Morven South Offshore Wind Array Project

Environmental Impact Assessment Report

Volume 3, Annex 15.1: Aviation (Military and Civil) Shared Technical Report

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1 Introduction

1.1.1.1 The Morven North Offshore Wind Array Project (hereafter "Morven North") and The Morven South Offshore Wind Array Project (hereafter "Morven South") are both located within the Morven Option Lease Agreement Site (hereafter "Morven Site") in Scottish offshore waters (Figure 1.1). Morven North is located approximately 66km from the Aberdeenshire coast (at its closest point) and Morven South is located approximately 97km from the Aberdeenshire coast (at its closest point). Each project will comprise wind turbines, Offshore Substation Platforms, associated foundations, inter-array and interconnector cables and cable protection. Consent for the offshore export cables of Morven North and Morven South will be sought separately.

1.1.1.2 As shown in Figure 1.1, Morven North is situated northwest of Morven South. The external boundaries of the projects correspond with the boundaries of the Morven Site.

1.1.1.3 The Morven North and Morven South Aviation (Military and Civil) Shared Technical Report (hereafter referred to as the "Aviation (Military and Civil) Shared Technical Report") presents the baseline characterisation of aviation and radar for both Morven North and Morven South.

1.1.1.4 Consent for Morven North and Morven South will be sought separately, aided by the development of a separate Environmental Impact Assessment (EIA) and Habitats Regulations Assessment (HRA) for each project. However, the survey campaign and/or desk-based studies that will support the impact assessments for Morven North and Morven South are based on the Morven Site, which accommodates both Morven North and Morven South. Given the comparability and consistency of information collected to inform the assessments for both projects, the baseline characterisation of aviation and radar for both Morven North and Morven South is reported in the present Aviation (Military and Civil) Shared Technical Report.

1.1.1.5 The information from this Aviation (Military and Civil) Shared Technical Report provides the technical baseline to inform the assessment of the likely significant effects of Morven North and Morven South on aviation and radar receptors. This report accompanies the EIA provided in Volume 2, Chapter 15: Aviation (Military and Civil), the respective EIA Reports for Morven North or Morven South to support the respective consent applications.

1.1.1.6 The aim of this Aviation and Radar Shared Technical Report is to:

- characterise the aviation and radar environment within and surrounding Morven North and Morven South
- to inform Volume 2, Chapter 15: Aviation (Military and Civil) being undertaken as part of the consenting process for Morven North and Morven South.

1.1.1.7 Data were collated through a detailed desktop study of existing resources available for aviation and radar within a defined study area to establish the potential for aviation receptors to be impacted. Airspace users at, and surrounding, the Morven North and Morven South Boundaries were also considered.

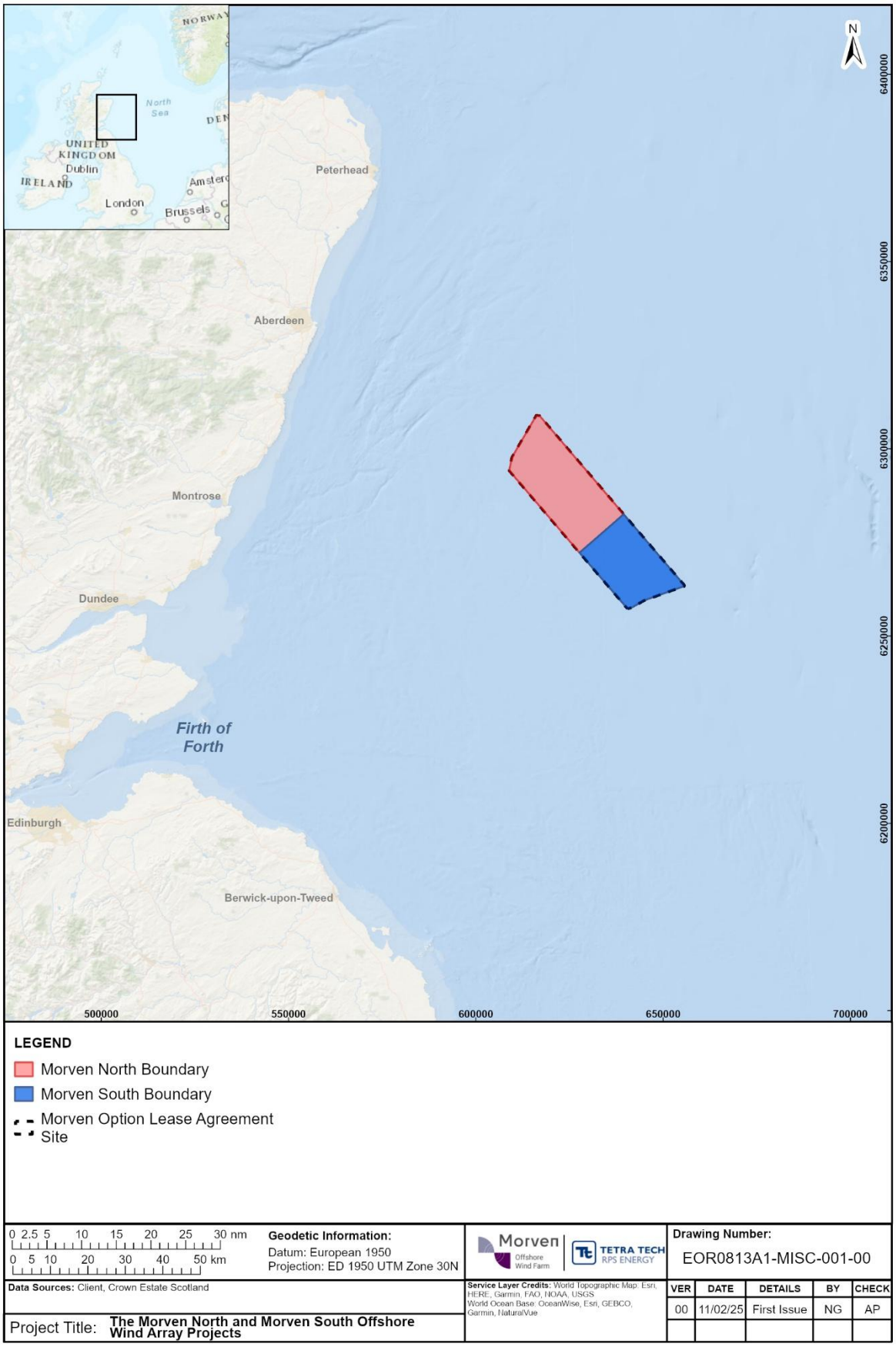

Figure 1.1: The boundaries of Morven North and Morven South within the Morven Option Lease Agreement Site

2 Study areas

2.1.1.1 To identify and characterise aviation and radar, a broad study area has been defined and based on recommendations provided by the Civil Aviation Authority (CAA) Civil Aviation Publication (CAP) 764 Policy and Guidelines on Wind Turbines (CAA, 2016). CAP 764 (CAA, 2016) provides criteria for assessing whether any wind turbine development might have an impact on aerodrome and radar related operations. Consideration of Morven North and Morven South potential to impact on aviation receptors has been undertaken in accordance with the recommended consultation distance for aviation within 30km of an aerodrome with a surveillance radar facility, as stated in CAP 764 (CAA, 2016). However, CAP 764 (CAA, 2016) states that the operational range of a radar system is dependent on the type of radar used and its operational requirement.

2.1.1.2 Although CAP 764 (CAA, 2016) provides a guide of 30km for assessment of radar impact, impact to aviation radar is dependent on radar detectability of operational wind turbines, the radar's operational range and the use of airspace in which the development sits. The identification of the Aviation and Radar Study Area and assessment of potential operational impact has considered physical safeguarding of flight, airspace characteristics and procedures as published in the CAA CAP 032, United Kingdom (UK) Integrated Aeronautical Information Package (IAIP) (CAA, 2025) and the Ministry of Defence (MOD) Military Aeronautical Information Publication (Mil AIP) (MOD, 2025).

