

Chapter 18 Military and Aviation

18.1 Introduction

1 This chapter provides a summary of the existing radar and military baseline conditions and an assessment of the potential impacts on these as a result of the Neart na Gaoithe wind farm development.

18.2 Guidance and Legislation

2 The key documents used in the development of this assessment are as follows. Additional reports and documents are detailed in the reference list:

- British Wind Energy Association (BWEA) (now RenewableUK), 'Wind Energy and Aviation Interests - Interim Guidelines' which outline some legislative processes and provide indicative safeguarding criteria (BWEA *et al.*, 2002);
- Civil Aviation Authority (CAA), CAP 168, 'Licensing of Aerodromes' (CAA, 2010a), which defines runway obstacle limitation surfaces (OLS) in Chapter 4, 'The Assessment and Treatment of Obstacles';
- CAA, CAP 393, 'Air Navigation: The Order and the Regulations', which set out the legislation for the lighting of offshore wind turbines (CAA, 2010b);
- CAA, CAP 764, 'CAA Policy and Guidelines on Wind Turbines', which state a number of safeguarding criteria (CAA, 2009);
- Meteorological Office online self-assessment map showing safeguarding zones around United Kingdom (UK) meteorological radars (MOD, 2011a);
- Ministry of Defence (MOD) low-flying self-assessment map, showing areas of low, medium and high priority for MOD low-flying activities (MOD, 2011b); and
- National Air Traffic Service (NATS) self-assessment website, an online resource with access to maps generated by NATS for the purpose of safeguarding their assets (NATS, 2011).

3 The impact assessment also refers to the results of the following technical trials which describe the impacts of wind turbines on radar and telecommunications systems:

- MOD aircraft trials describing and illustrating the effects of wind turbines on air defence (AD), air traffic control (ATC) radars, and precision approach radar (PAR) (MOD, 2005a; MOD, 2005b; ADATS, 2009); and
- Trials reports describing and illustrating the impacts of offshore wind turbines on marine radar and telecommunications systems (QinetiQ and MCA, 2004; MCA, 2005; Marico Marine, 2007).

18.3 Data Sources

18.3.1 Literature

4 The following sources of data were used to determine the radar and telecommunications baseline:

- Description of coastal users in 'Existing Users and Management Initiatives relevant to SEA [Strategic Environmental Assessment] 5, Final Report' (DTI, 2004);
- UK radio and television transmitter information from the British Broadcasting Corporation (BBC) (BBC, 2011);
- Digital audio broadcasting (DAB) transmitter databases (DAB, 2011; DigitalUK, 2011);
- Forth Ports vessel traffic services (VTS) description (Forth Ports, 2011);
- Firth of Forth admiralty charts (UKHO, 2002; 2004);
- Long range navigation (LORAN) network description (LORAN-C, 2011);
- List of locations of UK meteorological radars (Met Office, 2011);
- Mobile phone base station database (Ofcom, 2011a); and
- In addition, Appendix 18.1: Military and Aviation Technical Report contains the technical report prepared in support of the chapter.

18.3.2 Statistical Datasets

5 No statistical datasets were used to determine the radar and telecommunications baseline.

18.4 Engagement and Commitments

6 A series of commitments has been made on behalf of the developer. These commitments are both at the strategic and site-specific levels. Table 18.1 details the commitments made and cross references to the relevant sections within this chapter.

| Source | Comment | Relevance / reference |
|---|---|--|
| Blue Seas Green Energy - SEA Post Adoption Statement (Marine Scotland) | Resolution of radar issues is required - avoidance of potential conflicts with defence activities (in collaboration with relevant stakeholders). | The resolution of radar issues is discussed in Section 18.9 - Mitigation and Residual Impacts. |
| Scoping opinion (MOD advice) | Environmental Statement (ES) must take MOD aviation and radar operations into account. | MOD aviation and radar operations are taken into account in Section 18.7 - Impact Assessment. |
| | Defence Estates/MOD request consultation, and preplanning advice available (main concerns are interference with AD radar and ATC radar, plus the creation of obstacles in Low-Flying Areas (LFA)). | The MOD has been consulted as detailed in Section 18.4.1 - Consultation. |
| | Guidance: BWEA/[DTI/CAA/MOD] guidance document 'Wind Energy and Aviation Interests – Interim Guidelines', CAP 764 'CAA Policy and Guidelines on Wind Turbines'. | This guidance has been taken into account when carrying out the impact assessments, as noted in Section 18.2 - Guidance and Legislation. |
| | Concern over interference with PAR at Royal Air Force (RAF) Leuchars (turbines 34.2 km (to closest turbine) in line of sight). Has impact on radar - degrading tracking performance. | The potential impact on the PAR at RAF Leuchars has been considered in Section 18.7 - Impact Assessment. |
| | MOD explains that where there is Line Of Sight (LoS) to Primary Surveillance Radar (PSR) turbines will appear as aircraft targets and mask aircraft responses. The radar may also be desensitised, or shadowing of aircraft may also occur. | The significance of turbines being in LoS from a PSR has been considered in Section 18.7 - Impact Assessment. |
| | ES should look at impacts on MOD navigational impacts - consultation with MOD required. | The MOD has been consulted as detailed in Section 18.4.1 - Consultation. |
| Scoping opinion (NATS advice) | Guidance: MOD working towards trial to better understand the effects of wind turbines on PAR. Results will be provided to industry (ADATS, 2009). | The potential impact on the PAR at RAF Leuchars has been considered in Section 18.7 - Impact Assessment. |
| | NATS En-Route Plc. (NERL) offer pre-planning advice once information on tip heights and turbine layout is received. | The services offered by NERL have been noted. |
| Scoping opinion (CAA advice) | Civil Aviation Authority Directorate of Airspace Policy requires early consultation. | The CAA has been consulted as detailed in Section 18.4.1 - Consultation. |
| | Guidance: BWEA/[DTI/CAA/MOD] guidance document 'Wind Energy and Aviation Interests – Interim Guidelines', CAP 764 'CAA Policy and Guidelines on Wind Turbines'. | This guidance has been taken into account when carrying out the impact assessments, as noted in Section 18.2 - Guidance and Legislation. |

Table 18.1: Strategic and site level commitments and requirements – military and aviation

18.4.1 Consultation

18.4.1.1 Civil Aviation Authority

- 7 The CAA was notified of the proposed wind farm (then with a 173.5 m maximum blade tip height) in 2009. On 30 June 2009 the CAA confirmed it had no objections to the proposal (Mainstream, 2009).
- 8 As of 24 December 2010, the CAA ceased responding to wind farm pre-planning applications (CAA, 2010c). The reasons given for this included the availability of public domain aviation resources, and developers having an improved understanding of aviation issues and requirements.

