Environmental Impact Assessment Report
Volume 3, Appendix 31.1: Airspace Analysis and Radar Modelling

MarramWind Offshore Wind Farm

December 2025

MarramWind

Document code:	MAR-GEN-ENV-REP-WSP-000147
Contractor document number:	852346-WEIS-IA-O1-RP-C5-684982
Version:	Final for Submission
Date:	08/12/2025
Prepared by:	Cyrrus
Checked by:	WSP UK Limited
Approved by:	MarramWind Limited

Contents

1. Introduction

1.1 Overview

1.1.1.1 This document is an Appendix to **Volume 1, Chapter 31: Civil and Military Aviation** of the MarramWind Offshore Wind Farm ('the Project') Environmental Impact Assessment (EIA) Report. It provides detailed airspace analysis and radar modelling and outlines potential mitigation options where required.

1.1.1.2 The Project's wind farm site, known as the Option Agreement Area (OAA), is located approximately 75 kilometres (km) off the north-east coast of Scotland, to the north-east of Peterhead and would comprise up to 225 floating wind turbine generators (WTGs).

1.2 Impacts of wind turbine generators on aviation

1.2.1.1 WTGs can be problematic for aviation Primary Surveillance Radars (PSRs) as the characteristics of a moving WTG blade are like an aircraft. The PSR is unable to differentiate between wanted aircraft targets and clutter targets introduced by the presence of WTGs.

1.2.1.2 Secondary Surveillance Radars (SSRs) are less affected by WTGs, but turbine towers can cause physical blanking and diffracting effects and reflections can result in the SSR outputting false targets.

1.2.1.3 The Met Office has a network of radars throughout the United Kingdom (UK), which is used to monitor the weather. WTGs can block radar signals, and the rotation of WTG blades can create clutter and affect Doppler data and wind field measurements.

1.2.1.4 The significance of any radar impacts depends on the airspace usage and the nature of the Air Traffic Service (ATS) provided in that airspace. The classification of the airspace in the vicinity of the Project and the uses of that airspace (civil and military) are set out in this document. WTGs can also have a direct impact on airspace due to their physical presence. The airspace analysis considers the impact WTGs could have as obstacles for aviation activities such as military low flying, Search and Rescue (SAR) operations and offshore oil and gas helicopter operations.

1.2.1.5 Radar impacts may be mitigated by either operational or technical solutions, or a combination of both. In either case, the efficacy and acceptability of any operational and / or technical mitigation options available can only be determined through consultation with the radar operators and ATS providers.

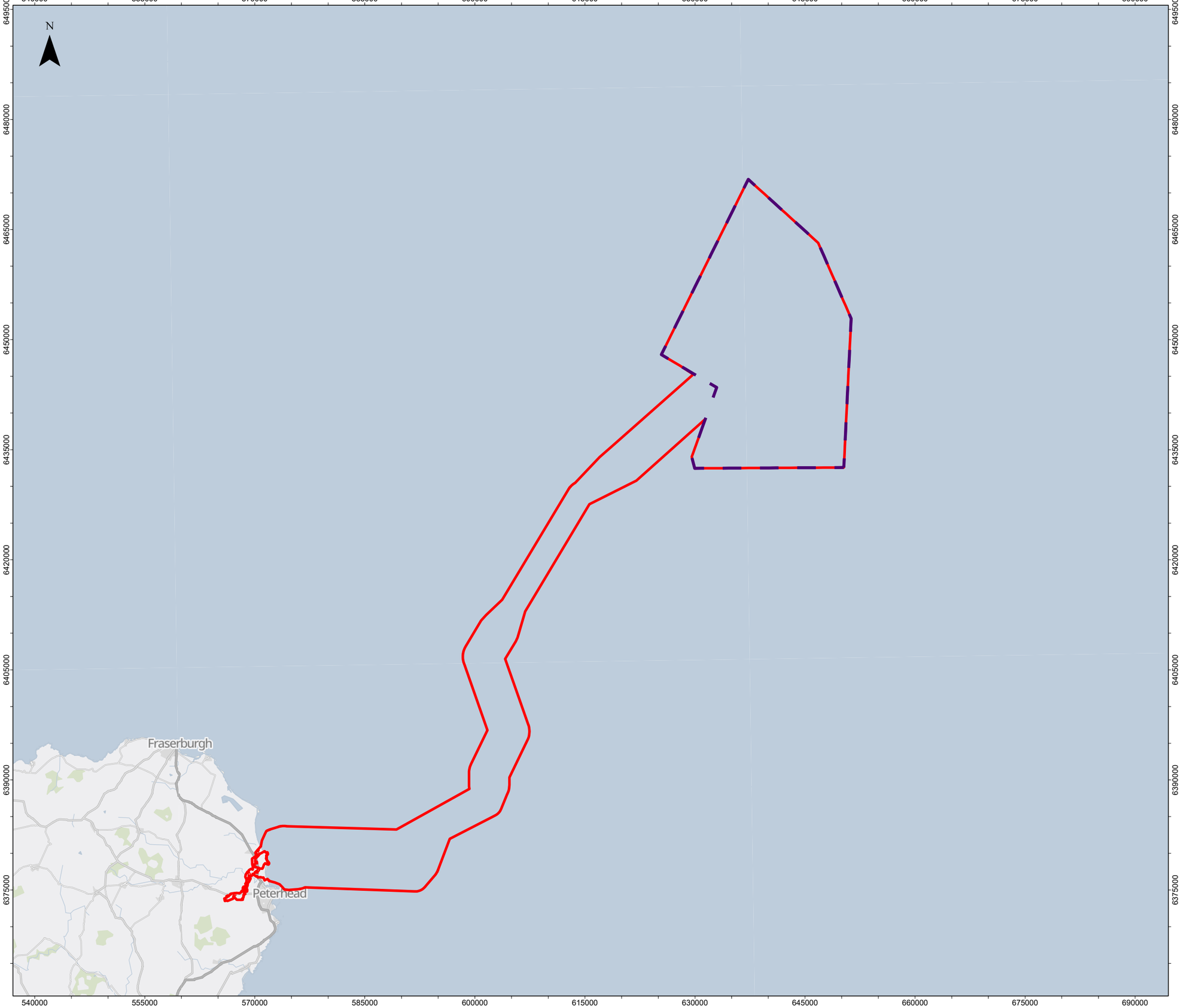
1.3 Technical data

1.3.1 Radar data

1.3.1.1 All radar parameters used in the assessment have been taken from data held on file by Cyrrus.

1.3.2 Red Line Boundary

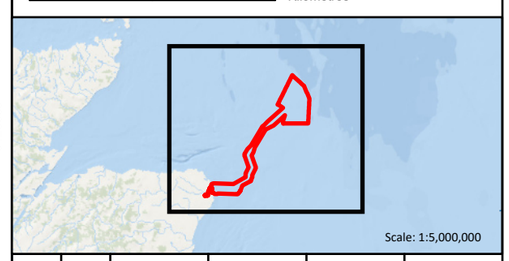
1.3.2.1 The overall Project Red Line Boundary (offshore and onshore) is depicted in **Figure 1**. Also shown is the OAA, the Project's wind farm site within which the proposed WTGs would be located.



Red Line Boundary

Option Agreement Area

0 10 20 Kilometres



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1	15/07/2025	PB	LT	LG	NC

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-C5-76703
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000260
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:500,000
PAGE SIZE	A3

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Figure 1 Proposed wind farm site

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1.3.3 Wind turbine generators

1.3.3.1 The WTG design parameters are presented in **Table 1.1**.

Table 1.1 WTG design parameters

Parameter	14MW WTG	25MW WTG
Maximum rotor blade tip height (above mean sea level (amsl))	274 metres (m)	350m
Maximum rotor diameter	236m	326m
WTG hub height (amsl)	142m	182m
Maximum number of WTGs	225	126

1.3.4 Terrain data

1.3.4.1 The terrain data used for the radar modelling was NextMap Great Britain 25m Digital Terrain Model (DTM).

1.3.5 Analysis tools

1.3.5.1 The following software packages were used for the airspace analysis and radar modelling:

- Blue Marble Global Mapper V26.1.3 Geographic Information System; and
- Advanced Topographic Development and Images HTZ communications V2025.6 release 1507 radio planning tool.

1.3.6 Mapping datum

1.3.6.1 Universal Transverse Mercator (UTM) Zone 30N (European Terrestrial Reference System 89 datum) is used as a common working datum for all mapping and geodetic references.

1.3.6.2 Where necessary, mapping datum transformations are made using Global Mapper or Grid Inquest II Coordinate Transformation Program.

1.3.6.3 All heights stated in this document are amsl (Newlyn datum) unless otherwise stated.

2. Airspace Analysis

2.1 Introduction

2.1.1.1 This assessment is a review of potential impacts on aviation arising from the presence of WTGs located within the OAA. Airspace altitudes are expressed in feet (ft), so for the purposes of this assessment a maximum blade tip height of 1,200ft amsl for the WTGs has been assumed, the equivalent of 350m rounded up to the nearest 100ft.

2.1.1.2 All airspace data has been referenced from the UK Aeronautical Information Publication (AIP) available online from source and is therefore the latest information available (Civil Aviation Authority (CAA), 2025). Additional information regarding offshore infrastructure has been sourced from the North Sea Transition Authority (NSTA) Open Data website (NSTA, 2025).

2.1.1.3 The purpose of this assessment is to identify areas of potential impact. It does not draw any conclusions. Likely significant effects on airspace receptors are assessed in Sections 31.9, 31.10 and 31.11 of **Volume 1, Chapter 31: Civil and Military Aviation**.

2.2 Scope

2.2.1.1 The scope of the assessment includes the Project Red Line Boundary and the surrounding airspace relating to aviation, its use and potential impacts. The types of airspace and limitations on its use are identified.

2.3 Airspace classification

2.3.1.1 In general, airspace can be characterised as either controlled or uncontrolled airspace. Aircraft in controlled airspace are being positively managed by Air Traffic Control (ATC) the entire time they are within that designated area (in other words, ATC are controlling the aircraft as opposed to providing advice and information on other traffic). This type of airspace is generally used by airlines and corporate aviation. Aircraft in uncontrolled airspace are operating within a framework of rules but are not being controlled by ATC, although many pilots flying in this environment may choose to report their position, altitude, and intentions to ATC to benefit from the enhanced situational awareness that brings. Users of this airspace tend to be small aircraft engaged in training or private (social) flying.

2.3.1.2 In addition, Special Use Airspace is airspace designated for specific activities such that limitations on airspace access may be imposed on other non-participatory aircraft. An example of such airspace would be a Danger Area (DA) established for military flight training.

2.3.1.3 There are five classes of airspace in the UK, namely classes A, C, D, E and G. Classes A to E are types of controlled airspace, while class G is uncontrolled airspace. Class A is the most strictly regulated controlled airspace whereby aircraft are positively controlled by ATC, compliance with ATC clearance is mandatory, and aircraft are flown and navigated solely with reference to aircraft instruments. Certain onboard equipment is also a prerequisite. Flight in class G airspace is generally visual, meaning pilots fly and navigate with reference to the natural horizon and terrain features they see outside. Pilots are required to maintain minimum distances from notified obstacles, including WTGs, and may only fly within the minimum weather and visibility criteria.

2.4 Aircraft vertical reference

2.4.1.1 An aircraft's vertical reference above the ground or sea can either be an altitude amsl or, above a designated altitude, a Flight Level (FL). An aircraft's altitude, expressed in feet, is based on the last known verified local barometric pressure while a FL, expressed in 100ft increments, is based on a common international barometric pressure setting of 1013.2 hectopascals. With aircraft using a common vertical datum, safe separation can be achieved by either ATC or between pilots of different aircraft.

2.4.1.2 The airspace where vertical reference changes from altitude to FL and vice versa is known as the Transition Layer and consists of a (lower) Transition Altitude and (higher) Transition Level. In UK airspace the Transition Altitude is set at 3,000ft amsl except in certain specified airspace where it is higher.

2.4.1.3 The vertical limits of airspace are defined in terms of either altitudes or FLs, with airspace commonly having a lower limit expressed as an altitude and an upper limit expressed as a FL.

2.5 Current airspace baseline

2.5.1.1 The Project lies within the Scottish Flight Information Region (FIR), which is airspace regulated by the UK CAA. The boundary between the Scottish FIR and the London FIR, also regulated by the UK CAA, lies approximately 335km south of the OAA. Approximately 152km to the north-east of the Project is the boundary between the Scottish FIR and the adjacent Polaris FIR, regulated by CAA Norway.

2.5.1.2 NATS (En-Route) plc (NERL) provides en-route civil ATS within the Scottish FIR, supported by a network of radar facilities which provide information on airborne traffic for both civil and military ATC.

2.5.1.3 A portion of Scottish FIR airspace known as North Sea Area II is delegated to Norway. Within this airspace Norway provides an ATS to all aircraft at FL85 (approximately 8,500ft amsl) and below. Procedures and communications within this area are as if the airspace was an integral part of the Polaris FIR. North Sea Area II is depicted in **Figure 2**, together with the Scottish FIR boundary, and lies approximately 115km east of the OAA at its closest point.

2.5.1.4 Immediately surrounding the OAA is uncontrolled class G airspace, extending vertically from sea level to FL195 (approximately 19,500ft amsl). This airspace is used by both civil and military aircraft, predominantly for low-level flight operations and generally by aircraft flying under Visual Flight Rules (VFR).

2.5.1.5 Aircraft operate under one of two flight rules: VFR or Instrument Flight Rules (IFR). VFR flight is permitted when the weather satisfies Visual Meteorological Conditions (VMC) and is conducted with visual reference to the natural horizon. VMC are weather conditions expressed in terms of visibility, distance from cloud, and cloud ceiling height equal to or better than specified minima. Under VFR flight the pilot is responsible for maintaining a safe distance from terrain, obstacles, and other aircraft.

2.5.1.6 Aircraft must be flown under IFR in class A controlled airspace and when weather restricts visibility, known as Instrument Meteorological Conditions (IMC). IMC exists when the weather conditions are less than the minima specified for VMC. IFR flight requires reference solely to aircraft instrumentation.