2.1.1.3 The Aviation and Radar Study Area covers the aviation radar systems that potentially detect the maximum (highest) wind turbine blade tip height of 363m above mean sea level (amsl). The accurate maximum tip height is confirmed to be 363m above Lowest Astronomical Tide (LAT); however, as this equates to a value less than 363m amsl, and as elevations in aviation are referenced to sea level, the value of 363m amsl has been used for assessment. The Aviation and Radar Study Area encapsulates the Morven Site, and applicable airspace between the Morven Site and the UK mainland from the location of the NATS (En Route) PLC (NERL) operated Allanshill Primary Surveillance Radar (PSR) to the north and the MOD operated Brizlee Wood Remote Radar Head (RRH) Air Defence Radar (ADR) to the south. The predicted impact to aviation receptors (including radar operated by NERL and those operated by littoral airfields) is the same for both Morven North and Morven South. Therefore, both Morven North and Morven South Boundaries are encapsulated into a shared study area.

2.1.1.4 The study area defined for aviation and radar is shown in Figure 2.1.

2.1.1.5 The study area for aviation and radar for the Morven Site were presented to and agreed during the scoping process for the Morven Site. The study area for Morven North and Morven South remains unchanged from the study area presented at scoping for the Morven Site. The study area for Morven North and Morven South for aviation and radar was presented to the Marine Directorate Licencing Operations Team (MD-LOT) via a "Targeted Consultation Exercise" undertaken in Quarter 1, 2025.

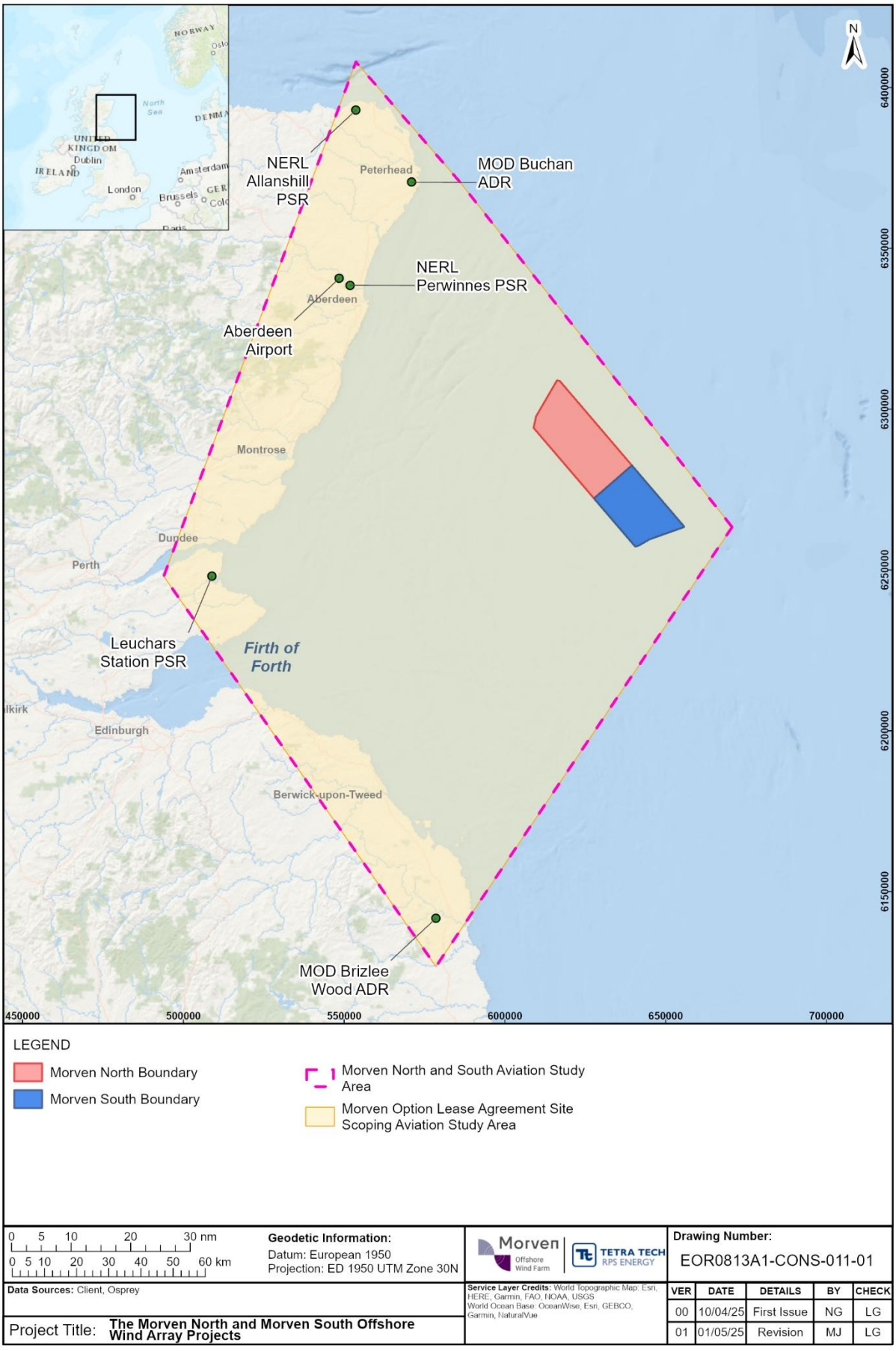

Figure 2.1: Morven North and Morven South Aviation and Radar Study Area

3 Methodology

3.1.1.1 A variety of national and international aviation publications contain information and guidance relating to the potential effects of an offshore wind development on aviation receptors; all relevant documents were considered in establishing the aviation and radar baseline. The primary source of aviation related data used during desktop studies in support of this report is the UK IAIP (CAA, 2025) and the Mil AIP (MOD, 2025). Both documents contain details on airspace and en route procedures as well as charts and other air navigation information. The aviation industry and the provision of an Air Navigation Services (ANS) (including radar services) are regulated through extensive legislation; however, the main mechanism for regulating the relationship between aviation and offshore wind is through the planning system.

3.2 Desktop study

3.2.1.1 A detailed desktop review of existing studies and datasets was undertaken to gather information on aviation (civil and military) and radar within the Aviation and Radar Study Area. Through the desktop study the identification of all aviation and radar receptors potentially affected by Morven North and Morven South was established in accordance with regulatory guidelines on safeguarding distances from CAP 764 (CAA, 2016).

3.2.1.2 Information on aviation and radar within the Morven North and Morven South Aviation and Radar Study Area was collected through a detailed desktop review of existing studies and datasets. Desktop study sources used to inform the aviation and radar assessment are summarised in Table 3.1.

Table 3.1: Summary of key desktop datasets and reports for aviation and radar

Title	Source	Year	Author
Policy and Guidelines on Wind Turbines (CAP 764)	CAA	2016	CAA
Air Navigation Order (ANO) (CAP 393)	CAA	2016 (as amended 2022)	CAA
Air Traffic Services Safety requirements (CAP 670)	CAA	2019	CAA
Air Traffic Control Surveillance Minimum Altitude Charts in United Kingdom Airspace Policy and Design Criteria (CAP 777)	CAA	2018	CAA
Safeguarding of Aerodromes (CAP 793)	CAA	2020	CAA
Licensing of Aerodromes (CAP 168)	CAA	2022	CAA
Department for Energy Security and Net Zero (DESNZ) Overarching National Policy Statement for Energy (EN-1)	DESNZ	2023	DESNZ
United Kingdom Visual Flight Rules Chart – 1:500,000 Sheet 2150ABCD Scotland Edition 36	CAA/NATS	2023	CAA/NATS
Implementation and Safeguarding of Instrument Flight Procedures (IFP) in the United Kingdom (CAP 785B)	CAA	2022	CAA

Title	Source	Year	Author
United Kingdom Integrated Aeronautical Information Package (IAIP) (CAP 032)	CAA/NATS	2025	CAA/NATS
Maritime and Coastguard Agency (MCA) Marine Guidance Note (MGN) 654 - Safety of Navigation Offshore Renewable Energy Installations (OREI) - Guidance on UK Navigational Practice, Safety and Emergency Response	MCA	2021	MCA
MCA MGN 654 Annex 5 – Offshore Renewable Energy Installations: Requirements, Guidance and Operational Considerations for Search and Rescue (SAR) and Emergency Response	MCA	2024	MCA
International Civil Aviation Organisation (ICAO) Document 8168 Ops/611 Procedures for Air Navigation Services – Aircraft Operations (PANS-Ops)	ICAO	2018	ICAO
ICAO Annex 14 Aerodromes Design and Operations containing Standards and Recommended Procedures (SARPs)	ICAO	2022	ICAO
Statement of the Operational Programme for the exchange of Weather Radar (OPERA) group on the cohabitation between weather radars and wind turbines	OPERA	2009	OPERA
United Kingdom Low Flying Handbook	MOD	2025	MOD
Military Aeronautical Information Publication (Mil AIP)	MOD	2025	MOD
United Kingdom En route Low Altitude North Sea West Offshore Installations UK (L) 5 OIL	MOD	2024	MOD
Ministry of Defence Lighting Review	MOD	2020	MOD
Aberdeen Airport Instrument Flight Procedures Safeguarding – Morven North Offshore Wind Array Project and the Morven South Offshore Wind Array Project (Volume 3, Annex 15.3: Aviation (Military and Civil) Shared IFP Assessment).	Osprey Consulting Services Limited	2025	Osprey

3.3 Site specific surveys

3.3.1.1 No aviation and radar site specific surveys were required.

4 Baseline characterisation

4.1 Morven North and Morven South Aviation and Radar Study Area

4.1.1.1 The results of the desktop study are provided below and apply to both Morven North and Morven South. Specific analysis conclusion differences between Morven North and Morven South are explained in the paragraphs below.

