoustical engineering consultancy focused on critical noise and vibration challenges for aerospace, aviation, and US Department of Defense projects. With experience from more than 250 civilian and military noise studies, BRRC's team of acoustical engineers is recognised as a trusted advisor to public, private, and academic clients in the space industry around the world.

8.1.11 BRRC's modelling evaluates the potential impacts of launch vehicle noise and sonic booms on a cumulative basis in terms of human annoyance. In addition, potential impacts are evaluated on a single-event basis in relation to hearing conservation, sleep disturbance, speech interference, and structural damage. As applicable, model results have then been incorporated into this AEE Report chapter by ITPEnergised.

8.1.12 The BRRC modelling assessment is provided in Volume IV Appendix 8.1. It is recommended that the reader reviews the BRRC report prior to proceeding with this chapter.

8.1.13 The sonic boom from launches will occur 60 km out to sea, away from populated areas, therefore further consideration of air overpressure effects on structures and human receptors has been scoped out of this assessment.

Glossary of Acoustics Terms

8.1.14 Acoustics and vibration are necessarily highly technical disciplines, and as such there are numerous specific terms which are used within this assessment. The terms are defined here to aid the lay reader.

- **Noise** – unwanted sound.
- **A-weighting** – an electronic filter applied to measured sound levels to approximate the hearing response of humans to different frequencies, denoted 'A' in noise indices.
- **Ambient level, $L_{eq,T}$** – the equivalent continuous sound pressure level (L_{eq}) of the totally encompassing sound in a given situation at a given time at the assessment location over a given time interval, T. Denoted $L_{Aeq,T}$ when A-weighted.
- **Background level, $L_{A90,T}$** - the A-weighted sound pressure level that is exceeded for 90 percent of a given time interval, T.
- **Maximum level, L_{Amax}** – the A-weighted maximum instantaneous sound level during a measurement period or noise 'event', recorded during a time interval, T.
- **Day-night noise level, L_{den}** - the A-weighted ambient level over a 24-hour period, with a +10 dB penalty for night-time noise (23:00 – 07:00) and a +5 dB penalty for evening noise (19:00 – 23:00). The L_{den} index is a cumulative yearly average, taking into account all noise 'events' associated with a particular source throughout the year.
- **Sound Exposure Level, SEL** – the SEL (alternatively the Single Event Noise Exposure Level, SENEL) is the one-second long steady level that contains as much sound energy as the varying level over the full event. The SEL is similar to the L_{eq}, however, the SEL uses a reference period of one second, whereas the L_{eq} can be expressed for any time interval.

8.2 Legislation, Policy and Guidelines

8.2.1 A short summary of relevant legislation, policy and guidelines that have been taken into consideration in this assessment is provided below. Where appropriate, detailed summaries of these documents for the lay reader are provided in Volume IV Appendix 8.2.

Legislation

Space Industry Act

8.2.2 The Space Industry Act (2018) regulates all spaceflight activities carried out in the United Kingdom, and associated activities. The Act requires any person or organisation to obtain the relevant licence to:

- launch a launch vehicle from the UK;
- return a launch vehicle launched elsewhere than the UK to the UK landmass or the UK's territorial waters;
- operate a satellite from the UK;
- conduct sub-orbital activities from the UK;
- operate a spaceport in the UK; or
- provide range control services from the UK.

8.2.3 As the applicant wishes to become a spaceflight operator and launch the RFA ONE NOM Launch Vehicle from the UK, they are required to apply for a launch operator licence, and as part of this application, submit an AEE of the proposed project.

Space Industry Regulations 2021

8.2.4 The Space Industry Regulations 2021 (the Regulations) set out in more detail the requirements for each licence the Regulators Licensing rules, which specify what information the UK Civil Aviation Authority (CAA), the regulator, requires in support of an application.

Control of Noise at Work Regulations, 2005

8.2.5 The Control of Noise at Work Regulations (CoNaW Regs.) seek to protect against hearing damage by controlling the exposure of employees to noise during the course of their working day by providing threshold noise exposure values which trigger particular requirements of employers and employees.

8.2.6 The threshold noise exposure values relate to either daily or weekly personal exposure; the individual 'noise dose' received by an employee during work hours is calculated over the appropriate time period. Where an employee is exposed to noise levels above the thresholds, certain requirements on behalf of the employer and employee are triggered, such that their risk of noise-induced hearing damage is minimised.

8.2.7 The threshold values are as follows:

- **Lower Exposure Action Value (LEAV);**
  - Daily or weekly personal noise exposure of 80 dB(A) and,
  - Peak sound pressure of 135 dB(C);
- **Upper Exposure Action Value (UEAV);**
  - Daily or weekly personal noise exposure of 85 dB(A) and,
  - Peak sound pressure of 137 dB(C);
- **Exposure Limit Value (ELV);**
  - Daily or weekly personal noise exposure of 87 dB(A) and,
  - Peak sound pressure of 140 dB(C);

8.2.8 A weekly value may be used where the exposure of an employee varies markedly from day to day.

8.2.9 The daily exposure is calculated using the following formula:

$$L_{EP,d} = L_{Aeq,Te} + 10\log_{10}(T_e/T_0)$$

8.2.10 Where:

- T_e is the duration of the person's working day in seconds;
- T_0 is 28,800 seconds (8 hours); and,
- $L_{Aeq,T}$ is the equivalent continuous A-weighted sound pressure level that represents the sound the person is exposed to during the working day.

Policy

Planning Advice Note PAN1/2011

8.2.11 PAN1/2011 (Scottish Government, 2011), sets out a series of noise issues for planning authorities to consider when making decisions on planning applications. A Technical Advice Note (TAN) on Assessment of Noise (Scottish Government, 2011) has been published to accompany PAN 1/2011. The TAN sets out appropriate technical guidance for evaluating different sources of noise and provides an example framework for determining impact magnitude and effect significance.

Consultation Response on UK Airspace Policy: A Framework for balanced decisions on the design and use of airspace

8.2.12 In February 2017 the UK Government put forward proposals to address the noise impact of aviation as part of a consultation on how changes to airspace could be implemented to allow airports to keep up with demand.

8.2.13 The consultation response noted that the UK Government believes that the 54 $dBL_{Aeq,16hr}$ metric remains appropriate, on the basis of a Survey of Noise Attitudes Study (SoNA, 2014) commissioned by the Department for Transport (DfT) which indicated that the degree of annoyance based on percentage of respondents 'highly annoyed' previously occurring at 57 $dBL_{Aeq,16hr}$ now occurs at 54 $dBL_{Aeq,16hr}$.

Shetland Local Development Plan 2014

8.2.14 The Local Development Plan notes that:

- Development should not have a significant adverse effect on existing uses;
- Development should not compromise acceptable health and safety standards or levels; and
- Development should be consistent with National Planning Policy, other Local Development Plan policies and Supplementary Guidance.

Guidance

Guidance for the Assessment of Environmental Effects

8.2.15 The Guidance for the Assessment of Environmental Effects (AEE) explains the process for completing an assessment of environmental effects as part of a licence application under the Space Industry Act.

8.2.16 The AEE Guidance requires that potential direct and indirect significant effects of proposed spaceflight activities on environmental features, including noise and vibration, are considered. The guidance further requires that:

- The launch operator AEE must cover all operations and activities that could have an environmental effect from the proposed launch(es);

- The applicant must provide a detailed assessment of the environmental effects of the specific launch(es) they are intending to apply for. The regulator will expect more detailed data for a launch operator AEE than for a spaceport AEE as the launch vehicle(s) will be known. The AEE must be based on the actual details of the class, type and detailed requirements of the launch vehicle and must not be based on assumptions;
- If more than one launch is being applied for, under the same launch operator licence application, then a cumulative assessment of those launches must be conducted. The launch operator AEE must also include any test launch(es) that will be authorised by the launch operator licence;
- The AEE must cover the entire launch operation, including:
  - from ground processing to the injection of the payload on orbit;
  - reusable or/and refurbishable elements, for example, the return flight of a reusable spaceplane;
  - objects jettisoned during the course of a nominal launch operation, for example, spent stages and fairings; and
  - for a sub-orbital operation, until the vehicle returns to earth
- The AEE must address a range of environmental topics, including noise.

Guidance to the Regulator on Environmental Objectives Relating to the Exercise of its Functions Under the Space Industry Act 2018

8.2.17 The Department for Transport issued its document '*Guidance to the regulator on environmental objectives relating to the exercise of its function under the Space Industry Act 2018*' in 2021, clarifying the government's environmental objectives relating to spaceflight and associated activities in the UK:

The environmental objectives for spaceflight are to:

- *Minimise emissions contributing to climate change resulting from spaceflight activities*
- *Protect human health and the environment from the impacts of emissions on local air quality arising from spaceflight activities*
- *Protect people and wildlife from the impacts of noise from spaceflight activities*
- *Protect the marine environment from the impact of spaceflight activities.*

8.2.18 The guidance identifies that noise from spaceflight activities is anticipated to be one of the greatest environmental concerns for impacts to humans and wildlife.

8.2.19 It is further noted that noise generated by spaceflight activities is not covered by WHO guidelines, ISO or BSI assessment methods, however, fixed spaceport activities should be assessed in accordance with BS 4142, as for any other type of industrial noise.

8.2.20 With regard to appropriate indices for the evaluation of rocket noise, the guidance notes the following:

"When assessing distinct and infrequent noise, such as rocket noise, measures of single events such as the maximum noise level (L_{Amax}) and the sound exposure level (termed SEL or LAE) are most appropriate. Unweighted maximum noise level (L_{max}) may also be appropriate for assessing risk of structural damage to the surrounding buildings and properties. To avoid acute damage to the human inner ear resulting from impulsive sounds, WHO noise guidelines suggest the maximum sound level (L_{Amax}) should never exceed 110 dBL_{ASmax}. To avoid and minimise the risk of structural damage the maximum unweighted noise level (L_{ASmax}) should not exceed 120 dB (unweighted)."

8.2.21 The guidance notes that the regulator must ensure:

- That where the rocket launch noise footprint could result in exposures in excess of 80, 85, 90, 95 and 100 dBL_{ASmax}, that these areas are published on suitable maps and used to communicate with local stakeholders.
- Where a night-time launch has been proposed by an applicant, the regulator should ensure that the applicant has assessed the risks to sleep disturbance in the vicinity around the launch using the following probability of awakening (equation provided in guidance).
- That any noise assessment provided takes into account an assessment of noise under predominant meteorological conditions and favourable weather conditions for launch where they differ.
- That any noise assessment provided clearly identifies the sources of noise and establishes what levels of noise have no observed effect, which have low observed adverse effects, and which have significant observed adverse effects.
- That a range of noise metrics have been assessed in addition to A-weighted measurements when considering a sonic boom. Where sonic booms over land cannot be avoided, the maximum overpressure should not exceed 47.88 pascals (Pa).
- All reasonable steps have been taken by operators to mitigate and minimise the adverse effects of noise events on human health and sensitive wildlife receptors.

8.2.22 The guidance notes that the noise assessment should include noise arising from ground operations and ancillary services, such as increased vehicle movement, generators and on-site equipment, assembly of launch vehicles, propellant loading and static fire testing.

8.2.23 Example mitigation measures are provided, including site selection away from sensitive receptors, applying operational procedures, e.g., restrictions during the night-time, seasonal restrictions, and implementing launch caps.

British Standard BS4142:2014+A1:2019

8.2.24 BS4142 describes methods for rating and assessing sound from industrial or commercial premises at residential receptors by comparison of the rating level due to the noise source with the background level in the absence of noise from the source.

8.2.25 The following evaluation impact significance identifiers are provided in the Standard, in which the difference between the rating level and measured background level are considered:

- The greater the difference, the greater the magnitude of impact;
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact;
- A difference of around +5 dB is likely to be an indication of an adverse impact;
- The lower the rating level, relative to the measured background level, the less likely that the specific sound source will have an adverse (or significant adverse) impact; and,
- Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact.

Calculation of Road Traffic Noise (CRTN)

8.2.26 CRTN (Department of Transport, 1988) provides a method for the prediction of noise levels due to road traffic based on traffic flows, average speed, road type and geometry.

Converting the UK traffic noise index $L_{A10,18hr}$ to EU noise indices for noise mapping

8.2.27 This report by TRL Ltd. may be used to convert CRTN 10th percentile ($L_{A10,18hr}$) noise index values to equivalent continuous ($L_{Aeq,T}$) index values, including $L_{Aeq,16hr}$, L_{day} and L_{night}.

Design Manual for Roads and Bridges (DMRB)

8.2.28 DMRB provides standards and advice regarding the assessment, design and operation of roads in the UK and provides significance criteria by which the percentage of people adversely affected by traffic noise can be related to the total noise level due to road traffic, or the increase over existing levels.

ISO 9613: Attenuation of sound during propagation outdoors, Part 1 and Part 2

8.2.29 ISO 9613 provides a calculation method for determining the attenuation of sound during propagation outdoors to predict the levels of environmental noise from a variety of sources.

The Environmental Noise (Scotland) Regulations 2006

8.2.30 The Regulations enact European Union Directive 2002/49/EC relating to the assessment and management of environmental noise in Scotland. The Regulations require that noise strategic noise maps are made showing the contribution of road, rail, aircraft and industrial activities. The strategic maps are to be used to develop noise action plans for areas close to major airports and other infrastructure. The Regulations use the noise indices L_{den} and L_{night}.

World Health Organization – Environmental Noise Guidelines for the European Region (WHO ENG)

8.2.31 The World Health Organization (WHO) was requested by the Member States in the European Region to produce noise guidelines that included not only transportation noise sources but also personal electronic devices, toys and wind turbines, which had not yet been considered in existing guidelines. Furthermore, European Union Directive 2002/49/EC relating to the assessment and management of environmental noise (END) and related technical guidance from the European Environment Agency both elaborated on the issue of environmental noise and the importance of up-to-date noise guidelines.

8.2.32 The WHO Regional Office for Europe has therefore developed environmental noise guidelines for the European Region, proposing an updated set of public health recommendations on exposure to environmental noise.

8.2.33 A strong recommendation can be adopted as policy in most situations. The guideline is based on the confidence that the desirable effects of adherence to the recommendation outweigh the undesirable consequences. The quality of evidence for a net benefit – combined with information about the values, preferences and resources – inform this recommendation, which should be implemented in most circumstances.

8.2.34 With regard to aircraft noise, the Guidelines provide the following recommendations:

"For average noise exposure, the Guideline Development Group (GDG) strongly recommends reducing noise levels produced by aircraft below 45 dB Lden, as aircraft noise above this level is associated with adverse health effects. For night noise exposure, the GDG strongly recommends reducing noise levels produced by aircraft during night-time below 40 dB Lnight, as night-time aircraft noise above this level is associated with adverse effects on sleep.

To reduce health effects, the GDG strongly recommends that policy-makers implement suitable measures to reduce noise exposure from aircraft in the population exposed to levels above the guideline values for average and night noise exposure. For specific interventions the GDG recommends implementing suitable changes in infrastructure."

8.2.35 The WHO ENG relies on meta-analysis of studies of the effects of aircraft noise on populations and determined that there was an absolute risk of 10% of a population would be 'highly annoyed' at an aircraft noise exposure level of 45.4 dB L_{den}. The quality of the supporting evidence was reported to be 'moderate'.

8.2.36 The International Civil Aviation Organization (ICAO) 2019 Environmental Report (ICAO. 2019) considers whether aircraft noise annoyance has increased over the last 50 years considered the case presented in the WHO ENG, given that the 45 dB L_{den} recommendation is 10 dB (i.e., an order of magnitude) below the previous recommendation of 55 dB L_{den}. The study concluded that there has been no change in people's response to aircraft noise over the past 50 years, however, there is a substantial spread in the annoyance response, which is attributed to non-acoustic factors, with examples such as noise sensitivity, fear of accidents, mistrust towards airport authorities, maximum noise levels, changes in exposure patterns and the duration of silent periods between noise events listed. On the basis of the ICAO report, this assessment considers the WHO ENG 45 dB L_{den} recommendation to be a highly conservative method for determining potential community annoyance.

World Health Organization –Guidelines for Community Noise (GCN)

8.2.37 The GCN notes the following with regard to sleep disturbance:

If the noise is not continuous, LAmax or SEL are used to indicate the probability of noise induced awakenings. Effects have been observed at individual LAmax exposures of 45 dB or less. Consequently, it is important to limit the number of noise events with a LAmax exceeding 45 dB.

Aircraft noise effect on sleep: application of the results of a large polysomnographic field

8.2.38 With regard to potential sleep disturbance, Basner et al. (2006) noted that a healthy adult briefly awakens around 20 times during an 8-hour night period in environments without external stressors, and there should be less than one additional awakening induced by aircraft noise per night for the avoidance of adverse health effects.

8.3 Consultation

8.3.1 Extensive statutory consultation on noise matters was carried out during preparation and determination of the planning application for the SaxaVord Spaceport, where the Proposed Project will be operated. Where directly relevant to this AEE, consultation responses received during the SaxaVord Spaceport planning application period and subsequent consultation with the CAA pertaining to this application has been summarised in Table 8.1.

Table 8.1 SaxaVord Spaceport Consultation Responses directly relevant to this AEE

Consultee	Consultation sent/response	Action taken
Shetland Islands Council	Email sent 11th July 2018 seeking agreement of representative study area and noise sensitive receptors, representative baseline survey locations (based on SaxaVord Spaceport project footprint at the time).	Shetlands Islands Council confirmed they could not respond prior to survey being undertaken. Robust survey undertaken with reference to appropriate UK guidance.

Consultee	Consultation sent/response	Action taken
Shetland Islands Council & SEPA	Email sent 9th June 2020 Outlining ITPEnergised's role in the noise and vibration assessment and seeking agreement on method of evaluation of construction, operational non-launch and launch noise for the SaxaVord Spaceport planning application EIA Report.	-
SEPA	15th June 2020 SEPA email received confirming it is unlikely that a licence under the Pollution Prevention and Control (PPC) regulations was required, therefore the Proposed Project is not within SEPA's remit	No action required
Shetland Islands Council	26th June 2020 email received confirming proposed approach and suggested threshold values are appropriate.	No action required
Shetland Islands Council	26th June 2020 sent further email confirming that ground-borne vibration associated with launches will be negligible, therefore requesting confirmation it may be scoped out of assessment of operational phase.	Ground-borne vibration during launches scoped out of study
Civil Aviation Authority (CAA)	ITPEnergised provided interpretation of the CAA guidance and described our proposed approach to the assessment. The CAA responded to confirm that it was unable to comment until an application was formally submitted, however, the interpretation of the guidance should be "*proportional and appropriate to the operation*."	Context regarding ITPEnergised's interpretation of the guidance is included within this report

8.4 Assessment Methodology and Significance Criteria

Consultation

8.4.1 Details of communications with regulatory bodies are provided in Section 8.3. Consultation was undertaken prior to the baseline survey in 2018 and at the time of the detailed assessment for the SaxaVord Spaceport planning application in 2020. ITPEnergised has had further correspondence with the CAA as part of the review process for AEE documents for the Spaceport and for other launch providers, giving greater understanding of CAA's interpretation and expected application of the guidance.

Environmental Zone of Influence

8.4.2 For a new development a noise impact study area, which in the context of this AEE is equivalent to the environmental zone of influence (EZI) for noise, is chosen based on the number of receptors at which the development may be audible or has the potential to exceed a particular noise threshold. A sample of the closest or most-affected noise-sensitive receptors (NSRs) would then be selected for the detailed evaluation of impacts, with impacts at more distant receptors considered to be lesser. Determining an acceptable level of impact at the closest NSRs is assumed to entail an acceptable level of impact at all receptors within the wider study area/EZI.

8.4.3 The Proposed Project comprises the preparation and launch of the RFA ONE NOM Launch Vehicle from Launch Pad 1 at the SaxaVord Spaceport situated at Lamba Ness on Unst, Shetland. The Applicant is applying for a maximum environmental budget of 10 launches per year which will make up one third of SaxaVord Spaceport's own assessed environmental budget of 30 launches per year.

8.4.4 Ancillary operations within scope of the Proposed Project include transport of personnel and equipment (including the RFA ONE NOM Launch Vehicle), assembly and fuelling.

8.4.5 The noise study area for this assessment has been informed by maps and aerial images of the Proposed Project areas and its surroundings, as well as site visits undertaken during the baseline noise survey. A buffer of five km from the boundary of the Proposed Project has been chosen for the consideration of noise effects. Noise effects may occur beyond this buffer; however, potential effects will be most significant within.

8.4.6 The SaxaVord Spaceport lies at the northernmost tip of the UK and all launch azimuths will all have a northerly bearing. The trajectory (i.e., the entire flight path of the launch vehicle, rather than the direction of launch) of each launch will vary according to launch-specific parameters and as such, is not currently known. This assessment therefore considers impacts associated specifically with launch activities, such that a circular study area centred on Launch Pad 1 is sufficient to consider the worst-case noise impacts. There will be no on-land ecological receptors north of launch site and noise impacts will diminish rapidly as the launch vehicle gains altitude, such that consideration of worst-case noise impacts to ecological receptors can be achieved within the five km circular study area buffer.

8.4.7 A sample of the closest, and therefore potentially worst-affected, Noise Sensitive Receptors (NSRs) to the Proposed Project have been identified and adopted for the evaluation of noise impacts. These are listed in Section 8.6. While vibration impacts have been scoped out of this assessment on the basis that vibration effects will be negligible, we note that the NSRs identified will also be the closest Vibration Sensitive Receptors (VSRs).

8.4.8 NSRs are typically considered to include residential buildings, such as private dwellings, as well as institutional and cultural buildings, such as schools, hospitals, churches and museums. Of these types of potential NSR, only residential buildings have been identified within the study area.

Site Visit and Baseline Noise Survey

8.4.9 ITPEnergised undertook a baseline noise survey in the vicinity of the Proposed Project on 19th and 20th July 2018. Approximately five years have elapsed since the baseline data was collected, however, given the rural and remote nature of the site setting, this assessment considers that no significant changes will have occurred to the baseline noise environment since the survey was completed. Monitoring was undertaken in accordance with the methods outlined in BS7445 and BS4142.

8.4.10 Measurements were undertaken using a Rion NL-52 Class I sound level meter (SLM). The SLM and calibrator were within their laboratory calibration period, and field calibration checks were performed before and after every measurement. No significant drifts in calibration were noted. A 5-minute averaging period was used for measurements, and the SLM was set to A-weighting and fast averaging. A hand-held anemometer was used to determine the wind speed at each monitoring position.

8.4.11 A single measurement of approximately 30 hours was undertaken at Saxa Vord, and supplementary spot measurements of shorter durations were undertaken at locations representative of residential properties close to proposed infrastructure associated with the Proposed Project, both during the daytime period (07:00 - 23:00) and the night-time period (23:00 – 07:00), as defined in PAN1/2011 TAN. The noise monitoring positions (NMPs) used are shown in Drawing 8.1.

8.4.12 Measurements were undertaken in accordance with the requirements of BS4142, with low wind speeds (<5 m/s) and no rain. Records of the baseline survey are provided in Volume IV Appendix 8.3.

Assessment of Potential Effect Significance

Overall Approach to Launch Operator AEE, Reliance on Previous Studies

8.4.13 ITPEnergised undertook the AEE for the SaxaVord Spaceport Operator Licence application. The input data for the SaxaVord Spaceport AEE noise assessment considered a 'worst-case' launch schedule of 30 launches of a 30 m tall launch vehicle. The RFA ONE NOM Launch Vehicle is 40 m tall and is therefore larger than the previously considered worst-case. Further predictions have been undertaken to consider the specific impacts associated with the 10 launches per year of the RAF ONE NOM launch vehicle cumulatively alongside 20 launches per year of the previously considered worst-case 30 m tall launch vehicle.

8.4.14 Specific road traffic movement numbers associated with the applicant's launches fall within the envelope considered for the SaxaVord Spaceport AEE, therefore no additional assessment of road traffic noise has been undertaken.

Receptor Sensitivity

8.4.15 The guidance contained within the Technical Advice Note to PAN 1/2011 has been drawn upon in the generation of an appropriate set of significance criteria. The receptor sensitivity criteria are presented within Table 8.2.

Table 8.2 NSR and VSR sensitivity criteria

Receptor Sensitivity	Description	Examples
High	Receptors where people or operations are particularly susceptible to noise and/or vibration.	Residential, quiet outdoor recreational areas, schools and hospitals.
Medium	Receptors moderately sensitive to noise and/or vibration, where it may cause some distraction or disturbance.	Offices and restaurants.
Low	Receptors where distraction or disturbance from noise and/or vibration is minimal.	Buildings not occupied, factories and working environments with existing levels of noise.

Impact Magnitude Criteria

8.4.16 Threshold noise levels have been defined for the Proposed Project. The derivation of threshold levels is described in subsequent sections, however, the general approach to deriving the magnitude of noise impacts for different aspects of the project is provided below.

Road traffic

8.4.17 A previous version to the current iteration of DMRB provided the following general relationship between changes in traffic flow and the resultant change in the traffic noise: *"In the period following a change in traffic flow, people may find benefits or disadvantages when the noise changes are as small as 1 dB(A) – equivalent to an increase in traffic flow of 25% or a decrease in flow of 20%. These effects last for a number of years"*. By contrast, PAN1/2011 advises that a change of 3 dB(A) is the minimum perceptible change in noise outside of laboratory conditions.

8.4.18 CRTN provides a procedure for calculating road traffic noise for links with low flows, defined as between 50 and 200 vehicle movements per hour, or 1,000 to 4,000 vehicle movements per day, and notes that calculations of noise level for traffic flows below these ranges are unreliable, recommending that measurements be undertaken when evaluating such cases.

8.4.19 Using these principles, the noise impact magnitude has been determined according to the criteria provided in Table 8.3.