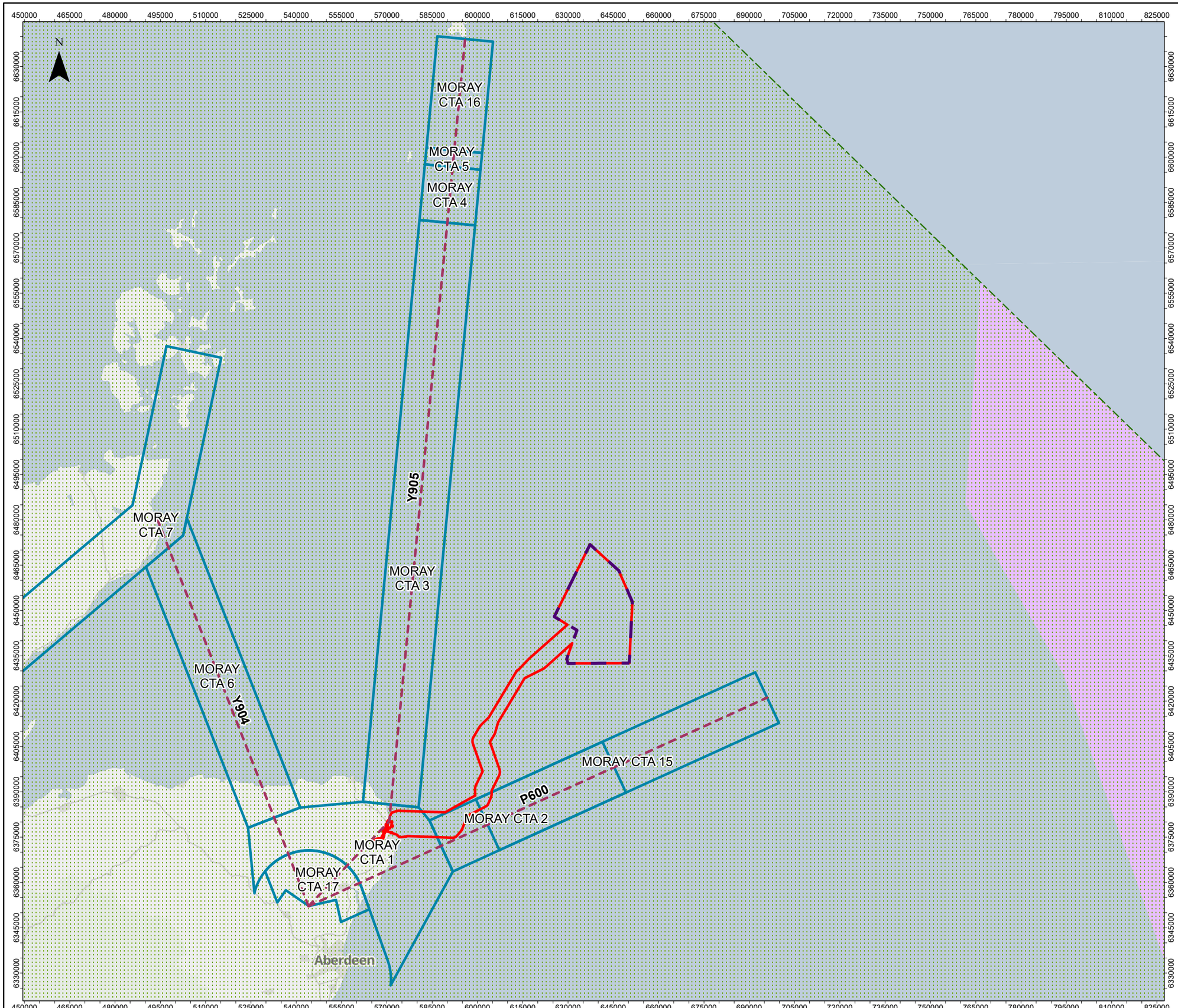
2.5.1.7 Above FL195 all airspace in the Scottish FIR is notified as class C controlled airspace. The airspace between FL245, approximately 24,500ft amsl, and FL660, approximately 66,000ft amsl, is known as the Upper Airspace Control Area and is designated as Free Route

Airspace. Within Free Route Airspace ATS route structure is removed, allowing aircraft to flight plan their own routes between defined airspace entry and exit waypoints.

2.5.1.8 Laterally, the closest controlled airspace to the OAA is the Moray Control Area (Moray CTA). The Moray CTA comprises CTAs 1 to 17 and is class E airspace, apart from CTAs 14 and 15 which are class C. Moray CTA 3 lies approximately 38km west of the OAA, Moray CTA 2 lies 26km south of the OAA and Moray CTA 15 lies 20km south-east, as shown in **Figure 2**. CTA 2 and CTA 3 extend vertically from a lower limit of FL105 (approximately 10,500ft amsl) to an upper limit of FL195 (approximately 19,500ft amsl) while CTA 15 extends vertically from FL195 to FL245 (approximately 24,500ft amsl), and between them they facilitate air traffic transiting along Lower ATS Routes P600 and Y905 respectively. ATS Routes are a network of airways that aircraft navigate via a combination of ground-based electronic aids and Global Navigation Satellite System waypoints.

2.5.1.9 Moray CTAs 2 and 3 are Transponder Mandatory Zones (TMZs). Within a TMZ the carriage and operation of aircraft transponder equipment is mandatory. This enables such aircraft to be detected and tracked by SSR systems.

2.5.1.10 Given the maximum blade tip height of 1,200ft amsl and the base of controlled airspace within the vicinity of the OAA, WTG structures would have no impact on aircraft operations within controlled airspace.



Red Line Boundary

Option Agreement Area

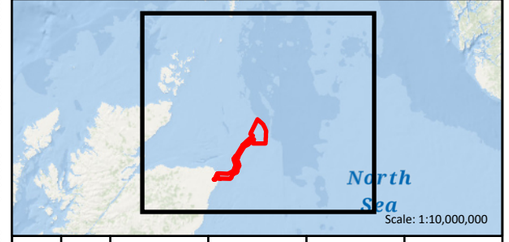
Moray Control Area (CTA)

Scottish Flight Information Region Boundary

North Sea Area II

Lower Air Traffic Service Routes

0 10 20 30 40 50 60 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
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Figure 2 Current airspace baseline

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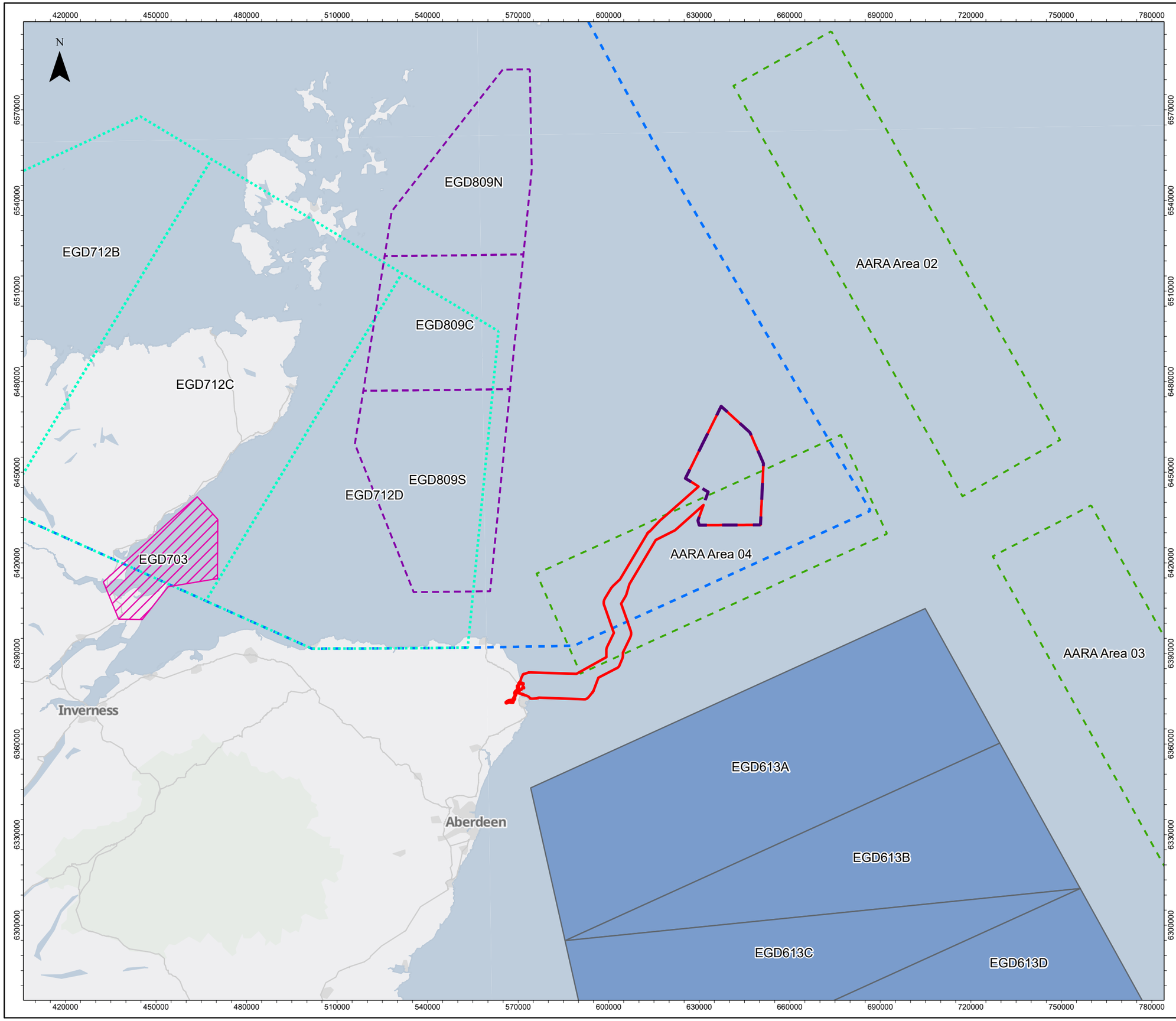
2.6 Special use airspace

2.6.1.1 Above the OAA is the Fast Jet Area North DA, EGD901, as shown in **Figure 3**. The DA has vertical limits from FL245 to FL550 (approximately 24,500ft to 55,000ft amsl) and is solely used in support of Exercise Joint Warrior, a biannual multinational military training exercise that takes place in the Spring and Autumn. High energy manoeuvres, ordnance, munitions and explosives activities take place within EGD901.

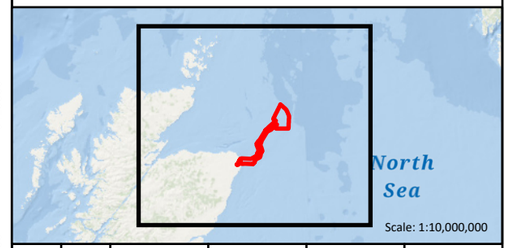
2.6.1.2 DA airspace is not permanently active but rather is activated on request and notified by appropriate agencies such as the Ministry of Defence (MOD) or CAA through the issue of a NOTAM (Notice to Aviation).

2.6.1.3 **Figure 3** also shows that the southern half of the OAA lies beneath airspace designated as Area 04. Area 04 is an Air-to-Air Refuelling Area (AARA) with vertical limits of FL70 to FL240 (approximately 7,000ft to 24,000ft amsl). Within AARA airspace, fuel is transferred from tanker aircraft to receiver aircraft under a Radar Control Service provided by military controllers based at Swanwick.



Red Line Boundary
Option Agreement Area
Tain Danger Area
Northern Complex Danger Area
Moray Firth Danger Area
Fast Jet Area North Danger Area
Air to Air Refuelling Area (AARA)
Central Complex Danger Area

0 10 20 30 40 50 60
Kilometres



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PROJECT TITLE
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Figure 3 Special use airspace

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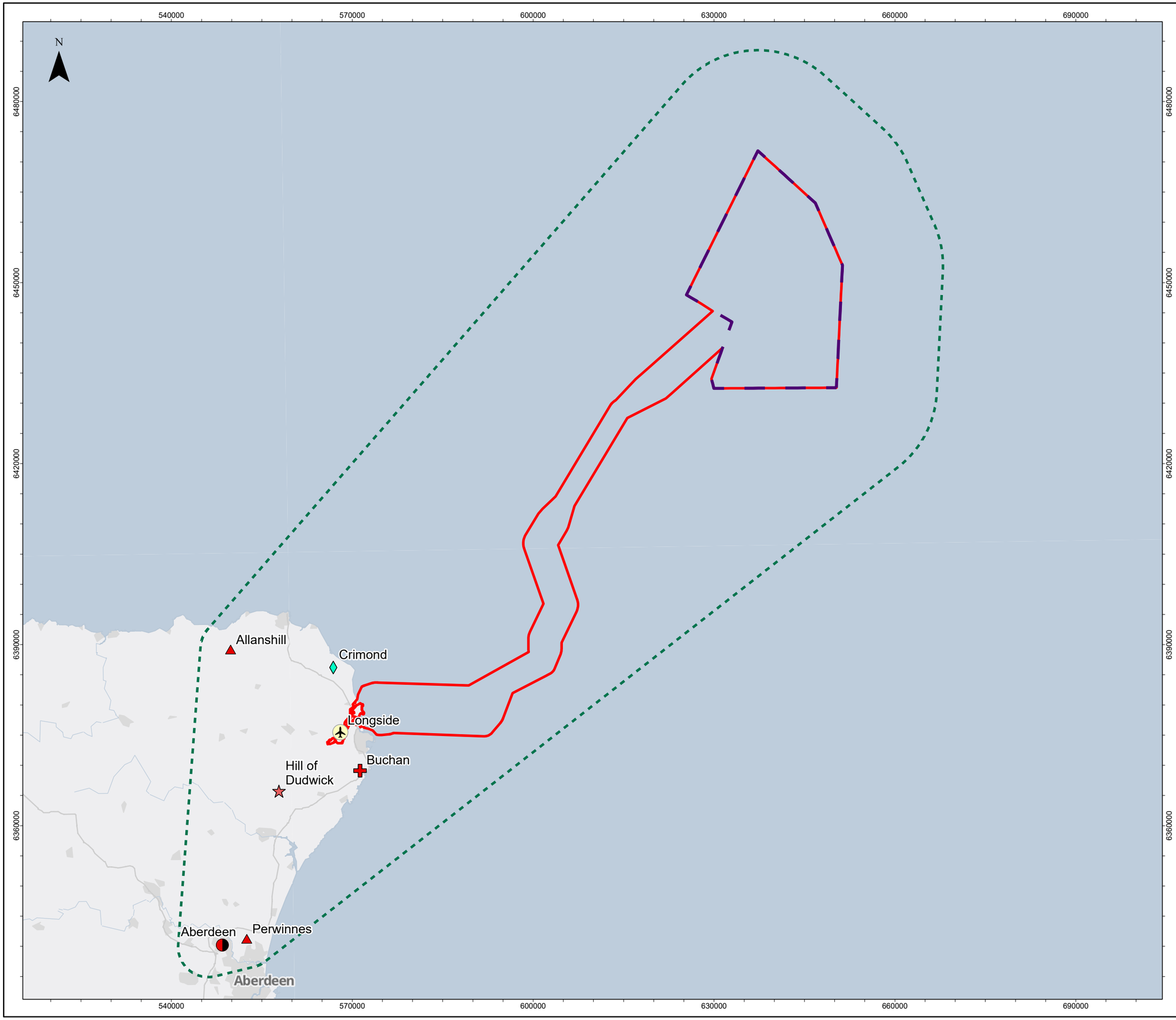
2.7 Northern north sea offshore operations

2.7.1.1 To enhance flight safety and expedite SAR operations over the Northern North Sea, various Flight Information Services are provided by the NERL Air Traffic Service Unit (ATSU) at Aberdeen Airport. These services are available to helicopters operating in support of the offshore oil, gas and renewable industries and to other civil and military aircraft transiting the airspace. The Aberdeen Offshore Safety Area (OSA), in which these services are available, extends from sea level to FL100 (approximately 10,000ft amsl) and is shown in **Figure 4**. The Project lies within the Aberdeen OSA.