18.4.1.2 Edinburgh Airport

- 9 The operators of Edinburgh Airport, British Airports Authority (BAA), were notified of the proposed wind farm (then with a 173.5 m maximum blade tip height) in 2009. On 25 July 2009 BAA confirmed it had no objections to the proposal (Mainstream, 2009).
- 10 On 21 September 2011, BAA was informed that the maximum blade tip height had increased to 197 m. No response has been received at the time of writing (January 2012).

18.4.1.3 Maritime and Coastguard Agency

- 11 The locations of VTS radars, very high frequency (VHF) radio antennas, automatic identification system (AIS) stations and radar beacons (racons) in the vicinity of the proposed wind farm have been requested from the Maritime and Coastguard Agency (MCA).
- 12 On 12 May 2011 the MCA provided details on the available coverage for VHF communications and AIS systems in the area, and confirmed that no MCA racons or VTS radars operated in the vicinity of Neart na Gaoithe (MCA, 2011).

18.4.1.4 Ministry of Defence

- 13 The MOD was notified of the proposed wind farm (then with a 173.5 m maximum blade tip height) in 2009. On 29 January 2010 the MOD responded stating the following potential concerns:
"The turbines will be 40.1 km (to field centre) from; in line of sight to; and will cause unacceptable interference to the ATC radar at RAF Leuchars" (Maisey, 2010).
"Currently, the MOD is not aware of any acceptable technical mitigation for the interference that will be caused to the PAR by your wind farm proposal" (Maisey, 2010).
- 14 The MOD response on the 29 January 2010 added that the AD technical advisors were assessing the proposal to confirm whether they would have any concerns (Maisey, 2010).
- 15 Meetings were held between the MOD, the developer and the project team on 12 February 2010 and 3 June 2010 (EMU 2010a, EMU 2010b). During these meetings it was established that ensuring turbines were built outside the PAR coverage cone would mitigate any potential impacts on RAF Leuchars PAR. The developer has committed to ensuring that no turbines will be built within the PAR exclusion zone.
- 16 The MOD was informed on 7 December 2010 that the maximum proposed blade tip height had increased to 190 m. The MOD responded on 10 December 2010:
"The whole site will be visible to the RAF Leuchars Primary Surveillance Radar (PSR), meaning the whole site will require mitigating rather than just a portion. Regardless of site layout and configuration, any turbines within the site area will be seen by the radar". (MOD, 2010c).
- 17 The MOD was informed on 21 September 2011 that the maximum blade tip height had increased to 197 m; Indicative layouts A and B were also supplied, noting that the turbine locations may be subject to micro-siting by up to 500 m. The MOD responded on 18 December 2011, reiterating the concern that the project will cause unacceptable interference to the ATC radar at RAF Leuchars (MOD, 2011c). If this concern can be overcome, the MOD states a requirement to fit all perimeter turbines with 2,000 candela omni-directional red lighting. The MOD confirmed that it no longer has any concerns over military practice and exercise areas (PEXA), low-flying or in relation to the impact on the RAF Leuchars PAR (MOD, 2011d). The removal of the objection on the potential impact on PAR follows the agreement that all of the proposed turbines lie outside of the MOD's exclusion zone (MOD, 2011d).

18.4.1.5 Ofcom, Atkins and Joint Radio Company

- 18 On 22 September 2011, Ofcom confirmed that Neart na Gaoithe will not affect any of the LoS links in its database. Ofcom recommended that further consultation be carried out with Atkins Global and Joint Radio Company (JRC). Atkins Global and JRC subsequently confirmed that they would have no objections to Neart na Gaoithe.

18.5 Impact Assessment Methodology

18.5.1 The Rochdale Envelope

- 19 The elements of the Rochdale Envelope scenario most relevant to the radar and telecommunications chapter are:
- Wind farm layout maximum blade tip height. The visibility of the wind farm and, hence, the operational impact, is dependent on this parameter. For the largest turbine considered for the site, the maximum blade tip height is 197 m above lowest astronomical tide (LAT) and the tip height of the smallest turbine is 171.25 m;
 - Height of platform. This is the height of the junction between the foundation and the turbine tower. Because different tower and foundation types reflect signals in different ways, this parameter may have an influence on the severity of impacts on systems being used by surface vessels. The platform height for all turbine/foundation combinations is 18 m LAT; and
 - Foundation design. Because different foundation designs reflect and obstruct signals in different ways, the choice of foundation may have an influence on the severity of impacts on radar receptors. Jacket and gravity base foundation types are being considered for the project.

20 The Rochdale Envelope considered for this chapter are summarised in Table 18.2:

| Parameter | Rochdale Envelope |
|------------------------------------|---|
| Maximum spread of turbines | <ul style="list-style-type: none"> ● 125 x 3.6 MW turbines, maximum tip height of 175 m; and ● The nominal locations are to be chosen from the 128 turbine locations from indicative Layout A, as shown in Chapter 5: Project Description. |
| Intermediate spread and tip height | <ul style="list-style-type: none"> ● 109 x 4.1 MW turbines, maximum blade height of 171.25 m; and ● The nominal locations are to be chosen from the 128 turbine locations from indicative Layout A, as shown in Chapter 5: Project Description. |
| Intermediate spread and tip height | <ul style="list-style-type: none"> ● 75 x 6 MW turbines, maximum blade tip height of 175.5 m; and ● The nominal locations are to be chosen from the 80 turbine locations from indicative Layout B, as shown Chapter 5: Project Description. |
| Maximum tip height | <ul style="list-style-type: none"> ● 64 x 7 MW turbines, maximum blade tip height of 197 m; and ● The nominal locations are to be chosen from the 80 turbine locations from indicative Layout B, as shown in Chapter 5: Project Description. |

Table 18.2: Rochdale Envelope worst (realistic) case parameters for military and aviation

18.5.2 The Approach to Impact Assessment

- 21 For each radar or telecommunications system, the potential effects are identified. For the purposes of the study an effect is defined as any change on a receptor from the baseline environment. The impacts of each effect will then be assessed. For the purpose of the study an impact is the consequence of an effect, normally described in terms of the operational significance in each case.
- 22 Impacts are assessed relative to the phase of development i.e., those arising in the construction, operation or decommissioning phases and are discussed individually.