Table 8.3 Road traffic noise impact magnitude criteria

Increase (i) over existing road traffic noise level due to project-generated traffic flows, dB	Impact magnitude
i ≥+5	High
+3 ≤ i < +5	Medium
+1 ≤ i < +3	Low
0 ≤ i < +1	Negligible

Noise from engine testing and launches

8.4.20 No standard UK or Scottish guidance exists upon which the magnitude of noise impacts associated with launch vehicle static fire engine testing or launches is available. This assessment has therefore considered as a robust basis of assessment, the potential for adverse health effects on the local population by reference to guidelines for aircraft noise provided by the WHO and the EU with regard to potential annoyance, and to the CoNaW Regs with regard to the potential for hearing damage.

8.4.21 Guidance relating to aircraft noise is a useful point of reference with regard to potential annoyance and sleep disturbance, however, it is noted that the character, duration and level of noise associated with launch vehicle launches will differ from that associated with conventional civilian or military airfields.

8.4.22 Given the nature of noise from launches, with high levels of noise occurring over a relatively short duration, two metrics have been considered for the determination of noise impact magnitude as follows:

- Firstly, the L_{den} noise level has been used to determine the potential for community annoyance; and,
- Secondly, instantaneous L_{Amax} noise levels have been considered with regard to potential adverse health/discomfort impacts.

8.4.23 This two-tier approach seeks to set in context the L_{den} levels generated by short-duration noisy events averaged over a year.

8.4.24 With reference to para. 8.4.13 this AEE relies on L_{den} calculations undertaken by BRRC which consider the cumulative effect of ten launches of the RFA ONE NOM Launch Vehicle (or similar equivalent) from Launch Pad 1 per annum, alongside 20 launches across the remaining two launch pads, including daytime, evening and night-time launches. The L_{den} is a cumulative metric considering annual exposure, including weightings for evening and night-time events. While the Proposed Project will account for approximately one third of the total number of launches and their respective impacts, the impact of these 10 launches cannot be meaningfully considered in isolation. This assessment therefore considers noise impacts from the Proposed Project in combination with those of other launch operators who will use the SaxaVord Spaceport for the L_{den} index.

8.4.25 The threshold criteria for the L_{Amax} index adopt the CoNaW Regs thresholds, and robustly assume that the highest predicted $L_{Amax,1sec}$ level occurs at each NSR for the full duration of the noise 'event'. By way of context, sustained noise levels above 110 dB may cause discomfort and levels of 120 dB and above are considered the threshold of pain, therefore the CoNaW Regs thresholds are substantially below noise levels which may cause instantaneous discomfort to nearby residents. The impact magnitude criteria are presented in Table 8.4.

Table 8.4 Operational noise impact magnitude criteria matrix – static engine testing and launches – likelihood of annoyance (L_{den}) and noise exposure ($L_{EP,d}$)

Likelihood of annoyance threshold, dB L_{den}	Noise exposure, dB$L_{EP,d}$	Rationale	Impact magnitude
>45	≥85	Above threshold of community annoyance and above UEAV	High
	≥80, <85	Above threshold of community annoyance and below UEAV	Medium
	<80	Above threshold of community annoyance and below LEAV	Low
<45	<80	Below threshold of community annoyance and below LEAV	Negligible

8.4.26 At all NSRs where the predicted L_{den} is below the threshold for community annoyance *and* the $L_{EP,d}$ derived from predicted $L_{Amax,1sec}$ values is below the daily LEAV, the impact magnitude will be 'negligible'.

8.4.27 At all NSRs where the 45 dBL_{den} threshold for community annoyance is exceeded, the impact magnitude will be greater than 'negligible', and the impact magnitude will be determined by the $L_{EP,d}$ relative to the CoNaW threshold values.

8.4.28 Further consideration has been given to the number of additional potential awakening events, with regard to the findings of the aircraft noise effect on sleep study (Basner, 2006), with potential for night-time sleep disturbance determined by SEL values above 90 dB (BRRC) and L_{Amax} values above 45 dB. The number of awakenings expected for launch events has been quantified using the equation referenced in the Guidance to the Regulator.

Noise from non-launch activities and plant

8.4.29 For noise from fixed plant and non-launch activities such as assembly, maintenance and control buildings and activities, significance criteria have been derived based on the guidance contained within BS4142, i.e., by consideration of the difference between the rating level from the plant noise and the prevailing background sound levels, but also with respect to context and the resulting sound levels in absolute terms.

8.4.30 The impact magnitude scale for noise associated with fixed plant and non-launch activities has been derived based on the PAN1/2011 and BS4142 guidance and is presented in Table 8.5.

Table 8.5 Non-launch plant and activity noise impact magnitude criteria

Difference (d) between predicted operational noise level and applicable noise limit, dB	Impact magnitude
d ≥+5	High
0 ≤ d < +5	Medium
-10 ≤ d < 0	Low
<-10	Negligible

Vibration from engine tests and launches

8.4.31 While consideration of groundborne vibration is scoped out, airborne vibration (air overpressure) associated with launches is considered with reference to predicted noise levels in the BRRC report, which notes that "*one damage claim in 100 households exposed is expected at an average continuous sound level of 120 dB (unweighted), and one in 1,000 households at 111 dB (unweighted)*". These levels match the criterion in the CAA guidance whereby "*…the maximum unweighted noise level (L_{ASmax})*[1] *should not exceed 120 dB (unweighted)*". Vibration criteria are provided for the determination of effect significance in Table 8.6.

Table 8.6 Operational vibration (air overpressure) impact magnitude criteria matrix – static engine testing and launches – likelihood of structural damage

Likelihood of structural damage threshold, dBL_{max}	Rationale	Impact magnitude
≥120	Likelihood of damage complaints greater than 1 in 100 households	Medium / High
≤111, <120	Likelihood of damage complaints lesser than 1 in 100 households, greater than 1 in 1,000 households	Low
<111	Likelihood of damage complaints lesser than 1 in 1,000 households	Negligible

Effect significance

8.4.32 This assessment determines the significance of effects drawing on the example criteria provided in PAN1/2011 (refer to Table 1 in Appendix 8.2). The adopted criteria are provided for a range of NSR sensitivities in Table 8.7.

Table 8.7 Effect significance criteria

Impact magnitude	Effect significance		
	Low	Medium	High
High	Slight / Moderate	Moderate / Large	Large
Medium	Slight	Slight / Moderate	Moderate
Low	Neutral / Slight	Slight	Slight
Negligible	Neutral	Neutral	Neutral

8.4.33 This assessment considers effects with a significance of 'moderate' and above are significant and effects with a significance of 'slight' or below are considered not significant.

8.4.34 All noise sensitive receptors (NSRs) considered in this assessment are considered to have a high sensitivity to noise and vibration.

[1] We note that the CAA guidance refers to "L_{ASmax}" values, however, we assume that the L_{max} (i.e. unweighted) value is intended here.

Limitations to Assessment

8.4.35 This assessment relies on information provided by BRRC. Launch data has been provided by the Applicant to BRRC, who undertook verification and predictions of launches using proprietary methods as described in their report, *Noise Study for Rocket Factory Augsburg Operations at SaxaVord Spaceport* included in Volume IV as Appendix 8.1.

8.4.36 This assessment considers the methods and models developed by BRRC to be appropriate and notes their routine use in the United States of America to evaluate noise from similar launch facilities, including for NASA and SpaceX. Further details of BRRC's capability and experience are given in the document *BRRC Shetland Space Centre Data Call* included for reference in Volume IV as Appendix 1.1.

8.5 Baseline Conditions

8.5.1 During the baseline survey, the baseline noise environment was determined to be consistent between all monitoring locations. There was little anthropogenic noise, and natural sources such as bird calls, wind and wind-induced rustling of vegetation were the primary contributors to overall noise levels. Very infrequent vehicle movements were a lesser contributor, with traffic typically slow-moving and fewer than five movements per hour. A summary of the measured noise levels is provided in Table 8.8. Full details of the survey are provided in Volume IV Appendix 8.3.

Table 8.8 Summary of measured baseline noise levels

Monitoring position / period	Monitoring duration, T	Measured level, dB(A)			
		Ambient, $L_{Aeq,T}$	Background, $L_{A90,T}$	Maximum, $L_{Amax,T}$	10th percentile, $L_{A10,T}$
NMP1 (day)	1 hr	38	27	57	39
NMP1 (night)	35 min	38	19	53	32
NMP2 (day)	1.5 hr	40	33	53	42
NMP2 (night)	40 min	27	18	45	25
NMP3	30 hrs	45	22	51	34
NMP3 (day)	5 hrs	42	21	55	36
NMP4 (day)	15 min	41	31	61	39
NMP5 (day)	1.5 hr	39	28	57	39

8.5.2 With reference to the measured levels presented in Table 8.8 above, time-event plots provided for each NMP in Volume IV Appendix 8.3 and field notes, the following observations may be drawn regarding the baseline noise environment:

- Noise levels across the study area are very low, representative of a remote, rural area with little or no influence from anthropogenic noise sources such as road traffic, air traffic, industry or power generation.
- The primary contributors to the noise environment are natural sources, such as bird calls and the wind, and agricultural sources, such as livestock.
- There is very little temporal variation in noise levels between the daytime and the night-time periods. This is particularly evident in the background (L_{A90}) trace for the 30-hour measurement at Saxa Vord, which ranges from <20 dB up to a maximum of 34 dB at 05:00, attributed to dawn chorus.

- There is very little spatial variation in noise levels between monitoring positions, with the main control on noise levels being the level of wildlife activity and atmospheric conditions.
- Throughout the daytime and the night-time period noise levels lower than the 'noise floor' of the SLM (the threshold below which accurate measurements cannot be obtained due to electrical 'noise' within the circuitry) were recorded at most of the NMPs.

8.5.3 Note that the higher noise levels recorded at NMP4 preceded a squall which required the measurement to be abandoned, therefore this measurement is not considered suitably representative of the noise environment and is provided for information only.

8.6 Receptors Brought Forward for Assessment

8.6.1 NSRs considered in this assessment comprise a representative sample of the closest inhabited dwellings to the Proposed Project falling within the study area extending in a 5 km radius from the SaxaVord Spaceport. The NSRs are shown in Drawing 8.1 and listed in Table 8.9.

Table 8.9 NSRs considered in assessment

NSR ID	NSR Name	Rationale for selection
NSR1	Booths	Representative of closest dwellings to the Proposed Project
NSR2	Valie	Representative of dwellings to the north-west of Norwick
NSR3	Norwick	Representative of dwellings within Norwick
NSR4	Millfield	Representative of slightly elevated dwellings to the east of Norwick
NSR5	Virse	Representative of dwellings to the south of Norwick
NSR6	Northdale	Representative of dwellings in Northdale
NSR7	Haroldswick	Representative of dwellings in Haroldswick

8.7 Standard Mitigation

8.7.1 The design and operation of the Proposed Project will incorporate the following standard mitigation:

- Assembly of the RFA ONE NOM Launch Vehicles and integration of Payload to be undertaken at appropriate facilities within the SaxaVord Spaceport and measures will be in place to minimise generation of unnecessary noise; and

8.7.2 No mitigation is possible to reduce instantaneous noise levels associated with launches; however, the following community engagement protocols will be followed to seek to minimise the potential for annoyance:

- The timing of the Applicant's launches will be advertised by SaxaVord Spaceport well in advance, in local media and online, such that local residents can avoid launch noise if they choose. Predicted noise levels inside the closest dwellings will be substantially below the level at which discomfort or hearing damage would occur and residents wanting to minimise their noise exposure may choose to remain indoors when a launch is scheduled;

- SaxaVord Spaceport plans to engage with the local community to support local jobs and increase employment, increase tourism to the area and connect with local schools and colleges to aid teaching of science and technology subjects. Further details of proposed community engagement and expected local benefits are provided in Chapter 4. Such measures are expected to make the local community feel engaged with the Proposed Project and reduce the likelihood of non-acoustic factors contributing to annoyance associated with noise from launches (refer to para. 8.2.36). The Applicant will support these community engagement initiatives.
- Suggestions for appropriate community liaison activities to which the Applicant may contribute to are provided below:
    - Establish Liaison Group Forum;
    - Produce project update newsletter;
    - Media, website update, social media;
    - Briefings with site neighbours, landowners, community representatives, interest groups and other key stakeholders;
    - Produce leaflet detailing upcoming activities;
    - Send letters to stakeholders likely to be immediately affected;
    - Hold public open days / exhibitions;
    - Manage community helpline and general email contact;
    - Attend community council meetings quarterly; and,
    - Manage complaints procedure.

8.7.3 The following precautionary mitigation to protect cultural heritage receptors will be undertaken:

- For structures of historical significance, typical practice is to document conditions prior, during, and after a launch event. In extremely sensitive cases, measurements on individual structural elements of interest may be performed during launch for comparison with established damage criteria.
- On this basis vibration monitoring will be undertaken on heritage sites 96, 98, 99 and 111 in the vicinity of Launch pad 3, heritage site 85 in the vicinity of Launch Pad 2 and heritage site 90 between Launch Pads 2 and 3 (refer to Chapter 14 of the SaxaVord Spaceport AEE, provided for reference as Appendix 2.5, for identification of the listed sites).
- Baseline data will be gathered prior to launches commencing and monitoring will initially take place during launches to ensure that there is no damage to structures as a result of the operation of the SaxaVord Spaceport.
- A programme of regular monitoring will be established thereafter and will be dependent upon the results of initial monitoring.
- Should monitoring identify the potential for structural damage, HES and the Shetland Regional Archaeologist will be informed immediately and further mitigation strategies will be discussed, agreed and implemented to prevent damage to any affected structures.

8.7.4 While levels of ground-borne vibration arising from launches of the larger RFA NOM ONE may be slightly greater than those of the RepLV considered in the SaxaVord AEE, the same monitoring and mitigation measures as previously proposed remain appropriate. Further information on ground-borne vibration assumptions and mitigation measures is detailed in Chapter 14 of the SaxaVord Spaceport AEE, provided for reference as Appendix 2.5.

8.8 Potential Effects

Noise from engine testing and launches

8.8.1 As noted above, this assessment relies on predicted noise levels associated with static engine tests and launches provided by BRRC. Full details of the modelling undertaken are provided in Volume IV Appendix 8.1, which should be read in conjunction with this AEE chapter.

8.8.2 The BRRC propulsion noise model utilised an atmospheric profile, which describes the variation of temperature, pressure, and relative humidity with respect to the altitude. Standard atmospheric data sources were used to create a composite atmospheric profile for altitudes up to 66 miles. Specifically, BRRC used median annual local atmospheric profile data and extended the profile to the Karman line using standard upper atmospheric data. As noted in Appendix 8.1, the propulsion noise modelling in Rumble takes into account temperature, pressure, and relative humidity. The modelling performed for planning purposes does not typically consider the effects of wind, as winds are specific to an instant in time which is not applicable for annualized (average) noise levels. Whether launches proceed will be predominantly determined by conditions in the upper atmosphere, rather than those at sea level. Meteorological conditions at sea level will have a negligible effect on noise propagation towards receptors; given the predicted noise levels at the closet NSRs, a variation of a few dB for upwind/downwind conditions will not be noticeable.

8.8.3 The predicted L_{den} values from all launch-related activities at the SaxaVord Spaceport, including launches from all three launch pads and static engine tests, of which the Proposed Project comprises up to 10 launches, are provided in Table 8.10. The predicted L_{den} values are shown as contours at five dB intervals in Drawing 8.2. Where NSRs lie between contours an interval of values has been reported.

Table 8.10 Predicted L_{den} values at NSRs

NSR ID	Predicted level, dBL_{den}
NSR1	<65, >60
NSR2	<60, >55
NSR3	<60, >55
NSR4	<60, >55
NSR5	<60, >55
NSR6	<60, >55
NSR7	<55, >50

8.8.4 To provide context to the lay reader, it is noted that normal conversation may register a typical noise level of 60 dB, while ambient noise levels within a quiet office may range from 40 – 50 dB.

8.8.5 Predicted L_{den} values at all of the representative NSRs considered are greater than 45 dB, therefore the impact magnitude exceeds 'negligible' at all NSRs. As discussed above, this assumes that noise from a space centre will generate similar levels of annoyance to noise from airports. This assessment considers that the very short duration and infrequent occurrence of noise from launches is likely to generate lower levels of annoyance than aircraft noise, which is far more frequent and regular and varies little from day to day. Launches will offer substantially greater periods of respite for nearby residents than an equivalent airport, and residents will be given warning in advance of each launch, such that they can plan accordingly to avoid the noise if they choose.

8.8.6 The predicted L_{Amax} values for static engine tests and for launches are provided in Drawing 8.3.

8.8.7 The predicted duration for which specific noise levels will be exceeded at NSR1 (the closest receptor to the Proposed Project), considering the previously modelled worst-case scenario (30 m launch vehicle) are provided in Table 8.11. While the time above durations for the Proposed Project will be marginally longer, this assessment considers that the previous predictions remain appropriately accurate for illustrative purposes.

Table 8.11 Time above durations at 2 km

Level / rationale for use of level	Static engine test – time above level (seconds)	Launch – time above level (seconds)
22 dB – representative 24-hour background level in Norwick.	5	340
45 dB – representative 24-hour ambient level in Norwick and also the external level which corresponds to the internal level of 30 dB via open-window transmission, above which sleep disturbance may occur.	5	190
66 dB – level above which speech intelligibility reduces; used to evaluate potential adverse effects of rocket noise within national parks in the USA.	5	70
89 dB – representative of maximum level during overflight by an oil rig shuttle helicopter, as occurs occasionally within the study area.	0	45

8.8.8 A time-history chart, showing how the predicted noise level changes at the closest NSR throughout a launch is provided in Figure 8.1.

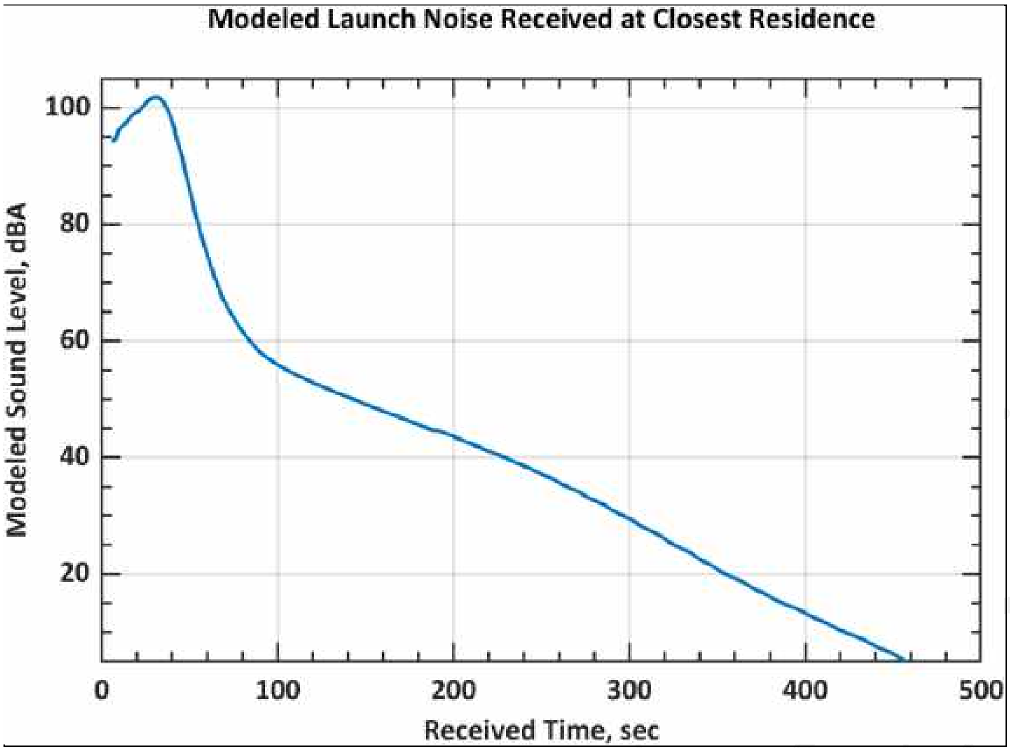

Figure 8.1 Time-history chart of launch noise

8.8.9 The noise levels at the closest NSR show a short-duration (approx. 50 seconds) peak where noise levels are in the range 80 – 100 dB(A), followed by a rapid decline to approx. 55 dB by 100 seconds. Figure 8.1 shows that the noise level drops to 45 dB, representative of the baseline ambient level, within 200 seconds. Table 8.11 above shows that the noise level drops below 22 dB, representative of the baseline background level and below which noise from the launch will trend towards being inaudible, within 340 seconds. The maximum duration of launches in terms of noise will therefore be approximately 340 seconds, or just under six minutes.

8.8.10 The BRRC report (Volume IV Appendix 8.1) considers an upper limit level of 110 dBL_{Amax} to protect human hearing from noise-induced hearing loss (NIHL), and notes that there are no dwellings within the 110 dB noise contour for operational noise associated with launches or engine tests.

8.8.11 With reference to Drawing 8.3, showing the predicted L_{Amax} contours for static engine tests, the highest predicted level occurs at NSR1, which lies between the 85 dB and 90 dB contours. Given an engine test duration of five seconds, and using the equation provided in para. 8.2.9, the resultant $L_{EP,d}$ is 49 dB. This is substantially below the LEAV and the impact magnitude at this worst affected NSR is therefore low.

8.8.12 At all other NSRs the predicted L_{Amax} levels are lower than at NSR1, therefore the resultant $L_{EP,d}$ will be lower, and the impact magnitude is low.

8.8.13 With reference to Table 8.7, the resultant effect significance for noise from static engine tests at high sensitivity receptors is slight. Noise effects associated with static engine tests are therefore not significant, resulting in **no likely significant effect.**.

8.8.14 Drawing 8.4 shows the predicted L_{Amax} contours for launches from Launch Pad 1 with a predicted level of between 100 dBL_{Amax} and 105 dBL_{Amax} at NSR1 (assumed approximately 104 dBL_{Amax}). With reference to Table 8.11 and Figure 8.1, the predicted noise level at NSR1 is below 60 dB after approximately 80 seconds.

8.8.15 In a highly conservative assumption, the $L_{EP,d}$ has been calculated assuming that the 104 dB noise level occurs throughout the 80 second period. Using the equation provided in para. 8.2.9, the resultant $L_{EP,d}$ is 76 dB. This is substantially below the LEAV and the impact magnitude at this worst affected NSR is therefore **low**.

8.8.16 With reference to Table 8.7, the resultant effect significance for high sensitivity receptors is slight. Noise effects associated with launches are therefore not significant, resulting in **no likely significant effect**.

8.8.17 When considering potential increased sensitivity to noise during the night-time period, it is noted that the BRRC report states SEL values greater than 90 dB generally lead to sleep disturbance. Further, given a predicted 104 dBL_{Amax} level at NSR1, and assuming a reduction of approximately 30 dB to external levels provided by the building envelope, it is highly likely that launches during the night-time period would result in internal noise levels above 45 dBL_{Amax} with resultant potential awakening of sleeping population at all NSRs within the study area, as per GCN guidance.

8.8.18 SaxaVord Spaceport has confirmed that of the proposed 30 launches per year, in any one month there may be up to two launches, however, at present it is unknown how many of these will be undertaken by the Applicant.

8.8.19 For the purposes of noise modelling in the AEE, a split of four day launches, three evening launches and three night launches has been used. However, it is noted that any number of night launches would still only result in a single launch during any given night, and therefore only one sleep disturbance per night.

8.8.20 Using the probability of awakening function given in the *Guidance to the regulator on environmental objective relating to the exercise of its functions under the Space Industry Act 2018* and population data gathered by SaxaVord Spaceport and predicted noise levels associated with the RepLV, the number of awakenings expected are provided in Table 8.12.

Table 8.12 Expected additional awakenings from night-time launches of the RepLV

Location (noise contour band)	Input value, dBL_{Amax}	$P_{awakening}$	Population	Number of awakenings
Closest residences	102	0.17	8	1
100-95	100	0.17	32	5
95-90	95	0.16	94	15
90-85	90	0.15	40	6
85-80	85	0.15	130	19
Total	-	-	**304**	**46**

8.8.21 For any one night launch it is expected that 46 people out of a total 304 will be awoken.

8.8.22 Given the proposed frequency of launches and the short duration of the noise events associated with launches, with reference to the 2006 Basner study wherein restricting additional awakenings due to aircraft noise to a maximum of one event per night is anticipated to have no adverse effect on human health, adverse effects associated with sleep disturbance due to night-time launches are considered to be minimal.

Noise from non-launch activities and plant

8.8.23 SaxaVord Spaceport has committed to meeting boundary noise limits for fixed plant, such that appropriate noise limits derived using BS4142 will be met at all NSRs. This assessment assumes that fixed plant associated with SaxaVord Spaceport will be specified such that the noise limits will be met.

8.8.24 No significant sources of noise are anticipated associated with the Proposed Project apart from noise emission from launch; therefore, noise associated with pre- and post-launch activities will arise only from operation of the SaxaVord Spaceport's own plant and has been assessed previously. RFA ONE NOM Launch Vehicles will be transported to the launch pads using a Transporter Erector Launcher (TEL) vehicle specified such that it does not result in breaches of BS4142-derived noise limits at NSRs.

8.8.25 The resultant worst-case predicted specific noise level at the closest receptor, NSR1, is 24 dB. In accordance with the BS4142 method, noise from fixed plant is not anticipated to include audible tonal, intermittent or impulsive characteristics, therefore the rating level is equal to the specific level, 24 dB.

8.8.26 With reference to Section 8.5, the typical background noise level in the vicinity of the Proposed Project is 22 dB. This level is representative of both the daytime period and the night-time period and is objectively a very low background level. In accordance with BS4142, whereby a rating noise level of less than five dB above the background level is indicative of a low impact, the noise limit for fixed and mobile plant at NSR1 is 27 dB.