Red Line Boundary

Option Agreement Area

Study Area

Air Defence Radars

Civil Airports

NERL Radars

DHFCS Transmitter Sites

Weather Radars

Unlicensed Airfield

0 10 20 30 Kilometres

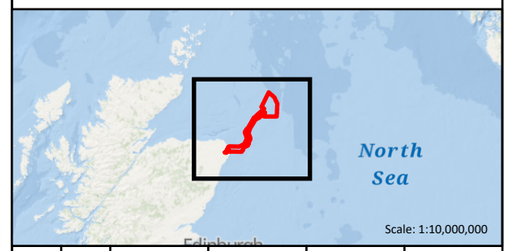


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Figure 31.1 Airports and radars within the civil and military aviation study area

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2.8 Helicopter main routing indicators

2.8.1.1 A network of offshore routes within the Aberdeen OSA are flown by civilian helicopters in support of offshore oil and gas installations. The routes typically and routinely flown are published on charts as Helicopter Main Routing Indicators (HMRIs) to alert other airspace users of the potential for frequent low-level helicopter traffic.

2.8.1.2 These routes have no lateral dimensions and assume the background airspace classification within which they lie. HMRIs over the Northern North Sea generally extend vertically from 1,500ft amsl to FL85 (approximately 8,500ft amsl), although icing conditions or other flight safety considerations may require helicopters to operate below 1,500ft amsl.

2.8.1.3 Civil Aviation Publication (CAP) 764: Policy and Guidelines on Wind Turbines (CAA, 2016) advises that planned obstacles within 2 nautical miles (nm) of an HMRI route centreline should be consulted upon with helicopter operators and the Air Navigation Service Provider (in this case Aberdeen ATSU). The 2nm distance is based upon operational experience, the accuracy of navigation systems, and practicality. Such a distance provides time and space for helicopter pilots to descend safely to an operating altitude below the icing level. A 2nm buffer around the OAA is depicted in **Figure 4**, which shows that HMRIs 044, 047, 050, 053 and 056 pass overhead the OAA and HMRI 059 passes within 2nm of the OAA southern boundary.

2.8.1.4 Helicopters operating under IFR must maintain at least 1,000ft vertical clearance above the highest obstacles within 5nm, and would therefore need to transit the OAA at a minimum of 2,200ft amsl for the maximum WTG tip height of 1,200ft amsl. Under VFR, helicopters must maintain a minimum of 500ft separation from obstacles.

2.8.1.5 The ability of a helicopter to fly higher over WTGs depends on the icing level, and on days of low cloud base helicopters could be required to fly lower and extend their routings around WTG obstacles.

2.9 Offshore helidecks

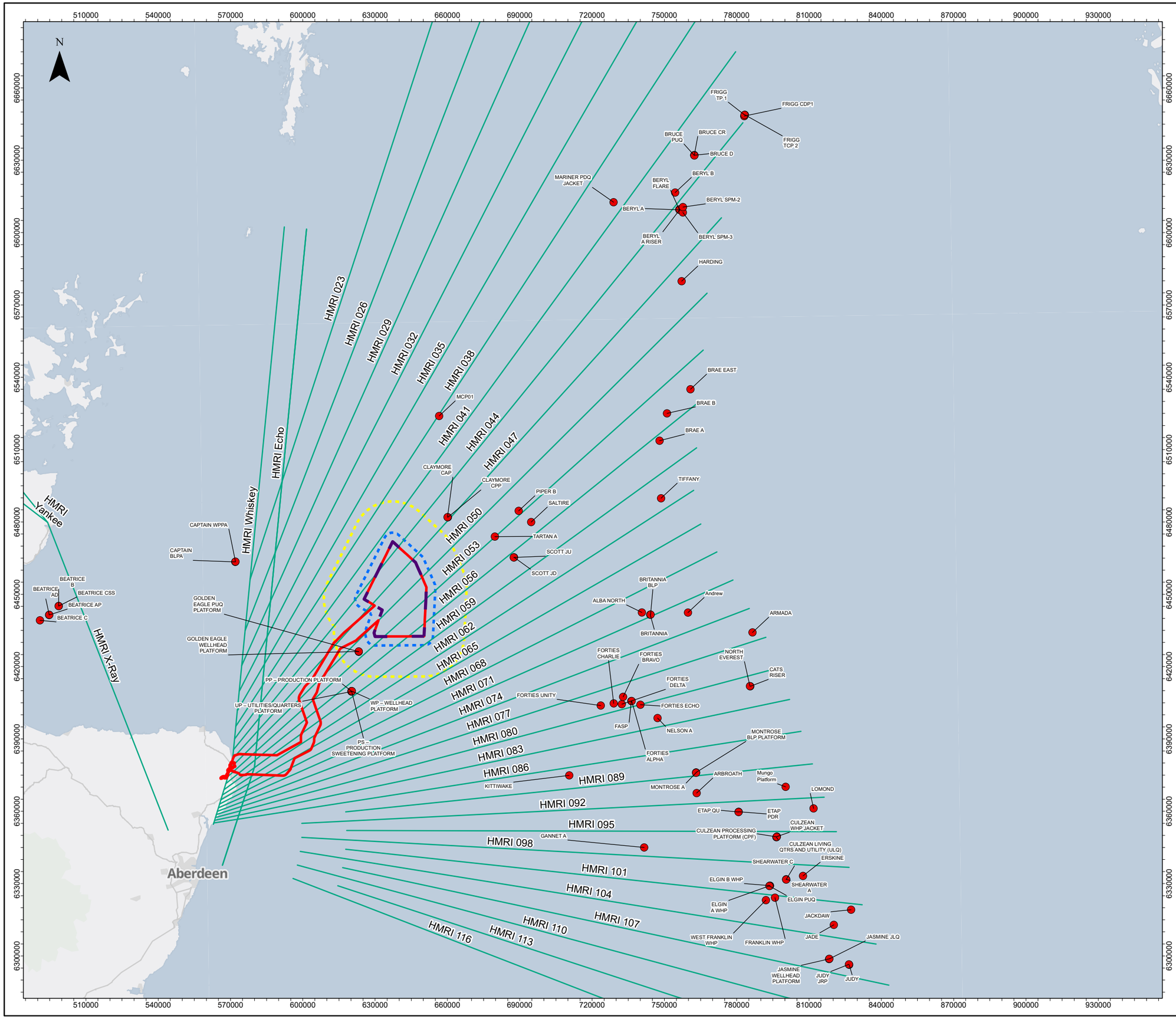
2.9.1.1 To help achieve a safe operating environment, a 9nm consultation zone for planned obstacles exists around offshore helicopter destinations. Within 9nm, obstacles such as WTGs can potentially impact upon the feasibility of helicopters to safely fly low visibility or missed approach procedures at the associated helideck site. There is one offshore helideck within 9nm of the OAA, as shown in **Figure 5**. The Golden Eagle production, utilities and quarters (PUQ) platform lies 5nm (9.2km) south-west of the OAA.

2.9.1.2 As stated in CAP 764, the 9nm zone does not prohibit development, but is a trigger for consultation with offshore helicopter operators, the operators of existing installations and exploration and development locations to determine a solution that maintains safe offshore helicopter operations alongside proposed developments. The CAA advises wind energy lease holders, oil and gas developers, and petroleum licence holders to discuss their development plans with each other to minimise the risks of unanticipated conflict.

2.9.1.3 When helicopters must route around the OAA due to the icing level, transit times between Aberdeen Airport and the following 13 platforms could potentially be increased:

- Beryl A;
- Beryl B;
- Beryl SPM-2;
- Brae A;

- Brae East;
- Bruce PUQ;
- Claymore CAP;
- Gryphon Alpha;
- Harding;
- Piper B;
- Saltire;
- Scott JU; and
- Tartan A.



Red Line Boundary

Option Agreement Area

2 Nautical Mile Buffer

9 Nautical Mile Buffer

Helicopter Main Routing Indicators (HMRIs)

Offshore Platforms

0 10 20 30 40 50 60 70 80 Kilometres

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SCALE	1:1,500,000	PAGE SIZE	A3

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Figure 5 Offshore platforms

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2.10 Search and rescue

2.10.1.1 SAR operations are a highly specialised undertaking involving not only aviation assets, but also small boats, ships, and shore-based personnel. SAR operations are generally carried out in extremely challenging conditions and at all times of the day and night. There are ten helicopter SAR bases, incorporating 22 aircraft, around the UK with Bristow Helicopters currently providing helicopters and aircrew on behalf of the Maritime and Coastguard Agency (MCA).

2.10.1.2 The nearest SAR base is at Inverness Airport, 200km west-south-west of the OAA. Its helicopters provide rescue services for both offshore and onshore incidents up to approximately 460km from their base.

2.10.1.3 The random nature of people, watercraft or aircraft in distress makes it very difficult to determine the routes taken by SAR aircraft. Fixed wing SAR aircraft would tend to stay at higher altitudes in a command-and-control role during major incidents, whilst helicopters would be used in a low-level role, sometimes in support of small rescue boats.

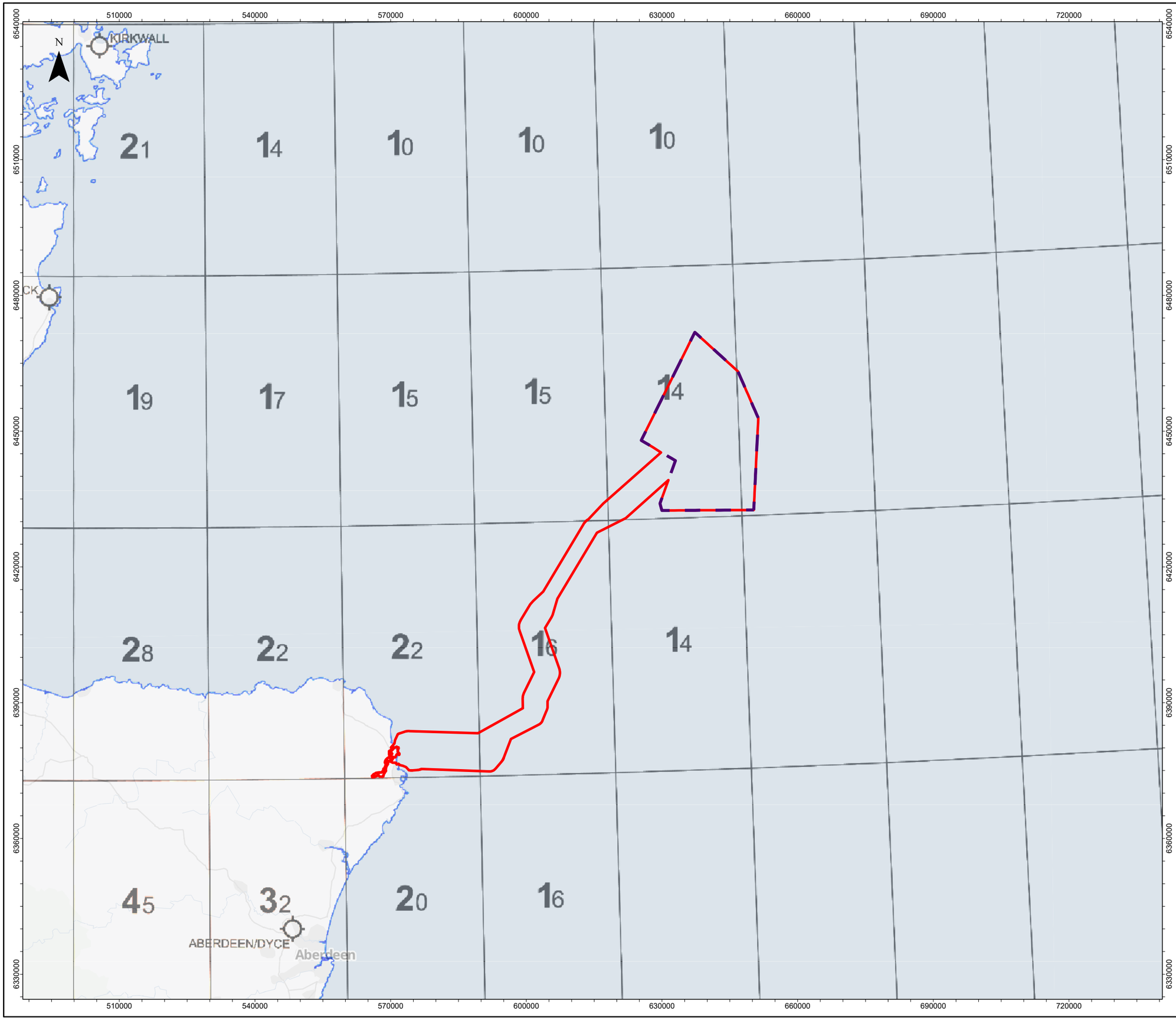
2.10.1.4 For SAR operations to be carried out safely and efficiently, the Project will be designed in accordance with MCA requirements regarding WTG spacing, marking and lighting as detailed in Marine Guidance Note (MGN) 654 Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response (MCA, 2021).

2.11 Area minimum altitudes

2.11.1.1 A chart of Area Minimum Altitudes (AMAs) across the London and Scottish FIRs is published in the AIP. An AMA provides a minimum obstacle clearance of 1,000ft within a specified area formed by lines of latitude and longitude in half degree steps. This provides pilots of aircraft flying under IFR the reassurance of properly designated obstacle and terrain clearance protection in poor visibility conditions (IMC).

2.11.1.2 The OAA is within an AMA area of 1,400ft amsl, as shown in **Figure 6**. Note that the AMA altitudes are marked as hundreds of feet on the chart, so 1,400ft is shown as ‘14’.

2.11.1.3 WTGs with a maximum tip height exceeding 400ft (121.9m) amsl would require the 1,400ft AMA to be increased to maintain the necessary 1,000ft obstacle clearance protection. If a maximum blade tip height of 1,200ft amsl is assumed for WTGs within the OAA, then the AMA would need to be increased to 2,200ft amsl.