18.5.2.1 Magnitude of Effect

- 23 For the radar and telecommunications assessment, the following definitions will be used to determine the magnitude of effects:
- Negligible: the effect on the radar or telecommunications system is not noticeable or determinable;
 - Low: the effect on the radar or telecommunications system is noticeable but does not meaningfully reduce or degrade the service provided by the system;
 - Medium: the effect on the radar or telecommunications system degrades the level or quality of service provided but the system is usable; there may be an economic implication for the service provider;
 - High: the effect significantly reduces or inhibits the service provided by the radar or telecommunications system; there is likely to be an economic or cost implication for the service provider.

18.5.2.2 Vulnerability

- 24 For the radar and telecommunications assessment, the following definitions are used to determine the vulnerability of receptors to effects:
- Negligible: in the context of typical usage of a radar or telecommunications system by a stakeholder, the effect has a negligible likelihood of occurrence;
 - Low: in the context of typical usage of a radar or telecommunications system by a stakeholder, the effect has a low likelihood of occurrence;
 - Medium: in the context of typical usage of a radar or telecommunications system by a stakeholder, the effect has a medium likelihood of occurrence; and
 - High: in the context of typical usage of a radar or telecommunications system by a stakeholder, the effect has a high likelihood of occurrence.

18.5.3 Cumulative and In-Combination Impact Assessment Approach

- 25 It is important to assess whether the construction of other offshore wind farms in the area (the cumulative effect) or the additive effects from other developments in the area (in-combination effects) may result in a more significant impact. Cumulative effects are assessed by mapping the locations of all turbines in the Firths of Forth and Tay area and determining whether the potential effects arising are influenced by the increased number of turbines in the assessment or whether the effect is unchanged from the site-specific assessment. In-combination effects may arise from the interaction of the radar with both the proposed development and with other developments.

18.6 Baseline Description

- 26 This section describes the current military, aviation, telecommunications and radar systems relevant to the Neart na Gaoithe offshore wind farm development. Further information on the existing radar and military conditions is provided in Appendix 18.1: Military and Aviation Technical Report.

18.6.1 Identification of Receptors

- 27 Radar is a term used to encompass devices designed to transmit or receive radio signals. These signals typically provide bearing and range data from a given point to targets of interest. Radars considered in this chapter have both civil and military applications and cover aviation, maritime or meteorological services. In addition to conventional radar services, this chapter will also assess the potential impact on communications systems including television and telephone transmissions and marine navigation aids. The following table (Table 18.3) summarises the receptors considered in this chapter and the potential interaction with the proposed development.

| Group | Function | System | Main operators |
|---|--|--|---|
| Military and civil radar | Primary surveillance radar (PSR) systems | ATC | Civil airports and MOD |
| | | Air Defence (AD) | MOD |
| | | PAR | MOD |
| | | VTS | MCA and local port authorities |
| | | Offshore early warning | Offshore oil and gas developers |
| | Meteorological | Meteorological Office | |
| | Other radar systems | Secondary Surveillance Radar | Civil airports and MOD |
| Telecommunications | Marine navigation aids | Radio beacons | Trinity House |
| | | VHF communications | Most private and commercial vessels, search and rescue (SAR) agencies |
| | | AIS | MCA |
| | Global navigation satellite system | LORAN | Trinity House |
| | | Global Positioning System (GPS) | United States of America (USA) Government |
| | Telephony | Mobile telephones | Telecommunication companies, e.g., Vodafone, Orange, O2 |
| | | Satellite | Telecommunication companies, e.g., Inmarsat and Iridium |
| | Television and public broadcast radio | Television | Television broadcasters, e.g., BBC |
| Public broadcast radio | | Public radio broadcasters, e.g., BBC | |
| Physical obstruction to aviation | Obstacle Limitation Surfaces (OLS) | OLS safeguard civil and military airports and aerodromes | |
| | Low-flying | MOD | |
| Military Practice and Exercise Areas (PEXA) | | PEXA | MOD |

Table 18.3: Identification of receptor

18.6.2 Study Area

- 28 Depending on the function of the radar, the operating ranges – and consequentially the study area boundary – can vary significantly. For example, some PSR systems have maximum operating ranges of hundreds of kilometres while some navigation aids have operating ranges of tens of kilometres.
- 29 When defining the baseline radar environment it is important to establish whether the proposed wind farm is within a sensor’s existing coverage area. Line of Sight (LoS) modelling is commonly used as a qualitative estimate of the coverage area of a radar system. Whether a turbine is in LoS to any given radar system will depend on its height and its location. In terms of height, the larger 197 m turbines will give the worst case LoS visibility results. However, the effect of terrain screening means there is not a simple relationship between turbine location and LoS visibility accordingly, no layout can be regarded as the worst case.
- 30 The baseline evaluation was undertaken prior to the development of the indicative project layouts. To enable an evaluation to be undertaken, an indicative layout was developed which evenly distributed 75 turbines within the offshore site ensuring that turbines lay close to the boundary edges. This indicative layout was used in the LoS calculations described in this section, assuming a 190 m maximum blade tip height throughout. The boundary of the proposed wind farm is defined in Chapter 5: Project Description.
- 31 The study area will depend on the maximum operating ranges of each of the systems of interest. This will vary from system to system, even between different installations of the same systems. Where relevant, the maximum operating ranges for each system identified is used in the baseline definition.

18.6.3 Military and Civil Radar

18.6.3.1 Primary Surveillance Radar

32 The purpose of PSR systems is to identify the location of objects of interest. Most PSR systems operate by transmitting short bursts of energy (pulses) from a rotating directional antenna. The radar system measures the time taken for the pulses to return and from this can calculate the range and bearing of the objects of interest. The following PSRs are considered in this chapter:

- ATC radars (both civil and military);
- Military AD radars;
- PAR;
- En-route radars;
- VTS radars; and
- Meteorological radars.