8.8.27 The predicted worst-case rating level for fixed and mobile plant of 24 dB is 3 dB below the derived noise limit. Referring to Table 8.5, the impact magnitude is therefore low. With reference to Table 8.7, the resultant effect significance is slight. At more distant NSRs the rating level will be lower, and the result effect significance will be similar or lower than at NSR1. Noise effects associated with fixed and mobile plant at NSR1 are therefore not significant, resulting in **no likely significant effect**.

Road traffic noise

8.8.28 Projected traffic flows associated with the SaxaVord Spaceport total 81 vehicle movements per day, based on an average of monthly traffic movements. This assessment assumes that projected movements for the SaxaVord Spaceport include movements associated with the Proposed Project.

8.8.29 Noting that:

- The 2019 estimated flow at the closest Department for Transport (DfT) monitoring location to the Proposed Project, located on the A968 near the centre of Unst, is 494 (details of the DfT data are provided in Volume IV Appendix 8.4);
- This is below the 1,000 vehicle movements per day minimum threshold for the calculation of noise for low traffic flow roads provided in CRTN. Baseline traffic flows are therefore considered to be ‘very low’;
- An increase of 81 vehicle movements per day represents an increase of 16% over baseline flows and corresponds to an increase in road traffic noise of approximately 1 dB or lower; and
- Most of the vehicle movements will be associated with daily operation of SaxaVord Spaceport and the Proposed Project will comprise a small number of vehicle movements per launch.

8.8.30 This assessment considers that road traffic movements associated with launches were factored into the total provided for the SaxaVord Spaceport AEE and no additional movements would arise associated with the Proposed Project.

8.8.31 Referring to Table 8.3 the impact magnitude of operational road traffic noise is negligible, and the resultant effect significance is neutral. Road traffic noise effects during the operational phase are therefore not significant, resulting in **no likely significant effect.**

Vibration from engine tests and launches

8.8.32 Predicted unweighted L_{max} noise contours associated with static engine tests and launches are provided in Drawing 8.5 and Drawing 8.6, respectively. With reference to these drawings there are no NSRs within the 120 dBL_{max} contour. Six of the representative NSRs lie within the 111 dB contour, with the remainder of NSRs lying outside the 111 dB contour. With reference to Table 8.6 the impact magnitude ranges from negligible to low. Referring to Table 8.7 the resultant significance of effect ranges from neutral to slight and is therefore not significant, resulting in **no likely significant effect.**

8.9 Additional Mitigation

8.9.1 As there are no likely significant effects, no additional mitigation is required.

8.10 Residual Effects

8.10.1 No additional mitigation is proposed, beyond the committed standard mitigation measures. Residual effects associated with operations remain unchanged resulting in **no likely significant effect**.

8.11 Cumulative Assessment

8.11.1 There are no intra-project cumulative effects that have the potential to result in significant effects and so no intra-project cumulative assessment is required.

8.11.2 This assessment considers up to 10 launches of the RFA ONE NOM Launch Vehicle per year which will make up one third of the SaxaVord Spaceport environmental budget of 30 launches per year. As the primary noise metric (L_{den}) considers cumulative annual noise and cannot meaningfully be applied to the Proposed Project in isolation; cumulative effects from other launches taking place at SaxaVord Spaceport have therefore been inherently considered within the assessment.

8.11.3 Shetland Islands Council confirmed during the planning application for SaxaVord Spaceport that there were no other committed development or infrastructure projects which needed to be considered in that assessment and there has been no change subsequent to planning consent. As such, as far as the Applicant is aware, there are no like for like or similar projects within the noise study area and therefore, no significant issues are likely to arise from developments other than the SaxaVord Spaceport.

8.12 Summary

8.12.1 Potential noise and vibration effects associated with the Proposed Project have been robustly assessed with regard to launches and associated non-launch activities.

8.12.2 The assessment of noise and vibration relies primarily on modelling and calculations undertaken by BRRC.

8.12.3 Noise effects associated with road traffic and non-launch activities have been assessed as not significant, resulting in **no likely significant effect**.

8.12.4 Noise during engine tests and launches will be audible at NSRs within and beyond the study area and levels will exceed the criterion for community annoyance associated with aircraft noise. Instantaneous noise levels will be below the threshold at which damage to hearing may occur. However, the short duration of audible noise 'events' associated with engine tests and launches, and their infrequent occurrence, will reduce the associated levels of annoyance to below that which may be associated with aircraft noise from conventional airports. Accordingly, adverse health effects are not anticipated. Noise at NSRs associated with launches is below the level at which the potential for cosmetic damage to structures is likely. Noise effects associated with launches have therefore been assessed as not significant, resulting in **no likely significant effect**.

8.12.5 Vibration (air overpressure) associated with launches has been evaluated and found to result in a low likelihood of damage complaints and has therefore been determined to be not significant, resulting in **no likely significant effect**.

8.12.6 Standard mitigation has been considered in the derivation of effect significance. Committed mitigation measures include a commitment to meeting noise limits for fixed and mobile plant items and assisting SaxaVord Spaceport in maintaining good communications with the local community with regard to all activities of the Proposed Project.

8.13 References

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Chapter 9 Accidents and Disasters

9. Accidents and Disasters

9. Accidents and Disasters

9.1 Introduction

9.1.1 This chapter considers the potential for the Proposed Project to cause major accidents or be affected by natural disasters, in both cases focussing on where harm to the environment as a consequence could reasonably occur.

9.1.2 The assessment is intended to inform management and mitigation of risks to the environment. It does not assess the probability of any major accident or disaster.

9.1.3 The chapter considers environmental hazards inherent to the Proposed Project, the receptor groups likely to be affected in the event of an accident event, and the potential severity of the impact. The management of these risks by design or further mitigation is discussed.

9.1.4 The chapter considers significant effects from major accidents and natural disasters, it does not represent an exhaustive treatment of every possible risk of environmental damage. “Major” is in this context defined as having the potential to cause permanent or long-term damage to a receptor, including loss of life or permanent destruction of habitat. Environmental hazards have been identified in collaboration with the Applicant’s operations team and through co-operation with SaxaVord Spaceport.

9.2 Legislation, Policy and Guidelines

Legislation

9.2.1 The treatment of major accidents and disasters within an AEE is a requirement since the Space Industry Regulations 2021 came into force. Guidance document ‘Guidance for the Assessment of Environmental Effects’ (CAA et. al., 2021) states in paragraph 4.65:

‘The AEE must include a description of the environmental effects of reasonable worst-case scenarios from accidents and disasters which could occur during, or as a result of, the proposed activities. These must include as a minimum:

- *Possible off-nominal launch scenarios, account for where these occur (for example, on the launch pad)*
- *Fuel and hazardous material storage and handling (for example, failure of containment).’*

9.2.2 The Proposed Project will be a workplace and The Health and Safety at Work Act (1974) (UK Government, 1974) and Management of Health and Safety at Work Regulations (1999) (UK Government, 1999) will apply. The Act’s position on controlling risks, as interpreted by the Health and Safety Executive, to a level “As Low as Reasonably Practical” (ALARP) informs the approach to mitigation in the AEE Report context.

9.2.3 The Control of Major Accident Hazards Regulations (2015) (COMAH) (UK Government, 2015) and the Town and Country Planning (Hazardous Substances)(Scotland) Regulations 2015 (Scottish Government, 2017) will not apply to the Proposed Project as the thresholds for storage of the relevant hazardous materials (principally kerosene-type fuel and nitromethane) will not be exceeded.[1]

[1] The lower tier COMAH threshold is 2500 tonnes for aviation fuels including kerosene as a “Named Substance” in Schedule 1 Part 2 of the COMAH Regulations. The threshold for nitromethane as a Category 3 flammable liquid (Schedule 1 Part 1 P5c) is 5,000 tonnes; this threshold will not be remotely approached.

Guidance

9.2.4 Specific guidance for the production of Accidents chapters for AEE is currently limited and therefore reference has been made to examples of current practice shared by the Institute of Environmental Management and Assessment (IEMA, 2020).

9.2.5 The Health and Safety Laboratory (HSL) has produced the guidance document "Safety at Spaceports" (Health and Safety Laboratory, 2018) on behalf of the Civil Aviation Authority and the UK Space Agency. This assessment recognises this guidance and sets out a list of potential hazard areas to examine the potential environmental effects as the guidance suggests. The HSL guidance then recommends a tiered risk assessment process tailored more towards the protection of occupational groups, and as such diverges from the AEE process. This element of the risk assessment is therefore included separately in the Spaceport licence application safety case.

9.3 Assessment Methodology and Significance Criteria

9.3.1 Under the guidance and regulations accompanying the Space Industry Act 2018, a safety case and quantitative operational risk assessments is required to be produced by the Applicant for approval by the regulator. This assessment for AEE does not replace these requirements but rather separately considers reasonably realistic accident and disaster events in the context of their environmental consequences. It would be unrealistic to exclude workers and nearby residents as receptor groups from this assessment however, since any environmental changes would affect these groups as well as potentially wildlife and habitat sites.

9.3.2 A list of potential major accident and disaster events has been drafted on the basis of the Proposed Project's potential vulnerabilities and a range of reasonably plausible accident scenarios.

9.3.3 Events which could potentially meet the definition were considered in terms of the nature of the potential environmental effects, the potential severity and significance of the effect and the requirements for mitigation.

9.3.4 The meaning of "major" should be understood in the context of the Proposed Project. The "major" events assessed are expected to represent the potential events with the highest severity before, during and after the launch of the RFA ONE NOM Launch Vehicle. These "major" events would not necessarily be considered as such in the context of a much larger aerodrome or a facility which stored or used flammable materials in far greater quantities such as a petrochemical refinery.

9.3.5 For context, 10 launches per year are proposed by RFA.

Environmental Zone of Influence

9.3.6 A one-kilometre buffer area around Launch Pad 1 has been considered for the potential effects of loss of containment and combustion events because effects meeting the definition of a major accident or disaster would be unlikely beyond this distance. Aeronautical events are treated in terms of a ground strike on Unst or a water strike downrange, beyond the stated one-kilometre buffer.

Assessment of Significance

9.3.7 Potential effect significance must be understood in the context of major accidents and disasters. These are inherently rare events, and it is entirely plausible that no major accident or disaster befalls any launch event. Even if such an event took place, it is also plausible that there might be no effects beyond the immediate vicinity of the Proposed Project and within the boundary of the SaxaVord Spaceport.

9.3.8 The terminology used in the assessment, to be consistent with other Chapters of the AEE Report and, notwithstanding the caveat in the above paragraph, are as follows:

- Sensitivity – all potential human, wildlife and habitat receptors are assumed highly sensitive on a precautionary basis;
- Magnitude of impact –The usual terminology for the significance of effect is irrelevant in this case as only events with potential for high impacts (loss of life or permanent damage to habitats) are considered; and,
- Significance of effect – Although receptors are assumed to all be of high sensitivity and impacts inherently large and adverse, the significance will still vary depending on the nature of the effect, particularly in terms of duration and reversibility. For instance, a catastrophic release of a toxic fluid could have a major effect on a human receptor, with the potential for fatality, but a minor effect on a habitat which could readily regenerate following brief exposure. The scale of significance used, in descending order, is major, moderate, minor and negligible, with major and moderate being considered as significant effects in terms of AEE.

Requirements for Mitigation

9.3.9 Mitigation of the risk of significant adverse environmental effects is generally embedded in the design of the Proposed Project as influenced by iterative hazard identification exercises.

Assessment of Residual Effect Significance

9.3.10 The residual effects are intended to be the management of the risk of a major accident or disaster to a level that is ALARP, noting that this AEE Report represents a high-level assessment of such risks, with further assessment undertaken elsewhere in the Launch Operator Licence application.

Limitations to Assessment

9.3.11 The assessment is qualitative. It includes no probabilistic treatment of risk, simply identifying plausible major accident and disaster events and commenting on their potential severity and the outline approach to mitigation. It purposely considers environmental effects as its focus, and where effects on human health are noted, it is not intended to substitute for current and future safety case development.

9.4 Baseline Conditions

9.4.1 Baseline conditions are assumed to be routine launch vehicle operations at the SaxaVord Spaceport, rather than any physical description.

9.5 Receptors Brought Forward for Assessment

9.5.1 The following receptors have been brought forward for assessment:

- Habitats within a one-kilometre radius of the launch site were reviewed. Norwick Site of Special Scientific Interest (SSSI) is a geological designation and not considered sensitive. Norwick Meadows SSSI is a habitat designation for its sand dunes and valley fen which support several plant species of national and international interest.
- Wildlife receptors: The immediate vicinity of the Proposed Project will continue to be populated by species identified in Chapters 5 and 6. These have been treated generically as residents of, or visitors to, the vicinity of the Proposed Project.
- Human receptors: The nearest inhabited receptor points outside of the spaceport boundary are Banks Cottage and the village of Norwick, though both are considerably over one kilometre from the Proposed Project i.e., Launch Pad 1. Employees and contractors working on the Proposed Project will therefore be the nearest human receptors considered.

9.6 Standard Mitigation

9.6.1 Standard mitigation measures have been informed by the safety case and risk assessment work undertaken as part of the application for launch operator licence. Standard mitigation will include the following:

- Development of the RFA Safety Operational Manual (document reference LIC-RFA-0008);
- Compliance with SaxaVord Spaceport procedures including Launch Site Safety User's Manual (SAXA-GRP-OPS-SSUM-001), Emergency Response Plan and Operational Environmental Management Plan. Third-party documents are reviewed against RFA documents to identify and resolve any incompatibility before launch campaigns begin.
- Establishment and maintenance of an appropriate exclusion when required;
- Minimal storage of reagents on site in favour of "just-in-time" delivery for any given launch campaign with bulk storage off-site (which will be managed by SaxaVord Spaceport as part of their service offering); and
- Propellant / oxidant transfer and storage on hardstanding with integral containment (i.e. a sump of sufficient volume to hold a spillage indefinitely).

9.7 Potential Effects

9.7.1 Major accident and disaster events which were screened out of assessment are shown in Table 9.1, along with reasons for no further consideration. They are generally natural disasters and extreme weather events with no serious risk of occurrence.

Table 9.1 Events screened out

Event	Reason for screening out
Tectonic activity	British Geological Survey records show no recorded earthquake above 4 local magnitude ("light") within 50 km of Unst since records began. A (British Geological Survey, 2020).
Extreme temperature	Highly unlikely under the most pessimistic climate change scenarios given Unst's latitude (see Chapter 4)
Extreme storm	Launches with the potential to be compromised by extreme weather conditions would be postponed until a storm event had passed.
Storm surge (inundation)	Elevation makes inundation highly unlikely. No accounts of storm surge at the Proposed Project launch site.

9.7.2 Climate-related risks are discussed in more detail in Chapter 4 of this AEE Report.

9.7.3 Events taken forward for assessment are summarised in Table 9.2. The events have been grouped into failure of containment (liquids), failure of containment (gases), ignition (liquids) and off-nominal launch scenarios. The nature of the hazards is discussed in the following sections.

Failure of containment (liquids)

9.7.4 The RFA ONE NOM requires a maximum of approximately (~) 25,000 kg of RP-1 and ~60,000 kg of liquid oxygen (LOx) as primary fuel and oxidant. ~500 kg of nitromethane is also used as an orbital stage fuel. ~700 kg of nitrous oxide is used as an oxidant for the RFA ONE NOM Launch Vehicle's orbital stage; this is discussed in the Gases subsection as it will rapidly vaporise if containment is lost.

Kerosene

9.7.5 RP-1 kerosene-based fuel will be delivered on a just-in-time basis by road on a launch campaign basis. The maximum on-site quantity (~25,000 kg) occupies two ISO containers.

9.7.6 It is assumed for this assessment that loss of containment, if uncontrolled by the mitigation measures in place at the Spaceport, could lead to damage to on-site soil and groundwater and ultimately designated habitat site and the wildlife supported.

Liquid oxygen

9.7.7 The RFA ONE NOM Launch Vehicle requires an inventory of ~60,000 kg of liquid oxygen. The approximate density of liquid oxygen is ~1.14kg/l hence the volume required for a launch event is ~53,000 litres.

9.7.8 Liquid oxygen will be tankered to the launch site on a just-in-time basis, in quantities required for a given campaign vehicle as per other materials. The maximum on-site quantity of liquid oxygen used for a launch campaign (~93,000 kg) would be approximately four cryogenic road tanker loads assuming a capacity of ~20,000 litres.

9.7.9 Following any loss of containment these fluids would rapidly boil off to atmosphere, but in the seconds following the loss may cause cold stress on infrastructure, liquid and vapour burns, and in the case of oxygen, changes to combustibility of nearby fuels.

Nitromethane

9.7.10 Nitromethane is used as an orbital stage fuel and will be brought site in drums or another suitable container. Up to ~500 kilograms is required per launch event.

9.7.11 Nitromethane has several hazardous properties: both the liquid and vapour phases are flammable; it is harmful by inhalation and a possible carcinogen and teratogen.

9.7.12 It is assumed for this assessment that loss of containment, if uncontrolled by the mitigation measures in place at the Spaceport, could lead to damage to on-site soil and groundwater and ultimately designated habitat sites and the wildlife supported.

Failure of containment (gases)

9.7.13 Up to ~700 kg of nitrous oxide (N_2O) will be used in the Launch Vehicle's orbital stages. Relatively small quantities of nitrogen (~45 kg) and helium (~200 kg) will also be transported to site in cylinders and added to each launch vehicle.

9.7.14 Failure of containment for any of these gases will not conceivably lead to a major incident and are noted in the interests of completeness.

9.7.15 None of the three gases used have acute health or environmental effects. Leaks may temporarily reduce atmospheric oxygen concentration within a built environment, but evacuation and ventilation would mitigate against short-term health effects particularly asphyxia. Nitrogen or helium loss in an outdoor environment would have no particular effect. Loss of nitrous oxide would have climate change impacts as it is a relatively strong greenhouse gas with a 100-year global warming potential of 265 relative to carbon dioxide, using the UNFCCC Fifth Assessment Report value. (UNFCCC, 2014)

9.7.16 There may be potential mechanical effects and risk of harm to occupational groups due to a sudden blast of pressurised gas.

Ignition of hazardous materials

9.7.17 RP-1 and nitromethane are the only flammable materials likely to be used in bulk quantities at the Proposed Project.

9.7.18 Ampoules of triethyl aluminium / triethylboron (TEA/TEB) mixture are used in kilogram quantities to ignite the bulk fuels on the launch vehicles. A maximum total of 35 kilograms of TEA/TEB are expected to be stored at the launch site. This does not constitute bulk storage but is noted due to the mixture's pyrophoric (self-igniting) properties.

9.7.19 Uncontrolled combustion of RP-1 during delivery or launch vehicle fuelling would result in deflagration rather than explosion and then only if vapour had built up to a concentration above the lower explosive limit of 0.6% in a given volume of air.

9.7.20 Nitromethane is also highly flammable in air but has a much higher lower explosive limit than RP-1 (>7%). Nitromethane chemistry is complex and includes a number of potential breakdown and combustion products including carbon monoxide and hydrogen cyanide. The quantities likely to be produced by combustion of the on-site nitromethane inventory are unlikely to lead to relevant ambient air quality standards being exceeded beyond the launch site boundary.

9.7.21 Release and pyrophoric reaction of TEA/TEB would not present any particular environmental effects other than the potential combustion of the other bulk materials.

Off-nominal Launch Scenarios

9.7.22 The resulting deflagration following ignition of propellant during a launch failure would create a short-lived initial fireball potentially extending several tens of metres from the pad, with the residual propellant rapidly burning off over several minutes.

9.7.23 Relatively little empirical data on the environmental effects of directly comparable catastrophic losses of a launch vehicle exist. Research by NASA summarising all available historic data for the accidental and planned test destruction of kerosene-propelled launch vehicles suggests that the initial overpressure wave, which approximately corresponds to the deflagration radius (fireball) decays within tens of metres of the point of ignition (Blackwood, 2015).

9.7.24 The initial deflagration radius is not therefore expected to extend beyond the boundary of the Proposed Project and the duration of any subsequent propellant burn-off would be minimal in the open air.

9.7.25 The working expectation is that the risk of ignition of peat will be low following a propellant deflagration. Some of the peat substrate closest to the launch sites has been removed for use in off-spaceport peatland improvement projects. A peat fire would in any case not be allowed to persist and would be extinguished by the spaceport and municipal fire services.

9.7.26 The loss of all or part of the RFA ONE NOM Launch Vehicle to the marine environment are considered in Chapter 10 – Marine and Transboundary Effects of this AEE Report.

9.7.27 The loss of all or part of the RFA ONE NOM Launch Vehicle to the terrestrial environment on Unst are not considered significant. Fuels and propellants would be expected to rapidly volatilise leaving no permanent change to the area affected. Any launch vehicle debris itself would be recovered if considered safe and practicable to do so by SaxaVord Spaceport and the emergency services.

Table 9.2 Events Assessed

Event	Receptors	Potential Consequences	Significance	Mitigation
Failure of containment – liquid				
RP-1, Nitromethane	Hu, W, Hab	Soil and groundwater contamination. Runoff to watercourse or sea.	**Moderate (Significant)**	Maintenance regime for storage, transfer and containment equipment under responsibility of SaxaVord Spaceport. Applicant to comply with all SaxaVord Spaceport operational procedures and controls.
Liquid oxygen (LOx)	Hu, W, Hab	Cryogenic injury and damage to receptors in close proximity to release before rapid evaporation takes place. Temporarily enhanced potential for fire and explosion during evaporation – oxygen enriched atmosphere.	**Minor (Not Significant)**	
Failure of containment – gas				
Nitrous oxide	Hu	No major hazard – possibility of asphyxia if release in an indoor environment but not considered realistic for a launch event	**Minor (Not Significant)**	None required
Ignition of bulk quantities				
RP-1, Nitromethane, TEA/TEB	Hu, W	Initial blast could affect human and wildlife receptors within the site boundary, with off-site effects less likely. Residual fires could cause a short-term episode of high air pollutant concentrations near the blast site and immediate downwind locations.	**Major (Significant)**	Bulk storage off-site. Fire risk assessment to inform safe working practices around flammable materials under responsibility of SaxaVord Spaceport. Applicant to comply with all SaxaVord Spaceport operational procedures and controls.
Aeronautical events				
RFA ONE NOM Launch Vehicle crash – ground strike	Hu, W, Hab	Damage to receptors through impact and loss of propellant containment, potential ignition of propellant vapour and flammable substrate (peat).	**Major (Significant)**	All launch trajectories are to the north and have minimal land overflight. Areas around launch pad are not peat rich and some peat has been removed. Propellants and oxidants would rapidly volatilise.
RFA ONE NOM Launch Vehicle crash – water strike.	W, Hab	Damage to receptors through impact and loss of propellant containment.	**Minor (Not Significant)**	Marine environment (Chapter 10) concludes this is not significant. Propellant load will be partially combusted.

* Key to receptor abbreviations: Hu(man), W(ildlife), Hab(itat).

9.8 Additional Mitigation

9.8.1 Other than where fluid containment and transfer arrangements are required to limit releases to the environment (noted in Table 9.2 and included within the design as standard mitigation), there are not considered to be further significant environmental risks which require additional mitigation measures. No additional mitigation beyond the measures identified in Section 9.6 are considered necessary.

9.8.2 Inherent safe operating practices are required under CAA licensing requirements. The prevention and mitigation of other accidents and disasters without significant environmental effects will be managed through parallel risk and hazard management processes under CAA licensing i.e., the RFA ONE NOM Launch Operations Safety Case.

9.9 Residual Effects

9.9.1 Residual effects are not relevant to the discussion of significant environmental effects of major accidents and disasters as the effectiveness of the proposed mitigation cannot be absolutely guaranteed as these are low-frequency random events.

9.10 Cumulative Assessment

9.10.1 Cumulative effects can be either inter-project or intra-project effects.

9.10.2 Intra-project risks on site will be managed in accordance with CAA licensing requirements and mitigated by use of Exclusion Zones. There are no intra-project cumulative effects that have the potential to result in significant effects and so no intra-project cumulative assessment is required.

9.10.3 Inter-project cumulative effects are those where an environmental topic/receptor is affected by impacts from more than one project at the same time and the impacts act together. Due to the location of the Proposed Project on the north coast of Unst, the most northerly of the Shetland Islands, it is considered that there are no potential inter-project cumulative effects as there are no other existing or proposed developments nearby of relevance. Shetland Islands Council was contacted during the planning application stage of the SaxaVord Spaceport and confirmed that there are no committed development or infrastructure projects on the Island which should be considered in the assessment.

9.11 Summary

9.11.1 This chapter considers the potential for activities at the Proposed Project to cause major accidents or be affected by natural disasters, in both cases, focussing on where harm to the environment as a consequence could reasonably occur. The assessment is quantitative for the context of an AEE Report and does not examine the probabilities of major accident events and disasters occurring.

9.11.2 A list of potential events was drawn up based on the Proposed Project activities.

9.11.3 Natural disasters including flooding and tectonic activity are considered highly unlikely given the location of the Proposed Project. Extreme weather effects have been addressed in the Climate Change Chapter 4 of this AEE Report and it is considered that the proposed infrastructure design provides sufficient resilience to the effects of extreme weather events over the design life of the Proposed Project.

9.11.4 Accident events were subcategorised into failure of containment of propellant, diesel fuel and hazardous materials, ignition and off-nominal launch scenarios. The effects on generic on-site human and wildlife receptors and off-site designated habitat sites were considered for each of these events.

9.11.5 Failures of containment were generally considered to be minor or moderate significance and largely restricted to the areas immediately within the vicinity of the release point, given the quantities in use and the rapid expected evaporation and/or dispersion of the majority of bulk liquids and gases used. Mitigation will be through adherence to the Applicant's own and SaxaVord Spaceport management procedures, robust containment and restrictions on the quantities stored at the Proposed Project site.