4.1.1.2 The airspace above and around the Morven North and Morven South Boundaries is used by both civil and military aircraft, which are tracked by radar systems operated by both NERL and the MOD. The Morven Site is located within the Scottish Flight Information Region (FIR) in an area of Class G uncontrolled airspace, which is established from surface up to Flight Level (FL) 195 (approximately 19,500ft amsl). Further sub-division of the Class G airspace occurs which enables definition of the area of responsibility in which the Aberdeen Air Traffic Service Unit (based at Aberdeen Airport) provides an Air Traffic Service (ATS) in the Aberdeen radar sector from the surface to FL85 (approximately 8,500ft amsl). Further sub-division above FL85 forms an area where predominately, military aircraft operate in a defined Practice and Exercise Area (PEXA). Above Class G airspace, Class C Controlled Airspace (CAS) is established. Figure 4.1 provides an illustration of the airspace construction.

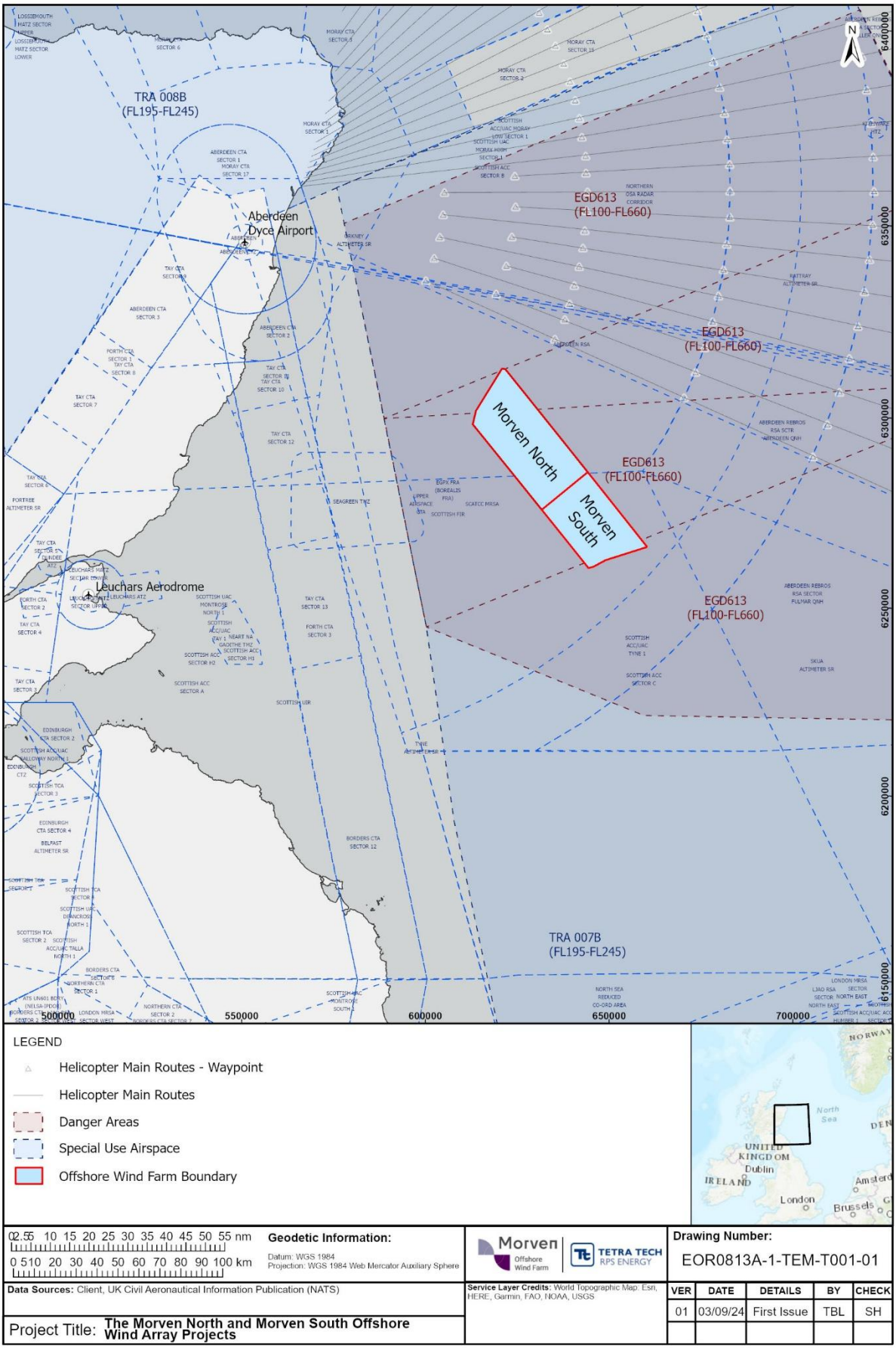

Figure 4.1: Morven North and Morven South airspace construction

4.1.1.3 Within Class G uncontrolled airspace an ATS is not mandatory. In Class G airspace, any aircraft may fly when and where they like, subject to a set of simple rules. Although there is no legal requirement to do so, many pilots notify Air Traffic Control (ATC) of their presence and intentions, and pilots take full responsibility for their own safety. Pilots may request an ATS which may be provided by NERL or military controllers located at an Area Control Centre (ACC) or Air Defence (AD) controllers, subject to suitable radar and radio coverage being available to them however, pilots are ultimately responsible for their own terrain and obstacle clearance. This is achieved through prudent planning (using published aviation charts, the UK IAIP and local aerodrome instructions) and diligent 'lookout' throughout the flight.

4.1.1.4 All aircraft operating within CAS must be in receipt of an ATS from NERL, military air traffic controllers located at a NATS ACC or under the control of military AD controllers. Within Class C CAS all flights are subject to mandatory ATC instructions with standard separation maintained between aircraft dependent on whether they are flying under Instrument Flight Rules (IFR) or Visual Flight Rules (VFR). When flying under IFR aircrews are referring to aircraft cockpit instruments for situation awareness and navigation and may not be able to operate the aircraft with visual reference to maintain visual separation from obstacles, terrain and other aircraft. When flying IFR aircraft will operate above a Minimum Safety Altitude (MSA) which maintains a minimum of 1,000ft between aircraft and obstacles/terrain below the aircraft. When flying under VFR, aircrews are referring to a set of regulations under which a pilot operates the aircraft in weather conditions which generally allow the pilot to maintain visual separation from obstacles, terrain and other aircraft.

4.1.1.5 Military low flying is a demanding but essential skill for military aircrew, gained through progressive training and continuous practice within the UK Low Flying System (UKLFS). The ability to operate effectively at low level by day and night is vital to fast jet, transport aircraft and helicopters as they support forces on the ground. Military aircraft are deemed to be low flying when operating below 2,000ft above the surface. The North Sea Class G airspace within which the Morven Site sits, is in the MOD Low Flying Area (LFA) 14 (part of the UKLFS). LFA 14 is the largest area in the United Kingdom and covers mainland Scotland, the Western Isles, Orkney and Shetland. There are areas located with LFA 14 where military low flying is prohibited or restricted, these include but not limited to congested areas, industrial sites and avoidance areas around major airports and glider sites.