Air Traffic Control, Air Defence and Precision Approach Radar

- 33 The role of ATC radars is to provide information on air traffic in the vicinity of an airfield. ATC radars are typically owned and operated by civil airports or by the MOD (in the case of military airfields). ATC radars are normally located at the airfield they support.
- 34 The MOD ATC radar safeguarding recommendation is that planning applications for wind farm developments be subject to scrutiny when in LoS of an airfield primary radar, regardless of range (MOD, 2005a). The same recommendation is given for AD radar systems (MOD, 2005b).
- 35 AD radars are owned and operated by the MOD and exist in order to provide a continuous recognised picture of air traffic over the UK. AD radars are typically situated in coastal locations. The only MOD AD or ATC radar identified in LoS to Neart na Gaoithe is the Watchman ATC PSR at RAF Leuchars, approximately 18.5 nautical miles (NM) from the proposed wind farm boundary at its closest point.
- 36 PAR provide lateral and vertical guidance for aircraft approaching a landing site. Air Traffic Control Officers (ATCOs) use PAR derived information to determine an aircraft’s course during approach and also provide advice using voice communications. In the UK, all PAR systems are operated by the MOD. The use of PAR is typically limited to a sector centred on the runway approach, extending tens of nautical miles in range.
- 37 The MOD recommended exclusion zone for safeguarding a PAR is a 30 degree sector centred on the runway extending out to a range of 20 NM (EMU, 2010a). The only PAR identified within 20 NM of the proposed wind farm boundary is at RAF Leuchars. This exclusion zone has a small overlap with the proposed Neart na Gaoithe boundary, estimated to be approximately 0.07 NM² (EMU, 2010c). The developer has committed to ensuring that no turbines will be built within the PAR exclusion zone.
- 38 The locations of RAF Leuchars, the PAR safeguarding zone and the proposed wind farm boundary are shown in Figure 18.1. There are no civil ATC radars identified in LoS of the wind farm.

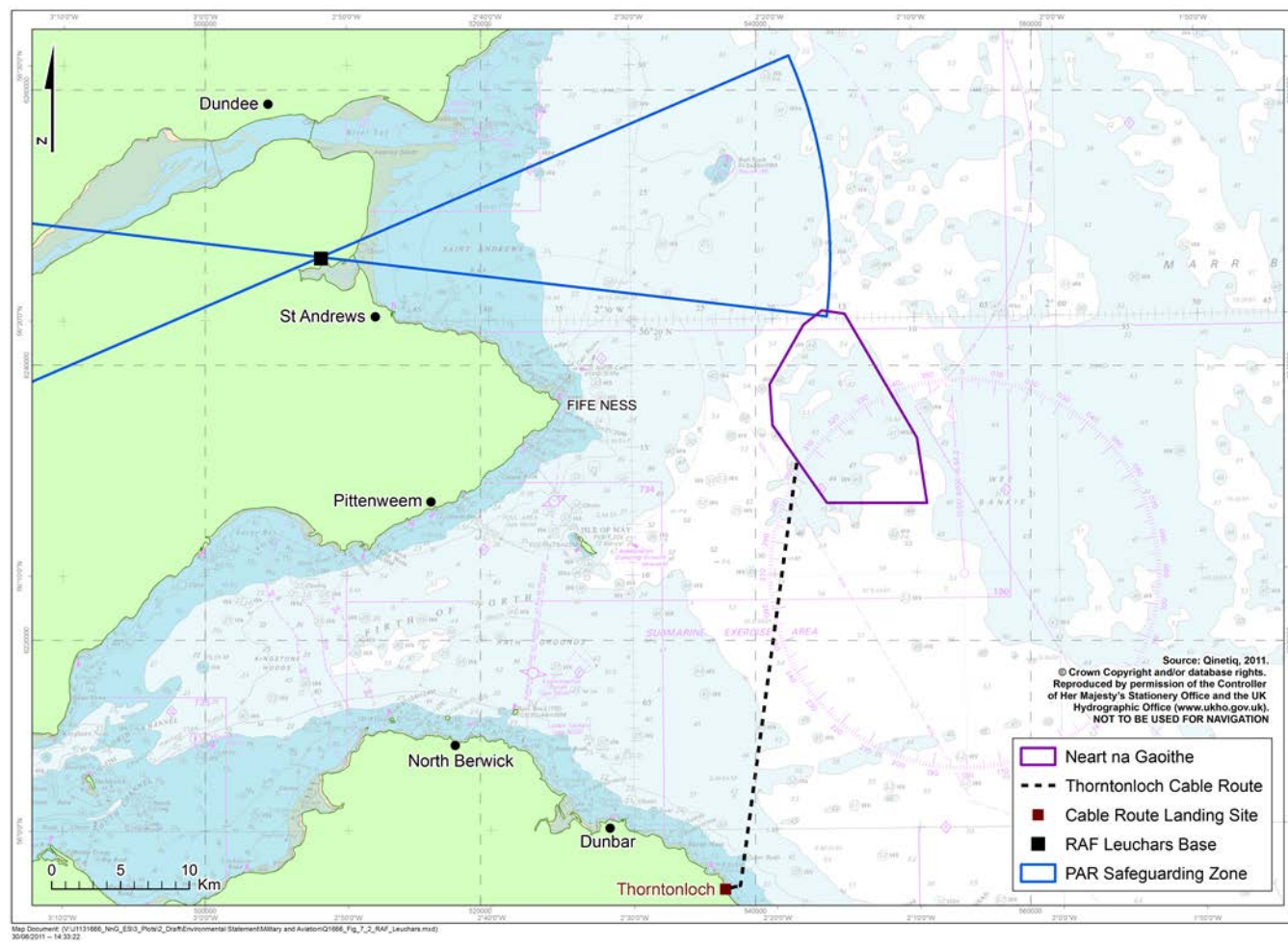


Figure 18.1: Locations of RAF Leuchars, the proposed wind farm boundary and the RAF Leuchars PAR safeguarding zone

En-Route Radar

- 39 The role of en-route radars (a type of PSR) is to provide long-range awareness of air traffic travelling between airfields. En-route radars typically have a larger maximum operating range than ATC radars. In the UK en-route radars are owned and operated by NERL. They are typically located on high terrain to give good long range onshore coverage.
- 40 The location of the closest en-route PSRs operated by NERL are shown in Figure 18.2. The closest radar is at Perwinnes Hill, approximately 54 NM from Neart na Gaoithe.