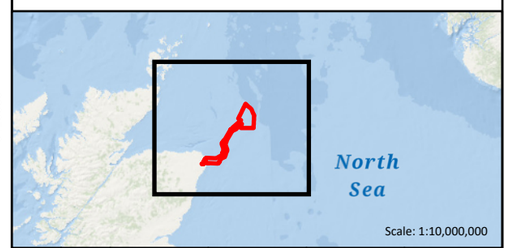


Red Line Boundary

Option Agreement Area

Note that the AMA altitudes are marked as hundreds of feet 1,400ft is shown as '14'.

0 10 20 30 40 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:800,000	PAGE SIZE	A3

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Figure 6 Area minimum altitudes

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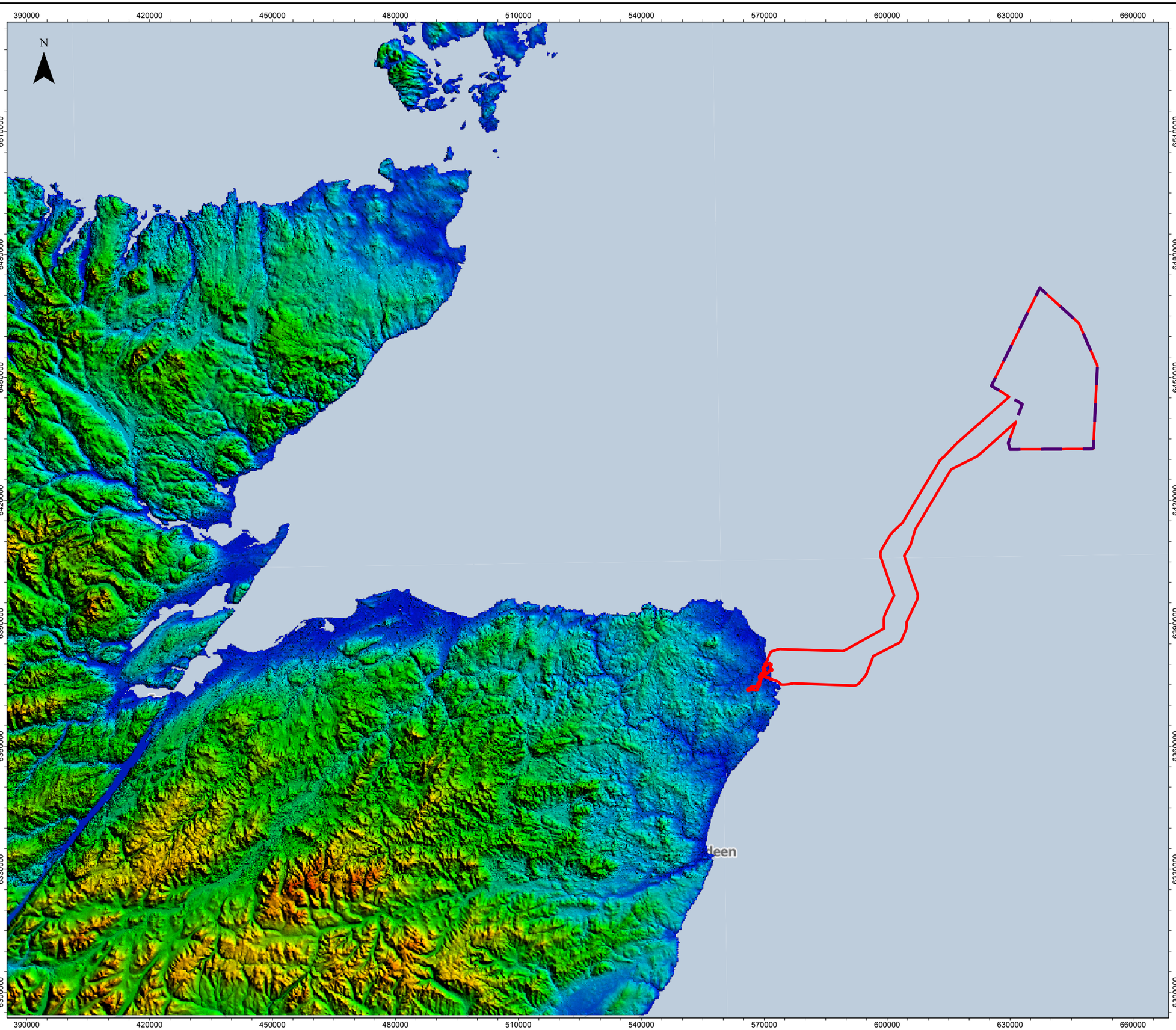
3. Radar Line of Sight assessment

3.1 Methodology

3.1.1.1 Radar Line of Sight (RLoS) is determined by use of a radar propagation model (Global Mapper) using 3D DTM data with 25m horizontal resolution (**Figure 7**). Radar data is entered into the model and RLoS to the WTGs from each radar is calculated.

3.1.1.2 Note that by using a DTM no account is taken of possible further shielding of the WTGs due to the presence of structures or vegetation that may lie between the radar and the WTGs. Thus, the RLoS assessment is a worst-case result.

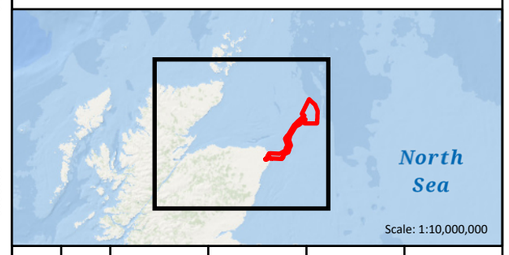
3.1.1.3 For PSR the principal source of adverse wind farm effects are the WTG blades, so RLoS is calculated for the maximum blade tip heights of the WTGs under consideration for the Project, that is, 274m and 350m amsl.



Red Line Boundary

Option Agreement Area

0 10 20 30 40 Kilometres



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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000187

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:900,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 7 25m resolution DTM used for RLoS modelling

Environmental Impact Assessment Report
Appendix 31.1

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wsp

MarramWind

3.2 Civil and military airfields with surveillance radar

3.2.1.1 In general, PSRs installed on civil and military airfields have an operational range of between 40nm and 60nm (between approximately 74km and 111km). There are no radar-equipped airfields within 60nm or 111km of the OAA.

3.2.1.2 Aberdeen Airport is 123km south-west of the OAA. It utilises the NERL en-route radar facilities located at Perwinnes and Allanshill. NERL radars are assessed in **Section 3.3**.

3.2.1.3 The closest radar-equipped civil airfield to the OAA is Inverness Airport, 200km to the west-south-west. CAP 764 recommends consultation with any aerodromes with a surveillance radar facility that are within 30km of WTGs, however this distance can be greater depending on the type and coverage of the radar and the particular operations at the aerodrome. The radar service provided at Inverness Airport has a designated operational coverage of 40nm (74km).

3.2.1.4 The closest radar-equipped military airfield to the OAA is Royal Air Force (RAF) Lossiemouth, 154km to the west-south-west of the OAA. Controllers at this station may provide a Lower Airspace Radar Service to aircraft operating outside controlled airspace to a maximum range of 40nm (74km) from the RAF Lossiemouth facility.

3.2.1.5 WTGs within the OAA would be beyond the maximum operational ranges of any civil or military airfield PSRs and would have no impact on their performance.

3.3 NATS (En-Route) plc radars

3.3.1 Closest NATS (En-Route) plc radars

3.3.1.1 Most en-route radars operated by NERL are required to provide coverage at ranges in excess of 60nm (111km). The closest NERL radars to the OAA are at Allanshill, 91km to the south-west, and Perwinnes, 120km to the south-south-west. NERL radar facilities are combined PSR and SSR systems. NERL only consider the impact of WTGs on their SSR facilities when they are within 15nm, approximately 28km.

3.3.2 Allanshill

3.3.2.1 Allanshill PSR is a Raytheon ASR-10SS system with an operational range of 60nm (111km).

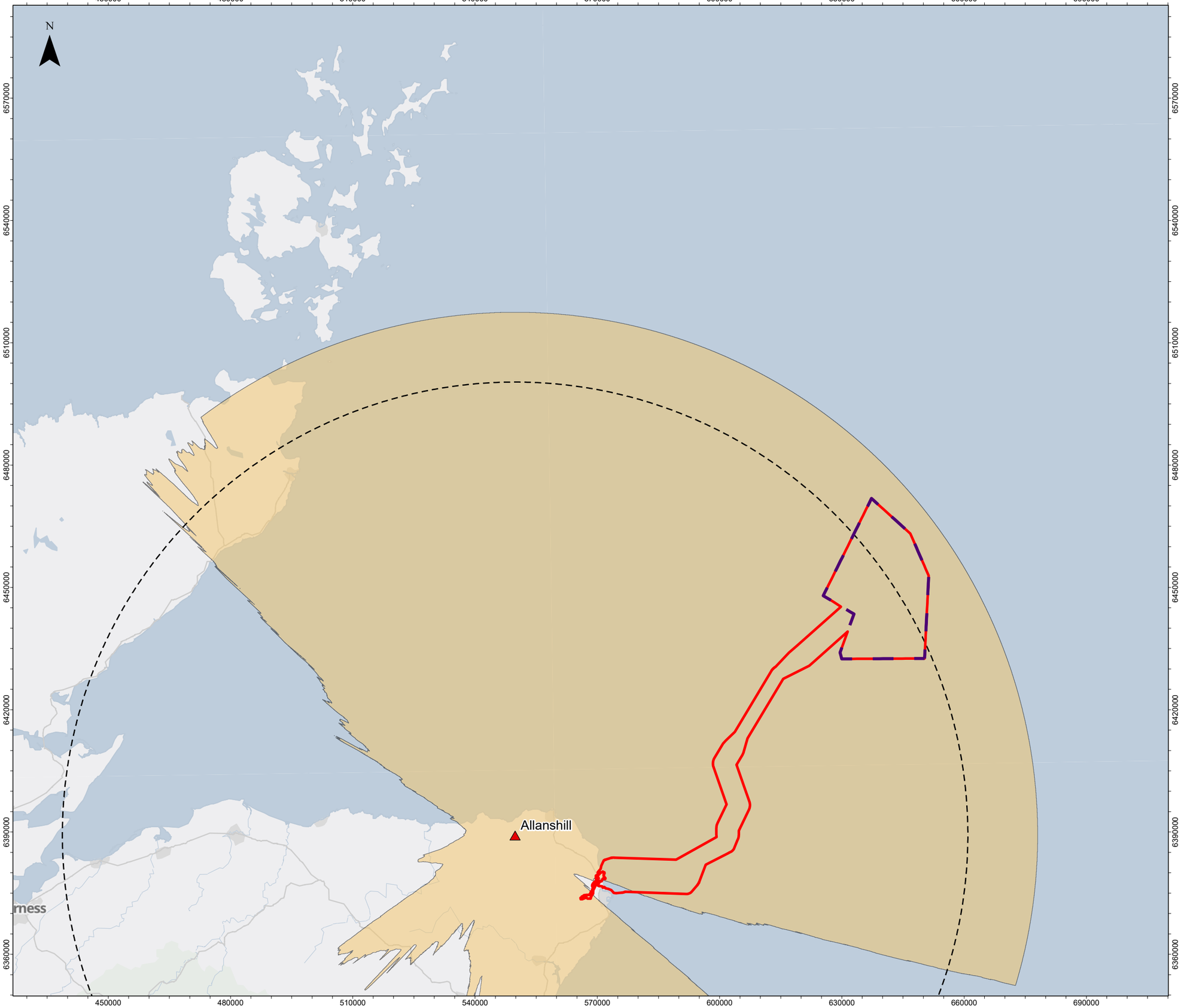
3.3.2.2 Allanshill RLoS coverage for a blade tip height of 350m amsl is shown in **Figure 8**.

3.3.2.3 All WTGs within the OAA with a maximum blade tip height of 350m amsl would be in RLoS of Allanshill PSR; however, Allanshill operational range is limited to 60nm (111km). 350m high WTGs that are in RLoS of Allanshill PSR and within 60nm (111km) of the facility are highly likely to be detected.

3.3.2.4 Allanshill RLoS coverage for a blade tip height of 274m amsl is shown in **Figure 9**.

3.3.2.5 274m high WTGs that are in RLoS of Allanshill PSR and within 60nm (111km) of the facility are highly likely to be detected.

3.3.2.6 61.2% of the OAA is within 60nm of Allanshill PSR.



Red Line Boundary

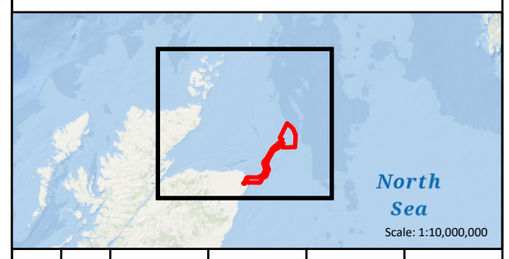
Option Agreement Area

Allanshill 60nm Operational Range

Allanshill RLoS 350m amsl

NERL Radars

0 10 20 30 40 Kilometres



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MarramWind DRAWING NUMBER: MAR-GEN-ENV-MAP-WSP-000190

DATUM: ETRS 89 | PROJECTION: UTM Zone 30N

SCALE: 1:900,000 | PAGE SIZE: A3

PROJECT TITLE: MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 8 Allanshill RLoS 350m amsl