4.2 Civilian aviation

4.2.1 Airports

Morven North

4.2.1.1 The civil airport closest to Morven North is Aberdeen Airport. The Aberdeen Airport Airfield Reference Point (ARP) (which is situated at the centre of the Aberdeen Airport main runway) is located on a bearing of 302°/40nm from the closest Morven North Boundary. Due to the location of Morven North, Aberdeen Airport is the only civil airport which may be impacted. Radar operations carried out from the airport are unique in that operations are split into two control elements:

- Airfield control – services provided to aircraft arriving and departing the airport and in the local vicinity;
- En Route control – offshore services provided to aircraft in support of the offshore oil and gas industries within the Area of Responsibility (AoR).

4.2.1.2 Instrument Flight Procedures (IFP) design covers the planning of routes used by pilots and ATC from take-off to landing and is a complex and highly regulated process. All IFP design must be undertaken by an approved procedure designer that is authorised by the relevant State. In the UK, all IFP design must be undertaken in accordance with CAA requirements. Wind turbines placed in proximity to IFP may adversely affect IFP safeguarded areas which may result in individual IFP being no longer fit for purpose without mitigation being applied. Volume 3, Annex 15.2: Aviation (Military and Civil) Shared IFP Assessment has assessed published Aberdeen Airport IFP which may be impacted by Morven

North and concludes that Aberdeen Airport IFP will not be affected by the development of Morven North (see Volume 3, Annex 15.2: Aviation (Military and Civil) Shared IFP Assessment).

Morven South

4.2.1.3 The description of the airport baseline characterisation provided for Morven North also applies to Morven South. Aberdeen Airport IFP will not be impacted by the development of Morven South (see Volume 3, Annex 15.2: Aviation (Military and Civil) Shared IFP Assessment).

4.2.2 Aviation radar systems

4.2.2.1 Figure 2.1 provides the location of the two NERL PSR systems which may be affected by the development of the Morven Site. Table 4.1 provides the distances taken from the closest boundary of Morven North and Morven South to each NERL PSR potentially affected.

Table 4.1: Range of NERL Primary Surveillance Radar systems from the Morven Site

Radar	Morven North	Morven South
NERL Perwinnes PSR	307°/38.7nm	321°/56.3nm
NERL Allanshill PSR	322°/56.3nm	323°/75.4nm

4.2.2.2 A PSR is a conventional radar sensor that illuminates a large portion of space with an electromagnetic wave and receives back the reflected waves from targets within that space. The term thus refers to a radar system used to detect and localise potentially non-cooperative targets. Typically, PSR systems employ a "cosec2 antenna" which produces two beams (low and high). The two beams give a capability to reduce fixed ground clutter in the immediate area of the radar. These systems provide target detection in range and azimuth only and are generally known as two dimensional (2D) radars. A wind turbine that is detectable by a PSR system can be a significant cause of radar false plots, or unwanted returns (clutter), and therefore, might be interpreted as aircraft targets. Additionally, the rotation of the wind turbine blades provides an indication to the radar system that the target acquired is moving and thus defeating Doppler processing techniques. This issue can be further compounded by a large number of wind turbines located together (such as a wind farm) which leads to a cumulative effect over a greater volume of airspace with higher densities of radar clutter produced.

4.2.2.3 Secondary Surveillance Radar (SSR) is a collaborative radar system which means that the radar will "interrogate" a transponder on the aircraft for useful information such as altitude and heading, which is then passed to the ATC display console. All military aircraft (and most civilian aircraft) carry transponders which respond to secondary radar interrogation. The CAA advises that effects on SSR are only relevant to consider when wind turbines are located less than 10km from the SSR (CAP 764) (CAA, 2016).

Morven North

4.2.2.4 Morven North is predicted to adversely impact both the Perwinnes and Allanshill PSRs. The closest aviation SSR systems to Morven North are co-located at the Perwinnes and Allanshill PSR locations which lie outside the area of interaction with any aviation related SSR systems. Morven North will not affect aviation related SSR systems.

Morven South

4.2.2.5 Morven South is predicted to adversely impact both the Perwinnes and Allanshill PSRs. The closest aviation SSR systems to Morven South are co-located at the Perwinnes and Allanshill PSR locations

which lie outside the area of interaction with any aviation related SSR systems. Similarly, Morven South will not affect aviation related SSR systems.

4.2.3 Offshore helicopter operations

4.2.3.1 Commercial offshore helicopter operations in this region encompass support to offshore oil and gas exploitation. Helicopters supporting offshore oil and gas in the northern North Sea use Helicopter Main Route Indicators (HMRIs), radiating from Aberdeen Airport (the main support base in the region) on a hub/spoke radial pattern as illustrated in Figure 4.2.

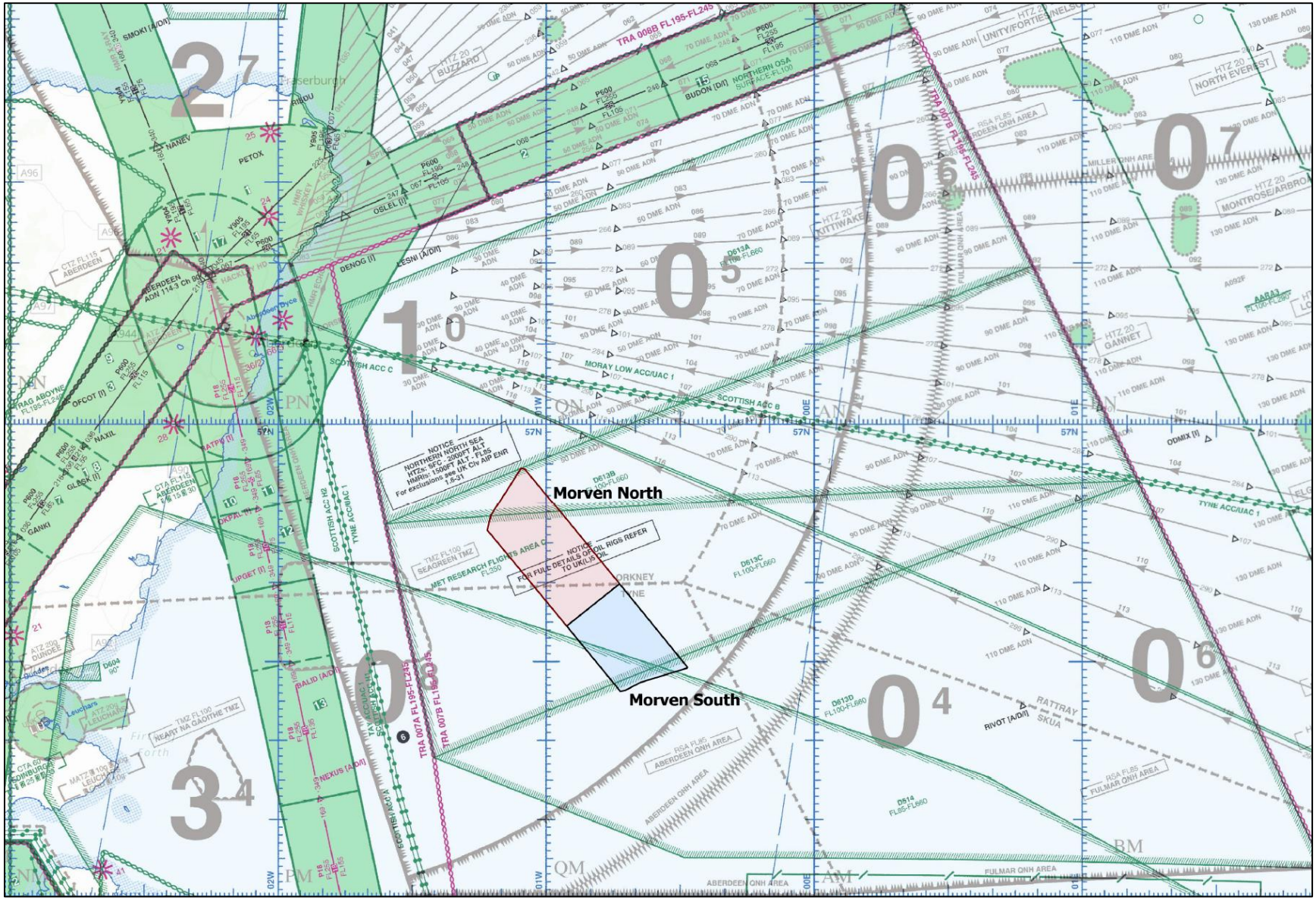

Figure 4.2: Helicopter Main Route Indicators in the vicinity of Morven North and Morven South

4.2.3.2 The HMRIs which radiate from Aberdeen Airport lie to the north of Morven North and Morven South; the closest HMRI being 10nm to the north of the Morven North northeastern boundary (16.5nm to the northeast of Morven South). The CAA recommend within CAP 764 (CAA, 2016) that there should be no obstacles within 2nm either side of the centreline of a HMRI. No impact to helicopter operations operating on HMRI is predicted to occur from the Morven Site and is not considered further.