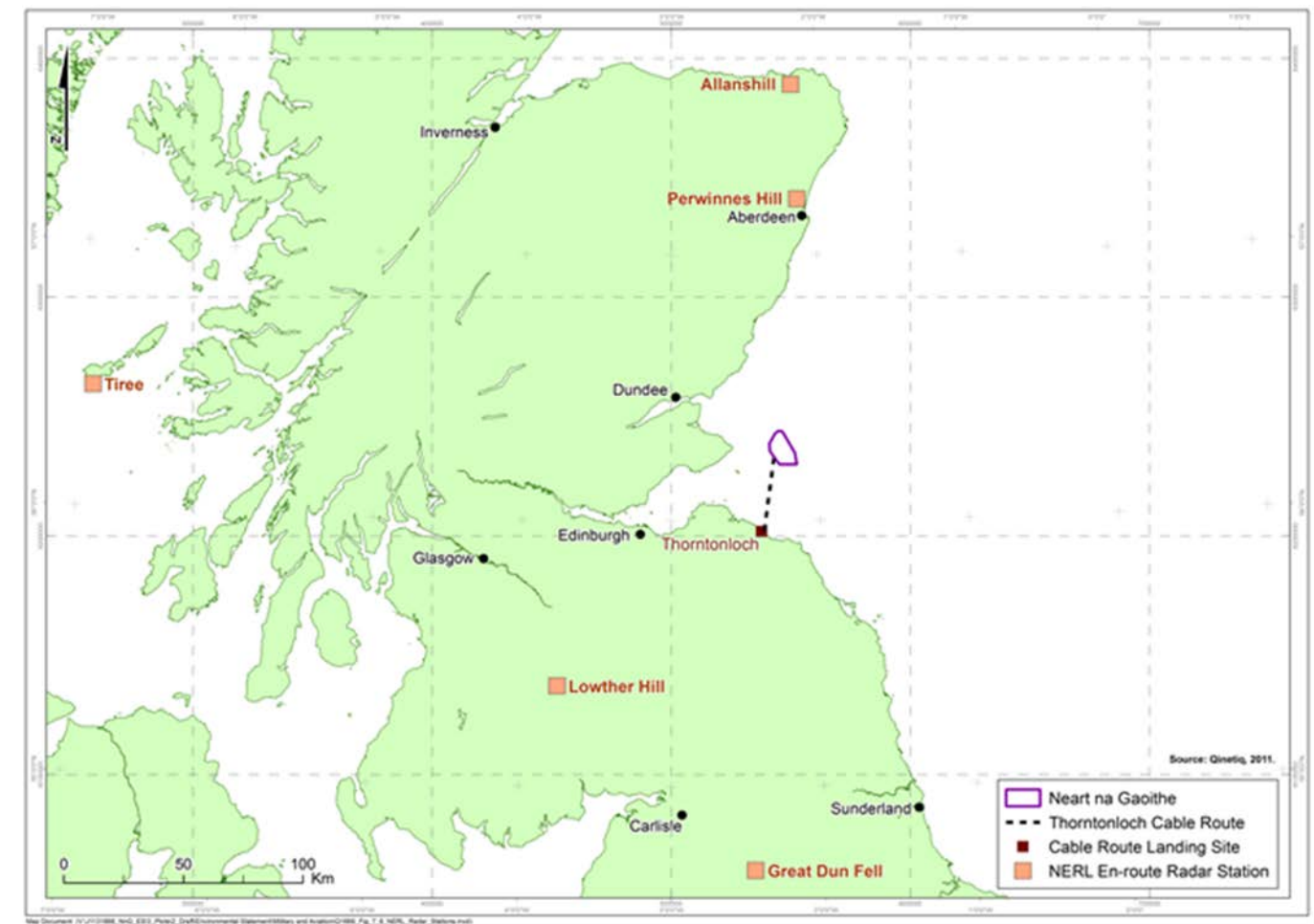


Figure 18.2: Locations of NERL en-route radars in relation to the proposed wind farm boundary

Vessel Traffic Service Radar

- 41 The role of VTS radars is to provide information on objects within a marine environment. VTS radars are typically operated by the MCA and are located on the coast.
- 42 The locations of the five VTS radars operated by Forth Ports in relation to the proposed wind farm boundary are shown in Figure 18.3 (Forth Ports, 2011). LoS checks show that the Port Edgar and Burntisland radar do not have LoS to any of the turbines in the indicative layout; Leith, Gullane and Budden Ness radars all have partial LoS to the wind farm.
- 43 The maximum coverage ranges of the VTS radars shown in Figure 18.3 are not confirmed. This information has been requested from the MCA but has not been received at the time of writing. Consultation with the MCA (refer to Chapter 17: Shipping and Navigation) indicates that AIS coverage extends as far as the Bell Rock area but that there is limited radar coverage and no active monitoring of this area at present.