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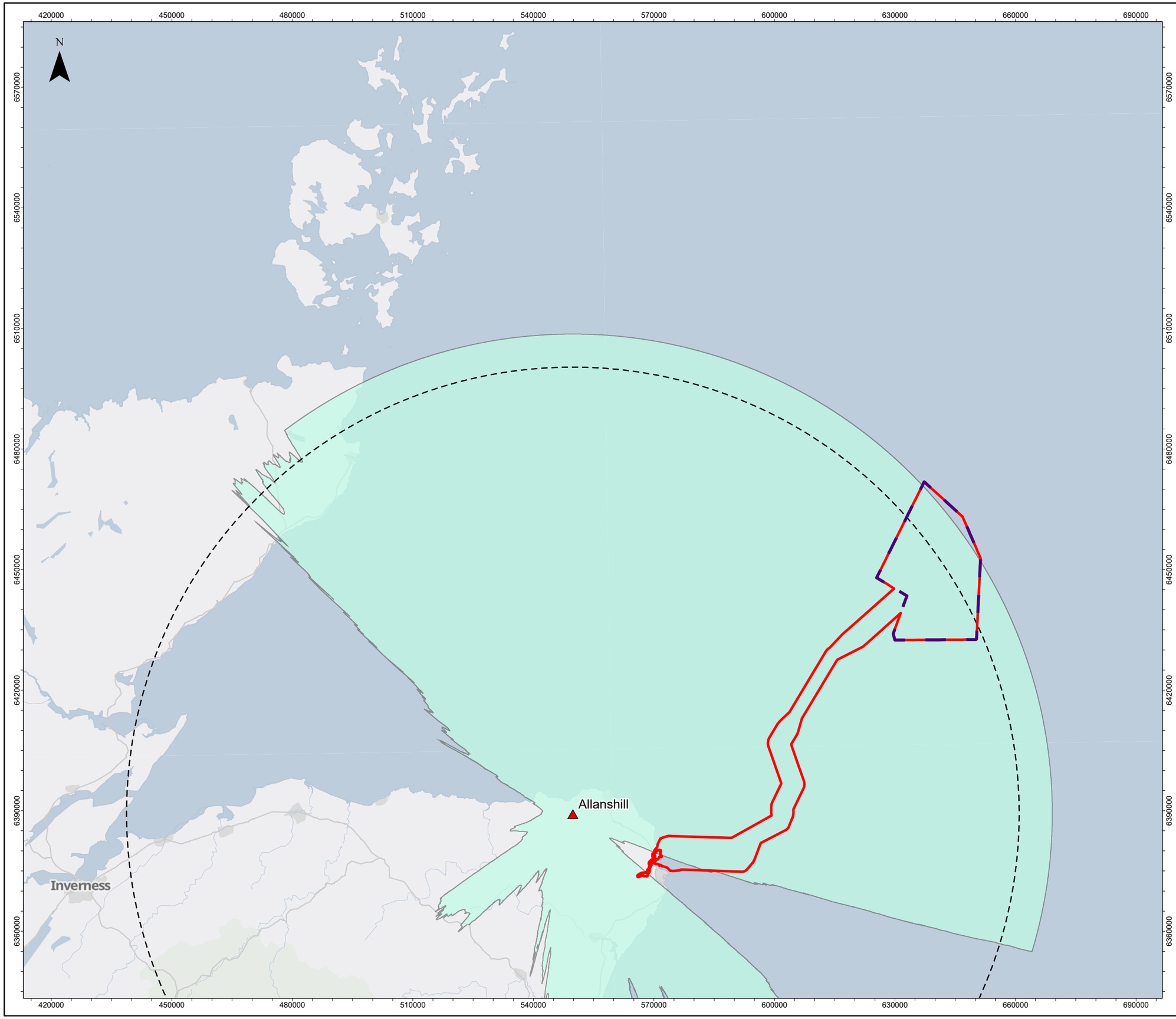
MarramWind



Red Line Boundary

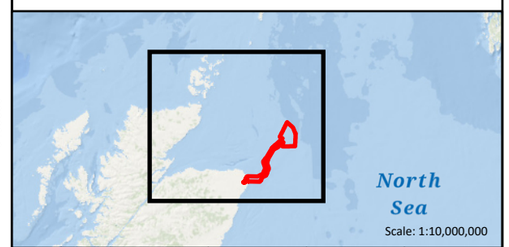
Option Agreement Area

Allanshill 60nm Operational Range

Allanshill RLoS 274m amsl

NERL Radars

0 10 20 30 40 Kilometres



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DATUM: ETRS 89 | PROJECTION: UTM Zone 30N

SCALE: 1:900,000 | PAGE SIZE: A3

PROJECT TITLE: MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 9 Allanshill RLoS 274m amsl

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Appendix 31.1

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wsp

MarramWind

3.3.3 Perwinnes

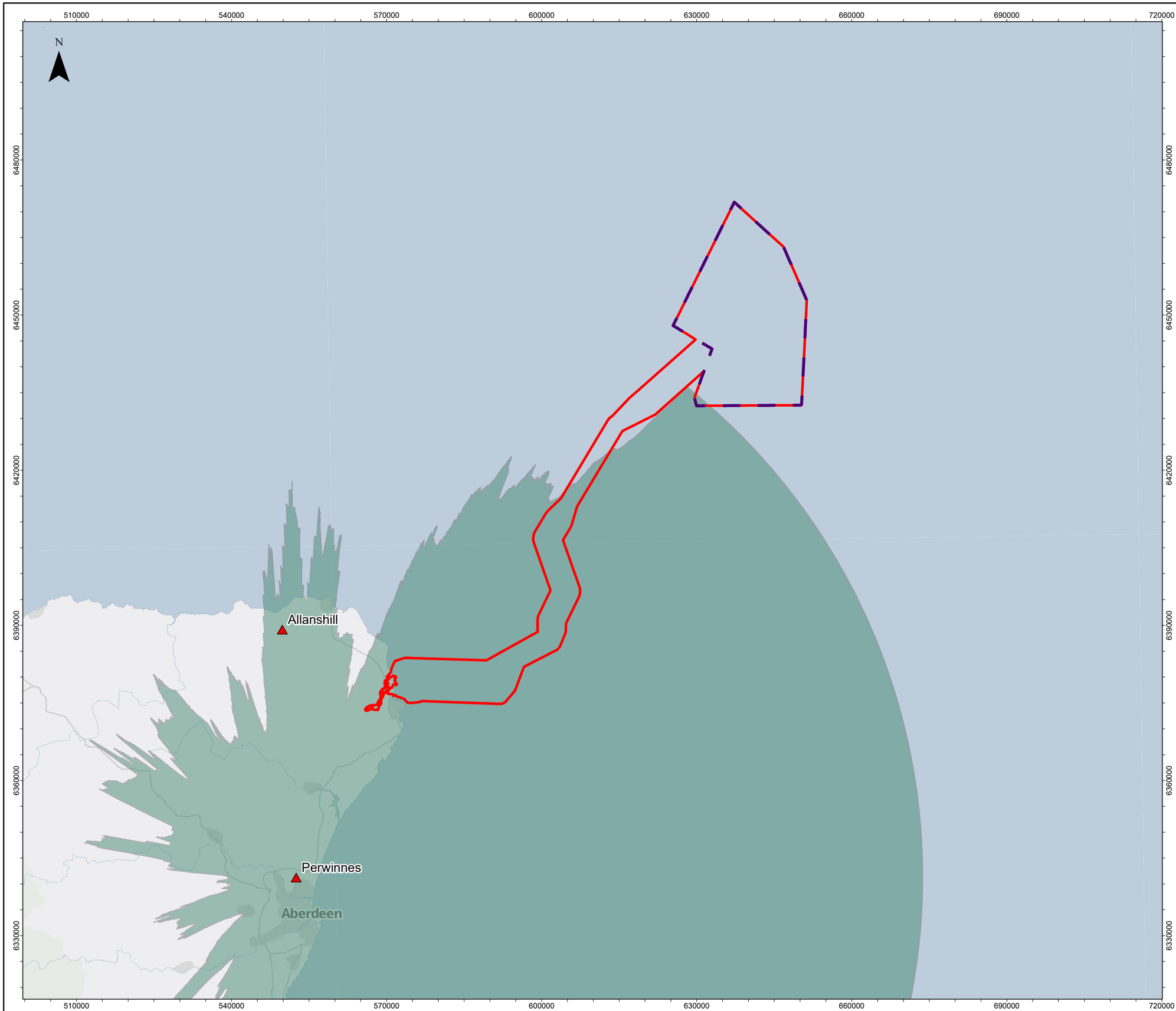
3.3.3.1 Perwinnes PSR is a Raytheon ASR-23SS system with an operational range of between 80nm (148km) and 180nm (333km).

3.3.3.2 Perwinnes RLoS coverage for a blade tip height of 350m amsl is shown in **Figure 10**.

3.3.3.3 WTGs with a maximum blade tip height of 350m amsl in the south-west corner of the OAA (0.5% of the OAA) would be in RLoS of Perwinnes PSR and highly likely to be detected.

3.3.3.4 Perwinnes RLoS coverage for a blade tip height of 274m amsl is shown in **Figure 11**.

3.3.3.5 WTGs with a maximum blade tip height of 274m amsl within the OAA would not be in RLoS of Perwinnes PSR. It is unlikely that 274m WTGs would be detected by Perwinnes PSR.



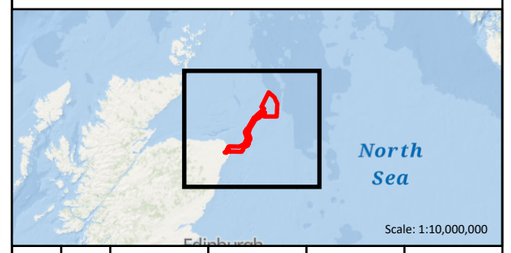
Red Line Boundary

Option Agreement Area

Perwinnes RLoS 350m amsl

NERL Radars

0 10 20 30 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:700,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 10 Perwinnes RLoS 350m amsl

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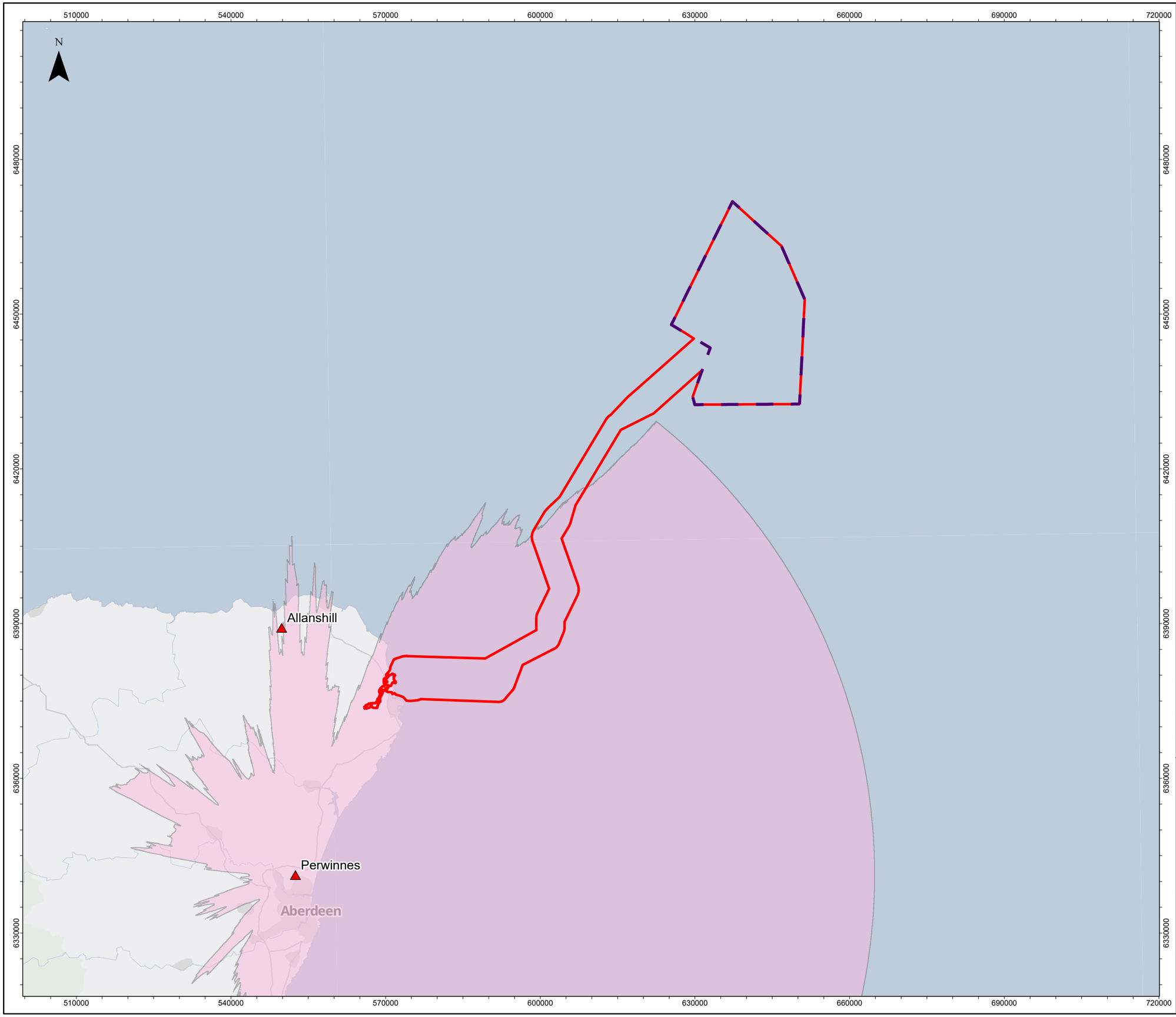
wsp

MarramWind



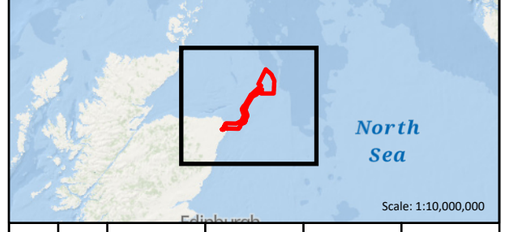
Red Line Boundary

Option Agreement Area

Perwinnes RLoS 274m amsl

NERL Radars

0 10 20 30 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:700,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 11 Perwinnes RLoS 274m amsl

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NOT TO BE USED FOR NAVIGATION