4.2.4 Meteorological Office radar

Morven North

4.2.4.1 The Meteorological Office (Met Office) safeguards its weather radar and provides site specific (radar) pre-planning advice for proposals sited in Met Office consultation zones. Morven North is located outside of the 30km consultation zone for the nearest Met Office radar at Hill of Dudwick, Aberdeenshire, which is located on a bearing of 315°/44nm/82km from the closest boundary of Morven North. The National Policy Statement (NPS) for Energy (EN-1) indicates that some energy structures, such as wind turbines, have the potential to adversely impact weather radar signals, even beyond 100km from the radar (Department for Energy Security and Net Zero (DESNZ), 2023). The Met Office offered no response at scoping however, during July 2025 the Met Office confirmed by email that Morven Northwill have no impact to the Hill of Dudwick radar

Morven South

4.2.4.2 The Met Office safeguards its weather radar and provides site specific (radar) pre-planning advice for proposals sited in Met Office consultation zones. Morven South is located outside of the 30km consultation zone for the nearest Met Office radar at Hill of Dudwick, Aberdeenshire, which is located on a bearing of 320°/62.8nm/116km from the closest boundary of Morven South. The NPS for Energy (EN-1) indicates that some energy structures, such as wind turbines, have the potential to adversely impact weather radar signals, even beyond 100km from the radar (DESNZ, 2023). The Met Office offered no response at scoping however, during July 2025 the Met Office confirmed by email that Morven South will have no impact to the Hill of Dudwick radar.

4.3 Military aviation

4.3.1 MOD Air defence radar

4.3.1.1 Figure 2.1 provides the location of MOD ADR systems with the potential to be impacted by the Morven Site. Table 4.2 provides the distances taken from the closest boundary of Morven North and Morven South to each MOD ADR potentially affected.

Table 4.2: Range of MoD air defence radar systems from the Morven Site

Radar	Morven North	Morven South
RRH Buchan ADR	325°/40.5nm	325°/59nm
RRH Brizlee Wood ADR	202°/75.1nm	210°/70.7nm

4.3.1.2 The MOD, through the Air Surveillance and Control System (ASACS), is responsible for compiling a Recognised Air Picture (RAP) to monitor the airspace in and around the UK to launch a response to any potential airborne threat. This is achieved through the utilisation of a network of long range ADR systems, some of which are located along the east coast of the UK. ADR systems typically employ complex rotating phased array antennas. The antennas produce many smaller 'pencil' beams which are stacked in elevation, this allows the system to process the received targets signal strength in

each of the pencil beams, which in turn gives the radar the ability to provide an indication of the coarse height of a target as well as its range and azimuth. These types of radar are generally referred to as three dimensional (3D) systems. ADRs are similarly impacted by the detection of operational wind turbines as listed in paragraphs 4.4.1.5 to 4.4.1.8. Any identified effect of wind turbines on the ADR systems that serve the airspace above and beyond the Morven Site may potentially reduce the capability of the MOD to effectively monitor airspace in locating a potential airborne threat.

Morven North

4.3.1.3 Morven North lies roughly central to the location of RRH Buchan (located to the northwest of Morven North) and RRH Brizlee Wood (located southwest of the Morven North). The TPS-77 (Type 92) ADR located at RRH Buchan, Aberdeenshire is closest to Morven North. A TPS-77 ADR is one of Lockheed Martin's radars which provides multi-mission ground-based radar solutions for medium to long range air surveillance. Radar LoS results (which are conservative in nature) indicates that Morven North is predicted to adversely impact both RRH Buchan and Brizlee Wood ADRs.

Morven South

4.3.1.4 Any identified effect of wind turbines on the ADR systems that serve the airspace above and beyond Morven South may potentially reduce the capability of the MOD to effectively monitor airspace in locating a potential airborne threat.

4.3.1.5 Morven South lies roughly central to the location of RRH Buchan (located to the northwest of Morven South) and RRH Brizlee Wood (located southwest of Morven South). Radar LoS results (which are conservative in nature) indicates that Morven South is predicted to adversely impact both RRH Buchan and Brizlee Wood ADRs.

4.3.2 MOD Airfield Radar

4.3.2.1 The only MOD ATC PSR that mat may be impacted is located at Leuchars Station.

Table 4.3: Range of MOD Leuchars Station air traffic control primary surveillance radar from the Morven Site

Radar	Morven North	Morven South
Leuchars Station ATC PSR	247°/59.5nm	260°/59nm

Morven North

4.3.2.2 Although there is potential for this PSR to detect the operational wind turbines, the location of Morven North is outside of the AoR for the provision of an ATS provided by Leuchars Station ATC, which extends to approximately 40nm radius from the Leuchars Station PSR position, therefore, Leuchars Station PSR is not considered further.

Morven South

4.3.2.3 The same consideration of the Leuchars Station ATC PSR AoR applies to Morven South, therefore, Leuchars Station PSR is not considered further.

4.3.3 MOD Practice and Exercise Areas

4.3.3.1 A number of military PEXA known as D613 A/B/C/D and abbreviated as the "613s". These Managed Danger Areas (MDAs) are created to provide segregated airspace for military flying training, bookings for which are managed by the Military Airspace Management Cell (MAMC). MDAs are only

activated on request. The vertical extent of the "613s" are from a base level of FL100 (approximately 10,000ft) to FL660 (approximately 66,000ft).

Morven North

4.3.3.2 Morven North straddles the lateral boundaries of the "613s" however, as the lower base height of aerial activity in the "613s" is well above the maximum height of Morven North wind turbines, no obstruction impact is predicted to the "613s" operation, operation of military PEXA is not considered further.

Morven South

4.3.3.3 As the lower base height of aerial activity in the "613s" is well above the maximum height of Morven South wind turbines, no obstruction impact is predicted.

4.3.4 United Kingdom Low Flying System

4.3.4.1 The UKLFS used for military low flying activity covers the airspace over the entire UK land mass and surrounding sea (excluding restricted, PEXA and built-up areas) generally out to 2nm from the coastline, from the surface to 2,000ft above ground level (agl) or above mean sea level (amsl), however, military low flying activities can take place further from the coastline out to sea. Morven North and Morven South have the potential to impact low flying operations due to the construction of multiple obstacles above sea level.

4.3.4.2 Military low flying activities take place in uncontrolled airspace below 2,000ft amsl offshore within defined LFAs. The UK is divided into 20 separate LFA where military low flying is permitted. With the introduction of radar-guided surface-to-air missile and gun systems, low level tactics are vital to enable aircraft to fly below radar coverage to evade or delay engagement, whether for offensive action, or to transport troops and equipment both in fixed and rotary-wing aircraft. Defence Infrastructure Organisation (DIO) which safeguards MOD operations and infrastructure will request aviation obstruction lighting (which may include a request for be infra-red lighting) to be fitted to wind turbines in accordance with CAP 393 (CAA, 2016 (as amended)).

4.4 Radar Line of Sight analysis

4.4.1.1 Line of Sight (LoS) in its most simplistic form is a calculation to determine whether one object can see another in a direct path. Wind turbines present reflecting surfaces on which a radar transmitting energy can be returned and processed from. If a radar can detect a wind turbine, then it will most likely be processed and cause an impact to the radar's ability to determine valid targets. The Advanced Topographic Development and Imaging (ATDI) ICS LT (Version 22.4.7 x 64) tool was utilised to model the terrain elevation profile between the identified ADR and PSR systems and Morven North and Morven South wind turbines at a maximum blade tip height of 363m amsl. Otherwise known as a point-to-point radar LoS analysis, the result is a graphical representation of the intervening terrain and the direct signal LoS, taking into account earth curvature and radar signal properties.