9.11.6 Again, noting the environmental context, ignition events are considered to be major with potential for significant effects inasmuch as damage to health or loss of life to human and wildlife receptors would be possible if in close proximity to the event. In the unlikely event that ignition of kerosene occurred, the deflagration radius or resulting jet fire would be relatively small (likely within the spaceport boundary) and the subsequent blaze limited in duration by the quantities stored and used. Mitigation will be through the restriction of ignition sources from flammable materials through standard operating practices. Uncontrolled ignition events during launches are assumed to be managed through the RFA ONE NOM Launch Vehicle design process and integrity checks.

9.11.7 Off-nominal launch scenarios are considered to be of major significance should a ground strike take place, with potential for severe damage to human, wildlife and habitat receptors from impact and subsequent ignition of remaining propellant. Mitigation is inherent to the remote, northerly location of the Proposed Project and exclusively northward launch trajectories to be used. Water strikes were considered of moderate significance as wildlife and marine habitat receptors could potentially be impacted and are discussed in the Marine Effects Chapter (Chapter 10) of this AEE Report.

9.12 References

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Chapter 10 Marine and Transboundary

10. Marine & Transboundary Effects

10. Marine & Transboundary Effects

10.1 Introduction

10.1.1 This chapter considers the marine and transboundary effects from the Proposed Project.

10.1.2 Transboundary effects of the Proposed Project are significant environmental effects that may arise in a different country as a consequence of the Proposed Project.

10.1.3 The majority of the potential environmental effects are expected at or near the Proposed Project. However, RFA ONE NOM Launch Vehicles will also splashdown in territorial and international waters and potentially interact with the marine environment. The scope of the transboundary effects chapter is therefore concerned with assessment of the marine environmental effects of returning RFA ONE NOM Launch Vehicle stages or debris arising. Therefore, this chapter considers the potential marine receptors present within the effects range of the predicted impact points from returning RFA ONE NOM Launch Vehicles.

10.1.4 The UK Government has consulted with the governments of countries where the stages or fairings are predicted to land to come to an agreement to allow stages to fall in their waters (SaxaVord Spaceport, 2020). The Pacific EZI of the RFA ONE NOM Launch Vehicle may overlap with the Exclusive Economic Zones (EEZs) of other countries; however, the second stage will not be released on any trajectory where it will fall within the EEZs of any of these nations, unless prior permission is obtained pertinent to the specific launch.

10.2 Legislation, Policy and Guidelines

Legislation and Guidance

10.2.1 This Assessment of Environmental Effects has been produced under the Space Industry Act 2018, as transposed into The Space Industry Regulations 2021. It has been informed using:

- Guidance to the Regulator on Environmental Objectives Relating to the Exercise of its Functions under the Space Industry Act 2018; and
- Guidance for the Assessment of Environmental Effects 2021.

Planning Policy

10.2.2 The launch aspect of Scotland's space sector is emergent in nature. As such developments occur only on land, the space sector has not been considered in marine planning policy such as Scotland's National Marine Plan (Scottish Government, 2015). Despite not being considered as a specific activity in Scotland's National Marine Plan (the Plan), policies are included in the Plan that may need consideration when assessing the Proposed Project. In order to address this potential, the Plan policies have been reviewed (Appendix 10.1) and screened to determine which of the policies are of relevance to the Proposed Project. Where policies are considered relevant, the related sections of the AEE have been signposted (Table 10.1) to ensure that the content of the AEE demonstrates due consideration of the issues highlighted by the Plan policies.

10.2.3 The screening of policies for relevance to the Proposed Project considered if the Plan policies were sector specific and therefore not relevant, or if the Plan policies related to a specific geographic location and were therefore not relevant to the Proposed Project. The reason for not including policies in the process is noted in the summary table presented in Appendix 10.1.

10.2.4 The results of the Plan policy review and screening process indicate that the following policies are of relevance to the marine environment and the Proposed Project:

- GEN 1 General planning principle;

- GEN 2 Economic benefit;
- GEN 3 Social benefit;
- GEN 4 Co-existence;
- GEN 5 Climate change;
- GEN 6 Historic environment;
- GEN 7 Landscape/seascape;
- GEN 8 Coastal process and flooding;
- GEN 9 Natural heritage;
- GEN 11 Marine litter;
- GEN 12 Water quality and resource;
- GEN 13 Noise;
- GEN 14 Air quality;
- GEN 15 Planning alignment A;
- GEN 17 Fairness;
- GEN 18 Engagement;
- GEN 19 Sound evidence;
- GEN 20 Adaptive management;
- GEN 21 Cumulative impacts;
- FISHERIES 1, 2 and 3;
- WILDFISH 1;
- OIL & GAS 4, 5, and 6; and
- TRANSPORT 1, 3 and 6.

10.2.5 Table 10.1 lists these Plan policies and indicates the section of the AEE where information is presented to account for the requirements of the policy.

Table 10.1 Scotland National Marine Plan policies and cross-reference to section where information is presented to account for the requirements of the policies

Policy ID	Policy Text	Relevant Section of AEE Report
GEN 1	*There is a presumption in favour of sustainable development and use of the marine environment when consistent with the policies and objectives of this Plan.*	Chapter 10
GEN 2	*Sustainable development and use which provides economic benefit to Scottish communities is encouraged when consistent with the objectives and policies of this Plan.*	Chapter 10
GEN 3	*Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of this Plan.*	Chapter 10
GEN 4	*Proposals which enable coexistence with other development sectors and activities within the Scottish marine area are encouraged in planning and decision-making processes, when consistent with policies and objectives of this Plan.*	Chapter 10
GEN 5	*Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change.*	Chapter 9
GEN 6	*Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance.*	Chapter 10, Sections 10.10.115 – 10.10.123
GEN 7	*Marine planners and decision makers should ensure that development and use of the marine environment take seascape, landscape and visual impacts into account.*	Chapter 11
GEN 8	*Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding.*	Chapter 11
GEN 9	*Development and use of the marine environment must:* *(a) Comply with legal requirements for protected areas and protected species.* *(b) Not result in significant impact on the national status of Priority Marine Features.* *(c) Protect and, where appropriate, enhance the health of the marine area.*	Chapter 10

Policy ID	Policy Text	Relevant Section of AEE Report
GEN 11	*Developers, users and those accessing the marine environment must take measures to address marine litter where appropriate. Reduction of litter must be taken into account by decision makers.*	Chapter 10, Section 10.10
GEN 12	*Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply.*	Chapter 10, Section 10.10.4 – 10.10.39
GEN 13	*Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects.*	Chapter 8
GEN 14	*Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits.*	Chapter 7
GEN 15	*Marine and terrestrial plans should align to support marine and land-based components required by development and seek to facilitate appropriate access to the shore and sea.*	Chapter 11
GEN 17	*All marine interests will be treated with fairness and in a transparent manner when decisions are being made in the marine environment.*	Chapter 10, Section 10.5
GEN 18	*Early and effective engagement should be undertaken with the general public and all interested stakeholders to facilitate planning and consenting processes.*	Chapter 10, Section 10.3.1
GEN 19	*Decision making in the marine environment will be based on sound scientific and socio-economic evidence.*	Chapter 10, Section 10.5
GEN 20	*Adaptive management practices should take account of new data and information in decision making, informing future decisions and future iterations of policy.*	Chapter 10
GEN 21	*Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation.*	Chapter 10, Section 10.13

Policy ID	Policy Text	Relevant Section of AEE Report
FISHERIES 1	*Taking account of the EU's Common Fisheries Policy, Habitats Directive, Birds Directive and Marine Strategy Framework Directive, marine planners and decision makers should aim to ensure:* - *Existing fishing opportunities and activities are safeguarded wherever possible.* - *An ecosystem-based approach to the management of fishing which ensures sustainable and resilient fish stocks and avoids damage to fragile habitats.* - *Protection for vulnerable stocks (in particular for juvenile and spawning stocks through continuation of sea area closures where appropriate).* - *Improved protection of the seabed and historical and archaeological remains requiring protection through effective identification of high-risk areas and management measures to mitigate the impacts of fishing, where appropriate.* - *That other sectors take into account the need to protect fish stocks and sustain healthy fisheries for both economic and conservation reasons.* - *Delivery of Scotland's international commitments in fisheries, including the ban on discards.* - *Mechanisms for managing conflicts between fishermen and/or between the fishing sector and other users of the marine environment.*	Chapter 10, Sections 10.10.78 – 10.10.86
FISHERIES 2	*The following key factors should be taken into account when deciding on uses of the marine environment and the potential impact on fishing:* - *The cultural and economic importance of fishing, in particular to vulnerable coastal communities.* - *The potential impact (positive and negative) of marine developments on the sustainability of fish and shellfish stocks and resultant fishing opportunities in any given area.* - *The environmental impact on fishing grounds (such as nursery, spawning areas), commercially fished species, habitats and species more generally.* - *The potential effect of displacement on: fish stocks; the wider environment; use of fuel; socio-economic costs to fishers and their communities and other marine users.*	Chapter 10, Sections 10.10.78 – 10.10.86

Policy ID	Policy Text	Relevant Section of AEE Report
FISHERIES 3	*Where existing fishing opportunities or activity cannot be safeguarded, a Fisheries Management and Mitigation Strategy should be prepared by the proposer of development or use, involving full engagement with local fishing interests (and other interests as appropriate) in the development of the Strategy. All efforts should be made to agree the Strategy with those interests. Those interests should also undertake to engage with the proposer and provide transparent and accurate information and data to help complete the Strategy. The Strategy should be drawn up as part of the discharge of conditions of permissions granted.* *The content of the Strategy should be relevant to the particular circumstances and could include:* - *An assessment of the potential impact of the development or use on the affected fishery or fisheries, both in socio-economic terms and in terms of environmental sustainability.* - *A recognition that the disruption to existing fishing opportunities/activity should be minimised as far as possible.* - *Reasonable measures to mitigate any constraints which the Proposed Project or use may place on existing or proposed fishing activity.* - *Reasonable measures to mitigate any potential impacts on sustainability of fish stocks (e.g., impacts on spawning grounds or areas of fish or shellfish abundance) and any socio-economic impacts.* *Where it does not prove possible to agree the Strategy with all interests, the reasons for any divergence of views between the parties should be fully explained in the Strategy and dissenting views should be given a platform within the Strategy to make their case.*	Chapter 10, Sections 10.10.78 – 10.10.86
WILD FISH 1	*The impact of development and use of the marine environment on diadromous fish species should be considered in marine planning and decision-making processes. Where evidence of impacts on salmon and other diadromous species is inconclusive, mitigation should be adopted where possible and information on impacts on diadromous species from monitoring of developments should be used to inform subsequent marine decision making.*	Chapter 10, Sections 10.10.78 – 10.10.86

Policy ID	Policy Text	Relevant Section of AEE Report
OIL & GAS 4	*All oil and gas platforms will be subject to 9 nautical mile consultation zones in line with Civil Aviation Authority guidance.*	Chapter 10, Sections 10.10.87 – 10.10.94
OIL & GAS 5	*Consenting and licensing authorities should have regard to the potential risks, both now and under future climates, to oil and gas operations in Scottish waters, and be satisfied that installations are appropriately sited and designed to take account of current and future conditions.*	Chapter 10, Sections 10.10.87 – 10.10.94
OIL & GAS 6	*Consenting and licensing authorities should be satisfied that adequate risk reduction measures are in place, and that operators should have sufficient emergency response and contingency strategies in place that are compatible with the National Contingency Plan and the Offshore Safety Directive.*	Chapter 10, Sections 10.10.87 – 10.10.94
TRANSPORT 1	*Navigational safety in relevant areas used by shipping now and in the future will be protected, adhering to the rights of innocent passage and freedom of navigation contained in UN Convention on the Law of the Sea (UNCLOS). The following factors will be taken into account when reaching decisions regarding development and use:* - *The extent to which the locational decision interferes with existing or planned routes used by shipping, access to ports and harbours and navigational safety. This includes commercial anchorages and defined approaches to ports.* - *Where interference is likely, whether reasonable alternatives can be identified.* - *Where there are no reasonable alternatives, whether mitigation through measures adopted in accordance with the principles and procedures established by the International Maritime Organization can be achieved at no significant cost to the shipping or ports sector.*	Chapter 10, Sections 10.10.105 – 10.10.114
TRANSPORT 3	*Ferry routes and maritime transport to island and remote mainland areas provide essential connections and should be safeguarded from inappropriate marine development and use that would significantly interfere with their operation. Developments will not be consented where they will unacceptably interfere with lifeline ferry services.*	Chapter 10, Sections 10.10.105 – 10.10.114

Policy ID	Policy Text	Relevant Section of AEE Report
TRANSPORT 6	*Marine planners and decision makers and developers should ensure displacement of shipping is avoided where possible to mitigate against potential increased journey lengths (and associated fuel costs, emissions, and impact on journey frequency) and potential impacts on other users and ecologically sensitive areas.*	Chapter 10, Sections 10.10.105 – 10.10.114

10.2.6 In addition to the policies in Scotland's National Marine Plan, the Shetland Local Development Plan (the Shetland Plan) (Shetland Islands Council, 2014) has also been reviewed to determine if any policies exist that may be relevant to the Proposed Project. The Shetland Plan outlines several policies that must be considered in applications for new development. The policies that are of relevance to the marine environment and the Proposed Project include:

- NH2 Protected Species;
- NH3 Furthering the Conservation of Biodiversity;
- NH 7 Water Environment; and
- HE4 Archaeology.

10.2.7 Table 10.2 lists these Shetland Plan policies and indicates the section of the AEE where information is presented to account for the requirements of the policy. Further information is presented in Appendix 10.1.

Table 10.2 Shetland Local Development Plan policies and cross-reference to section where information is presented to account for the requirements of the policies

Policy ID	Policy Text	Relevant Section of the AEE Report
NH 2	*"Where there is good reason to suggest that a species protected under the Wildlife and Countryside Act 1981 (as amended), Annex IV of the Habitats Directive or Annex 1 of the Birds Directive is present on site, or may be affected by a Proposed Project, the Council will require any such presence to be established. If such a species is present, a plan should be provided to avoid or mitigate any adverse impacts on the species, prior to determining the application.* *Planning permission will not be granted for development that would be likely to have an adverse effect on a European Protected Species unless the Council is satisfied that:* *• The development is required for preserving public health or public safety or for other imperative reasons of overriding public interest including those of a social or economic nature and beneficial consequences of primary importance for the environment; and* *• There is no satisfactory alternative; and* *• The development will not be detrimental to the maintenance of the population of the European Protected Species concerned at a favourable conservation status in their natural range.* *Planning permission will not be granted for development that would be likely to have an adverse effect on a species protected under Schedule 5 (animals) or 8 (plants) of the Wildlife and Countryside Act 1981 (as amended) unless the Council is satisfied that:* *• Undertaking the development will give rise to, or contribute towards the achievement of, a significant social, economic or environmental benefit; and* *• There is no satisfactory solution.* *Planning permission will not be granted for development that would be likely to have an adverse effect on a species protected under Schedules 1, 1A or A1 (birds) of the Wildlife and Countryside Act 1981 (as amended), unless the Council is satisfied that:*	Chapter 10, Section 10.10

Policy ID	Policy Text	Relevant Section of the AEE Report
	• The development is required for preserving public health or public safety; and *• There is no other satisfactory solution.* *Applicants should submit supporting evidence for any development meeting these criteria, demonstrating both the need for the development and that a full range of possible alternative courses of action have been properly examined and none found to acceptably meet the need identified.* *The Council will apply the precautionary principle where the impacts of a Proposed Project on natural heritage are uncertain but potentially significant. Where development is constrained on the grounds of uncertainty, the potential for research, surveys or assessments to remove or reduce uncertainty should be considered. "*	
NH 3	*"Development will be considered against the Council's obligation to further the conservation of biodiversity and the ecosystem services it delivers. The extent of these measures should be relevant and proportionate to the scale of the development.* *Proposals for development that would have a significant adverse effect on habitats or species identified in the Shetland Local Biodiversity Action Plan, Scottish Biodiversity List, UK Biodiversity Action Plan, Annexes I and II of the Habitats Directive, Annex I of the Birds Directive (if not included in Schedule 1 of the Wildlife and Countryside Act) or on the ecosystem services of biodiversity, including any cumulative impact, will only be permitted where it has been demonstrated by the developer that;* *• The development will have benefits of overriding public interest including those of a social or economic nature that outweigh the local, national or international contribution of the affected area in terms of habitat or populations of species; and* *• Any harm or disturbance to the ecosystem services, continuity and integrity of the habitats or species is avoided or reduced to acceptable levels by mitigation."*	Chapter 10, Section 10.10

Policy ID	Policy Text	Relevant Section of the AEE Report
NH 7	*"Development will only be permitted where appropriate measures are taken to protect the marine and freshwater environments to an extent that is relevant and proportionate to the scale of development. Development adjacent to a watercourse O or water body must be accompanied by sufficient information to enable a full assessment of the likely effects.* *Where there is potential for the development to have an adverse impact the applicant/developer must demonstrate that:* • *There will be no deterioration in the ecological status of the watercourse or water body;* • *It does not encroach on any existing buffer strips and that access to these buffer strips has been maintained; and* • *Both during the construction phase and after completion it would not significantly affect:* o *Water quality flows in adjacent watercourses or areas downstream* o *Natural flow patterns and sediment transport processes in all water bodies or watercourses."*	Chapter 10, Section 10.10
HE 4	*"Scheduled monuments, designated wrecks and other identified nationally important archaeological resources should be preserved in situ, and within an appropriate setting. Developments that have an adverse effect on scheduled monuments and designated wrecks or the integrity of their settings should not be permitted unless there are exceptional circumstances.* *All other significant archaeological resources should be preserved in situ wherever feasible. Where preservation in situ is not possible the planning authority should ensure that developers undertake appropriate archaeological excavation, recording, analysis, publication and archiving in advance of and/ or during development."*	Chapter 10, Sections 10.10.115 – 10.10.123

10.3 Consultation

10.3.1 Extensive consultation on the scope of the Marine Environmental Risk Assessment (MERA) matters was carried out during preparation and determination of the planning application for the SaxaVord Spaceport, from where the Proposed Project will operate. Where directly relevant to this AEE, consultation responses received during the SaxaVord Spaceport planning application period have been summarised in Table 10.3.

Table 10.3 SaxaVord Spaceport Consultation Responses directly relevant to this AEE

Consultee and Date	Issue Raised	Response/Action Taken
Marine Scotland 28/05/2020	The Marine Scotland Licensing Operations Team do not have anything to add in relation to the planning or construction aspects of the Space Centre, nor are we suitably placed to inform you as to what should or should not be scoped into your MERA. However, you should ensure we are contacted regarding marine licensing requirements of launch activities taking place at the Space Centre. We would also recommend that you consult with the MMO (Marine Management Organisation) to confirm whether or not there are any further UK licensing requirements.	A response was provided by email to assure that marine licensing requirements had already been discussed and addressed, and that these did not fall within the scope of the MERA. The MMO were consulted with (see below).
Scottish Environmental Protection Agency (SEPA) 17/06/2020	The information provided suggest that marine issues appear to be further away offshore and is therefore not within SEPA's remit to provide advice. Following your statement in the email below; it is unfortunate that the proposals seem to be one that would be polluting the marine environment especially the Arctic as it is stated that, it is not expected that any part of the launch vehicles will be retrieved. In regard to the impact on the marine environment, it appears the 4 bullet points that have been scoped out would need to be considered because planned launches which go wrong may end up landing in the waters close to Marine Protected Areas (MPA) and offshore oil platforms rather than in the arctic.	Acknowledged. As assessed in the MERA, the impact is predicted to be minor at worst. The 4 bullet points to which the email refers (offshore marine protected areas; offshore renewable developments; offshore oil and gas platforms; aggregated extraction areas) were characterised as part of the baseline for the EZI in Section 10.6. The EZI encompasses the launch site, so as to be precautionary about where the impact zones will be.
Royal Society for the Protection of Birds (RSPB) 03/06/2020	We feel that consideration of the assessment approach required for the return of parts of launch vehicles to the marine environment is somewhat outwith our expertise. However, in general terms, looking at the receptors that you intend to scope in, my opinion would be that you seem to be covering all relevant factors. Also, the receptors being scoped out seem acceptable.	Acknowledged; no further action required.

Consultee and Date	Issue Raised	Response/Action Taken
Maritime and Coastguard Agency (MCA) [Offshore Renewables Advisor] 03/06/2020 and 04/06/2020 [via phone discussion]	A series of clarification queries were raised by the MCA via return email. Issues raised in relation to the MERA included: Have the scoped-out receptors been checked with current datasets? Will 'Shipping Activities' cover all vessel types; recreational, fishing, commercial and other offshore users including oil and gas, and dredging? Has vessel traffic been assessed in the study area to make this conclusion [that in-combination effects can be ruled out]?	Clarification was provided via a phone call on 04/06/2020. The scoped-out receptors were characterised as part of the baseline for the EZI in Section 10.6. Shipping activities, characterised in Section 10.6, have assessed all vessel types. Vessel traffic has been described in Section 10.6 and assessed in Section 10.10. Effects on shipping and navigation have been considered in the cumulative assessment in Section 10.13. Acknowledged, no further action required.
09/09/2020 [via email]	Based on [the further information provided in response to previous questions], I believe (at this point) that the impact on shipping and navigation should be suitably addressed through your approach to the MERA. I can only respond within the MCA's remit and you will of course need to consult with other interested parties to ensure nothing has been omitted from the approach.	
Marine Management Organisation (MMO) 29/05/2020 [via phone discussion]	Enquiries with regards to marine licensing should be submitted through our online marine licensing portal the Marine Case Management System (MCMS).	A response was provided by email to assure that marine licensing requirements had already been discussed and addressed, and that these did not fall within the scope of the MERA

10.4 Scope of Assessment

Environmental Zone of Influence

10.4.1 The proposed trajectory of the RFA ONE NOM Launch Vehicle will have an overall northerly direction from the SaxaVord Spaceport. Considering the impact zone for the payload fairing, up to three impact zones are expected per launch (first and second stages, and the payload fairing). The third stage carries the payload into orbit. The impact zones are expected to occur in marine locations between Scotland and Greenland. The indicative locations of impact zones have been provided to the CAA separately as they are commercially confidential. The resultant study area for all launches, termed the Environmental Zone of Influence (EZI), is presented in Drawing 10.1 (North Atlantic EZI) and Drawing 10.2 (Pacific EZI).

10.4.2 The EZI falls within the jurisdiction of several countries including Scotland, Norway, Faroe Islands (Denmark), Iceland, and Greenland (Denmark). The Pacific EZI overlaps with the EEZs of a number of Pacific Island nations, however this stage will not be released on any trajectory where it will fall within the EEZs of any of these nations, unless prior permission is obtained pertinent to the specific launch. The EZI also falls within areas beyond national jurisdiction. The EZI lies mostly within OSPAR Region 1: Arctic Waters, with the waters up to 200 km north of Shetland falling within Region II: Greater North Sea (OSPAR, 2020).

Desk Study

10.4.3 This assessment comprises a desk study. The primary resources used to inform this chapter include:

- OSPAR resources;
- Conservation of Arctic Flora and Fauna (CAFF) 2017 State of the Arctic Marine Biodiversity Report;
- National Snow and Ice Data Centre (NSIDC) Sea Ice Index;
- National Oceanic and Atmospheric Administration (NOAA) resources;
- European Marine Observation and Data network (EMODnet);
- ICES landings data;
- National Biodiversity Network (NBN) Atlas;
- NatureScot resources;
- Marine Scotland resources, including the National Marine Plan interactive viewer;
- Consultation responses;
- Project-specific Navigational Risk Assessment; and
- Published and unpublished literature.

10.5 Assessment Methodology

10.5.1 To assess the level of potential impact (likely significant effects) resulting from launch events at the Proposed Project, a methodology has been developed to establish the level of environmental risk of the Proposed Project to a range of receptors. This takes account of the sensitivity of the receptor, the exposure of the receptor to effects and the magnitude of the effects over and above the baseline condition. Therefore, for the purposes of this assessment, the term 'risk assessment' can be used interchangeably for 'impact assessment'.

10.5.2 More information on the criteria considered when determining levels of sensitivity, exposure and magnitude is provided below. In all cases, the assessment considers impacts, over and above those that may have already occurred, to determine whether the proposal constitutes a significant risk (likely significant effect) to the water quality, biodiversity or human and human activity environment in the vicinity of the EZI. It should also be noted that where receptors are grouped together, or where a wide range of scores exists, the worst-case scores of sensitivity (comprising worst-case scores of tolerance, adaptability and recoverability), exposure and magnitude are taken for each of the individual receptors.

Criteria Employed to Determine Levels of Sensitivity, Exposure and Magnitude

Sensitivity

10.5.3 The sensitivity assessment used is an assessment of the relative sensitivity of the receptor features within the EZI to effects associated with returning RFA ONE NOM Launch Vehicle components. In relation to this assessment, sensitivity has been defined in terms of the receptor's value (importance, quality and rarity), and as a product of tolerance, adaptability and recoverability to a pressure/effect:

- Tolerance is the susceptibility (ability to be affected or unaffected) of a receptor from an external factor;
- Adaptability relates to the ability of the receptor to adapt to, or avoid, an external factor; and
- Recoverability is the ability of a receptor to return to a state close to that which existed before the activity or event caused change within a specified period of time.

10.5.4 For each receptor, consideration is given to each of these component parts of the sensitivity assessment, with overall sensitivity being governed by the combined scores for each part. The scores for each element range from 0-3 (Negligible to High) and are determined based on consideration of the available evidence.

10.5.5 The sensitivity assessments of the receptors (grouped or their component sub-features) are based upon a series of scientific review documents. These include Tyler-Walters and Hiscock (2005) and the Marine Habitats Reviews (Jones et al., 2000). Further detailed consideration of sensitivity (specifically in the context of benthic receptors but also more widely applicable) is provided at the MarLIN website. (MarLIN, 2019).