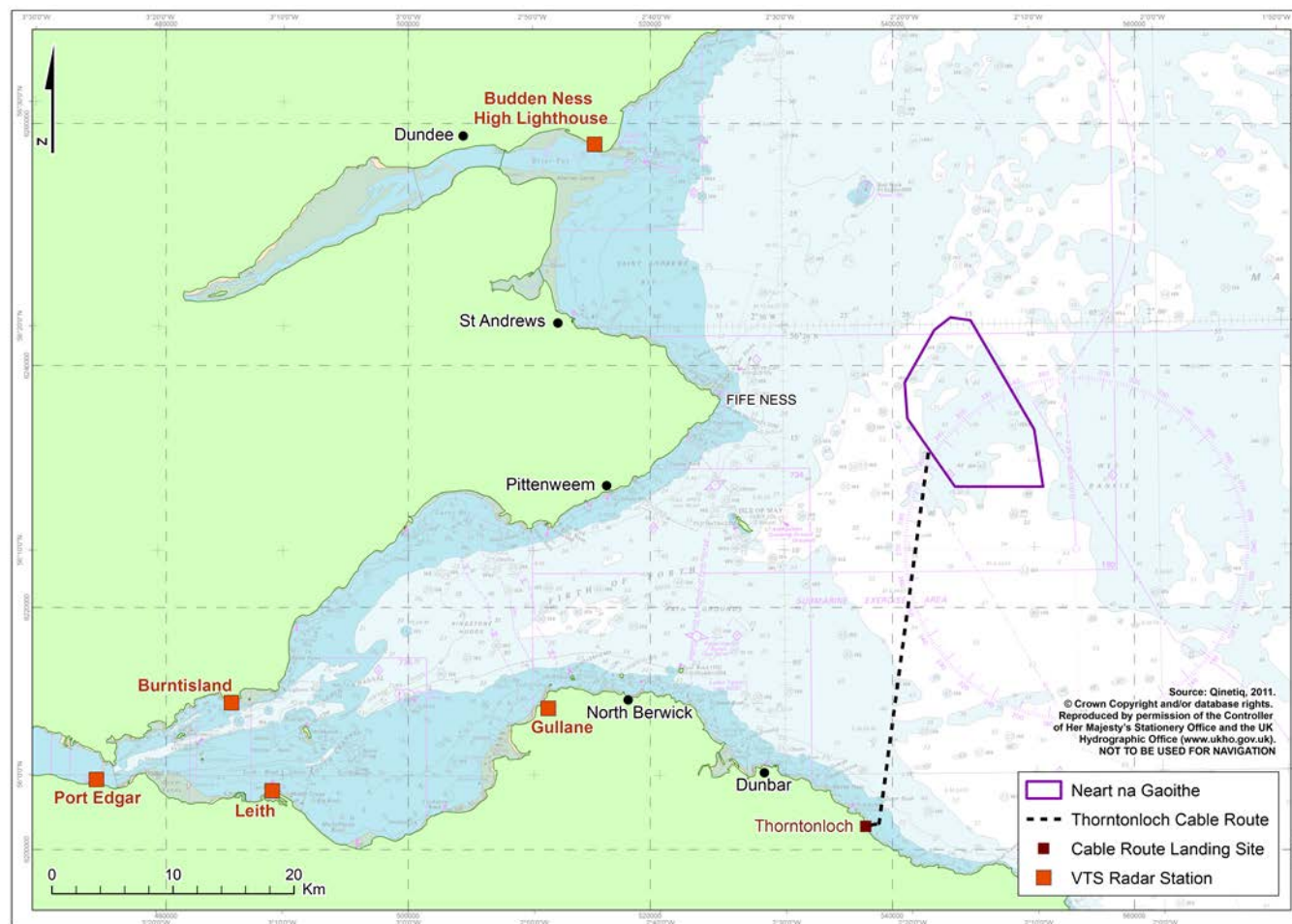


Figure 18.3: The location of VTS radar station in the Firth of Forth in relation to the proposed wind farm boundary

Offshore Oil and Gas Platform Radars

44 Some offshore oil and gas platforms have radar systems installed, mainly to provide an early warning system for collision avoidance. The closest oil and gas activities are approximately 100 NM to the east of the proposed wind farm (DTI, 2004). No radar systems have been identified.

Meteorological Radar

45 The role of meteorological radars is for the detection of precipitation. There are seventeen of these radars in operation in the UK.

46 The locations of meteorological radars in the north of the UK are shown in Figure 18.4 (Met Office, 2011). LoS checks showed that all of the turbines in the indicative layout are in full or partial LoS of Munduff Hill (approximately 33 NM from the boundary at its closest point); five of the turbines are in partial LoS from Holehead (approximately 65 NM from the boundary at its closest point). No other UK meteorological radar has LoS to any of the turbines in the indicative layout.