4.4.1.2 It should be noted that this is a limited and theoretical desk-based study; in reality there are unpredictable levels of signal diffraction and attenuation within a given radar environment that can influence the probability of a wind turbine being detected. The analysis is designed to give an indication of the likelihood of the wind turbine being detected such that the operational significance of the Morven North and Morven South wind turbines, relative to the assessed radar systems, can be assessed. The aim of the LoS analysis is to determine which radar systems have the potential to detect operational wind turbines at the maximum blade tip height placed within a projected Array area; the layout of wind turbines does not have a material effect on establishing theoretical radar LoS. Therefore, to enable the analysis, points of reference in the form of a regular grid pattern were established across the Morven North and Morven South Boundaries with wind turbines on all array vertices at the maximum tip height of 363m amsl, which is considered to be the Maximum Design

Scenario (MDS) for aviation. The radar LoS analysis completed provides a conservative result to establish a potential worst case scenario of radar detectability so that potential negative effects and not underestimated. The scoping response provided by radar operators (MOD and NATS) predicts an operational impact to radar systems. The layout of wind turbines as presented in the radar LoS analysis figures (Figure 4.3 to Figure 4.6) does not reflect any future or past layout of Morven North and Morven South wind turbines.

4.4.1.3 The qualitative definitions utilised in the LoS assessment are defined in Table 4.4.

Table 4.4: Radar Line of Sight qualitative definitions

Result	Definition
Yes	The wind turbine is highly likely to be detected by the radar; direct LoS exists between the radar and the wind turbine.
Likely	The wind turbine is likely to be detected by the radar at least intermittently.
Unlikely	The wind turbine is unlikely to be detected by the radar but cannot rule out occasional detection.
No	The wind turbine is unlikely to be detected by the radar as significant intervening terrain exists.

4.4.1.4 A radar LoS analysis across Morven North and Morven South has been completed in order to establish theoretical radar detectability of the wind turbines, placed within the Morven North and Morven South Boundaries to selected ADR and PSR systems based on a maximum upper blade tip height of 363m amsl.

4.4.1.5 Radar operates by alternately transmitting a stream of high-power radio frequency pulses and “listening” to echoes received back from targets within its radar LoS. Radio frequency does not just propagate in straight ‘optical’ lines, but rather it spreads after it leaves the antenna. This spread is known as the Fresnel zone, objects which appear in the Fresnel zones can cause in phase or out of phase reflections of the radio wave. Generally, air surveillance (aviation) radars employ a rotating antenna that provides 360° coverage in azimuth; the typical scan rate is 15rpm thus illuminating a given target every four seconds.

4.4.1.6 A PSR system can distinguish between moving and static targets; for targets that are moving towards or away from the radar, the frequency of the reflected signal from a moving target change between each pulse (transmit and receive) which is known as the Doppler shift. This can be most practically explained by considering the change in frequency of the engine sound heard by a pedestrian when a car passes by on the road, the sound as the car approaches is higher than the sound heard by the pedestrian as it travels away. The Doppler shift has the effect of making the sound waves appear to bunch up in front of the vehicle (giving a higher frequency) and spread out behind it (lower frequency). The true frequency of the engine is only heard when the car is immediately next to the pedestrian. The aviation radar receiver is 'listening' to the radio waves reflected from the moving object and working out whether the returned signal is of a higher or lower frequency (moving object) or if the returned frequency is the same as the transmitted signal (a stationary object).

4.4.1.7 Wind turbines are a significant cause of PSR false plots or clutter, as the rotating blades can defeat the Doppler filter processing within the radar and therefore may be interpreted as aircraft movements. Significant effects have been observed on radar sensitivity caused by the substantial Radar Cross Section (RCS) of the wind turbine structural components (blades, tower and nacelle) which can exceed that of a large aircraft; the effect ‘blinds’ the radar (or the operator) to wanted targets in the immediate vicinity of the wind turbine. False plots and reduced radar sensitivity may

reduce the effectiveness of the radar system itself to an unacceptable level and compromise the provision of a safe radar service to participating aircraft.

4.4.1.8 The generalised effects wind turbines have on non-cooperative radar systems through radar detection of operational wind turbines are as follows:

- Twinkling appearance/blade flash effect can distract the air traffic controller from their primary task.
- Masking of real aircraft targets caused by increased clutter being displayed on the radar data display screen.
- Increase in unwanted targets or false aircraft tracks.
- Receiver saturation: if a large clutter signal sends a radar system into saturation, the result is a modification to the spectrum of the signal. This change in spectral content reduces the ability of the signal processor to carry out Doppler processing and degrades the detection of aircraft.
- Target desensitisation where real aircraft targets may not be displayed to the air traffic controller.
- Shadowing behind the wind turbines caused by physical obstruction (blocking of radar transmitted signal).
- Degradation of target processing capability and processing overload which will lead to the loss of genuine aircraft targets.
- Degradation of tracking capabilities including track seduction.

Radar Line of Sight conclusions

4.4.1.9 Due to the location of Morven North and Morven South and the maximum blade tip height elevation, possible effects are likely to impact the operations associated with the following PSR/ADR due to the predicted detectability of the operational wind turbines:

- NERL Perwinnes PSR;
- NERL Allanshill PSR;
- MOD RRH Buchan ADR;
- MOD RRH Brizlee Wood ADR.

4.4.1.10 Figure 4.3 to Figure 4.6 provide an illustration of the radar LoS results for each radar system assessed. Radar detectability of operational wind turbines may lead to the effects as listed in paragraph 4.4.1.8.

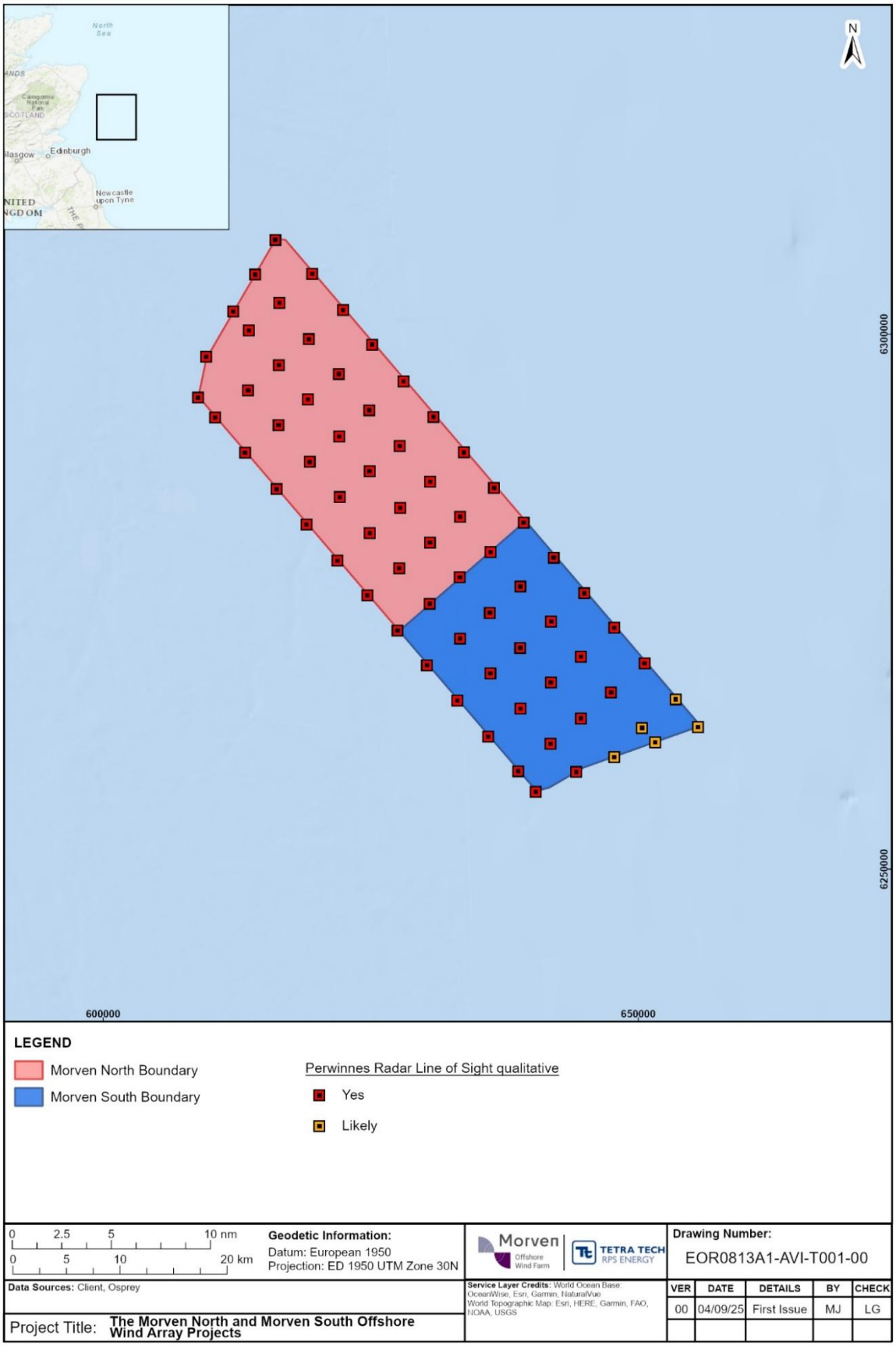

Figure 4.3: Perwinnes primary surveillance radar Line of Sight of Morven North and Morven South at 363m blade tip height