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MarramWind

3.4 Ministry of Defence air defence radars

3.4.1 Closest air defence radars

3.4.1.1 The closest air defence (AD) radar to the OAA is at Remote Radar Head Buchan, 86km to the south-west.

3.4.2 Remote radar head Buchan

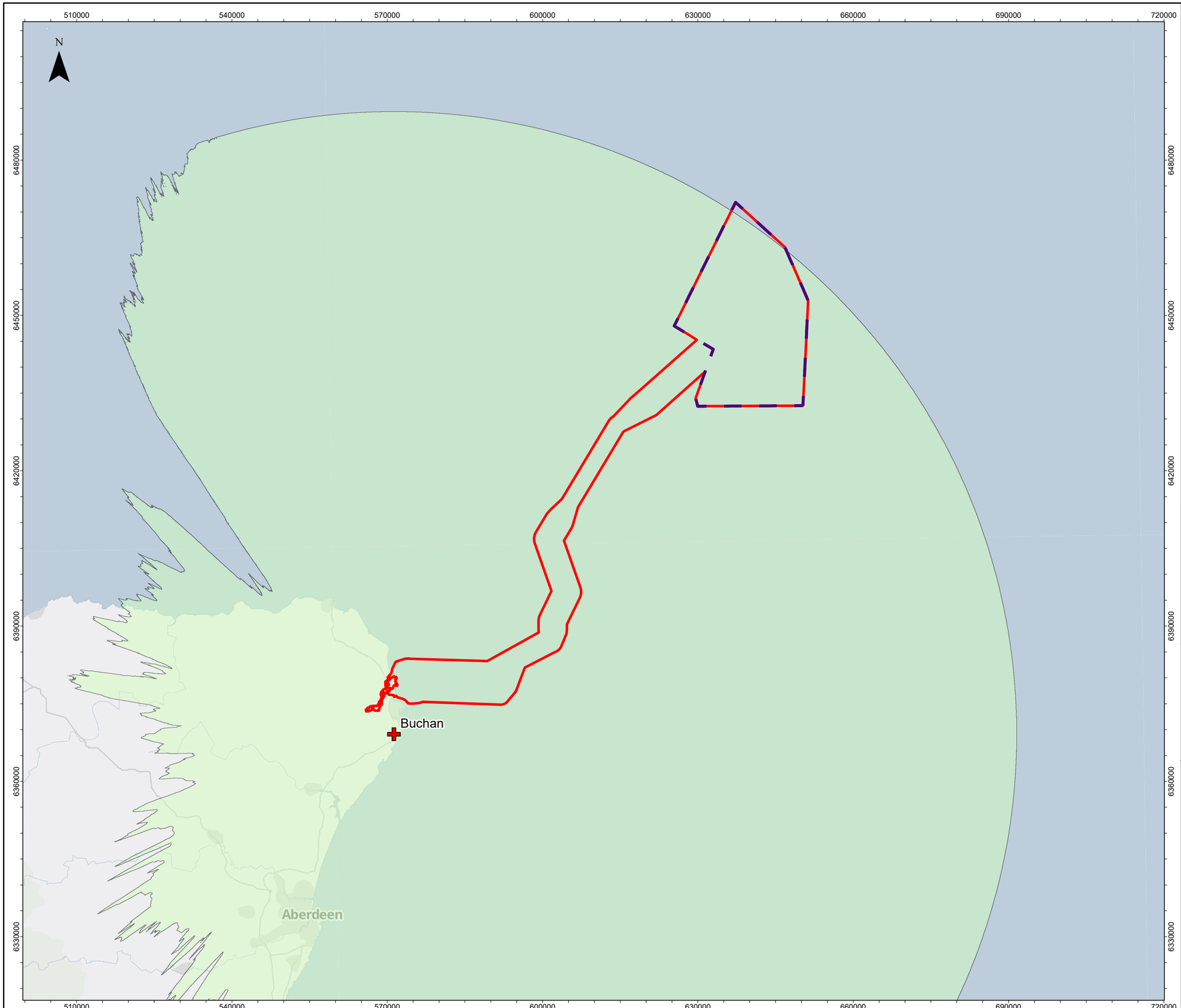
3.4.2.1 Buchan AD PSR is a Lockheed Martin TPS-77 system with a maximum operational range of up to 250nm (463km).

3.4.2.2 Buchan RLoS coverage for a blade tip height of 350m amsl is shown in **Figure 12**.

3.4.2.3 WTGs with a maximum blade tip height of 350m amsl within 98.2% of the OAA would be in RLoS of Buchan AD PSR and highly likely to be detected.

3.4.2.4 Buchan RLoS coverage for a blade tip height of 274m amsl is shown in **Figure 13**.

3.4.2.5 WTGs with a maximum blade tip height of 274m amsl within 72.3% of the OAA would be in RLoS of Buchan AD PSR and highly likely to be detected.



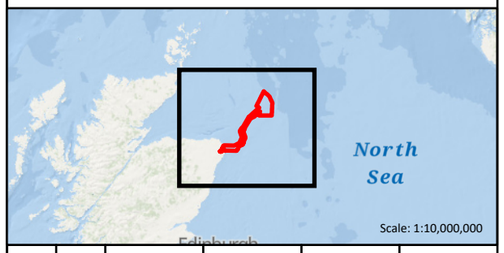
Red Line Boundary

Option Agreement Area

Buchan RLoS 350m amsl

AirDefence Radars

0 10 20 30 Kilometres



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SCALE	1:700,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 12 Buchan RLoS 350m amsl

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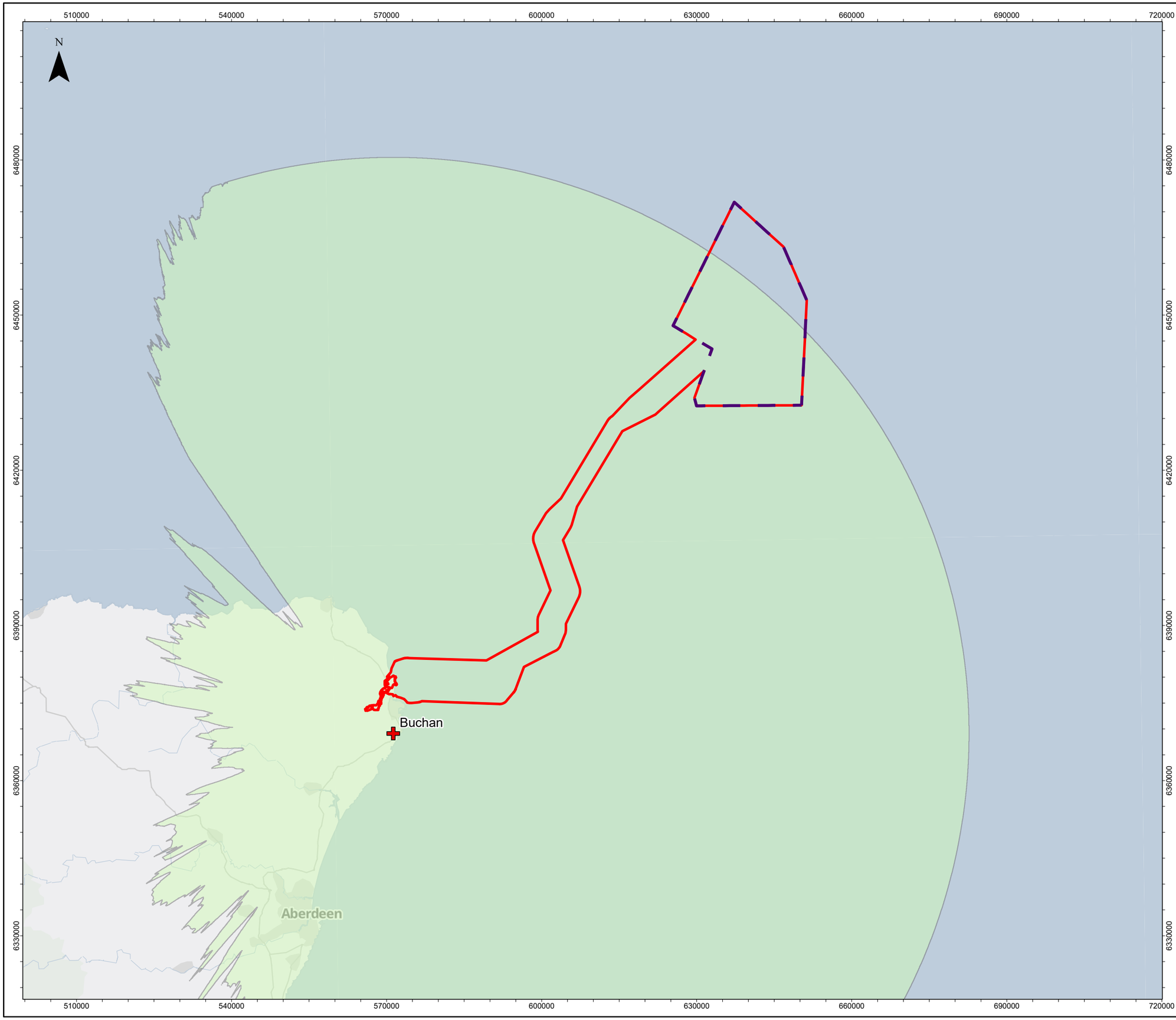
MarramWind



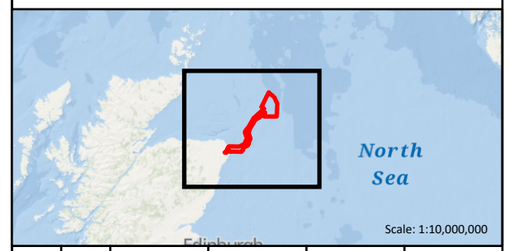
Red Line Boundary

Option Agreement Area

AirDefence Radars

Buchan RLoS 274m amsl

0 10 20 30 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:700,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 13 Buchan RLoS 274m amsl

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NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.5 Met Office radar

3.5.1 Closest Met Office radar

3.5.1.1 The closest Met Office radar to the OAA is at Hill of Dudwick, 98km to the south-west.

3.5.2 Hill of Dudwick

3.5.2.1 Hill of Dudwick weather radar is a C-band Doppler system.

3.5.2.2 Hill of Dudwick RLoS coverage for a blade tip height of 350m amsl is shown in **Figure 14**.

3.5.2.3 All WTGs within the OAA with a maximum blade tip height of 350m amsl would be in RLoS of Hill of Dudwick weather radar.

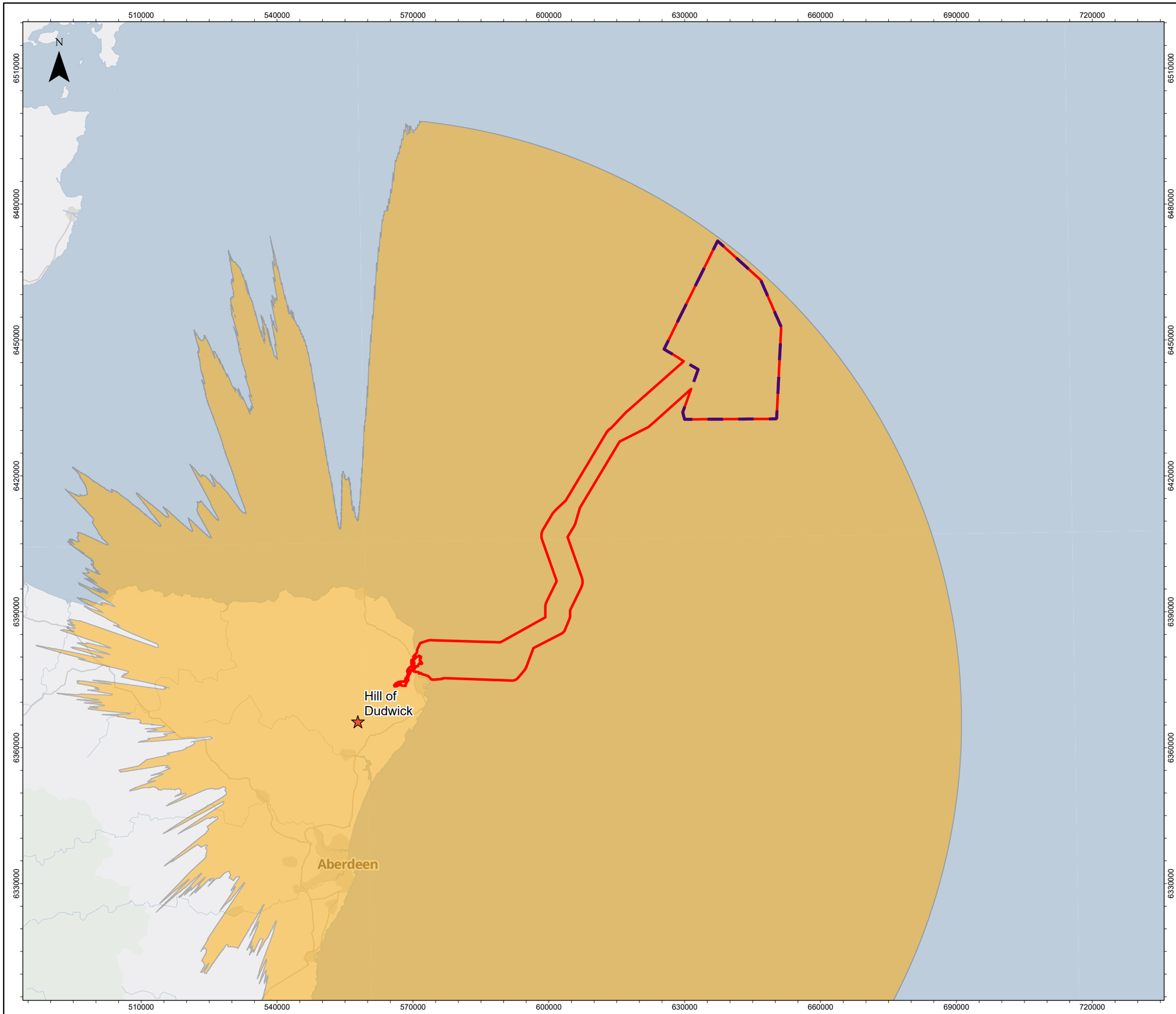
3.5.2.4 Hill of Dudwick RLoS coverage for a blade tip height of 274m amsl is shown in **Figure 15**.

3.5.2.5 WTGs with a maximum blade tip height of 274m amsl within approximately two thirds of the OAA would be in RLoS of Hill of Dudwick weather radar.

3.5.2.6 In operation, Hill of Dudwick weather radar completes a series of scans about a vertical axis at low-elevation angles, typically between 0.5 and 9.0 degrees. Provided obstacles such as WTGs are below the lowest elevation scan of the weather radar, there should be no interaction with the radar signal.

3.5.2.7 If the lowest elevation scan is assumed to be 0.5 degrees and the beam width is 1.0 degrees, then the base of the radar beam at the lowest elevation scan is approximately 757m amsl at a range of 98km (closest point of the OAA). This is shown in **Figure 16**, where 757m obstacles have been assessed against Hill of Dudwick to a maximum range of 150km from the radar. It therefore follows that, despite being in RLoS, all WTGs within the OAA would be below the beam of the radar and would not have any detrimental impacts.

3.5.2.8 The blue shaded area in **Figure 17** shows where 350m high WTGs can be safely deployed without having an impact on Hill of Dudwick weather radar.