10.5.6 A combination of screening against sensitivity criteria per receptor/grouped receptors and expert judgement, based upon supporting statements within the baseline, have then been used to deliver the sensitivity assessment component of the risk assessment.

10.5.7 Where grouped receptors have been used (e.g., for some parts of the benthic ecology assessment), then the receptor with the known highest sensitivity (greatest intolerance) to the pressure assessed has been used as the benchmark. This has allowed a conservative/precautionary assessment process for sensitivity to feed into the risk assessment matrix.

10.5.8 In practice, to determine the sensitivity of a receptor each characteristic (value, adaptability, tolerance and recoverability) is scored from 0-3. In most cases, 0 represents a negligible score whereas 3 will indicate a high value for the characteristic. In the case of recoverability, adaptability, and tolerance, a low score indicates that the receptor is capable of withstanding the impact pressure and should reduce the sensitivity score, whereas a high score for these characteristics will lead to a high sensitivity.

10.5.9 The following limits have subsequently been used to determine whether the sensitivity of the receptor is negligible, low, medium, or high:

Combined Score	Sensitivity
0-3	Negligible (0)
4-6	Low (1)
7-9	Medium (2)
10-12	High (3)

10.5.10 The sensitivity score is then carried forward to the final risk assessment (see below).

Exposure

10.5.11 Exposure is defined in terms of how the impacts affect a receptor, including the spatial extent of the impact, its longevity above baseline levels and the frequency at which the impact occurs.

10.5.12 In practice, to determine the exposure of a receptor to a particular impact, each characteristic (spatial extent, longevity and frequency) is scored from 0-3. The combined scores are then used to determine the level of exposure that a receptor will experience.

10.5.13 The following limits have subsequently been used to determine whether the exposure to the impact is negligible, low, medium or high:

Combined Score	Exposure
0	Negligible (0)
1-4	Low (1)
5-7	Medium (2)
8-9	High (3)

10.5.14 The exposure score is then carried forward to the final risk assessment (see below).

Magnitude

10.5.15 Magnitude is defined in terms of the level of the impact above background conditions and natural variability by whatever parameters are measurable.

10.5.16 In practice, to determine the magnitude of an impact, each characteristic (level above background, level in the context of natural variability) is scored from 0-3. The combined scores are then used to determine the level of exposure that a receptor will experience.

10.5.17 The following limits have subsequently been used to determine whether the magnitude of the impact is negligible, low, medium, or high:

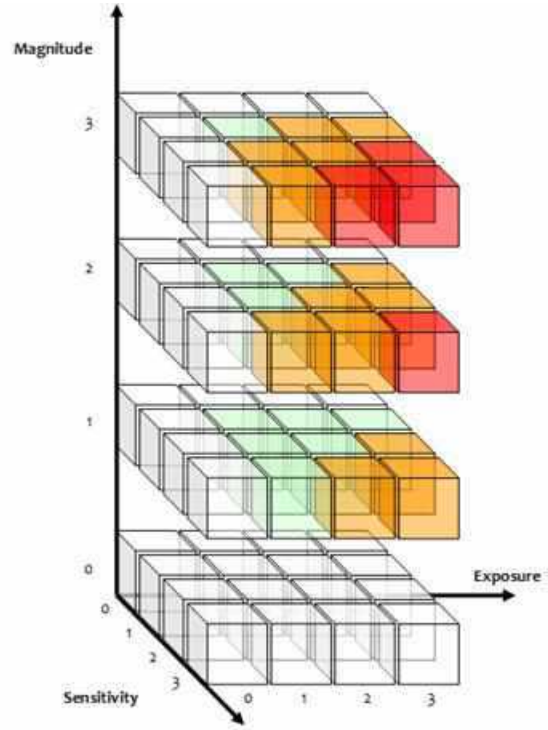
Combined Score	Magnitude
0	Negligible (0)
1-2	Low (1)
3-4	Medium (2)
5-6	High (3)

Summary of Methodology Used to Determine Level of Environmental Risk

10.5.18 As noted, the methodology adopted for this assessment utilises three elements: receptor sensitivity, exposure to impact and the magnitude of impact. As described, limits have been defined to assist in ascribing relevant values to these elements for all the receptors and potential impacts considered. The parameters adopted to ascribe values to the level of sensitivity, exposure, and risk (impact) have been adjusted according to the nature of the receptor and the impact.

Environmental Risk Assessment Matrix

10.5.19 An environmental risk assessment matrix has been developed to determine the risk posed by a range of impacts to a range of receptors. The matrix is illustrated in Figure 10.1. In practice, to determine the level of risk posed by an impact to a receptor, the scores resulting from the assessment outlined above are multiplied to determine the level of risk.



For the purposes of this assessment, the following limits have been set.

Score		Risk Value
0	=	Negligible
1-5.99	=	Low
6-17.99	=	Medium
18-27	=	High

Figure 10.1 The risk assessment matrix

10.5.20 Table 10.4 presents the transposition of the risk values into the terminology used in the wider AEE Report.

Table 10.4 Risk assessment values and transposition into wider AEE Report terminology

Risk Value	AEE terminology	Potential Significant Effect
Negligible	Negligible	No Likely Significant Effect
Low	Minor	No Likely Significant Effect
Medium	Moderate	Likely Significant Effect
High	Major	Likely Significant Effect

10.5.21 It should be noted that broad receptor groups e.g., benthic habitats, are made up of a range of individual receptors e.g., bivalves, polychaetes, corals, sponges etc. As such, the risk assessment has been undertaken to account for the most sensitive elements of the broad receptor groups, with an overall risk summary for each broad group presented in the document.

Requirements for Mitigation

10.5.22 For the purposes of this assessment, risk scores of <6 (Low or Negligible Risk) are considered insignificant, and mitigation is unnecessary as no likely significant effects arise.

10.5.23 Risk scores of 6-17.99 (Medium Risk) are considered to result in likely significant effects. Where mitigation can be applied impacts may be reduced to Low or Negligible Risk resulting in residual effects equating to no likely significant effect. If specific mitigation measures are not applied likely significant effects will remain.

10.5.24 Risk scores ≥18 (High Risk) are considered to result in likely significant effects and impacts are likely to be mitigated only through application of specifically targeted measures and/or acquisition of further environmental information to better determine impact significance. If specific mitigation measures are not applied significant effects will remain.

Assessment of Residual Effect Significance

10.5.25 Where mitigation practices are required to reduce the level of risk to no likely significant effect, these measures are presented along with a subsequent assessment of likely residual effect.

Limitations to Assessment

10.5.26 Following the risk assessment, a consideration of the confidence of the assessment has been undertaken based on the nature of evidence used, and the application of the evidence, to determine the risk of the proposals.

10.6 Baseline Conditions

10.6.1 The baseline conditions are described in terms of their water quality, biodiversity and humans/human activities for the EZI. Parameters included in the assessment are water quality, biodiversity and human activities which are discussed in detail in Appendix 10.2.

10.7 Receptors Brought Forward for Assessment

10.7.1 Following characterisation of the baseline, certain receptors have been screened out due to a lack of presence in the EZI and/or pathway of effect.

10.7.2 Physical features have been screened out for the EZI due to a lack of pathway of effect.

10.7.3 It is noted that through consultation for SaxaVord Spaceport, the North Sea Transition Authority confirmed that there was negligible risk to the oil and gas surface infrastructure present to the west and north-east of Shetland for the UK Continental Shelf. There is minimal presence of oil and Gas surface infrastructure in the North Atlantic Environmental Zone of Influence in Norwegian waters, however any trajectory that is assessed as having the potential to interact with this infrastructure will be aborted through activation of the Flight Termination System. Any impacts within the Pacific Environmental Zone of Influence will be restricted within the EEZ of any country (without prior agreement), therefore there is no likely interaction with oil and gas infrastructure in this area. Should an agreement come into place in future, this will be assessed at that time, but is expected to fall under the same mitigation strategy covered by the Flight Termination System. Accordingly, oil and gas surface infrastructure are scoped out of the assessment, for both study areas.

10.7.4 As described in the baseline environment, there is negligible presence of other sea users and socio-economics/tourism in the study area. Accordingly, these human activities have been scoped out for the study area.

10.7.5 Details of which features/receptors are being taken forward for assessment are presented in Table 10.5.

Table 10.5 Receptors taken forward in the assessment

Receptor	Taken Forward
Water and Sediment quality	
Contaminants	Yes
Microplastics	Yes

Receptor	Taken Forward
Biodiversity	
Physical features	No
Plankton	Yes
Benthic species	Yes
Fish and shellfish	Yes
Marine ornithology	Yes
Marine megafauna	Yes
Marine protected area	Yes
Human/human activities	
Shipping and navigation	Yes
Oil and gas infrastructure	No
Cables and pipelines	Yes
Military	Yes
Other sea users	No
Socioeconomics/tourism	No
Marine archaeology	Yes
Commercial fisheries	Yes

10.8 Assessment Envelope

10.8.1 As per the AEE Regulations, the impact assessment should be based on the worst-case parameters, known as the Rochdale envelope.

10.8.2 Certain worst-case scenarios, such as the maximum number of launches or maximum rocket size, are already known and have been set as limits as part of the project design.

10.8.3 A full description of the proposal is provided in Chapter 3 Proposed Project. For completeness, this assessment envelope presents a subset of the project description that is relevant to this chapter.

Launch Vehicles

10.8.4 The effects of the returning RFA ONE NOM Launch Vehicle components on the marine environment will depend on the physical properties of the RFA ONE NOM Launch Vehicle as well as the marine environmental receptor at the specific EZI. The physical properties of the returning RFA ONE NOM Launch Vehicle which may influence the level of effect include aspects such as the amount of residual fuel, the materials present and their reaction in the marine environment, and the dimensions of the components.

10.8.5 The frequency of operations is also relevant to the magnitude of effects. It is noted that there will be a maximum of 10 launches in any given year.

Physical properties

10.8.6 The RFA ONE NOM Launch Vehicle is approximately 40.5 m long and 2.1-3.3 m in diameter when including the dimensions of the hammerhead fairing. It is a three stage liquid fuelled orbital launch vehicle intended to place customer payloads into polar and sun synchronous (SSO) and mid-inclination low earth (LEO) orbits.

10.8.7 Indicative parameters for the RFA ONE NOM Launch Vehicle are summarised in Table 10.6.

Table 10.6 Summary RFA ONE NOM Launch Vehicle parameters

Parameters	Stage 1	Stage 2	Stage 3* Redshift OTV	Payload Fairings
Maximum height (m)**	21.0	5.2	Enclosed within fairings	8.0
Maximum diameter (m)	2.1	2.1	Enclosed within fairings	2.1-3.3
Gross lift off weight (kg)	~75,000			
Payload weight (kg)	~500 – ~2,000			
Dry mass (kg)	~5,000	~1,000	~500	~200
Approximate amount of propellant left upon re-entry (kg)	636	63	8	N/A
Likely fate	It is anticipated that significant sections of the RFA ONE NOM Launch Vehicle will burn up in the atmosphere resulting in debris components. The first stage will enter the marine environment intact after launch. The fairing halves and the second stage may fragment whilst returning to Earth and lead to debris entering the marine environment. The third stage is planned to enter orbit. The worst-case scenario is to assume that the RFA ONE NOM Launch Vehicle components do not burn up and instead enter the marine environment and this has been the assumption of the AEE.			
Environmental Zone of Influence	See section below.			

*The third stage components will not splash down, and thus will not interact with the marine environment.

**Note: Stage heights detailed in Table 10.6 relate to the first launch specification of the RFA ONE NOM; however, AEE data and analysis has been provided on the maximum RFA ONE NOM dimensions of 40.5m.

Environmental zones of influence

10.8.8 Drawing 10.1 and Drawing 10.2 present the EZIs (North Atlantic and Pacific) within which the first stage, second stage, and fairings are predicted to return. These have been based on example trajectories provided by RFA in relation to the three-stage RFA ONE NOM Launch Vehicle. The Pacific EZI (Drawing 10.2) has three distinct sections (a, b, and c), which may be used under different scenarios, but which have been assessed here as a single zone as a worst-case envelope. Sections a, b, and c of the Pacific EZI may overlap with the EEZs of several countries, however the second stage will not be released on any trajectory where it will fall within the EEZs of any of these nations, unless prior permission is obtained pertinent to the specific launch. The North Atlantic EZI overlaps with Jan Mayen. Jan Mayen has no permanent population but supports a meteorological station and airstrip. Mitigation measures (flight termination system) will be enacted for trajectories where fairings or other debris being jettisoned form the RFA ONE NOM Launch Vehicle could otherwise impact overflown land areas, to ensure a 100 km buffer from any inhabited area.

10.9 Standard Mitigation

10.9.1 The Federal Aviation Administration (FAA) methodology will be applied to define an exclusion zone, which will apply to sea and air. Using FAA defined exclusion zones ensures a precautionary approach. The direction from land will vary with the launch azimuth, with bearings currently projected to range from 330 to 030 True. The exclusion zone will fan between the aforementioned bearings and will extend outwards from the SaxaVord Spaceport as described in Chapter 3. Once an exclusion zone has been identified, the area will be registered on Marine Charts and will be activated via a Notice to Mariners.

10.9.2 An exclusion zone is not anticipated to be required for the stages and fairings. For these, a Notice to Mariners will be published, with the exact areas dependent upon individual launches.

10.10 Potential Effects

10.10.1 A series of effect pathways on the marine environment have been identified as a result of the return of launch vehicles to Earth. Table 10.7 summarises the effect pathways to be considered for the Proposed Project.

10.10.2 The effects of direct strike on vessels has been screened out. There is no pathway for effect due to the standard operating procedure of implementing a Notice to Mariners and an exclusion zone around the RFA ONE NOM Launch Vehicle.

Table 10.7 Impacts considered for the impact assessment of launches.

Key: ✓ = Impact present; ✗ = Impact not present

Impact	Launches
Effects on Water, Sea Ice, and Sediment Quality, and Ecological Receptors from Fuel Spillage	✓
Effects on Water, Sea Ice, and Sediment Quality, and Ecological Receptors from Metal Corrosion and Toxic Contamination	✓
Effects on Water, Sea Ice, and Sediment Quality, and Ecological Receptors from Debris and Microplastics (Including Ingestion)	✓
Smothering of Marine Organisms, Habitat Alteration (Including Reef Effects) and Habitat Loss via Deposition of Material on the Seabed or Sea Ice	✓
Direct Strike	✓
Acoustic Disturbance (including Underwater Noise) from the Impact of the Jettisoned Objects Hitting the Sea Surface or Sea Ice	✓
Thermal Effects of Jettisoned Objects	✓
Visual Disturbance	✓
Displacement of Fish	✓
Damage to Human Infrastructure (Subsea Cables/Pipelines)	✓
Interference with Military Exercise Areas	✓
Impacts to Vessel Navigation Including Floating Debris, Changes to Topography and Re-routing of Vessel Traffic	✓
Damage to Marine Archaeology/Shipwrecks	✓
Interference with Marine and Coastal Tourism Activities/Industry	✗

10.10.3 The risk assessment matrices that correspond to the written description of the environmental effects in the sections below are provided in:

- Appendix 10.3 – water quality risk matrix;
- Appendix 10.4 – biodiversity risk matrix; and
- Appendix 10.5 –human activity risk matrix.

Environmental Zone of Influence

Effects on Water, Sea Ice, and Sediment Quality and Ecological Receptors from Fuel Spillage

10.10.4 It has been assumed that the worst-case scenario of total residual propellant upon re-entry would be 699 kg. This amount would be split across two stages: first stage - 636 kg RP1-LOx; second stage - 63 kg RP1-LOx.

10.10.5 The impact area for the second stage falls within an area of the Arctic where year-round ice cover may be present for multiple years between more extensive melts. It is therefore likely that this stage will make impact with sea ice. Debris from the second stage has the potential to remain on the sea ice for extended periods, as the EZI encompasses areas within the mean extent for September (1981-2010), when sea ice is at a minimum (NSIDC, 2022). Therefore, the potential impacts of the second stage within the EZI have been considered both on sea ice and in the aquatic marine environment, as a precautionary measure.

10.10.6 The propellant for the first and second stages will comprise of Rocket Propellant-1 (RP1) and Liquid Oxygen (LOx). RP1 is a highly refined form of kerosene, with a high flash point. It is stable at room temperatures and therefore presents lower explosion hazard compared to fuels such as petrol or liquid hydrogen. The propellant for the third stage will comprise of Liquid Nitromethane (LNM) and Nitrous Oxide (N_2O), however this stage is predicted to burn up on re-entry and not enter the marine environment. LOx is a cryogenic liquid with boiling point of -183 ˚C and is a powerful oxidizing agent.

10.10.7 NOAA (2019) has provided a description of the effects of kerosene in the marine environment. Kerosene-type oils spread very quickly on water to form a thin film, which may be less than 0.01 mm thick. When forming this film, approximately 1,000 US gallons/3,785 L are present per square nautical mile of coverage. Considering the total amount of residual kerosene in any one stage (636 kg/785 L), the maximum size of the surface film from 785 L of kerosene would be approximately 0.21 square nautical miles, equivalent to ~0.72 km^2. Kerosene has a low boiling point and viscosity, meaning that, when spilled on water or sea ice, most will evaporate or naturally disperse within a day or less. Kerosene that is dispersed in the water column can adhere to sediment and be transported to the sea bottom, however this is highly unlikely in the EZI given the low sediment load. As stated by NOAA (2019), this process is not likely to result in measurable sediment contamination for small spills like those potentially associated with this assessment. Small spills of kerosene that reach the shoreline would be expected to quickly penetrate the sediment and/or be washed off. Kerosene can be completely degraded in the marine environment on the timescale of one to two months.

10.10.8 The majority of research on hydrocarbon interactions with sea ice concerns the fate of hydrocarbons following oil spills in the arctic, for example their biodegradation potential by microbial communities (Brakstad et al., 2008; Garneau et al., 2016). For kerosene-type propellant such as is used in the RFA ONE NOM Launch Vehicle, it is likely that degradation through volatisation will occur over a similar or slightly longer timescale compared to on the sea surface. Results for an experiment investigating degradation of light fuel (Special Antarctic Blend) on an Antarctic beach showed up to 99% loss of fuel within 2 months (Green et al., 1992). In a field experiment of kerosene degradation on high-arctic intertidal beach sediment, 94-98% was degraded through abiotic processes within 2 days (Røberg et al., 2007). The primary factors influencing fuel migration and extent of contamination of kerosene fuel on sea ice are the ice properties (e.g. age), and the amount of snow coverage (Christensen, 2008). It is not currently possible to predict these factors for potential impacts of RFA ONE NOM Launch Vehicle with sea ice, due to variability in sea ice extent/snow cover, and in launch trajectories.

10.10.9 It is anticipated that any residual propellant in the returning stages will be expelled upon impact on the sea surface or on sea ice. Due to the nature of kerosene-like fuels, only the very surface of the water column is anticipated to be within the zone of effect from propellant release. The marine biodiversity receptors that have the potential to be in this zone of effect for a non-negligible period of time are plankton. The biodiversity receptors that have the potential to be in the zone of effect for a sea ice impact are primarily bacteria or microalgae. All other marine biodiversity receptors are present in the surface waters or edge of sea ice (circumpolar) on a transient basis and so would not be exposed to potential residual propellants for any notable period of time.

10.10.10 It is possible that aquatic organisms that come into direct contact with naturally dispersed and entrained propellant will be killed (NOAA, 2019). However, given the small area of effect and the abundance and turnover of plankton, this is not anticipated to cause significant changes to the marine community.

10.10.11 Though effects to marine organisms higher up the food web have been excluded, it is worth noting that NOAA (2019) confirms that fish kills are unlikely to occur as a result of jet fuel spills in the open ocean due to evaporation and therefore concentrations are below lethal effects. This is expected to be applicable to other marine megafauna too.

10.10.12 The water quality and biodiversity of the EZI has an important environmental value. The biodiversity receptor which may be impacted by hydrocarbons, plankton, may experience lethal effects as a result of exposure to hydrocarbons. Hydrocarbons are anticipated to remain at the sea surface, over a small area, and be present over a short timescale (one to two months). Given this and the abundance and turnover of plankton, the sensitivity of these receptors is moderate.

10.10.13 Water quality and biodiversity receptors may be exposed to the effects of contaminants over an extensive period of time i.e., the full duration of the licence. Within the licence timeframe, launches are anticipated to occur up to a maximum of 10 times per year. It is noted that, due to the large spatial extent over which the RFA ONE NOM Launch Vehicle components could return, it is extremely unlikely that the receptors would be exposed more than once, further reducing the frequency at which they could be exposed to hydrocarbon spills. It is also noted that the event of a hydrocarbon spill is unlikely. The zone of effect of hydrocarbon spills is anticipated to be spatially limited to the immediate vicinity (<0.5 km^2) of the Launch Vehicle stages. Therefore, overall exposure of the receptors to the effect is low.

10.10.14 Direct effects on the hydrocarbon concentration of the sea water or sea ice is likely to be measurable above natural variability, as there are limited other sources of hydrocarbons in the marine environment. Similarly, potential impact to the water or ice quality is likely to be measurable above the baseline in that the hydrocarbon concentration will be elevated. However, only a small percentage change above the baseline or natural variation is predicted due to the small amount and rapid evaporation/dispersion of kerosene in the marine environment. The magnitude of the impact is therefore low.

10.10.15 Moderate sensitivity, combined with low exposure and low magnitude, means that the risk to these receptors is low, which is equivalent to minor risk. **No likely significant effect.**

Effects on Water, Sea Ice, and Sediment Quality and Ecological Receptors from Metal Corrosion and Toxic Contamination

10.10.16 Several types of metal are present in the RFA ONE NOM Launch Vehicle. The marine environment of the EZI is therefore described in terms of these specific metals.

10.10.17 Lithium (Li) in the open ocean is present in low concentrations in seawater (typically 1 ppm) (SAMCO, 2018). The main input of lithium to the ocean is weathering of continental crust, though there has been a reported increase in anthropogenic inputs near populated areas (e.g., Choi et al., 2019). Lithium is a non-essential nutrient to marine biota (Campbell et al., 2005). Campbell et al. (2005) reported that, for Arctic waters, lithium is present in high concentrations in zooplankton as a result of bioconcentration from seawater. The concentration in seals, fish, and birds was several orders of magnitude lower than in plankton, which indicates that lithium decreases trophically through the food web (Campbell et al., 2005). Lithium therefore only has the potential to affect the zooplankton and such lower levels in the food chain. Given that only a small proportion of the food web (zooplankton) has the potential to be affected, and that zooplankton are abundant and have high turnover, the effects are expected to be negligible.

10.10.18 Aluminium (Al) is one of the most resistant metals to corrosion in the marine environment, and so is used widely in the shipping industry (Almet-Marine, 2020). The primary natural input of aluminium to the marine environment is from aeolian sources, though this input is limited in Arctic waters. Here, aluminium is low in surface waters and increases with depth (Wong et al., 1983).

Aluminium is present in seawater in trace levels, ranging from 5-20 nmol/L, and is non-essential to marine life (Wong et al., 1983; Gilmore, 2014). The low number of studies on species' sensitivity to aluminium has shown there is great interspecies variability (Gilmore, 2014). So far, it has been reported that species of urchin, coral and macroalgae are tolerant, whereas some species of molluscs and phytoplankton show toxicity responses to lower concentrations of aluminium (Gilmore, 2014). The potential effects of elevated aluminium on marine life are therefore highly variable and species-specific. Nevertheless, it is unlikely that the introduction of aluminium as a result of the presence of the RFA ONE NOM Launch Vehicle components would increase aluminium concentration to levels where a toxic effect occurred, except in the immediate vicinity of the RFA ONE NOM Launch Vehicle component.

10.10.19 Stainless steel is one of the most resistant metals to corrosion in the marine environment, and thus is used widely by numerous marine industry sectors (Davis, 2020). Stainless steel derives its resistant properties via the formation of a protective chromium oxide skin on the surface of the metal, protecting the base metal (and importantly the iron present). This prevents exposure to moisture, mitigating the formation of iron oxide or rust (Thyssenkrup, 2022). In addition, the inclusion of molybdenum in stainless steel helps to stop the saltwater causing pitting or crevice corrosion. As an alloy metal, stainless steel is not naturally present in the marine environment. However, many anthropogenic structures and vessels present within the Arctic circle use steel and stainless steel, such as oil and gas platforms. Iron (the base metal of stainless steel) occurs naturally in the marine environment, but generally in very low concentrations (being at its lowest in surface waters and increasing with depth) (Wong et al., 1983; Street and Payton, 2005). Iron is used primarily by phytoplankton in the marine environment, as it is required for the synthesis of chlorophyll and for the reduction of CO_2, SO_4(2-), and NO_3(-) during the photosynthetic production of organic compounds (Street and Paytan, 2005). Considering the low corrosion potential of stainless steel, and the fact that it is not considered a toxic metal for marine species (no great sensitivity is known) (UKMSACP, 1995), and factoring the small amounts of material composing the debris fields, then the effects of introducing stainless steel into the environment are expected to be negligible.