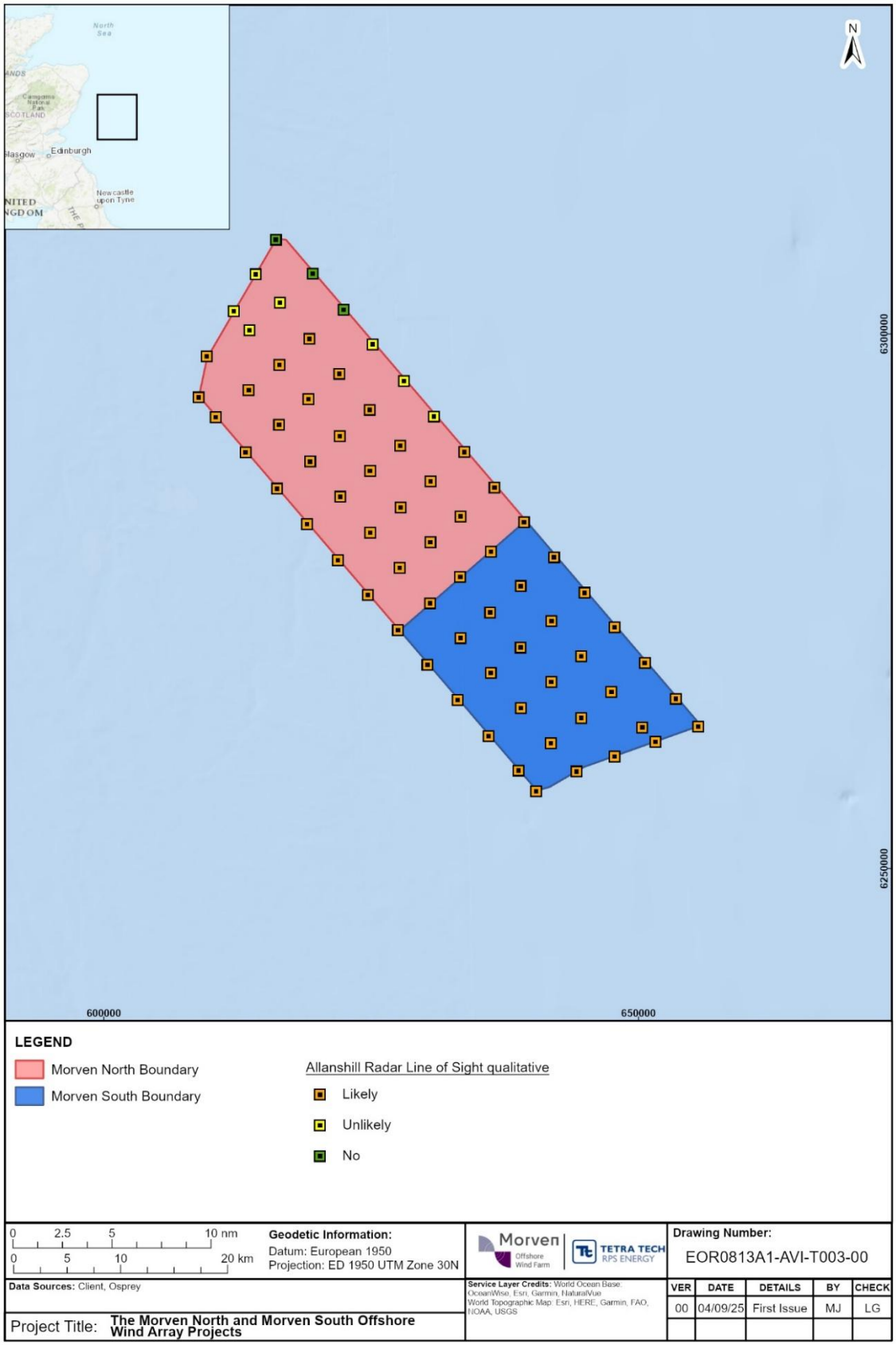

Figure 4.4: Allanshill primary surveillance radar Line of Sight of Morven North and Morven South at 363m blade tip height

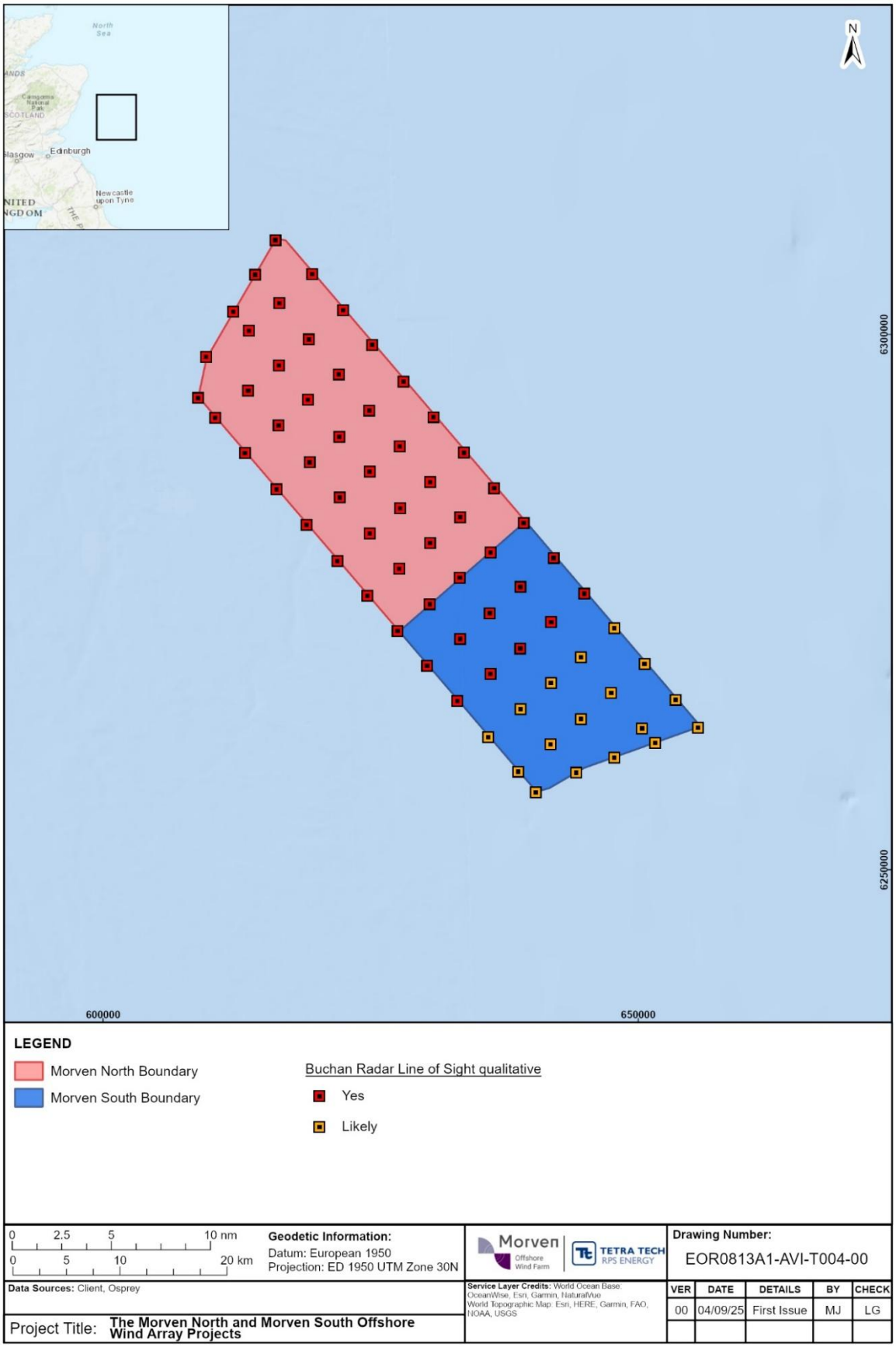

Figure 4.5: RRH Buchan air defence radar Line of Sight of Morven North and Morven South at 363m blade tip height