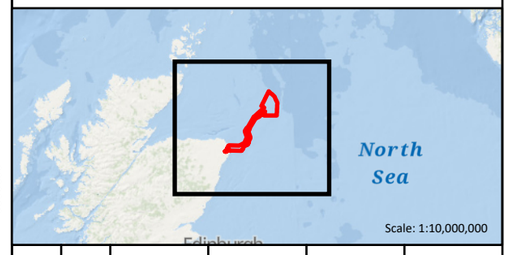
Red Line Boundary

Option Agreement Area

Hill of Dudwick RLoS 350m amsl

Weather Radars

0 10 20 30 40
Kilometres



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MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000268

DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:800,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 14 Hill of Dudwick RLoS 350m amsl

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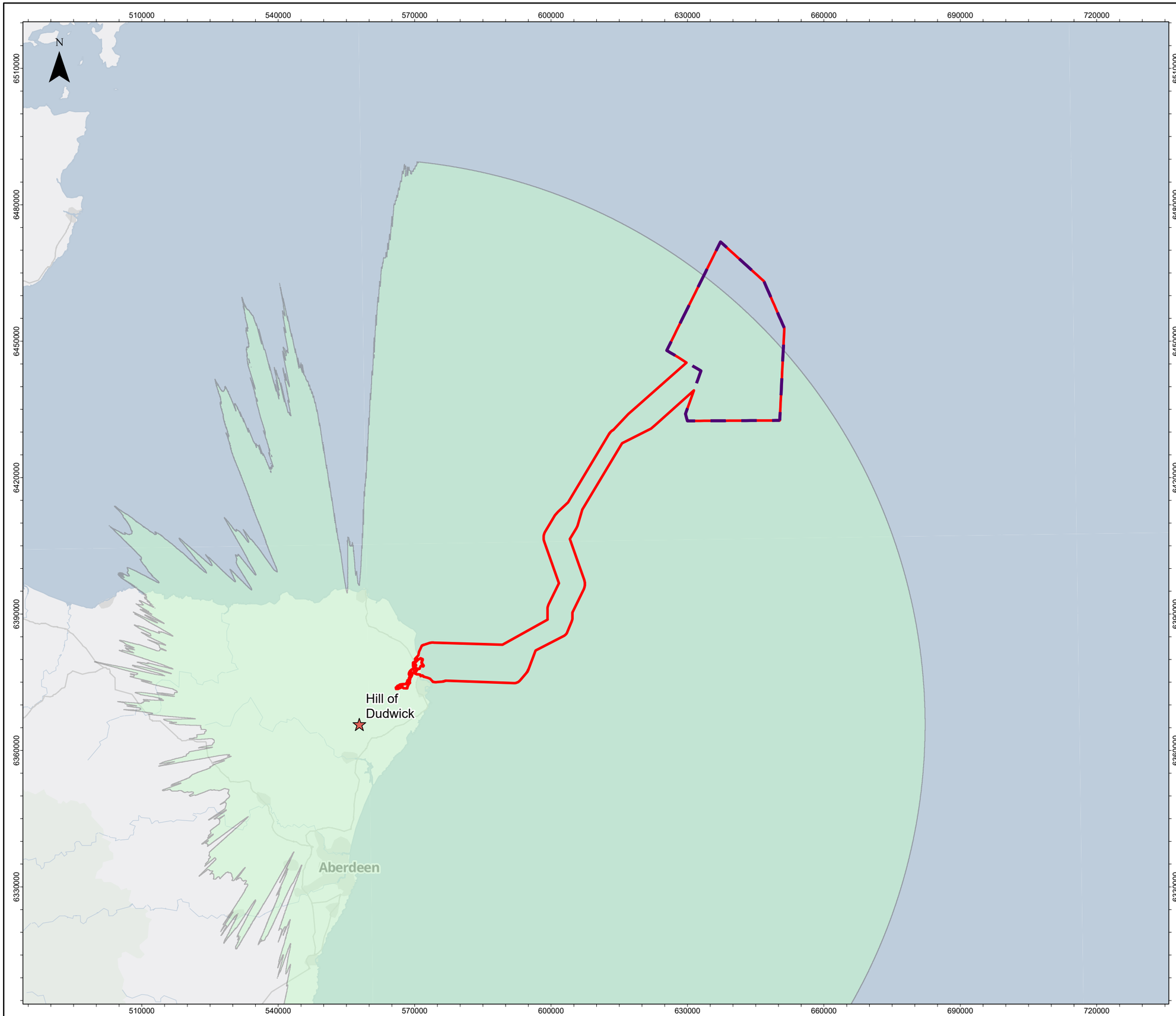
MarramWind



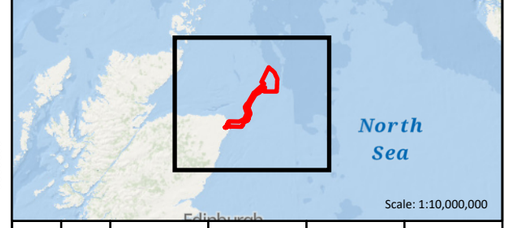
Red Line Boundary

Option Agreement Area

Hill of Dudwick RLoS 274m amsl

Weather Radars

0 10 20 30 40 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:800,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

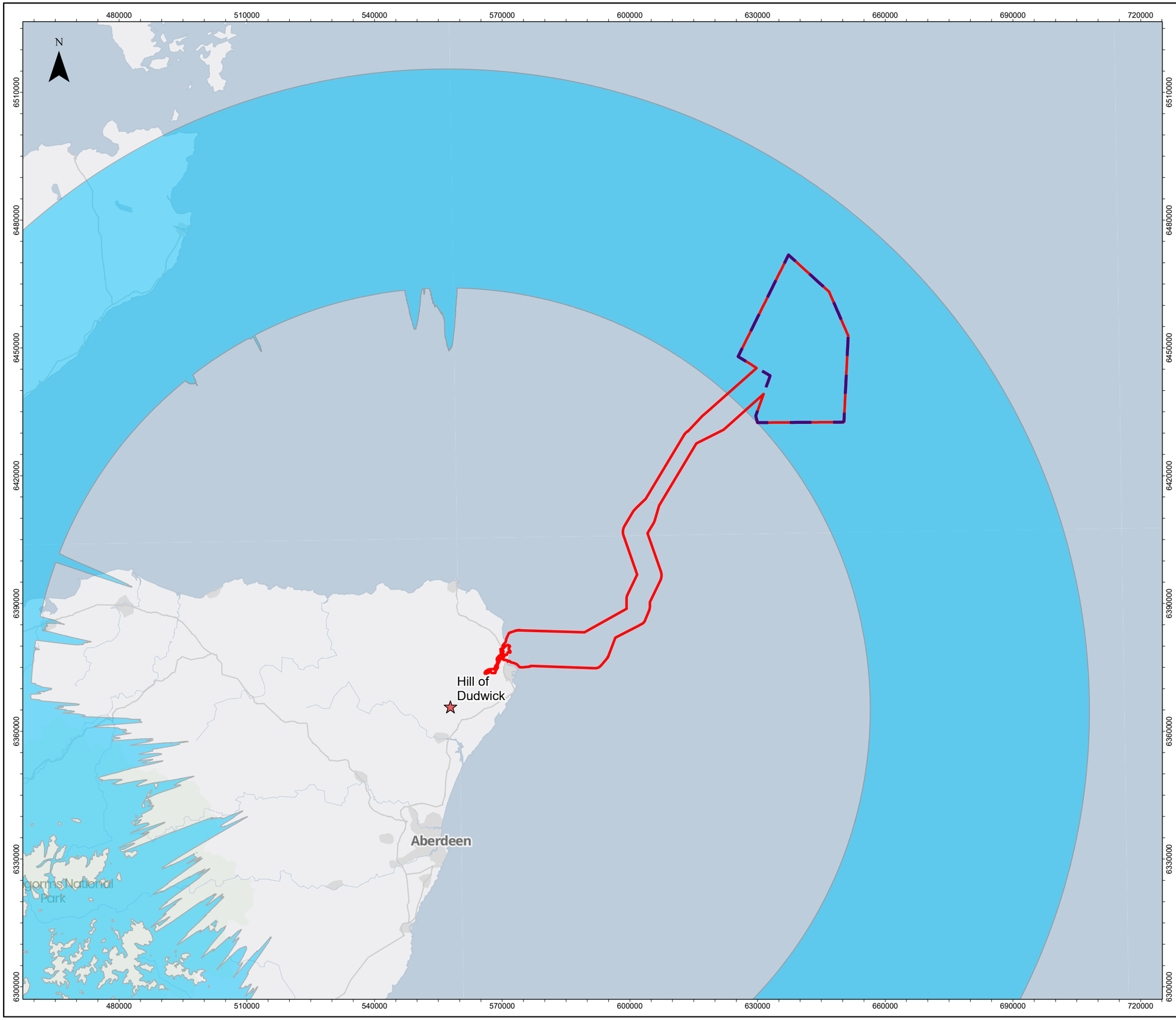
Figure 15 Hill of Dudwick RLoS 274m amsl

Environmental Impact Assessment Report
Appendix 31.1

NOT TO BE USED FOR NAVIGATION

wsp

MarramWind



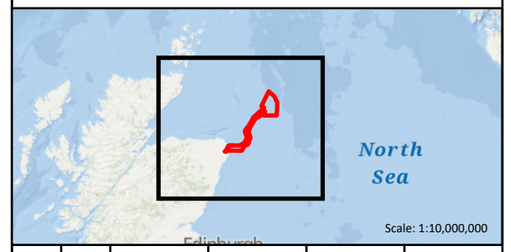
Red Line Boundary

Option Agreement Area

Hill of Dudwick - 757m amsl WTG Safe Deployment

Weather Radars

0 10 20 30 40 Kilometres



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DATUM	ETRS 89	PROJECTION	UTM Zone 30N
SCALE	1:850,000	PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 16 Hill of Dudwick - 757m amsl WTG safe deployment

Environmental Impact Assessment Report
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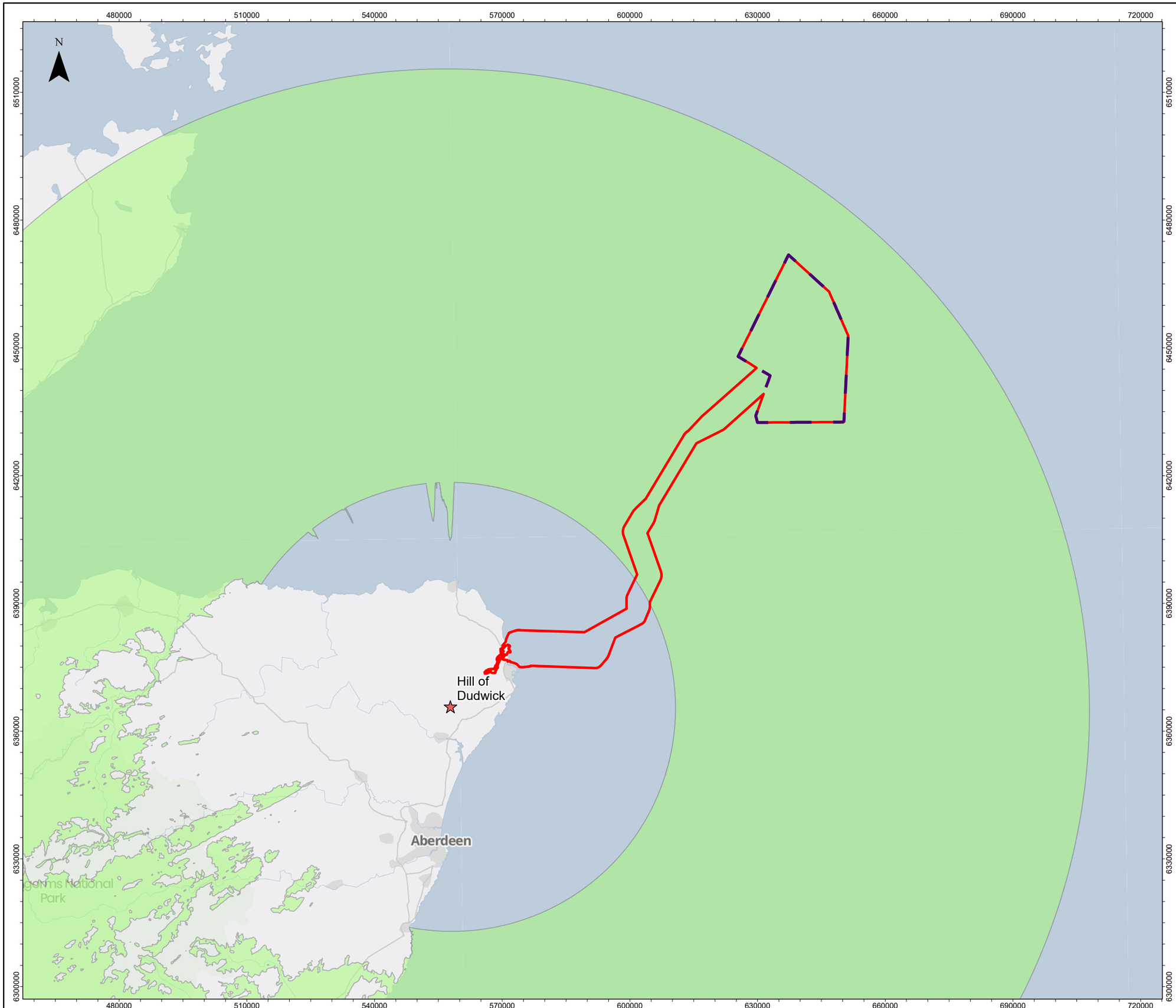
NOT TO BE USED FOR NAVIGATION

wsp

MarramWind



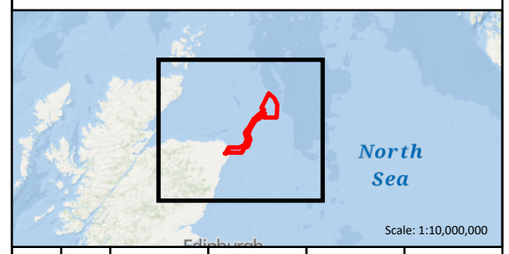
Red Line Boundary

Option Agreement Area

Hill of Dudwick - 350m amsl WTG Safe Deployment

Weather Radars

0 10 20 30 40 Kilometres



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PROJECTION	UTM Zone 30N
SCALE	1:850,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 17 Hill of Dudwick - 350m amsl WTG safe deployment

Environmental Impact Assessment Report
Appendix 31.1

NOT TO BE USED FOR NAVIGATION

wsp

MarramWind

3.6 Radar mitigation

3.6.1 NATS (En-Route) plc radars

3.6.1.1 The most likely mitigation option for WTGs that are detected by the NERL radars at Allanshill and Perwinnes would be to blank the radars in the impacted area. This removes the unwanted WTG generated clutter from the controller's radar display but also means that wanted aircraft returns are not displayed within the blanked area. Therefore, for offshore wind developments, blanking is usually used in combination with the imposition of a TMZ.

3.6.1.2 A TMZ allows ATC to track an aircraft target using solely SSR within an area in which PSR clutter may otherwise have obscured the target. Existing TMZs that have been established to mitigate the impacts of offshore wind developments include Moray Firth TMZ, Neart na Gaoithe TMZ and Seagreen TMZ.

3.6.1.3 To implement a new TMZ requires the submission of a formal airspace change proposal to the CAA. This process has recently been revised to make it more efficient, and specific guidance for TMZs is detailed in CAP 1616H: Guidance on Airspace Change Process for Level 3 and Pre-Scaled Airspace Change Proposals (CAA, 2023).