10.10.20 Any debris from the second stage that lands upon sea ice is expected to remain in an environmentally benign state (due to the minimal corrosive atmosphere associated with Arctic conditions and freshwater moisture not being present in a liquid state

10.10.21 Copper (Cu) is present in the marine environment naturally and via anthropogenic sources at a mean concentration of 145 ng/kg (ppt) (Rauch and Graedel, 2007), however this varies greatly by region, and is elevated in coastal areas influenced by anthropogenic activities (Leal et al., 2018). In the Atlantic Ocean, copper (Cu) concentration increases with depth and latitude (Pohl et al., 1993). Copper concentration is higher near the shelf due to dissolution from shelf sediments and higher inputs from freshwater sources (Pohl et al., 1993). There is no interannual variation in copper levels in the Atlantic and Arctic oceans (Pohl et al., 1993). The input of copper into the marine environment has increased four-fold since the start of the industrial era (Lopez et al., 2019). Most copper is deposited through the atmosphere into the surface layer (Lopez et al., 2019). Of the total copper that is inputted to the surface layers, only a fraction is soluble and so able to be used by marine life (Lopez et al., 2019). Copper is an essential nutrient in the marine environment (Stern, 2010); hence it is typically present in high concentrations in all marine life across all trophic levels and does not bioaccumulate (Campbell et al., 2005). Many organisms produce organic ligands that bind copper to reduce its free ionic form (Cu^{2+}) and reduce its toxicity (Sueur et al., 1982; Gledhill et al., 1999). At high concentrations in seawater copper can be toxic to phytoplankton, though this is typically in areas subject to heavy anthropogenic emissions (Lopez et al., 2019). It is unlikely that the copper concentrations in the EZI are sufficiently high as to be toxic, as it is away from major coastal anthropogenic inputs. Copper alloys also present in the launch vehicle (e.g. brass and bronze), are similarly unlikely to result in significant impacts to marine life (Sclodnick et al., 2020), and have no added toxicity above that of the pure metals (Earley et al., 2020). With several years of degradation these metals may act as a substrate for marine life (MacLeod, 1982). As copper in the EZI is not predicted to be present in toxic levels, and is an essential nutrient, a small, localised increase in copper concentrations in seawater is not likely to be detrimental to marine life.

10.10.22 Titanium is found naturally in sea water, at extremely low concentrations, in the form of an oxide (Lide, 2004). Dissolved titanium is depleted at the ocean surface and enriched in deeper waters by an order of magnitude. The dominant form of dissolved titanium in sea water is that of $TiO(OH)_2$, which has a short particle-reactive oceanic residence time, and is also present in ferro-manganese nodules (Orians et al., 1990). Titanium nanoparticles have been shown to have adverse effects in some species of algae, fish, and phytoplankton (Galletti et al., 2016), however are relatively inert at larger sizes (Sahoo et al., 2019). A recent baseline study of titanium in marine mammal tissues found levels to be generally low, with a global mean level equal to 4.5 +/0 0.25 µg/g (Wise et al., 2011). Dissolved titanium is potentially analogous to aluminium, which is more strongly studied, and discussed above. The magnitude of impact is predicted to be low and highly localised.

10.10.23 Zirconium (Zr) is considered non-toxic and environmentally benign (Emsley, 2014). It is used in the space and aeronautical industry where resistance to heat and corrosion is a necessity (Stwertka, 1996). It is used in relatively small quantities and is not predicted to have any major impact on marine life.

10.10.24 The water quality and biodiversity of the EZI has an important environmental value, with certain biodiversity features also having an important cultural value. The most sensitive receptor is expected to be slightly tolerant and adaptable to increase in the contaminant levels. The source of contaminants (components of the RFA ONE NOM Launch Vehicles) will either sit atop the sea ice until it melts or will pass through the water column and then rest on the seabed. Biodiversity receptors will be exposed to increased contaminants as the RFA ONE NOM Launch Vehicle component passes through the area of the water column that they occupy. Water quality will be affected throughout the passage of the component. Given the predicted small increase in concentration of contaminants, it is anticipated that biodiversity and water quality receptors will be able to recover within short timescales (<1 year). The sensitivity of these receptors is therefore low.

10.10.25 Water quality and biodiversity receptors may be exposed to the effects of contaminants over an extensive period of time i.e., the full duration of the licence. Within the licence timeframe, launches are anticipated to occur up to a maximum of 10 times per year. It is noted that, due to the large spatial extent over which the RFA ONE NOM Launch Vehicle components could return, it is extremely unlikely that the receptors would be exposed more than once, further reducing the frequency at which they could be exposed. The zone of effect of contaminants is anticipated to be highly spatially limited to the immediate vicinity (i.e., metres) of the RFA ONE NOM Launch Vehicle components. Therefore, overall exposure of the receptors to the effect is low.

10.10.26 Any impact is likely to be small and slightly above the range of natural variation in the marine environment. This is suitably precautionary as little is known about the fine-scale variation of contaminant concentration in the marine environment of the EZI. Potential effects on the water quality are expected to be measurable above the present baseline, though for biodiversity it is anticipated that potential effects will not affect the baseline. The magnitude of the impact is therefore low.

10.10.27 Low sensitivity, combined with low exposure and low magnitude, means that the risk to these receptors is low, which is equivalent to minor risk. **No likely significant effect.**

Effects on Water, Sea Ice, and Sediment Quality and Ecological Receptors from Debris and Microplastics (Including Ingestion)

10.10.28 There is the potential for plastic to enter the marine or sea ice environment as plastic is used for liners of the propellant tanks. Plastic may be present in Stages 1, 2, and 3.

10.10.29 The plastic classes present in the RFA ONE NOM Launch Vehicle are high-density polyethylene (HDPE), polytetrafluoroethylene (PTFE), POLYOLEFIN FOAM, ethylene propylene diene monomer rubber (EPDM), nylon, polyvinyl chloride (PVC), fluorocarbon rubber (FPM), nitrile rubber (NBR), and fluorinated ethylene propylene (FEP). These plastics are commonly used in the aerospace industry and in harsh environments, due to their durability when exposed to extreme temperatures or harsh chemicals. As a result, they maintain structural integrity in marine environments, and have the potential to accumulate over time. As an example, HDPE has been discussed below.

10.10.30 HDPE is already present in the baseline of the marine environment as it is a type of plastic commonly found in marine litter, specifically plastic milk and juice jugs (Andrady, 2011). HDPE has been reported in the Arctic and given that the Arctic is a hotspot for plastics, it is likely that HDPE is already present in notable concentrations in the EZI (Obbard et al., 2014). HDPE has a specific gravity of 0.94, less than the 1.025 of seawater, indicating that it floats in the marine environment (Andrady, 2011). The average specific surface degradation rate for HDPE in the marine environment is 4.3 µm/year (Chamas et al., 2020). HDPE in the marine environment has an estimated half-life of 58 years, shorter than in landfill/compost/soil conditions (250 years) (Chamas et al., 2020). It is anticipated that any plastic present in the returning components would be large (>5 mm), and so classified as macroplastics at the point of entry (NOAA, 2020a), but would breakdown over a period of time during which microplastics (<5 mm) would be emitted.

10.10.31 Macroplastics on the sea ice may be ingested by seabirds, pinnipeds, or polar bears during periods where the impact site overlaps with their range. These animals are circumpolar, therefore for the majority of the area comprising the Pacific EZI these animals will not be present. For impacts within the Beaufort or Chukchi Seas or in the Bering Strait, these animals may be present but in low densities. These animals are known to ingest plastics, however limited data prevents the establishment of baselines or impacts (Collard and Ask, 2021).

10.10.32 Microplastics are readily ingested by marine organisms either through direct ingestion or indirectly by trophic transfer from contaminated prey (Nelms et al., 2018). These can have accumulation and ecotoxicological effects, both directly on primary consumers, and indirectly through trophic transfer (Anbumani and Kakkar, 2018; Botterell et al., 2019; Prokić et al., 2019). There are records of microplastic polyethylene ingestion in a range of holoplankton and meroplankton, including ichthyoplankton, though the recorded taxa are likely an underestimation due to the frequency of not reporting plastic class (Botterell et al., 2019). As summarised by the review of Nelms et al. (2018), there has been many inferences of trophic transfer of microplastics due to the recorded presence of microplastics in the faeces and stomach contents of species groups at higher trophic levels including fish, birds, and marine mammals.

10.10.33 Studies on the biological effects of microplastics in the field are rare (Botterell et al., 2019). In smaller organisms, microplastic ingestion has been shown to cause detrimental physiological impacts such as reducing feeding capacity, energy reserves, and reproductive output (Nelms et al., 2018). The effects on higher marine organisms are not well known. A few studies have shown that microplastics can be excreted after some days in the stomach, indicating a lower likelihood of the more severe physiological effects seen in small organisms (Nelms et al., 2018).

10.10.34 Debris, which would primarily comprise carbon composite, may also enter the environment from either the stages or the fairing of the RFA ONE NOM Launch Vehicle. An example of the composite used by the RFA ONE NOM vehicle is carbon fibre-reinforced polymers (CFRP), which are carbon polymers bound within a thermoset resin such as epoxy or polyester. There are few studies on how such composite material might break down in the marine environment, and in turn how the subsequent contaminants present may affect marine life. One study on Japanese rice fish (*Oryzias latipes*) found no toxicity associated with carbon fibres under semi-static conditions, where water was in flux (Ueda et al., 2020). When returning to earth, the stages and fairing will hit the ocean or sea ice at high velocity and therefore incur mechanical damage upon impact. The carbon composite is likely to sink upon entry into the marine environment, as has been recorded for other returning rocket stages. For impacts with sea ice, the materials are likely to further fracture and remain at the impact site until melting of the ice allows it to enter the water column. The rocket components are designed to withstand the extreme conditions of launch and travel; therefore, it is considered likely that any corrosion would be limited and only occur over long timeframes. To illustrate, the thrust chamber of one of the first stage F-1 rocket engines to launch the Saturn V rocket over 50 years ago has been recently detected on the seafloor, intact, and has been recovered (Space.com, 2013) (noting that these were made from aluminium and not a composite structure). The worst-case scenario, of a limited amount of corrosion of the composite material, may result in an increase in various contaminants in the marine environment, however due to the large quantity available for dilution of relatively small parts, toxic concentrations are not likely to occur.

10.10.35 The water quality and biodiversity of the EZI has an important environmental value, with certain biodiversity features also having an important cultural value. The most sensitive receptor, plankton, is expected to be slightly tolerant to low levels of microplastic ingestion which could potentially occur as a result of plastic from the RFA ONE NOM Launch Vehicle entering the marine environment. As a result of this potential ingestion and subsequent change plankton could be noticeably affected. The source of microplastics (plastic liners) will be of unknown size upon entering the marine environment, though it is hypothesized that they will enter as macroplastics encased within, or bonded to, the relevant stage of the launch vehicle and will sink through the water column to rest on the seabed. The quantities of plastic within the launch vehicle stages are not predicted to inhibit its sinking to the seabed. Biodiversity and water quality receptors will be exposed to increased microplastics as the RFA ONE NOM Launch Vehicle components break down on passage through the area of the water column that they occupy. Given the predicted small increase in concentration of microplastics, the high turnover and abundance of the most sensitive receptor (plankton), and the potentially short residence time in the gut of larger marine organisms, it is anticipated that biodiversity and water quality receptors will be able to recover within short timescales (<1 year). The sensitivity of these receptors is therefore moderate.

10.10.36 Water quality and biodiversity receptors may be exposed to the effects of microplastic over an extensive period of time i.e., the full duration of the licence. Within the licence timeframe, launches are anticipated to occur up to a maximum of 10 times per year. It is noted the large spatial extent of the EZI will act to reduce the likelihood of exposure to any individual. The zone of effect of microplastics is anticipated to be spatially limited, with concentrations of microplastics decreasing to below effect levels outside of the immediate vicinity of the RFA ONE NOM Launch Vehicle components. Therefore, overall exposure of the receptors to the effect is low.

10.10.37 Any increase in microplastics is likely to be small and slightly above the range of natural variation in the marine environment. This is suitably precautionary as there is minimal information on natural variation, though background levels are predicted to be high in the Arctic waters that overlap the EZI. The impact on water quality is expected to be measurable above the present baseline, at a local scale, though for biodiversity it is anticipated that potential impacts will not affect the baseline. The magnitude of the impact is therefore low.

10.10.38 Moderate sensitivity, combined with moderate exposure and low magnitude, means that the risk to these receptors is low, which is equivalent to minor risk. **No likely significant effect.**

10.10.39 It is noted that there are elements of uncertainty in the overall impact assessment of debris and microplastics, particularly with regards to the assessment envelope. However, the conclusions of the assessment concurs with the conclusion of the Draft Environmental Impact Statement for the Mars 2020 Mission (NASA, 2020) for impact of contaminants on the local marine environment, which assessed significantly larger rockets than the Proposed Project.

Smothering of Marine Organisms, Habitat Alteration (Including Reef Effects) and Habitat Loss via Deposition of Material on the Seabed or Sea Ice

10.10.40 The EZI is poorly understood in terms of its benthic habitats, as described in Appendix 10.1. It is likely that the most species rich group is arthropods, followed by polychaetes and molluscs (Figure A10.3). In the north Pacific Ocean, within the Pacific EZI, urchins, holothurians, and sponges are also common. Vulnerable Marine Ecosystems (VMEs) are also present in the EZI (Figure A10.4; Drawing 10.3). VMEs are sensitive to benthic pressures, though protection measures from these pressures are only applicable where they arise from fishing. There are a few Marine Protected Areas (MPAs) in the region that have designated benthic habitat features, therefore, the benthic habitats receptor is considered to have a high value.

10.10.41 The landing of the second stage on sea ice may directly impact the ice surface habitat. It is predicted that debris that collides with sea ice will be stationary following impact and only affect the habitat directly within the footprint of the debris. There is not anticipated to be a smothering effect of the material on any sensitive habitat on the sea ice.

10.10.42 The landing of the components at the seabed may directly impact benthic habitats in the EZI. If the component lands in/on a sensitive benthic habitat, it would likely be intolerant of the change and unable to adapt, with potentially lethal or destructive effects It is anticipated that following impact, the RFA ONE NOM Launch Vehicle Stage 1 will likely remain at the water surface for a number of hours before sinking (maximum 12 hours; 1-2 hours probable time frame). Studies of surface water circulation in the Norwegian basin using Lagrangian drifters indicate that typical horizontal drift is not predicted to exceed 10 km in 24 hrs (Poulain *et al.*, 1996; Jakobsen *et al.*, 2003). Eddies further contribute to constraining the region. Therefore, it is not likely that debris will drift outside of the predicted greater impact area before (or after) sinking. Due to the extremely large spatial extent of the Pacific EZI, it is not possible to accurately predict the currents in one area due to unknowns in trajectory and ocean state at the time of launch. However, as the second stage is smaller than the first stage and made of similar materials, impacts are predicted to be similar but of lesser magnitude. After sinking through the water column, it is predicted to come to rest at a single place at the seabed, only impacting the habitat directly within the footprint (maximum of 21 m by 2.1 m, with a volume of ~73 m³). The footprint of the impact is likely to be smaller than the full extent of the benthic habitat in a given area. Therefore, it is likely that once the component has fully broken down, the surrounding benthic habitat will enable the impacted zone to be recolonised, though this can only happen over a long timescale. There is also the possibility that the novel infrastructure surface could be colonised whilst intact on the seabed i.e., act like an artificial reef, though this is not confirmed. The introduction of artificial habitats into an environment are known to have a number of impacts on the local environment. The addition of hard substrate may allow for the colonisation of species that would otherwise be unable to exist in the local environment. Fish aggregating device effects may also result from the addition of hard substrate within the environment, causing a localised increase in species richness and abundance, and potentially decreasing these measures in the surrounding area. Further, increased biological activity surrounding the debris may result in an increased level of local nutrient levels through increased deposition flow of organic material. All of these effects are however likely to be confined to the close vicinity of any debris. Over the next 30 years it is anticipated that up to 10 RFA launches will take place per year (totalling300 launches), resulting in a potential total debris volume of approximately 1,105,020 m³ for all stages and fairings combined. Debris from second stage components, which has the potential to land on sea ice, would make up to a total mass of 332,250 kg maximum, however only a fraction of these launches would have a trajectory with the second stage landing in an area of potential sea ice, and summer launches or sea ice melts are likely to result in debris entering the water column and sinking to the seabed. When compared to the total volume of the EZI, this potential reef volume is likely to have a negligible impact on the marine environment. It is also likely that larger bits of debris will break up with time, further reducing the total volume of potential reef. In conclusion, the most sensitive benthic habitats have a low tolerance or adaptability, though the habitat may recover on a long timescale.

10.10.43 Due to the high value, low tolerance, adaptability, and recoverability, benthic habitats are considered to have high sensitivity to direct loss of seabed habitat via deposition of material on the seabed.

10.10.44 The Proposed Project will have a maximum plan of up to 10 launches per year. Although the licence term is considered to have high longevity, the likelihood of RFA ONE NOM Launch Vehicle components impacting the same area of benthic habitat is extremely low, considering the total extent over which the RFA ONE NOM Launch Vehicle components could enter the marine environment. Therefore, the longevity of the impact has been reduced to low to reflect this short time period per impact.

10.10.45 As evidenced by Figure A10.4 and Drawing 10.3, VMEs (Vulnerable Marine Ecosystems) are numerous in the EZI, particularly around the coasts of landmasses. There are only a few MPAs with benthic features, though these are typically large in extent. There are multiple large MPAs within the Pacific EZI, however the second stage will not be released on any trajectory where it would land in one of these areas. The impact zone around the RFA ONE NOM Launch Vehicle stages/fairing are extremely small in comparison to the areas of sensitive and/or protected benthic habitats. Therefore, the spatial extent of the impact is low.

10.10.46 An overall low longevity and spatial extent result in a low exposure of benthic habitats to direct loss caused by the returning component.

10.10.47 Any potential impact to benthic habitats is likely to result in a small measurable change to the baseline in the immediate vicinity of the component. This change is likely to be measurable above natural variability, as sensitive benthic habitats such as VMEs are long-lived and there are few other sources of direct loss. Therefore, the magnitude of impact in terms of baseline and natural variability is low.

10.10.48 High sensitivity, combined with low exposure and low magnitude, mean that the risk to benthic habitats from direct loss caused by the returning RFA ONE NOM Launch Vehicle component is minor. **No likely significant effect.**

Direct Strike

10.10.49 Marine ecological receptors that have the potential to be present at, above, or just below the sea surface, concurrent with a returning RFA ONE NOM Launch Vehicle component, include seabirds and marine megafauna. Many species of these ecological receptor groups are protected under various nature conservation legislation and constitute and essential part of the ecosystem. Accordingly, the receptors that may be affected by this impact pathway have been ascribed a high value.

10.10.50 The maximum i.e., worst-case mass of a returning RFA ONE NOM Launch Vehicle stage is anticipated to not exceed approximately 5,937 kg, calculated from the maximum dry mass of the first stage plus the assumed amount of residual fuel. The returning components will be travelling at considerable speed at the point of entry into the marine environment. The return speed is expected to be 169 m/s for the first stage, 40 m/s for the fairing, and 77 m/s for the second stage.

10.10.51 The return of the RFA ONE NOM Launch Vehicle components through the Earth's atmosphere and into the marine environment has potential to cause injury and/or death to marine ecological receptors which are in the return flightpath. A component may collide with species that spend time at, above, or just below, the sea's surface. The ecological receptors and their specific behaviours which may lead to them being affected by a returning RFA ONE NOM Launch Vehicle component include:

- Foraging or migrating seabird species, which may be flying above the water;
- Foraging or loafing seabird species, which may be floating on the water surface;
- Pinniped species, which may be at or just below the water surface, or resting on sea ice;
- Polar bear *Ursus maritimus*, which may be foraging or resting on sea ice;
- Cetacean species, which may be at or just below the water surface;
- Basking shark (*Cetorhinus maximus*), whale shark (*Rhincodon typus*), and oceanic sunfish (*Mola mola*), which may be at or just below the water surface; and
- Designated seabird features of MPAs, behaving as described above.

10.10.52 Given the size of the components and the speed at which they are predicted to return, it is anticipated that any receptors struck by the returning component would experience mortality. Larger animals such as baleen whales may experience serious physical injury if not directly struck, however this is also considered likely to lead to mortality, albeit indirectly. Individual marine ecological receptors are not tolerant, adaptable, or able to recover from mortality events.

10.10.53 A high ecological and cultural value, combined with no tolerance, adaptability, and recoverability, results in the aforementioned ecological receptors having a high sensitivity to direct strike from returning RFA ONE NOM Launch Vehicle components within the EZI.

10.10.54 The Proposed Project will have a maximum plan of up to 10 launches per year, therefore the longevity of the potential impact is high. The frequency of the impact is low at a maximum of two launches per month. This is further reduced when it is considered that a single individual is only likely to exposed to this impact up to once in a lifetime. The returning RFA ONE NOM Launch Vehicle component will only impact the area directly where it lands, which, compared to the total available habitat within the EZI (including the entire water column below the surface layers and total air space for flying birds), is low.

10.10.55 A low frequency and spatial extent, combined with a high longevity, result in a low exposure of ecological receptors to direct strike from the returning component.

10.10.56 The likelihood of such an impact occurring is considered to be very low. Should it occur, it is expected that only single individuals would be affected. Collisions between these ecological receptor groups and vessels (in water) or anthropogenic infrastructure (in air) is not an uncommon occurrence. Similarly, the natural level of mortality in these species would mean that the additional mortality of a limited number of individuals would not affect the population baseline nor be detectable above the natural variability of populations which fluctuates on a range of timescales. Therefore, the magnitude of effect is negligible.

10.10.57 A high sensitivity, combined with a low exposure, and negligible magnitude, mean that the risk to ecological receptor populations (seabirds, marine megafauna, and MPAs) in the EZI from direct strike by the returning RFA ONE NOM Launch Vehicle component is negligible. **No likely significant effect**.

Acoustic disturbance (including underwater noise) from the impact of the jettisoned objects hitting the sea surface or sea ice

10.10.58 The occurrence of excessive noise input into the ocean can elicit a range of responses in marine ecological receptors, such as mortality, physiological injury, auditory injury (either permanent or temporary), disturbance, and masking. The magnitude of the response is dependent on the properties of the sound source, such as the loudness, frequency, and duration, as well as the state of the receiving individual. The marine ecological receptor groups with demonstrated sensitivity to noise include plankton, fish, and marine megafauna. Benthic habitats are also known to be sensitive to noise but given the probable water depths at the point of RFA ONE NOM Launch Vehicle component return, it is unlikely that the received noise at the seabed will be above the threshold to cause a response. Seabirds have limited sensitivity to underwater noise and are also highly unlikely to be present in the water in the immediate vicinity of the RFA ONE NOM Launch Vehicle component when the noise occurs, therefore these are not considered further.

10.10.59 The characteristics of the acoustic emission produced by the RFA ONE NOM Launch Vehicle component hitting the water or sea ice is not known. Taking into consideration the speed at which the component will be travelling (estimated first stage impact speed 169 m/s), the maximum size (first stage: 21 m × 2.1 m), and the weight (~5,300 kg), it is likely that the sound will comprise a single pulse, of high intensity and short duration (impulsive). There may be some fragmentation of the second stage through burning up on re-entry. If this were to occur, the sound from these fragments would likely be less intense but with multiple pulses near-simultaneously. These acoustic properties are similar to the sound produced by explosive detonation in the marine environment. As considerably more is known about the sound emissions of explosives, this source has been used a proxy for the sound emitted by returning RFA ONE NOM Launch Vehicle components in this assessment.

10.10.60 Explosive noise is characterised as broadband i.e., occurs across a wide frequency range, with a peak energy content in the low frequency bands of 63-500 Hz (Paro et al., 2015). It has a high peak sound pressure level that can exceed 200 dB re 1µPa at distances around 200-300 m distance from the source (Paro et al., 2015).

10.10.61 Due to the high intensity of the noise, it is possible that marine receptors in the immediate vicinity (i.e., metres) of the impact would experience physiological trauma and therefore experience a mortality effect. At increased distances, the severity of the response will decrease. Noise from sea ice impact of the second stage is likely to propagate through the sea ice, however attenuation is higher than in sea water (Mikhalevsky, 2001), and little transference from surface impact into the sub-ice aquatic marine environment is predicted. As biological noise is concentrated in the marginal ice zones near the edge of the sea ice, noise generated from impact is not likely to cause significant disturbance.

10.10.62 As explosive noise is broadband, with peak content in the low frequency band, it falls within the hearing range of many marine ecological receptor groups. All fish species have a hearing range that overlaps this low frequency band, including hearing specialists (such as Atlantic herring) and hearing generalists (such as basking sharks). All marine mammal hearing groups, including low-, mid- and high- frequency cetaceans, and pinnipeds in water, would be able to detect the noise produced as it falls within the lower end of their hearing range (NOAA, 2018). Zooplankton have been shown to be sensitive to low frequency underwater noise from seismic sources which produce sound in a similar frequency range to explosions (McCauley et al., 2017).

10.10.63 The potential impact ranges for the different receptors are as follows. The assessment of impact ranges has been based on an environmental assessment of drilling and blasting by National Grid (2018). In this assessment, the maximum injury ranges were as follows: 104 m for low-frequency cetaceans; 43 m for mid-frequency cetaceans; 171 m for high-frequency cetaceans; 65 m for phocid pinnipeds; and 14 m for fish. The maximum disturbance ranges were: 139 m for low-frequency cetaceans; 57 m for mid-frequency cetaceans; 227 m for high-frequency cetaceans; and 87 m for phocid pinnipeds (fish were not assessed for disturbance). With regards to zooplankton, McCauley et al. (2017) reported that, for seismic airguns, impacts were reported out to the maximum 1.2 km sampled.

10.10.64 The Proposed Project will have a maximum of up to 10 launches per year, therefore the longevity of the potential impact is high. The frequency of the impact is low at up to maximum two launches per month. The returning RFA ONE NOM Launch Vehicle components will create an impact zone with a radius of 10s of metres for seabirds, 14 m for fish, 277 m for marine mammals, 1.2 km for plankton. The spatial extent of these impact zones is low when compared to the total available habitat within the EZI for these marine ecological receptors.

10.10.65 A low frequency and spatial extent, combined with a high longevity, result in a moderate exposure of ecological receptors to direct strike from the returning component.