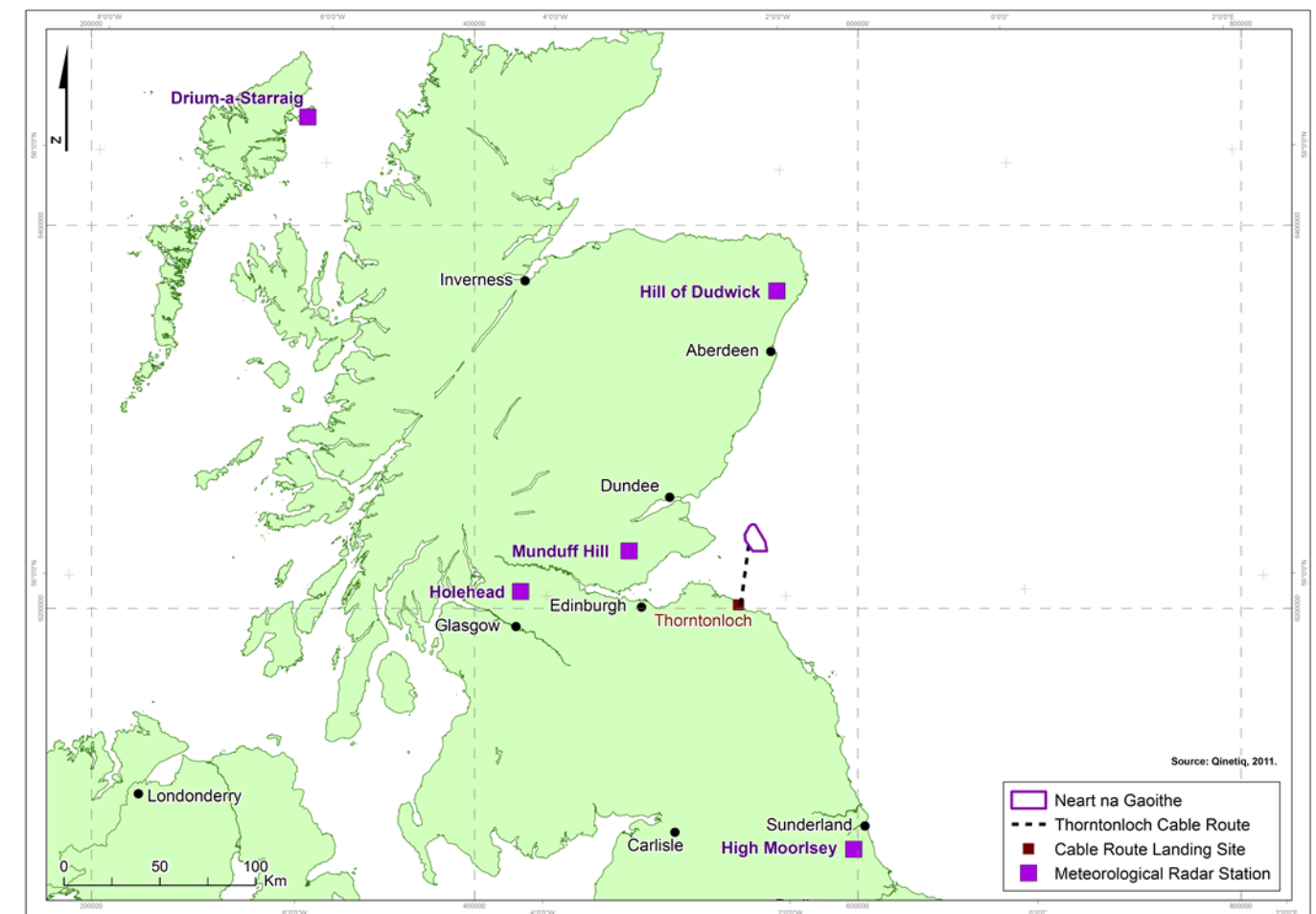


Figure 18.4: Meteorological radar stations

47 The MOD publishes a safeguarding map to advise developers on the likely areas where wind farms will have an impact on meteorological radar stations (MOD, 2011a). The portion of the safeguarding map in the vicinity of the Neart na Gaoithe site is shown in Figure 18.5. The proposed Neart na Gaoithe boundary does not lie inside any safeguarded zones.

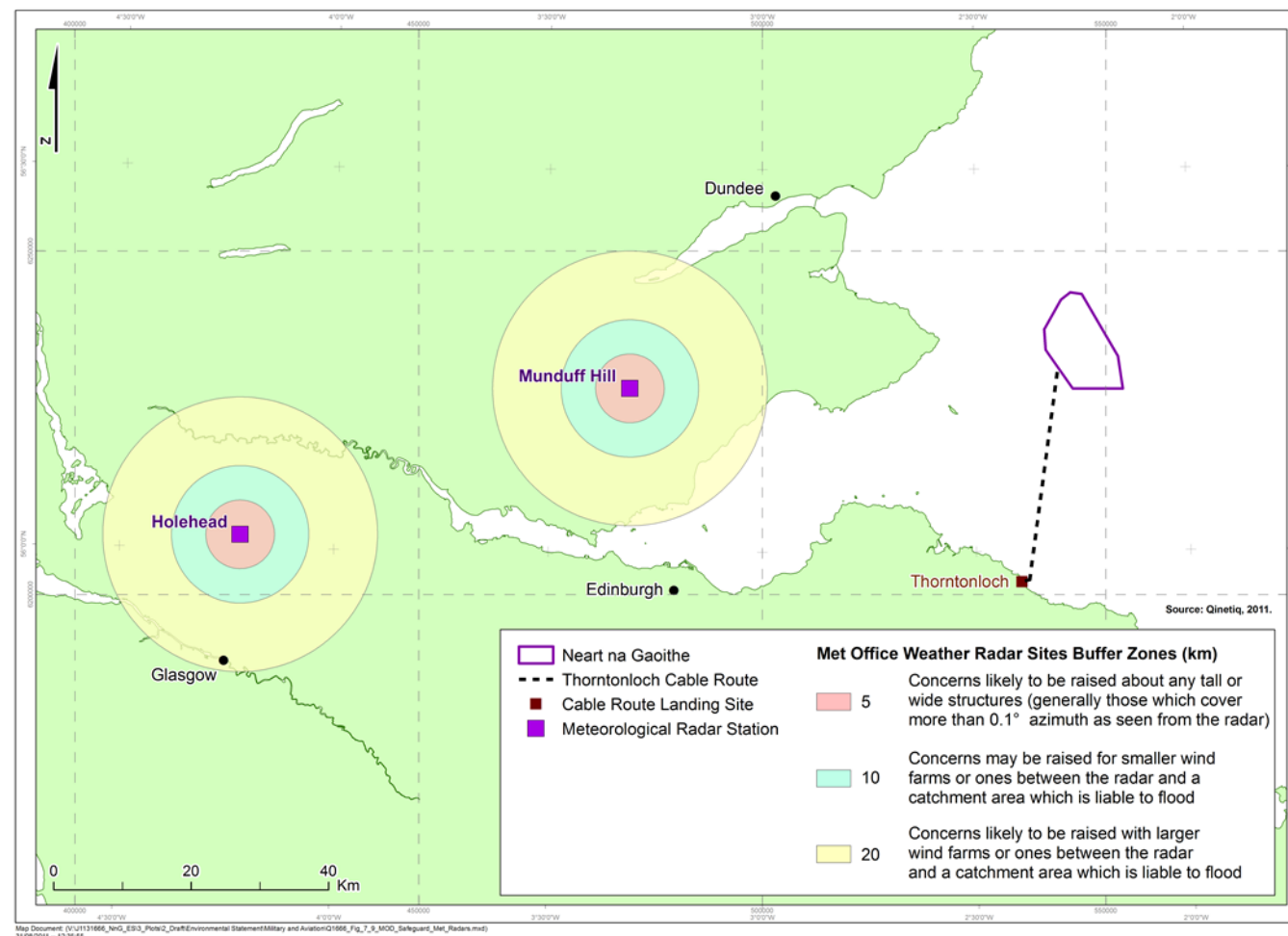


Figure 18.5: MOD safeguarding map for meteorological radars, also showing the location of the proposed wind farm boundary