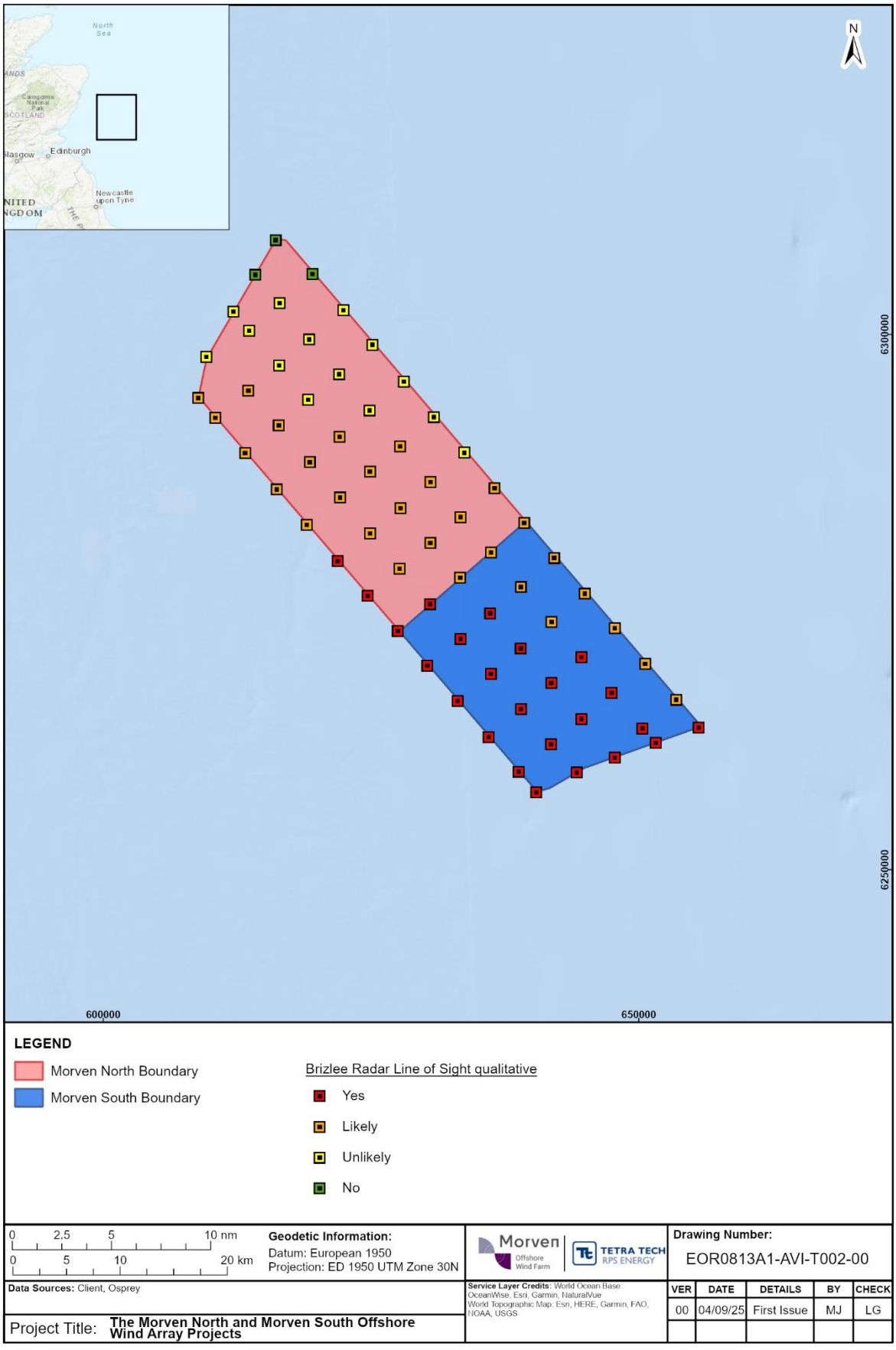

Figure 4.6: RRH Brizlee Wood air defence radar Line of Sight of Morven North and Morven South at 363m blade tip height

5 Summary

5.1 Overview

5.1.1.1 For the purposes of assessment, in order to identify and characterise aviation and radar receptors, a broad study area has been defined and covers the aviation radar systems that could potentially detect the maximum (highest) wind turbine blade tip height of 363m amsl. The combined Morven North and Morven South Aviation and Radar Study Area is presented in Figure 2.1.

5.1.1.2 Based on modelling results, stakeholder consultation responses and the conclusions of the assessments completed for radar detectability and IFP (as provided in Volume 3, Annex 15.2: Aviation (Military and Civil) Shared IFP Assessment) report conclusions are summarised in the following Sections 5.2 to 5.4.

5.2 Aviation radar

5.2.1.1 Radar clutter created by radar detection of Morven North operational detectable wind turbines could cause air traffic controllers to potentially lose aircraft track identity and hence they may be unable to maintain the appropriate separation standard on fixed airspace procedures or other aircraft manoeuvring under their control when providing a relevant ATS from the following PSR and ADR systems:

- NERL Perwinnes PSR;
- NERL Allanshill PSR;
- MOD RRH Buchan ADR;
- MOD RRH Brizlee Wood ADR.

5.2.1.2 Table 5.1 provides the theoretical radar LoS conclusions for Morven North at a maximum blade tip height of 363m amsl.

Table 5.1: Radar Line of Sight analysis conclusions for Morven North

Radar	Morven North
Perwinnes PSR	Detection of wind turbines is highly likely.
Allanshill PSR	Intermittent detection may occur in the northeastern part of Morven North.
RRH Buchan ADR	Detection of wind turbines is highly likely.
RRH Brizlee Wood ADR	The southwestern corner of Morven North is highly likely to be detectable. Detectability reduces across the remaining Morven North Boundary due to increased distancing from the radar position however, intermittent detectability cannot be ruled out.

5.2.1.3 Table 5.2 provides the theoretical radar LoS conclusions for Morven South at a maximum blade tip height of 363m amsl.

Table 5.2: Radar Line of Sight analysis conclusions for Morven South

Radar	Morven South
Perwinnes PSR	The majority of Morven South is highly likely to be detectable.
Allanshill PSR	None of the wind turbines will be detectable.
RRH Buchan ADR	Approximately half of Morven South is likely to be highly detectable, intermittent detectability cannot be ruled out from the rest of the Morven South Boundary.
RRH Brizlee Wood ADR	The majority of Morven South is highly likely to be detectable.

5.3 Instrument flight procedures

5.3.1.1 Volume 3, Annex 15.2: Aviation (Military and Civil): Shared IFP Assessment provides the conclusions of the assessment of published Aberdeen Airport IFPs.

Morven North

5.3.1.2 Large wind turbine developments, dependent on location and proximity to published airport IFP and airspace safeguarded areas, may impact the safe operation of these published procedures. Aberdeen Airport IFPs are the only airport procedures which may be affected by the development of Morven North. The assessment indicated that Morven North will have no effect on the published IFP for Aberdeen Airport at a maximum blade tip height of 363m amsl.

Morven South

5.3.1.3 Large wind turbine developments, dependent on location and proximity to published airport IFP and airspace safeguarded areas, may impact the safe operation of these published procedures. Aberdeen Airport IFPs are the only airport procedures which may be affected by the development of Morven South. The assessment indicated that Morven South will have no effect on the published IFP for Aberdeen Airport at a maximum blade tip height of 363m amsl.

5.4 Military low flying

5.4.1.1 The creation of offshore obstructions may affect military low flying operations within LFA 14 airspace which forms part of the UKLFS and surrounds the Morven Site. A range of adopted measures, in the form of appropriate notification to aviation stakeholders which are likely to include: regularity of layout, inclusion on aviation charts, and lighting and marking to minimise effects to low flying operations would apply to the development of Morven North and Morven South. These will comply with current guidelines where appropriate and be agreed with the appropriate stakeholders.

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