10.10.66 The likelihood of a severe disturbance impact occurring is considered to be very low. Should it occur, it is expected that only a low proportion of the population would be affected (in the region of <0.01%). The proportion of the population that could experience a minor disturbance effect could be an order of magnitude greater, as the impact zones for such effects are typically larger, but this would still be a small proportion in the context of the population. As such, it is considered that the impact of disturbance from the component returning would not affect the baseline nor be detectable above the natural variability. Therefore, the magnitude of effect is negligible.

10.10.67 A high sensitivity, combined with moderate exposure, and negligible magnitude, mean that the risk to ecological receptors (plankton, fish, marine megafauna, seabirds) in the EZI from disturbance by the returning components is negligible. **No likely significant effect.**

Thermal effects of jettisoned objects

10.10.68 While it is likely that the RFA ONE NOM Launch Vehicle component will have associated thermal energy, any heating of the marine environment will be highly localised. There is the potential under certain conditions for fragments of debris to impact with sea ice, however for the majority of launches this is unlikely. Sea ice extent is variable across years and seasons, and the RFA ONE NOM Launch Vehicle has the potential for launch along a broad range of trajectories, obfuscating detailed analysis of interactions with debris. Heated debris from any second stage impacts with sea ice are predicted to cool quickly through exposure to low air temperatures and thick sea ice surface. Tidal and wind driven currents will allow for heated water to dissipate into the surrounding waters rapidly. It is highly unlikely that any marine receptors will be impacted as a result of these temporary heating events, nor is it likely (for sea ice impacts) for thermal effects from debris to have any effect on melting of sea ice beyond the direct footprint. Due to heating being highly localised and temporary, thermal effects are likely to have a footprint similar to those determined for Direct Strike effects. Thermal effects are therefore considered negligible. **No likely significant effect.**

Visual Disturbance

10.10.69 Once the RFA ONE NOM Launch Vehicle component has impacted the surface of the marine environment, it will likely remain at the water surface for a short time before sinking through the water column (with the exception of materials with specific gravity lower than seawater). Whilst it is at the surface or in the water column there is the potential for visual disturbance to marine ecological receptors. The component will be stationary once in the water, moved only by the ocean movements. The size of the component will be a maximum of 21 m × 2.1 m, corresponding with the size of the first stage. In essence, it is anticipated to behave like a large item of marine litter and will therefore be difficult to predict in terms of sinking rate or likelihood of washing up on coastlines. For example, movements may be dependent on near-surface currents, surface current, wind, and wave action. This evidence gap should be addressed by independent research, that is outside of the scope of this assessment.

10.10.70 For some trajectories, debris from the second stage has the potential to impact with, and remain on, the sea ice. Whilst on the sea ice there is a high potential these fragments will be covered by snow. The impact area is predicted to fall within an area of partial summer melt and partial multi-year sea ice; therefore, debris has the potential to rest on sea ice for multiple years, but may also enter the water column and sink during periods of increased ice melt. It is considered unlikely that the debris will cause any significant visual disturbance to marine ecological receptors. If the debris were to enter the marine environment, the effects would fall within the scope of those outlined here for an aquatic marine impact.

10.10.71 In general, fish species are not considered sensitive to visual disturbance (Natural England, 2017). Though basking shark has been observed to show visual disturbance from moving craft, they are unlikely to show a response to a stationary object (Natural England, 2017). Fish are therefore not considered sensitive to potential visual disturbance from the components in the water. Marine mammals have been observed showing behavioural response to non-motorised craft, which is almost certainly due to visual disturbance as opposed to noise disturbance (Natural England, 2017). However, the likelihood of a behavioural response occurring is variable. To illustrate, only half of common bottlenose dolphin encounters with kayaks in Cardigan Bay resulted in the dolphins moving away (Natural England, 2017). It is considered highly unlikely that the stationary presence of a RFA ONE NOM Launch Vehicle component would cause any impacts, therefore marine mammals are also not considered further for visual disturbance.

10.10.72 Seabirds have been reported as showing visual disturbance to vessels whilst in air and also on water (Natural England, 2017). Similarly, certain species of seabird have been reported to avoid large anthropogenic structures in the marine environment such as wind farms, though these cover a much larger extent than the proposed components. The distance at which birds typically initiate a flight response and flush from an area as a result of visual disturbance is typically <40 m (Natural England, 2017). This disturbance distance is applicable to the scenario of the RFA ONE NOM Launch Vehicle component floating towards seabirds loafing on the sea surface. The most sensitive seabirds have been assumed to show a visual disturbance effect up to 4 km from large marine infrastructure such as windfarms. As windfarms are several orders of magnitude larger than the size of RFA ONE NOM Launch Vehicle components, with an associated high degree of visibility/sightlines above relative sea level, it is anticipated that the disturbance zone for the component would be several orders of magnitude smaller than this i.e., in the tens of metres.

10.10.73 The marine ecological receptor groups that have the potential to are either commercially, environmentally and/or culturally important and therefore for the purpose of this assessment have been ascribed a high value.

10.10.74 A high ecological and cultural value, combined with no tolerance, adaptability, and recoverability, results in the aforementioned ecological receptors having a high sensitivity to disturbance effects from returning launch vehicle components within the EZI.

10.10.75 A low frequency and spatial extent, combined with a high longevity, result in a moderate exposure of ecological receptors to direct strike from the returning component.

10.10.76 The likelihood of a severe disturbance impact occurring is considered to be very low. Should it occur, it is expected that only a low proportion of the population would be affected (in the region of <0.01%). The proportion of the population that could experience a minor disturbance effect could be an order of magnitude greater, as the impact zones for such effects are typically larger, but this would still be a small proportion in the context of the population. As such, it is considered that the impact of disturbance from the component returning would not affect the baseline nor be detectable above the natural variability. Therefore, the magnitude of effect is negligible.

10.10.77 A high sensitivity, combined with moderate exposure, and negligible magnitude, mean that the risk to ecological receptors (plankton, fish, marine megafauna, seabirds) in the EZI from disturbance by the returning RFA ONE NOM Launch Vehicle components is negligible. **No likely significant effect.**

Displacement of Fish

10.10.78 The commercial fishing activity in the EZI is described in Appendix 10.2. The EZI comprises an important area for commercial fisheries from several different nations, with primarily benthopelagic and pelagic fish targeted. Figure A10.7 displays commercial fishing vessel activity, as recorded by AIS transmission, showing that most AIS datapoints are located in the southern portion of the EZI, with decreasing effort with distance north. As the fisheries industry in the EZI is valuable and culturally important to several countries, the receptor is considered to have a high value.

10.10.79 The landing of the components on the sea surface may indirectly impact commercial fisheries. If the component lands in a productive fishing ground, target fish species may be disturbed and displaced from the location, thus reducing the productivity of said fishing ground. Whilst displacement can be considered an adverse impact, it is possible that this impact will act as mitigation against the displacement of fishing vessels. If the landing of the component displaces target fish species from the impact zone, the abundance of fish in other fishing grounds may increase. As fish species are highly mobile, they have a high tolerance and adaptability to displacement.

10.10.80 Due to their mobility, and the short period of impact and low magnitude of disturbance, fish species will be able in return to the impact zone within a short timescale of the component passing through. Therefore, the recoverability of fish stocks is high.

10.10.81 Despite the high value, a high tolerance, adaptability, and recoverability result in fish stocks having a low sensitivity to displacement caused by the components entering the marine environment.

10.10.82 The Proposed Project will have a maximum of up to 10 launches per year. Therefore, the frequency of the impact is low at maximum up to two launches per month. Although the full licence term is considered to have high longevity, displacement to fishing stock is predicted to happen only on a short-term scale whilst the RFA ONE NOM Launch Vehicle component is present in that specific area. Therefore, the longevity of the impact has been reduced to low to reflect this short time period per impact.

10.10.83 As evidenced by the AIS data (displayed in Figure A10.7), fishing grounds in the EZI are wide-spread and of high spatial extent. The impact zone around a component is extremely small in comparison to the fishing grounds. Therefore, the spatial extent of the impact is low.

10.10.84 A low frequency, longevity, and spatial extent result in a low exposure of fish stocks to displacement caused by the returning component.

10.10.85 Fish are highly mobile and often make use of a range of habitats and rarely remain in one specific location for extended periods. As the displacement caused by the returning components is of small spatial and temporal scale, the magnitude of impact in terms of baseline and natural variability is negligible.

10.10.86 Low sensitivity, combined with low exposure and negligible magnitude, mean that the risk to fish stocks from displacement caused by the returning RFA ONE NOM Launch Vehicle components is negligible. **No likely significant effect.**

Damage to Human Infrastructure (Subsea Cables/Pipelines)

10.10.87 As described in Appendix 10.1 there are several subsea cables and pipelines in the EZI, concentrated in the southern portion of the area. The subsea cables are operated by companies of several different nationalities and are of significant commercial and communications value to the countries where cable landfall is made. The oil and gas pipelines in the EZI supply nearby countries with hydrocarbons, and so is also of significant value. Accordingly, subsea cables and pipelines in the EZI as a whole has been ascribed a high value.

10.10.88 The landing of the components at the seabed may directly impact subsea cables and pipelines in the EZI. If the component lands on such infrastructure, there is a possibility that the integrity of the cable or pipeline would be compromised, and significant structural damage could occur. The likelihood of this is reduced where such infrastructure is buried, however for the purpose of this assessment it is assumed that they are not buried. If a subsea cable or pipeline was compromised it would not be possible to tolerate, adapt, or recover from the impact (without anthropogenic intervention).

10.10.89 Due to the high value, and lack of tolerance, adaptability, and recoverability from the worst-case scenario effects, subsea cables and pipelines are considered to have high sensitivity to direct impact via deposition of material on the seabed.

10.10.90 The Proposed Project will have a maximum of up to 10 launches per year. Although the licence term has a high longevity, with a high associated number of launches, the likelihood of a RFA ONE NOM Launch Vehicle component impacting the same subsea cable or pipeline is extremely low, considering the total extent over which the component could enter the marine environment. Therefore, the frequency of the impact has been reduced to low to reflect this.

10.10.91 Subsea cables and pipelines are restricted in their distribution in the EZI. It is anticipated that the maximum size of any single component that comes to rest on the seabed will be a maximum 21 m × 2.1 m, to which the footprint of the impact will be limited. The receptor will therefore be impact over a low spatial scale.

10.10.92 An overall low longevity and spatial extent result in a low exposure of benthic habitats to direct loss caused by the returning component.

10.10.93 There is no natural variation in subsea cables and pipelines as they are a constant presence on the seabed. Any potential impact to subsea cables or pipelines would cause a measurable change to the baseline, though this change would be temporary as it would require reparation. In addition, it is noted that, considering the small footprint of the impact, and the total area over which the RFA ONE NOM Launch Vehicle components will return, the likelihood of the impact occurring is negligible. Therefore, the magnitude of impact is low.

10.10.94 High sensitivity, combined with low exposure and low magnitude, mean that the risk to subsea cables and pipelines from direct impact of returning RFA ONE NOM Launch Vehicle components is minor. **No likely significant effect.**

Interference with Military Exercise Areas

10.10.95 As described Appendix 10.1, the EZI is utilised for military exercises by a variety of nations on an intermittent basis. Military activities are of significant financial and defence importance, and therefore have been assigned a high value.

10.10.96 Any military activity that occurs in the EZI concurrently with the return of RFA ONE NOM Launch Vehicle components has the potential to be affected. It is anticipated that, to ensure navigational safety, an exclusion zone will be implemented around the predicted landing position of the returning component. As the return to Earth of the components are monitored, communication with vessels operating nearby will be maintained to provide updates on the location and predicted impact zone of the components.

10.10.97 If the impact zone of a RFA ONE NOM Launch Vehicle component is within an operational military exercise area, any vessels in the location would be temporarily displaced/excluded. Displacement or exclusion of military vessels whilst on transit could result in increased expenditure on fuel and sundries, and increased time for vessels to reach their destination due to having to take alternative routes/detours. Displacement of military vessels whilst on exercise would perhaps cause them to relocate the exercise, but this is unlikely to cause significant issues as the exercises are not location-specific (at the fine-scale of several kilometres). Therefore, with standard safety and communications in place, military activities are considered to have a high tolerance and adaptability to displacement, as military vessels are mobile and can easily adjust their course and positioning as required.

10.10.98 Once the RFA ONE NOM Launch Vehicle and associated exclusion zone has passed, military vessels would be able to return to the area immediately. Therefore, military vessels have a high recoverability to displacement effects.

10.10.99 A high value, and high tolerance, adaptability, and recoverability, mean the sensitivity of military exercises within the EZI to displacement from returning components is low.

10.10.100 The Proposed Project will comprise a maximum of 10 launches per year. Although the licence term has a high longevity, with many associated launches, the exclusion zones will only be in place for the duration of the return of the RFA ONE NOM Launch Vehicle, and therefore the longevity of the impact has been reduced to low to reflect this short time period per launch. Furthermore, to our knowledge, military exercises are not regular and only occur on an intermittent basis in the EZI and so the frequency of exposure is further reduced.

10.10.101 In order to be precautionary, it is assumed that components could return anywhere within the EZI. There is therefore the potential that the components could return in an area of military exercise. However, it is noted that such exercises are not spatially restricted in the EZI, and indeed could occur over large areas. The small spatial extent of the exclusion zone, which will be limited to the immediate vicinity of the RFA ONE NOM Launch Vehicle return, will therefore affect a small proportion of the total area that could be used by military activity. Therefore, the spatial extent of the impact is low.

10.10.102 A low frequency, high longevity, and low spatial extent result in a low exposure of military activity to displacement from returning components.

10.10.103 Vessels are mobile and are often required to relocate for a variety of reasons, including adverse weather and displacement from other vessels. As the displacement caused by returning components of small spatial and temporal scale, the magnitude of impact in terms of baseline and variability is negligible.

10.10.104 Low sensitivity, combined with low exposure and negligible magnitude, mean that the risk to military activities from interference arising from is negligible. **No likely significant effect**.

Impacts to Vessel Navigation Including Floating Debris, Changes to Topography and Re-routing of Vessel Traffic

10.10.105 As described in Appendix 10.1, shipping and commercial fishing activity within the EZI is relatively high. In particular, the southern portion of the EZI, which has considerable fishing effort (Figure A10.7) and is a main area of vessel traffic (Figure A10.5) and shipping density (Figure A10.6). Due to this level of activity, it is possible for returning components and the associated exclusion zone to have an impact on shipping and commercial fishing vessels. The high level of activity indicates the financial importance of the area to the surrounding countries; therefore, the value of the receptor is high.

10.10.106 It is anticipated that, to ensure navigational safety, an exclusion zone will be implemented around the predicted landing position of the returning component. At the time of writing, it is not expected that any components will be recovered. As the return of the component is monitored, communication with vessels operating nearby will be maintained to provide updates on the location and predicted impact zone of the component.

10.10.107 If the impact zone of a RFA ONE NOM Launch Vehicle is within fishing grounds or along vessel transit routes, any vessels in the location would be temporarily displaced. Displacement of vessels or interruptions to transit routes can result in increased expenditure on fuel and increased time for vessels to reach their destination due to having to take alternative routes/detours. Displacement of fishing vessels from fishing grounds can result in loss of income as catch per unit effort is likely to be reduced if alternative productive fishing grounds cannot be exploited whilst the temporary exclusion zone is in place. The majority of the EZI is offshore therefore it is anticipated that most fishing vessels and shipping in the area will be large and so able to adapt their movements. Therefore, with standard safety and communications in place, shipping and commercial fishing activities have high tolerance and adaptability, as vessels are mobile and can easily react to adjust their course and positioning as required.

10.10.108 Once the RFA ONE NOM Launch Vehicle component has entered the marine environment, exclusion zones can be removed and therefore transiting vessels and active fishing vessels can return to normal operation immediately. The recoverability is therefore considered high.

10.10.109 A high value, and high tolerance, adaptability, and recoverability, mean the sensitivity of shipping and commercial fishing activities within the EZI to displacement from returning components is low.

10.10.110 The Proposed Project will have a maximum of up to 10 launches per year. Although the licence term has a high longevity, with many associated launches, the exclusion zones will only be in place for the duration of the return of the RFA ONE NOM Launch Vehicle, and therefore the longevity of the impact has been reduced to moderate to reflect this short time period per launch.

10.10.111 In order to be precautionary, it is assumed that components could return anywhere within the EZI and could be present on the water surface (floating), within the water column, or on the seabed. There is therefore the potential that the components could return in an area of high shipping density such as near the coast of a landmass, or in a key fishing area. However, it is noted that such areas of high fishing and shipping activity are widespread in the EZI. The small spatial extent of the exclusion zone, which will be limited to the immediate vicinity of the component return, will therefore affect a small proportion of the total area used highly by shipping and fishing vessels. Therefore, the spatial extent of the impact is low.

10.10.112 A low frequency, moderate longevity, and low spatial extent result in a low exposure of shipping and commercial fishing activity to displacement from returning components.

10.10.113 Vessels are mobile and are often required to take alternative routes or use other fishing grounds for a variety of reasons, including adverse weather and displacement from other vessels. As the displacement caused by returning RFA ONE NOM Launch Vehicle components of small spatial and temporal scale, the magnitude of impact in terms of baseline and variability is negligible.

10.10.114 Low sensitivity, combined with low exposure and negligible magnitude, mean that the risk to shipping and commercial fishing activities from interference arising from launches is negligible. **No likely significant effect**.

Damage to Marine Archaeology/Shipwrecks

10.10.115 As described in Appendix 10.1, it has not been possible to determine the extent of the presence of marine archaeological features in most of the EZI. For the purpose of this assessment, however, it is assumed that marine archaeological features are present and so have the potential to be impacted by the proposed operations.

10.10.116 The value of marine archaeological features can vary depending on the feature type and level of preservation. As a worst-case scenario, it is assumed that any given marine archaeological feature in the EZI has a high value, due to its cultural and historical significance.

10.10.117 The landing of the components at the seabed may directly impact marine archaeological features in the EZI. If the component lands on such a feature, there is a possibility that the integrity would be compromised, and significant structural damage could occur. The likelihood of this is reduced where such infrastructure is buried, however for the purpose of this assessment it is assumed that they are not buried. If a marine archaeological feature were compromised it would not be possible to tolerant, adapt, or recover from the impact.

10.10.118 Due to the high value, and lack of tolerance, adaptability, and recoverability from the worst-case scenario effects, marine archaeological features are considered to have high sensitivity to direct impact via deposition of material on the seabed.

10.10.119 The Proposed Project will have a maximum of up to 10 launches per year. Although the licence term has a high longevity, with many associated launches, the likelihood of the RFA ONE NOM Launch Vehicle components impacting the same marine archaeological features is negligible considering the total extent over which the components could enter the marine environment. Therefore, the frequency of the impact has been reduced to low to reflect this.

10.10.120 It is anticipated that the maximum size of any single component that comes to rest on the seabed will be a maximum 21 m × 2.1 m, to which the footprint of the impact will be limited. The RFA ONE NOM Launch Vehicle components are expected to sink through the water column and come to rest at a single place at the seabed, and not move once at the seabed, thereby only impacting the features directly within the footprint the receptor will therefore be impact over a low spatial scale.

10.10.121 An overall high longevity, low frequency and low spatial extent result in a low exposure of marine archaeological features to direct loss caused by the returning component.

10.10.122 There is no natural variation in the presence of marine archaeological features although the amount of coverage by sediment may vary with time. Any potential impact to marine archaeological features would cause a measurable change to the baseline, though it is noted that there may not be a record of this change the eventual location of the component will not be monitored. In addition, it is noted that, considering the small footprint of the impact, and the total area over which the RFA ONE NOM Launch Vehicle component may return, the likelihood of the impact occurring is extremely low. Therefore, the magnitude of impact is low.

10.10.123 High sensitivity, combined with low exposure and low magnitude, mean that the risk to marine archaeological features from direct impact of returning RFA ONE NOM Launch Vehicle components is minor. **No likely significant effect**.

Aeronautical Events – Water Strike Following Failure During Flight

10.10.124 Chapter 9 Accidents and Disasters of this AEE considers major accidents that could occur during the project life cycle, in terms of those with serious effects on the environment. One type of accidental event would be an off-nominal flight failure resulting in impact of the RFA ONE NOM with the marine environment. The predicted magnitude of effects of such an event are not considered 'major', therefore an assessment of the effects of failure during flight has been considered in this chapter, rather than Chapter 9.

10.10.125 There is the potential for failure of the RFA ONE NOM during flight. The worst-case scenario would be the loss of the entire RFA ONE NOM before any of the routine separation phases, as this would lead to the maximum quantity of RFA ONE NOM material potentially entering the marine environment at a single location, i.e., impact zone.

10.10.126 Due to their northerly trajectory and flight planning strategy, RFA ONE NOM Launch Vehicles are mainly above water once they have left the Proposed Project, therefore it is assumed that any failure during would result in the RFA ONE NOM entering the marine environment rather than coming down over land. The receiving marine environment of any flight failures is described in Appendix 10.1.

10.10.127 The worst-case scenario is to assume that the RFA ONE NOM components do not burn up, and instead enter the marine environment whole. This is similar to the worst-case scenario of a failure during flight, except that in a failure during flight the entire RFA ONE NOM Launch Vehicle may enter the marine environment at a single impact zone, rather than several impact zones associated with the separate return of the stages and fairings. Nonetheless, the impact pathways that may arise can be considered as the sum of the impacts at the separate impact zones.

10.10.128 The assessment is based on the return of Stage 1 to the marine environment, as it comprises the largest single part of the RFA ONE NOM Launch Vehicle and is assumed to be intact upon entering the marine environment. The addition of the remainder of the RFA ONE NOM components does not greatly add to the total infrastructure mass entering the marine environment and is therefore not expected to result in a greater significance of effect than for Stage 1 alone. To illustrate, Stage 1 comprises approximately 50% of the total length and 75% mass of a RFA ONE NOM Launch Vehicle (described in Table 10.6) and contains all the indicative materials present in the RFA ONE NOM Launch Vehicle.

Therefore, it is considered that the results of the impact assessment undertaken for Stage 1 entering the marine environment is applicable to the event of the entire RFA ONE NOM Launch Vehicle entering the marine environment. The conclusion of negligible or minor risk of likely significant effect on the receptors is considered applicable. **No likely significant effect**.

10.10.129 There is one difference to the impact assessment of the full RFA ONE NOM compared to Stage 1 only; consideration of propellant left upon re-entry. In the case of a failure during flight, it is possible that the vast majority of the propellant will be unused and therefore could enter the marine environment. This would be the worst-case scenario in terms of potential hydrocarbon pollution to the marine environment. Assuming that the amount of propellant at launch remains upon entry, there is the potential for a surface film of up to 7.5 square nautical miles or ~26 km^2 to form in the marine environment (assuming 1,000 US gallons/3,785 L are present per square nautical mile of coverage and a propellant capacity of 22,500 kg). Though this area is larger than the area of surface film predicted for routine events, the duration of the film will remain low (a day or less). The environmental effects are still predicted to be low (as per the assessment of this pathway, underpinned by NOAA (2019)), therefore there is predicted to be minor risk to the environment as a result of fuel release due to RFA ONE NOM flight failure.

10.11 Additional Mitigation

10.11.1 No additional mitigation has been proposed to mitigate the effects from the aforementioned pathways.

10.12 Residual Effects

Effects on Water, Sea Ice, and Sediment Quality and, Ecological Receptors from Fuel Spillage

10.12.1 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

Effects on Water, Sea Ice, and Sediment Quality, and Ecological Receptors from Metal Corrosion and Toxic Contamination

10.12.2 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

Effects on Water, Sea Ice and Sediment Quality, and Ecological Receptors from Debris and Microplastics (Including Ingestion)

10.12.3 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

Smothering of Marine Organisms, Habitat Alteration (Including Reef Effects) and Habitat Loss via Deposition of Material on the Seabed or Sea Ice

10.12.4 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

Direct Strike

10.12.5 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Acoustic Disturbance (including Underwater Noise) from the Impact of the Jettisoned Objects Hitting the Sea Surface or Sea Ice

10.12.6 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Thermal Effects from Jettisoned Objects

10.12.7 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Visual Disturbance

10.12.8 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Displacement of Fish

10.12.9 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Damage to Human Infrastructure (Subsea Cables/Pipelines)

10.12.10 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

Interference with Military Exercise Areas

10.12.11 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Impacts to Vessel Navigation Including Floating Debris, Changes to Topography and Re-routing of Vessel Traffic

10.12.12 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is negligible. **No likely significant effect**.

Damage to Marine Archaeology/Shipwrecks

10.12.13 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

Aeronautical Events – Water Strike Following Failure During Flight

10.12.14 No additional mitigation is required to mitigate this impact. The residual risk of the impact pathway is minor. **No likely significant effect**.

10.13 Cumulative Assessment

10.13.1 The cumulative assessment aims to determine the potential for effects of the Proposed Project to combine with other 'reasonably foreseeable projects and plans'. Reasonably foreseeable projects can comprise projects that are planned but not yet operational, be they under construction, or under approval for construction. Projects and plans that are fully implemented and in operation are not considered under the cumulative assessment as they will have been considered under the baseline environment within each of the chapters.

Identification of Projects and Plans

10.13.2 The key sources utilised to provide a long list of reasonably foreseeable plans and projects are:

- 4C Offshore Global Offshore Wind Map;
- Submarine Cable Map;
- KIS-ORCA Offshore Renewables and Cables Awareness;
- Marine Scotland's National Marine Plan interactive site;
- The Crown Estate Scotland maps;
- UK North Sea Transition Authority;
- Norwegian Petroleum Directorate;
- NATO exercises website (https://shape.nato.int/nato-exercises); and
- Shetland Islands Draft Regional Marine Plan.