3.6.2 Ministry of Defence Air Defence radars

3.6.2.1 In respect of the TPS-77 PSR at Buchan, the most common WTG mitigation technique applied for previous offshore wind farm developments has been the application of a Non-Auto Initiation Zone (NAIZ) in the TPS-77's lowest beam over the footprint of any detectable WTGs. A NAIZ is a pre-defined geographical area where spurious radar returns from turbines will not initiate a track that could be interpreted as an aircraft. However, in August 2018 the MOD issued a statement indicating that the TPS-77 NAIZ mitigation had not performed to expectations at flight trials over two offshore wind farm developments and as a result immediately paused the receipt and assessment of any technical mitigation reports or submissions relating to TPS-77 radars and multi-turbine wind farms.

3.6.2.2 More recently the MOD has softened its stance regarding the acceptability of NAIZ mitigation, albeit mainly for smaller, and generally onshore, wind farm developments. The MOD may still consider the use of a NAIZ as an interim solution for the Project, pending the outcome of the initiatives described in the following paragraphs.

3.6.2.3 In August 2019 an Air Defence and Offshore Wind Windfarm Mitigation Task Force was formed as a collaborative initiative between the MOD, the Department for Business, Energy and Industrial Strategy (which is now the Department for Energy Security and Net Zero [DESNZ]), the Offshore Wind Industry Council (OWIC) and The Crown Estate. The Scottish Government and Crown Estate Scotland joined the Task Force in March 2022. The aim of the Task Force is to enable the co-existence of UK Air Defence and offshore wind by identifying potential mitigations and supporting processes, allowing offshore wind to contribute towards meeting the UK Government's Net Zero target without degrading the nation's AD surveillance capability.

3.6.2.4 Following the appointment of a new UK Government in July 2024, a new policy was released for delivery and funding of air defence radar mitigation within the Clean Power 2030 Action Plan in December 2024. An enduring radar mitigation solution will be identified, procured and implemented by the MOD via Programme Njord (in collaboration with DESNZ, The Crown Estate and OWIC) with government funding, removing the funding requirement for a radar mitigation solution from offshore wind developers.

4. Onshore Assessment

4.1 Onshore infrastructure

4.1.1.1 Onshore infrastructure associated with the Project would have the potential to impact the performance of nearby radars and aviation radio navigation aids. For example, large buildings could block radio navigation aid signals from being received by aircraft, or they could reflect signals and cause multipath interference.

4.1.1.2 The presence of onshore infrastructure and construction activities could also have an impact on flying activities at airfields in the vicinity.

4.2 Safeguarded zones

4.2.1.1 In order to protect navigation aid signals, safeguarded zones are established around the facility sites. The purpose of the safeguarded zone is to identify obstacles with the potential to cause unacceptable interference to the signals. Large structures can block signals and reflections of signals from obstacles can result in multipath interference. Structures that infringe the safeguarded zone must undergo technical assessments to determine the degree of potential interference, if any, and whether the interference would be acceptable to the Air Navigation Service Provider.

4.2.1.2 The International Civil Aviation Organisation (ICAO) document EUR Doc 015 European Guidance Material on Managing Building Restricted Areas (ICAO, 2015) details safeguarding criteria to protect the radio signals of communication, navigation and surveillance facilities from interference caused by buildings or other large objects. The document defines Building Restricted Area (BRA) shapes for both directional and omni-directional navigation aid facilities.

4.2.1.3 The Met Office publishes maps of consultation zones for each of its weather radars, which extend to a radius of 20km around the sites.

4.3 Communication, navigation and surveillance assessment

4.3.1.1 A military communication site known as Defence High Frequency Communications Service (DHFCS) Crimond is located approximately 6km north-north-west of the Onshore Red Line Boundary. The closest surveillance facilities to the Onshore Red Line Boundary are the MOD Buchan AD PSR, approximately 5km to the south-south-east, and the NERL Allanshill PSR, approximately 22km to the north-west.

4.3.1.2 Communication and surveillance facilities are omni-directional, and their associated BRAs comprise cylinders and inverted cones around the facility antennas.

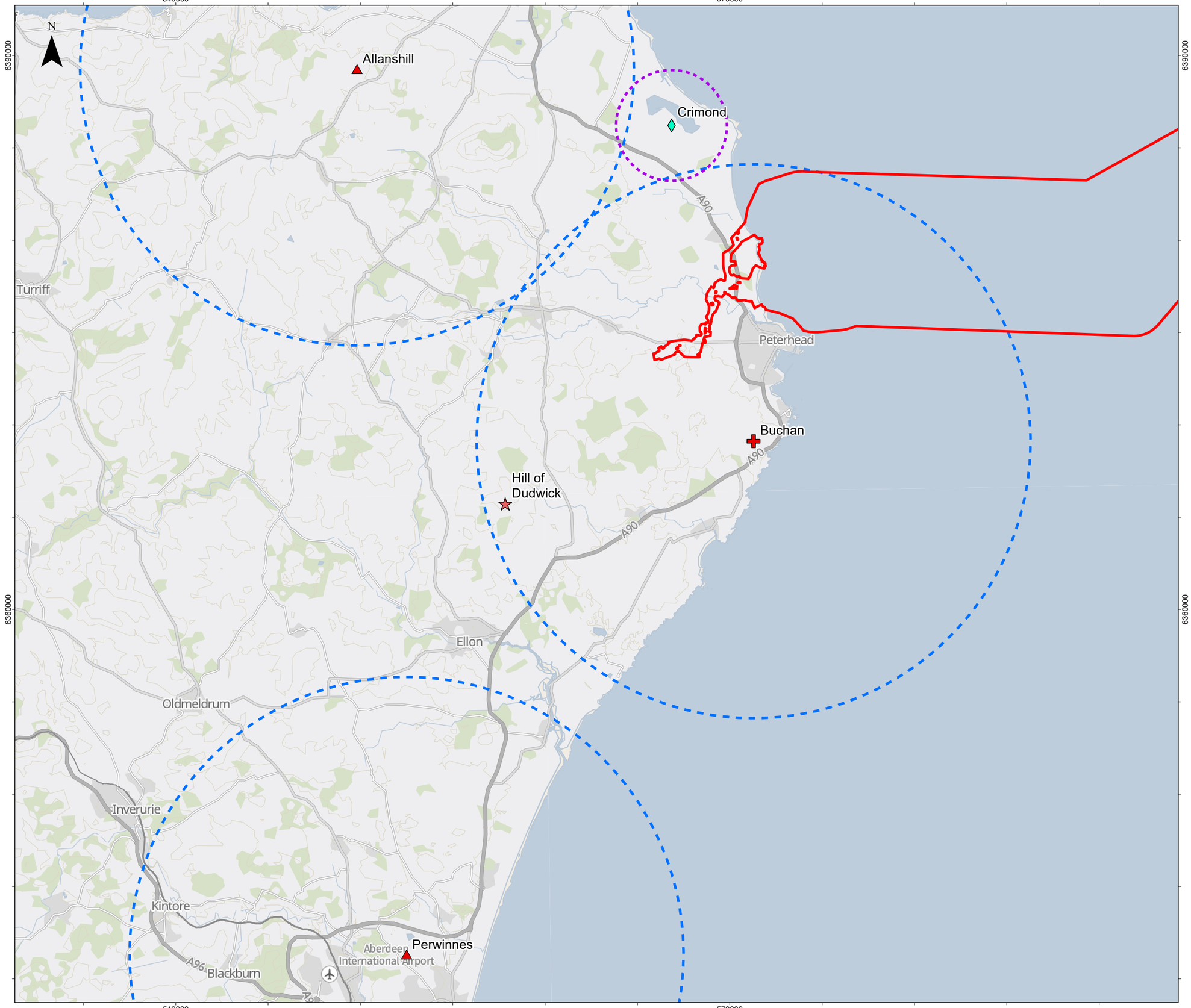
4.3.1.3 The BRA cylinder for a communication facility extends to a radius of 300m and the inverted cone to a radius of 2km. The Onshore Red Line Boundary is considerably further than 2km from DHFCS Crimond and therefore onshore infrastructure should have no impact.

4.3.1.4 The BRA cylinder for a PSR extends to a radius of 500m and the inverted cone to a radius of 15km, therefore infrastructure within the Onshore Red Line Boundary would be within the cone radius of Buchan AD PSR. The site elevation at Buchan AD PSR is 99.4m amsl and the highest ground elevation within the Onshore Red Line Boundary is 58.9m amsl, therefore only obstacles exceeding 40m in height could infringe the safeguarded surface. The slope of the BRA inverted cone is 0.25 degrees, originating from the base of the PSR antenna at ground level. If the slope of the cone is factored in, then at the highest point

within the Onshore Red Line Boundary only obstacles exceeding 64m in height could infringe the safeguarded surface. It can therefore be concluded that onshore infrastructure would not have any impact on the performance of surveillance facilities.

4.3.1.5 Hill of Dudwick weather radar is 11km south-west of the Onshore Red Line Boundary and therefore onshore infrastructure would be within the 20km safeguarded zone. However, the Met Office planning map shows that the Onshore Red Line Boundary is within a blue area, where consultation with the Met Office is only required for buildings, structures or works exceeding 91.4m in height above ground level.

4.3.1.6 The applicable safeguarded zones are depicted in **Figure 18**.



Red Line Boundary

Air Defence Radars

NERL Radars

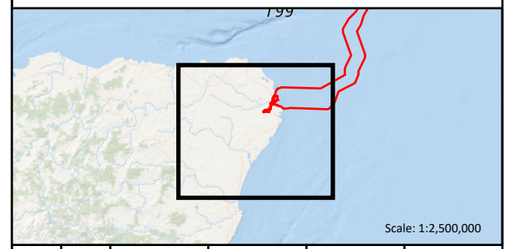
Weather Radars

DHFCS Transmitter Sites

VHF Transmitter 3km Safeguarding Zone

PSR 15km Safeguarding Zone

0 10 Kilometres



Scale: 1:2,500,000

	dd/mm/yyyy	--	--	--	--
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1	05/08/2025	PB	LT	LG	NC
REV	REV DATE	GIS CREATOR	GIS REVIEWER	TECHNICAL CHECKER	TECHNICAL APPROVER

WSP DRAWING NUMBER	808368-WEIS-IA-E5-FG-C5-71128
MarramWind DRAWING NUMBER	MAR-GEN-ENV-MAP-WSP-000169
DATUM	ETRS 89
PROJECTION	UTM Zone 30N
SCALE	1:200,000
PAGE SIZE	A3

PROJECT TITLE

MarramWind Offshore Wind Farm

DRAWING TITLE

Figure 18 Safeguarded zones

Environmental Impact Assessment Report
Appendix 31.1

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4.4 Airfields assessment

4.4.1.1 Guidance in CAP 764 (CAA, 2016) states that wind turbine developments within 3km of non-radar equipped unlicensed aerodromes with a runway of less than 800m might have an impact on operations. This guidance can also be applied for other infrastructure or construction activities within the Onshore Red Line Boundary. Longside Airfield is an unlicensed airfield that lies immediately adjacent to the west of the Onshore Red Line Boundary. There are no other known airfields within 3km of the Onshore Red Line Boundary.

4.4.1.2 Longside Airfield lies around 3km west of Peterhead and is the home of Buchan Aero Club. It has an east-west paved runway of 500m in length. The Onshore Red Line Boundary crosses the extended runway centreline approximately 200m east of the runway 28 threshold.

4.4.1.3 Plant equipment and construction activities associated with the excavation of trenches for the onshore export cables could potentially impede flying activities at Longside Airfield. Digging and exposure of topsoil could attract birds which are a hazard to aircraft.

4.4.1.4 Engagement with the owner of Longside Airfield would be necessary to ensure that the airfield is made aware of construction activities that could potentially affect operations at the airfield and hence determine the locations within the Onshore Red Line Boundary that would be of concern. Coordination of construction activities with the airfield would enable the airfield to raise awareness of potential obstacle hazards for visiting pilots.

5. Glossary of Terms and Abbreviations

5.1 Abbreviations

Acronym	Definition
AARA	Air-to-Air Refuelling Area
AD	Air Defence
AIP	Aeronautical Information Publication
AMA	Area Minimum Altitude
amsl	above mean sea level
ATC	Air Traffic Control
ATS	Air Traffic Service
ATSU	Air Traffic Service Unit
BRA	Building Restricted Area
CAP	Civil Aviation Publication
CAA	Civil Aviation Authority
DA	Danger Area
DESNZ	Department for Energy Security and Net Zero
DHFCS	Defence High Frequency Communications Service
DTM	Digital Terrain Model
FIR	Flight Information Region
FL	Flight Level
HMRI	Helicopter Main Routing Indicator
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
km	kilometres
m	metres
MCA	Maritime and Coastguard Agency
MOD	Ministry of Defence

Acronym	Definition
NAIZ	Non-Auto Initiation Zone
NERL	NATS (En-Route) plc
nm	nautical mile
NOTAM	Notice to Aviation
NSTA	North Sea Transition Authority
OAA	Option Agreement Area
OSA	Offshore Safety Area
OWIC	Offshore Wind Industry Council
PSR	Primary Surveillance Radar
PUQ	production, utilities and quarters
RAF	Royal Air Force
RLoS	Radar Line of Sight
SAR	Search and Rescue
SSR	Secondary Surveillance Radar
TMZ	Transponder Mandatory Zone
UK	United Kingdom
UTM	Universal Transverse Mercator
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
WTG	wind turbine generator

5.2 Glossary of terms

Term	Definition
Controlled airspace	Defined airspace within which pilots must follow Air Traffic Control instructions implicitly. In the UK, Classes A, C, D and E are areas of controlled airspace.
Flight Information Region	Airspace managed by a controlling authority with responsibility for ensuring air traffic services are provided to aircraft flying within it.
Flight Level	An aircraft altitude expressed in hundreds of feet at a standard sea level pressure datum of 1013.25 hectopascals.

Term	Definition
Instrument Flight Rules	Instrument Flight Rules are rules which allow properly equipped aircraft to be flown under Instrument Meteorological Conditions.
Instrument Meteorological Conditions	Instrument Meteorological Conditions are meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling less than the minima specified for Visual Meteorological Conditions.
Primary Surveillance Radar	A radar system that measures the bearing and distance of targets using the detected reflections of radio signals.
Radar	Radar is a commonly accepted noun that is in fact an abbreviation of Radio Detection and Ranging. It is a system of radio waves used to detect the presence and movement of aircraft, maritime vessels, and other moving objects and surface features.
Secondary Surveillance Radar	A radar system that transmits interrogation pulses and receives transmitted responses from suitably equipped targets.
Uncontrolled airspace	Defined airspace in which Air Traffic Control does not exercise exclusive authority but may provide basic information services to aircraft in radio contact. In the UK, Class G is uncontrolled airspace.
Visual Flight Rules	Visual Flight Rules are the rules that govern the operation of aircraft in Visual Meteorological Conditions, conditions in which flight solely by visual reference is possible.
Visual Meteorological Conditions	Visual Meteorological Conditions are the meteorological conditions expressed in terms of visibility, distance from cloud, and ceiling equal to or better than specified minima.

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