10.13.3 All reasonably foreseeable plans and projects that have the potential to act cumulatively with the marine effect pathways associated with the Proposed Project are presented in Table 10.8. Plans and projects have been identified for offshore wind, marine renewables, oil and gas, and subsea cables. With regard to the sectors of military, recreation and tourism, and disposal sites, no proposed plans or projects have been identified.

10.13.4 Shipping and navigation, commercial and recreational fishing, and tourism, have not been considered as future projects and plans for the purposes of this cumulative assessment. Although it is understood that these sectors may increase over time in the EZI, this is not as part of any specific plan or project. The potential impacts to these receptors as a result of cumulative effects has been considered.

10.13.5 Table 10.9 details which of the effect pathways included in the assessment are applicable to each of the projects or plans. The pathways which have the potential to act cumulatively between the Proposed Project and the reasonably foreseeable projects and plans have been taken forward in the assessment.

Table 10.8 All reasonably foreseeable plans and projects in the Environmental Zone of Influence

Plan/Project	Description	Location	Stage	Source
Hywind Tampen Floating Offshore Wind Farm	The Hywind Tampen is being developed by Equinor ASA in Norwegian waters. The windfarm capacity is 88 MW and will comprise floating turbines.	Norway, adjacent to the south-east corner of the EZI	Pre-construction	4COffshore (2020)
Celtic Norse Subsea Cable	The Celtic Norse cable will be ready for service in 2022. It connects Grindavik, Iceland, Killala, Ireland, Caithness, Scotland, and Øysanden, Norway. It is approximately 2,000 km in length and is owned by Eidsiva Energi, NTE, and TrønderEnergi.	Norway, Iceland, Scotland, crossing the southern part of the EZI	Pre-construction	Submarine Cable Map (2020)
UK Offshore Licensing Round for Oil and Gas	There have been several UK Offshore Licensing rounds for Oil and Gas in recent years, most recently the 32nd Offshore Licensing Round in 2019. These licensing rounds have included blocks and part-blocks in the EZI. It is likely that a proportion of these recently licensed blocks will be developed, either by drilling exploration wells, undertaking seismic surveys, or field development planning.	West of Shetland, Faroe-Shetland Basin, East Shetland Platform	Exploration and Pre-development	Oil and Gas Authority (2020; Now the North Sea Transition Authority)
Norway Offshore Licensing Round for Oil and Gas	Similar to the UK, Norway also undertakes licensing for its offshore oil and gas blocks. The latest announcement of new blocks up for award in pre-defined areas was in June 2020. Blocks awarded in previous rounds may be developed in the future	Norwegian waters of the EZI. Examples of overlapping blocks are Licence 933 and 993	Exploration and Pre-development	Offshore Mag (2020) Norwegian Petroleum Directorate (2020)
Faroese Licensing Round for Oil and Gas	Similar to the UK, the Faroe Islands also undertakes licensing rounds for its offshore oil and gas blocks. In 2019 the 5th Faroese Licensing Round occurred, in conjunction with the UK's 32nd Licensing Round. The blocks on offer were near to the boundary of the UKCS. There is therefore potential for future oil and gas exploration and production in these blocks.	Faroese waters of the EZI, specifically in the south-west of the EZI near the border with the UKCS	Exploration and Pre-developm	Jardfeingi (2019)

Plan/Project	Description	Location	Stage	Source
Jan Mayen oil exploration	There has been interest in the potential oil and gas reserves of Jan Mayen. Although there have been no recent updates on progress (in the last five years), there is the potential that exploration and production activities could occur in the future.	Jan Mayen EEZ of the EZI	Exploration and Pre-development	Reuters (2013)
Faroe Islands marine renewable energy	Minesto has signed an agreement to install two tidal kites in Faroese waters. Site development is in progress; installation of the first kite happened in Q2 2020, with the second unit also planned for 2020.	Faroese coastal waters, just outside the EZI	Pre-construction	Minesto (2020)
Space Hub Sutherland	Space Hub Sutherland EIA report identifies Risk Assessment Study Area (area of likely debris impact zones).	Faroese coastal waters, within and just outside the EZI	Pre-construction	Planning application reference 20/00616/FUL

Table 10.9 Screening exercise assessing which of the pressures relevant to the Proposed Project apply to other projects screened in for cumulative assessment

Key: ✓ = pressure applied to both projects; × = no exposure pathway for this pressure from the other project

Plan/Project	Fuel Spillage	Metal Corrosion	Microplastics	Disturbance/ Displacement/ Interference	Impact At Seabed	Direct Strike
Hywind Tampen Floating Offshore Wind Farm	×	✓	×	✓	✓	×
Celtic Norse Subsea Cable	×	×	✓	✓	✓	×
UK Offshore Licensing Round for Oil and Gas	✓	✓	✓	✓	✓	×
Norway Offshore Licensing Round for Oil and Gas	✓	✓	✓	✓	✓	×

Plan/Project	Fuel Spillage	Metal Corrosion	Microplastics	Disturbance/ Displacement/ Interference	Impact At Seabed	Direct Strike
Faroese Licensing Round for Oil and Gas	✓	✓	✓	✓	✓	×
Jan Mayen oil exploration	✓	✓	✓	✓	✓	×
Faroe Islands marine renewable energy	×	✓	×	✓	✓	×
Space Hub Sutherland	×	✓	✓	✓	✓	✓

Methodology

10.13.6 The potential cumulative effects of the plans and projects listed in Table 10.8 are considered on individual receptors in the subsequent sections. It should be noted that there is limited information on the plans and projects that are less progressed, and therefore less certainty on the potential cumulative effects of the projects.

10.13.7 As part of the AEE Report, the effect upon a receptor may be concluded as negligible or minor risk. However, an effect that has negligible or minor risk from the project alone cannot be ruled out from the cumulative assessment as there is the potential for an increased risk as effects may accumulate with other plans or projects. Therefore, all effects for which there are pathways with the receptors have been considered.

10.13.8 The assessment of cumulative effects between the project and the associated EZI and other plans and projects takes into account the:

- Potential for project/plan effect envelopes to overlap temporally and spatially with a specific receptor;
- Magnitude of cumulative effect (where known or possible to deduce); and
- Receptor-specific sensitivity (including their value), as determined as part of the AEE Report process.

Assessment

10.13.9 In recognition of the level of information availability regarding the projects screened into this assessment, a detailed matrix-based risk (impact) assessment (see methodology detailed in Section 10.4) is not feasible. Expert judgment is used to consider all information available and determine the potential for combination of effects to cause increased effects on regional fish and shellfish populations.

Water Quality

10.13.10 Sections 10.9.5,10.9.16 and 10.9.23 provide a risk assessment of the potential impacts on the water quality environment from the Proposed Project. The potential effects on water quality are the increase in hydrocarbons from fuel spills, metal from corrosion, and microplastics.

10.13.11 With the exception of Space Hub Sutherland, the projects and plans detailed in Table 10.9 all comprise construction in the marine environment. The primary material used for construction will be metals for most projects (such as oil and gas, offshore wind etc), with subsea cables comprising plastic (on the outer layer) and metal. All infrastructure placed in the marine environment as part of these projects will have been designed to have a long lifespan with minimal breakdown as this would impact infrastructure integrity. Returning items from Space Hub Sutherland will likely be similar in nature to those of the Proposed Project. Therefore, the combined input of metals and microplastics as a result of identified projects in combination with the Proposed Project is negligible. **No likely significant effect**.

10.13.12 Microplastics may enter the marine environment from offshore platforms as part of the waste produced e.g., wastewater. However, this is controlled by international regulations and standard operating procedures to minimise the input (Press and Journal, 2018), therefore this input of microplastics alongside the Proposed Project is considered negligible. **No likely significant effect**.

10.13.13 Of the additional plans and projects, significant input of hydrocarbons will likely only arise from oil and gas operations. Hydrocarbons can enter the marine environment through accidental events such as spills or intentional means such as through the deposition of drill cuttings at the seabed. The oil and gas sector is governed by international regulations on drill cuttings (OSPAR Decision 2000/3 and Recommendation 2006/5) and has standard operating procedures to reduce the likelihood and severity of oil spills, thereby minimising the potential for hydrocarbon input into the marine environment. Taking into account the low likelihood and severity of hydrocarbon input from oil and gas projects, as well as the proposed launches, the in-combination risk is considered negligible. **No likely significant effect**.

Biodiversity Receptors

10.13.14 The potential effects on biodiversity receptors are the increase in contaminants (hydrocarbons, metal, microplastic), direct strike from components, disturbance and displacement from components, payloads and vessels, and direct loss of seabed habitat.

10.13.15 The results of the assessment of cumulative effects on water quality as a result of contaminant pathways is directly applicable to the biodiversity receptors within the marine environment. Accordingly, there is negligible risk of cumulative effects on biodiversity receptors as a result of contaminants from the Proposed Project in-combination with other reasonably foreseeable plans and projects. **No likely significant effect**.

10.13.16 The other projects and plans that also have the potential to result in direct strike of marine ecological receptors are Space Hub Sutherland and tidal arrays/kites. Impacts from returning items from Space Hub Sutherland will likely be similar in nature to those of the Proposed Project and considered not significant. Historically, the risk of collision from tidal arrays/kites has been of concern during developments and has resulted in significant pre-construction modelling and post-construction monitoring. At present there is still poor understanding of the real-life level of collision risk for marine ecological receptors. It is noted that, with regards to marine mammals, there have been no reports of collisions as the animals have been shown to instead display an avoidance response (NERC, 2013). Even though there is limited information, it is likely that the number of individuals lost from a population as a result of tidal turbines is low. To illustrate, collision risk modelling for MeyGen, Pentland Firth, Scotland, concluded that up to 243 salmon would collide with an array of 200 turbines per year. The number of individuals from other receptor groups that may be affected is likely to be much smaller (it is high in fish due to shoaling behaviour). In addition, the number of individuals affected is further reduced as it is highly unlikely that any tidal arrays or kites in the EZI would comprise such a large array. The subsequent low number of affected individuals is anticipated to comprise a negligible proportion of the marine ecological receptor populations in the EZI. Therefore, it is considered that the risk of mortality as a result of direct strike from the Proposed Project in combination with other projects is negligible. **No likely significant effect**.

10.13.17 The projects and plans detailed in Table 10.8 have the potential to disturb marine ecological receptors through either visual pathways, i.e. physical presence of the infrastructure and associated vessel traffic, or acoustic pathways i.e. through underwater noise emitted. The area of displacement associated with these projects is anticipated to be similar in scale to the displacement for the proposed project i.e., no more than several kilometres around the disturbance source. Perhaps one type of activity which could lead to larger areas of disturbance is piling, which can be used for fixing infrastructure to the seabed such as offshore wind or tidal devices, however it is not known if piling will be used for the additional projects. It is considered highly unlikely that the area of disturbance around a project or plan will overlap with the area of disturbance around returning RFA ONE NOM Launch Vehicle component, due to the safety issue of being nearby a returning launch vehicle. Therefore, the area of displacement is unlikely to increase due to two potential sources of effects within a single disturbance zone. No launches would occur simultaneously from Space Hub Sutherland and SaxaVord Spaceport and so no cumulative disturbance from this activity will occur. For other identified projects, there is the potential that the disturbance zones around projects in the EZI will be additive, increasing the total amount of area from which a marine ecological receptor is displaced. However, given the total habitat available to marine ecological receptors across the EZI, this is determined to have negligible risk at the population-level. **No likely significant effect**.

10.13.18 The benthic habitat in the EZI comprises predominantly deep-sea habitats that are expected to be homogeneous. Also present in the EZI are sensitive benthic habitats, VMEs and MPA features, however these are widespread and large in spatial extent, respectively. The majority of projects and plans detailed in Table 10.8 will have a limited seabed footprint as they comprise a single impact area, single infrastructure or a series of single infrastructure. The exception is the Celtic Norse subsea cable, which will have a considerably larger seabed footprint. All these projects will be required to undertake an assessment of the seabed conditions prior to development, including an assessment of benthic habitats with focus on any protected species or habitats. Should protected habitats be discovered, it is anticipated that the project location will be amended to minimise effects, as per international regulations and best practice. Therefore, due to the minimised effect from the proposed projects and plans, in conjunction with the extremely low likelihood of effect from the Proposed Project, the cumulative risk is considered negligible. **No likely significant effect**.

Human and Human Activities

10.13.19 The potential effects on humans and human activities are direct impact from RFA ONE NOM Launch Vehicle components at the seabed and disturbance and displacement from the RFA ONE NOM Launch Vehicle itself.

10.13.20 The two human activities which may be affected by pathways at the seabed are subsea cables and pipelines and marine archaeology. All of the proposed projects and plans detailed in Table 10.8 will result in some level of seabed disturbance due to emplacement of infrastructure. However, as the existing infrastructure at the seabed described in the baseline are already known, they will form part of the baseline assessment of future projects, prior to construction at the seabed. Therefore, avoidance of infrastructure should occur and negate the possibility that future projects and plans will affect pre-existing infrastructure at the seabed, such as subsea cables. Therefore, there is no pathway for these projects to act cumulatively with effects from launch operations as a result of Proposed Project or Space Hub Sutherland. Similarly, future projects and plans will have to undertake an assessment of the presence of marine archaeological features in the project footprint and minimise effects to these features through amending the location. Therefore, the likelihood that the proposed plans and project detailed in Table 10.8 will affect the marine archaeological features that have the potential to interact with the launch operations from the Proposed Project is mitigated through accepted best practice planning procedures and assessments.

10.13.21 The human and human activities in the EZI that utilise vessels have the potential to be affected via disturbance. No launches would occur simultaneously from Space Hub Sutherland and SaxaVord Spaceport and so no cumulative disturbance from this activity will occur. For other identified projects, Disturbance from the Proposed Project can arise during the return of RFA ONE NOM Launch Vehicle components. It is anticipated that an exclusion zone will be implemented around returning launch items, thereby excluding other human activities from the area on a temporary basis (the exact duration is not yet known). It is likely that future infrastructure projects (except subsea cables) will also implement an exclusion zone around the infrastructure, to ensure safety to navigation in their immediate vicinity (noting that subsea cable installation vessels also implement safety exclusion zones whilst installing the cables). In the case of oil and gas offshore platforms, such safety zones are typically 500 m (Step Change in Safety, 2017). The spatial extent of the area from which vessels are excluded will therefore be added to by each infrastructure project and associated exclusion zone. The cumulative area of exclusion is anticipated to be small in the context of the total area of navigation available to vessels. In the case of commercial fishing vessels, cumulative displacement from fishing grounds can result in loss of income as catch per unit effort is likely to be reduced. However, the exclusion zones around other future infrastructure will be permanent, as opposed to the temporary exclusion zone for the Proposed Project, therefore the fishers will have already modified their fishing areas to accommodate these zones. It is considered that the small size of the area of exclusion in the context of total area available to navigation, or the area available for fishing, will result in a negligible cumulative risk of the Proposed Project with other projects and plans. **No likely significant effect**.

Impact Zone Overlap with Space Hub Sutherland

10.13.22 Multiple launches within the Applicant's own EZI are not anticipated to produce significant cumulative effects due to the fact that the likelihood of RFA ONE NOM Launch Vehicle components from one launch impacting the same marine feature/area as those from another launch is considered to be negligible when taking into account the total extent over which the components could enter the marine environment. In the same way, components from RFA ONE NOM launches are highly unlikely ever to be deposited in the exact same area as those from launches from the Space Hub Sutherland, and therefore the potential for significant cumulative effects, particularly given the low frequency and number of launches proposed by the Applicant, is considered to be negligible. **No likely significant effect**.

Conclusion

10.13.23 Negligible risk has been determined for all receptors screened into this assessment for in combination effects from the Proposed Project with reasonably foreseeable plans and projects. **No likely significant effect**.

10.14 Summary

10.14.1 This chapter considers the marine and transboundary effects from the Proposed Project. Effects on the marine environment will arise from the return to earth of RFA ONE NOM Launch Vehicle components. Such marine effects may occur in Scottish waters or in the waters of other countries (i.e., transboundary effects), specifically; Denmark (Faroe Islands, Greenland), Iceland, and Norway (including Jan Mayen).

10.14.2 The EZI encompasses an area between the SaxaVord Spaceport and approximately 4,007 km north of the launch pad. The North Atlantic and Pacific EZIs encompass the expected impact zones associated with debris from the first and second stage and payload fairing. The third stage will enter orbit.

10.14.3 The EZI comprises mostly deep water with a small amount of continental shelf and many bathymetric features. The water quality of the EZI is high, in that it does not have significant local input of anthropogenic contaminants such as metals, microplastics, and hydrocarbons. The EZI supports numerous marine biota such as plankton, benthic habitats, fish and shellfish, seabirds, and marine mammals. The EZI has few marine protected areas (Drawing 10.3).

10.14.4 In the EZI, human activities are concentrated in the southern portion (as far as the Faroe Islands to the north). This includes shipping and navigation, oil and gas cables and pipelines, and commercial fishing (Drawings 10.4 – 10.6). There is occasional use of the area for military activities. Marine archaeology is poorly known and so assumed to be present. There is presence of oil and gas infrastructure, subsea cables and pipelines, marine renewable energy, dredge disposal sites, tourism, and marine archaeological features as shown on Drawings 10.4 – 10.6.

10.14.5 Launches have the potential to affect the aforementioned water quality, biodiversity and human activities. The pathways of effect have been identified: impacts from the presence of the RFA ONE NOM Launch Vehicle and associated materials, such as metals, microplastics, and hydrocarbons; impacts from direct strike and impact at the seabed from when the returning components come to rest.

10.14.6 The potential impacts on water quality, biodiversity, and human activities in the EZI have been assessed. All pathways have a negligible or minor risk of a likely significant effect on the receptors. **No likely significant effect**.

10.14.7 Because the risk is negligible or minor there is no requirement to apply mitigation in order to reduce the risk further. Accordingly, the residual effects to the receptors is also negligible or minor. **No likely significant effect**.

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Chapter 11 Summary of Environmental Effects

11. Summary of Environmental Effects

11. Summary of Environmental Effects

11.1 Introduction

11.1.1 The Summary of Environmental Effects provides a summary of effects of the Proposed Project, mitigation measures and the residual effects anticipated after mitigation measures have been applied.

11.2 Summary of Environmental Effects

11.2.1 Pre-mitigation and residual environmental effects are summarised in Table 11.1. The table provides a concise reference to each of the pre-mitigation and residual environmental effects identified in the technical sections of the AEE Report (with the exception of the Ornithology and Ecology Assessments), as well as a cross reference to the relevant mitigation measures identified.

11.2.2 Table 11.2 below provides a concise reference to each of the residual environmental effects identified to receptors in the Ornithology and Ecology Assessments of the AEE Report.

Table 11.1 Summary of Pre-mitigation and Residual Environmental Effects

Description of Effect	Pre-mitigation Effect			Mitigation Measure(s)	Residual Effect		
	Magnitude	Beneficial/ Adverse	Significance		Magnitude	Beneficial/ Adverse	Significance
Climate Change							
GHG emissions arising from operation.	Minor	Adverse	No likely significant effect	Applicant committed to procuring goods and services locally, where feasible.	Minor	Adverse	No likely significant effect
Damage to launch vehicle, pay load and lightning tower and delay of launches due to high wind speeds.	Moderate	Adverse	Potential significant effect	Applicant to suspend launch activities in high winds.	Minor	Adverse	No likely significant effect
Suspension of ferry routes and flights due to high wind speeds will limit access to the Proposed Project for launch cycle personnel and goods.	Minor	Adverse	No likely significant effect	Applicant to source materials in Shetland or as close to the Proposed Project as possible, where applicable.	Negligible	Adverse	No likely significant effect
Heavy precipitation resulting in flooding and erosion of access roads and limiting access for launch cycle vehicles.	Moderate	Adverse	Potential significant effect	SaxaVord Spaceport to maintain drainage system; ditches cut by spaceport operator in the flatter areas to aid drainage into natural streams. Applicant to comply with any relevant operational procedures required to implement and maintain drainage.	Minor	Adverse	No likely significant effect
Water ingress causing failure of electrical equipment (e.g., generators and deluge pumps)	Minor	Adverse	No likely significant effect		Negligible	Adverse	No likely significant effect
High temperatures causing site personnel welfare impacts such as heat stress	Minor	Adverse	No likely significant effect	Applicant to implement health and safety procedures e.g., provision of appropriate PPE.	Negligible	Adverse	No likely significant effect
Overheating of equipment and potential fire due to high temperatures.	Minor	Adverse	No likely significant effect	Deluge pumps to be designed and installed by the Applicant. Deluge system to maintained by the Applicant and SaxaVord Spaceport.	Negligible	Adverse	No likely significant effect
Air Quality							
Effects at sensitive ecological and human receptors from operational phase traffic emissions	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Effects at sensitive human receptors from launch event emissions	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Noise							
Non-launch noise from fixed and mobile plant	Minor	Adverse	No likely significant effect	SaxaVord Spaceport has committed to meeting derived noise limits at NSRs and appropriate specification of plant. Applicant to comply with any required noise limits.	Minor	Adverse	No likely significant effect
Noise and vibration from engine test and launches	Minor	Adverse	No likely significant effect	Applicant to engage in clear communication with the local community on the Proposed Project. Likely to fall within the wider SaxaVord Spaceport community engagement program.	Minor	Adverse	No likely significant effect
Road traffic noise	Negligible	Adverse	No likely significant effect	None proposed	Negligible	Adverse	No likely significant effect
Vibration from engine test and launches	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect
Accidents							
This subject has not been assessed in a manner comparable with other environmental aspects as it considers scenarios which are both theoretical and extreme rather than reasonably expected occurrences. Only the accidents and disaster scenarios considered likely to cause major adverse effects were considered, as is inherent to the scope of the chapter. The pre-mitigation effects are generally major, adverse and significant . Residual effects may remain similarly significant but this would be predicated on the combined failure of design, operational and physical mitigation measures.							

Description of Effect	Pre-mitigation Effect			Mitigation Measure(s)	Residual Effect		
	Magnitude	Beneficial/ Adverse	Significance		Magnitude	Beneficial/ Adverse	Significance
Marine and Transboundary Effects							
Effects on Sea Ice, Water, and Sediment Quality, and Ecological Receptors from Fuel Spillage.	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect
Effects on Sea Ice, Water, and Sediment Quality, and Ecological Receptors from Metal Corrosion and Toxic Contamination.	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect
Effects on Sea Ice, Water, and Sediment Quality, and Ecological Receptors from Debris and Microplastics (Including Ingestion).	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect
Smothering of Marine Organisms, Habitat Alteration (Including Reef Effects) and Habitat Loss via Deposition of Material on the Seabed or Sea Ice.	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect
Direct Strike.	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Acoustic Disturbance (including Underwater Noise) from the Impact of the Jettisoned Objects Hitting the Sea Surface or Sea Ice.	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Thermal Effects of Jettisoned Objects.	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Visual Disturbance.	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Displacement of Fish.	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Damage to Human Infrastructure (Subsea Cables/Pipelines).	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect
Interference with Military Exercise Areas	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Impacts to Vessel Navigation Including Floating Debris, Changes to Topography and Re-routing of Vessel Traffic.	Negligible	n/a	No likely significant effect	None proposed	Negligible	n/a	No likely significant effect
Damage to Marine Archaeology/Shipwrecks.	Minor	Adverse	No likely significant effect	None proposed	Minor	Adverse	No likely significant effect

Table 11.2 Summary of Residual Environmental Effects – Ornithology and Ecology

Description of Effect/Receptor	Significance of Pre-mitigation Effect			Mitigation Measure	Significance of Residual Effect		
	Magnitude	Beneficial/ Adverse	Significance		Magnitude	Beneficial/ Adverse	Significance
Ornithology							
Black Guillemot	Negligible	Adverse	Not significant	SaxaVord Spaceport to implement a Breeding Birds Protection Plan to be informed by, and updated annually through, targeted breeding bird surveys. SaxaVord Spaceport to implement Habitat Management Plan to: ➢ Enhance habitats for species of importance present on, or linked to, the study area. ➢ Restore important habitats and associated species. ➢ Peatland restoration. Applicant to comply with any relevant operating procedures/controls required as part of the above plan.	Negligible	Adverse	Not significant
Common Guillemot	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Puffin	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Razorbill	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Shag	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Kittiwake	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Fulmar	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Merlin	No effect	n/a	Not significant		No effect	N/A	Not significant
Ringed Plover	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Golden Plover	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Dunlin	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Whimbrel	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Curlew	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Arctic Tern	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Arctic Skua	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Great skua	Negligible	Adverse	Not significant		Negligible	Adverse	Not significant
Confidential species	Minor	Adverse	Potentially significant		Negligible	Adverse	Not significant
Ecology							
Designated sites	Negligible	Adverse	Not Significant	Embedded mitigation within the development of SaxaVord Spaceport included: ➢ Construction of ten artificial holts/shelters in suitable locations across the top of Lamba Ness to provide additional resting places away from the coast. ➢ Retention of an important otter underpass. ➢ Enforced low vehicle speed limits (10 mph) would greatly reduce the likelihood of otter injury or death caused by vehicle traffic. ➢ Implementation of the Habitat Management Plan Applicant to comply with any relevant operating procedures/controls required as part of the above plan.	Negligible	n/a	Not Significant
Semi-natural habitats	Negligible	Adverse	Not Significant		Negligible	n/a	Not Significant
Otter	Negligible-minor	Adverse	Not Significant		Negligible	n/a	Not Significant

11.3 Significant Residual Effects

11.3.1 Post mitigation, there are no remaining significant residual effects.

11.4 Monitoring

11.4.1 There are no adverse significant residual effects and therefore no monitoring is required as a result of this AEE.

11.5 Conclusion

11.5.1 The conclusion of this AEE is that there are no significant operational effects of concern from the Proposed Project and that the proposed activities will comply with statutory requirements and environmental policy objectives. As described in each of the technical chapters, this takes into consideration international, national and local legislation and objectives.