18.6.3.2 Secondary Surveillance Radar

- 48 Secondary Surveillance Radar (SSR) systems have a different principle of operation to PSRs and are generally used to identify and communicate with incoming aircraft. A sequence of pulses is transmitted by the ground station (the up-link or interrogation), which is received by the aircraft. A transponder on the aircraft then replies (the down-link) with information such as its identification and altitude. SSRs are commonly located in the same place as PSRs at civil or military aerodromes.
- 49 The CAA recommended safeguarding distance for SSRs is 24 km (13 NM) (CAA, 2009). Specifically, the guidance states that 24 km should be used as the trigger point for further discussions with the appropriate Air Navigation Service Provider (ANSP) who can make a more detailed, accurate assessment of the likely effect on their SSR. However, the majority of effects are likely to be within 10 km but, because the possibility exists for effects out to 24 km, these should be considered (CAA, 2009). There are no SSRs within 13 NM of the proposed boundary. It is noted that the SSR at RAF Leuchars is in LoS from the turbines but is approximately 18 NM from the wind farm boundary at its closest point.
- 50 For illustration, the two closest CAA licensed airports are Dundee Airport and Edinburgh Airport, as shown in Figure 18.6. The closest CAA licensed airport is Dundee at approximately 24 NM.

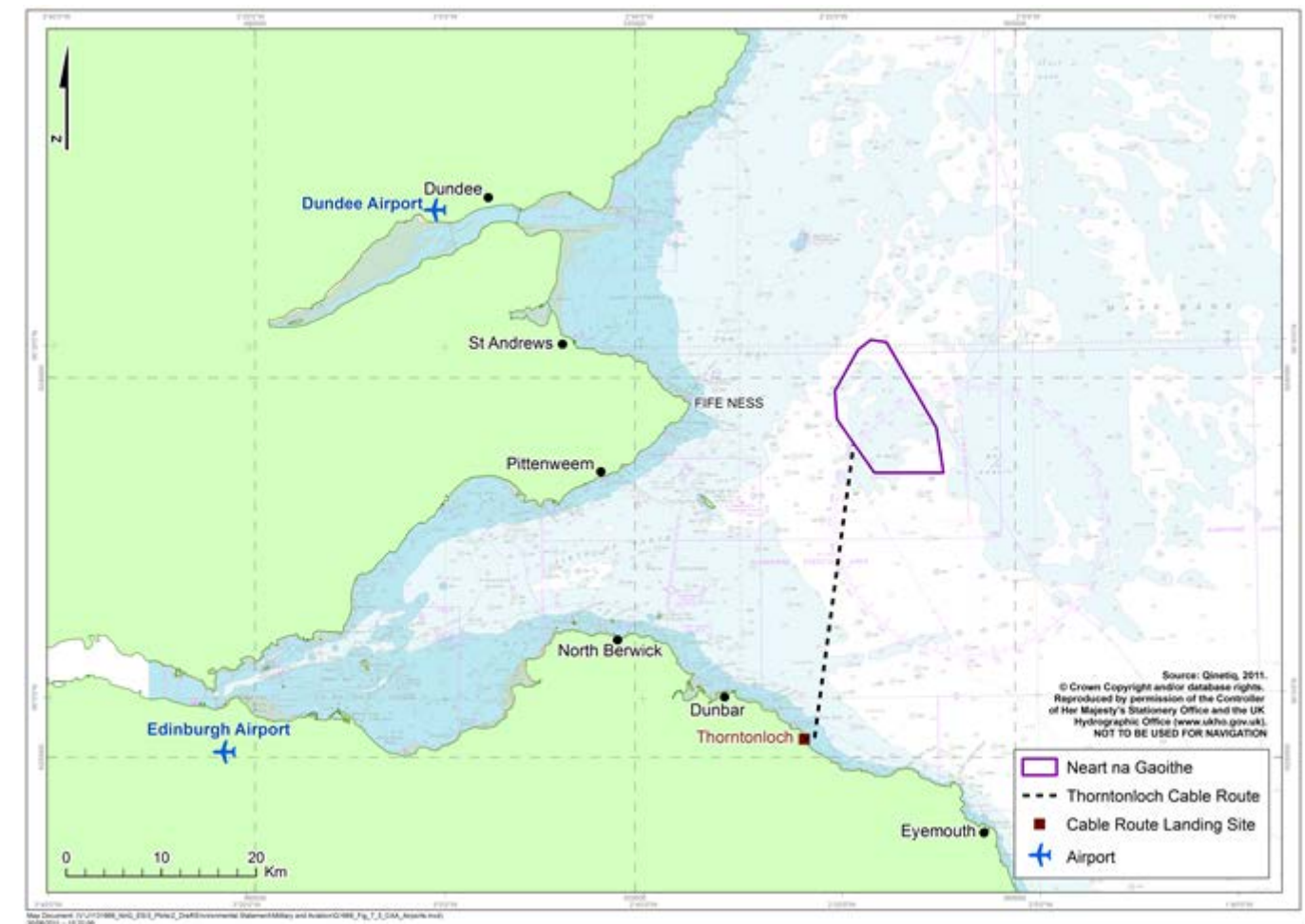


Figure 18.6: Locations of the two closest CAA licensed airports in relation to the proposed wind farm boundary

18.6.4 Telecommunications

- 51 For the purposes of this study, telecommunications refer to wireless systems where information is transmitted using electromagnetic waves. Some systems are one-way, e.g., television, where one antenna always transmits and another always receives the information. Other systems, e.g., VHF communications, are two-way, where the role of transmitter and receiver can interchange.

18.6.4.1 Marine Navigation Aids

- 52 There are three types of marine navigation or communication aids which are considered: VHF radio communications (also refer to Chapter 17: Shipping and Navigation), racons and AIS.

Very High Frequency Radio Communications

- 53 VHF radio communications systems are two-way voice communication links. VHF radio systems are used extensively for purposes including VTS advice, SAR operations and ship to ship communications.
- 54 VHF radio communications are likely to be used by a number of maritime users in the vicinity of the proposed wind farm. Onshore VTS operators will be in communication with offshore vessels. Vessel to vessel communications will be made alongside and possibly across the development. SAR operators, e.g., lifeboats and helicopters may need to use VHF communications in and around the wind farm.
- 55 The location of the VHF communication base stations operated by the MCA in the vicinity of Neart na Gaoithe are shown in Figure 18.7 (MCA, 2011).

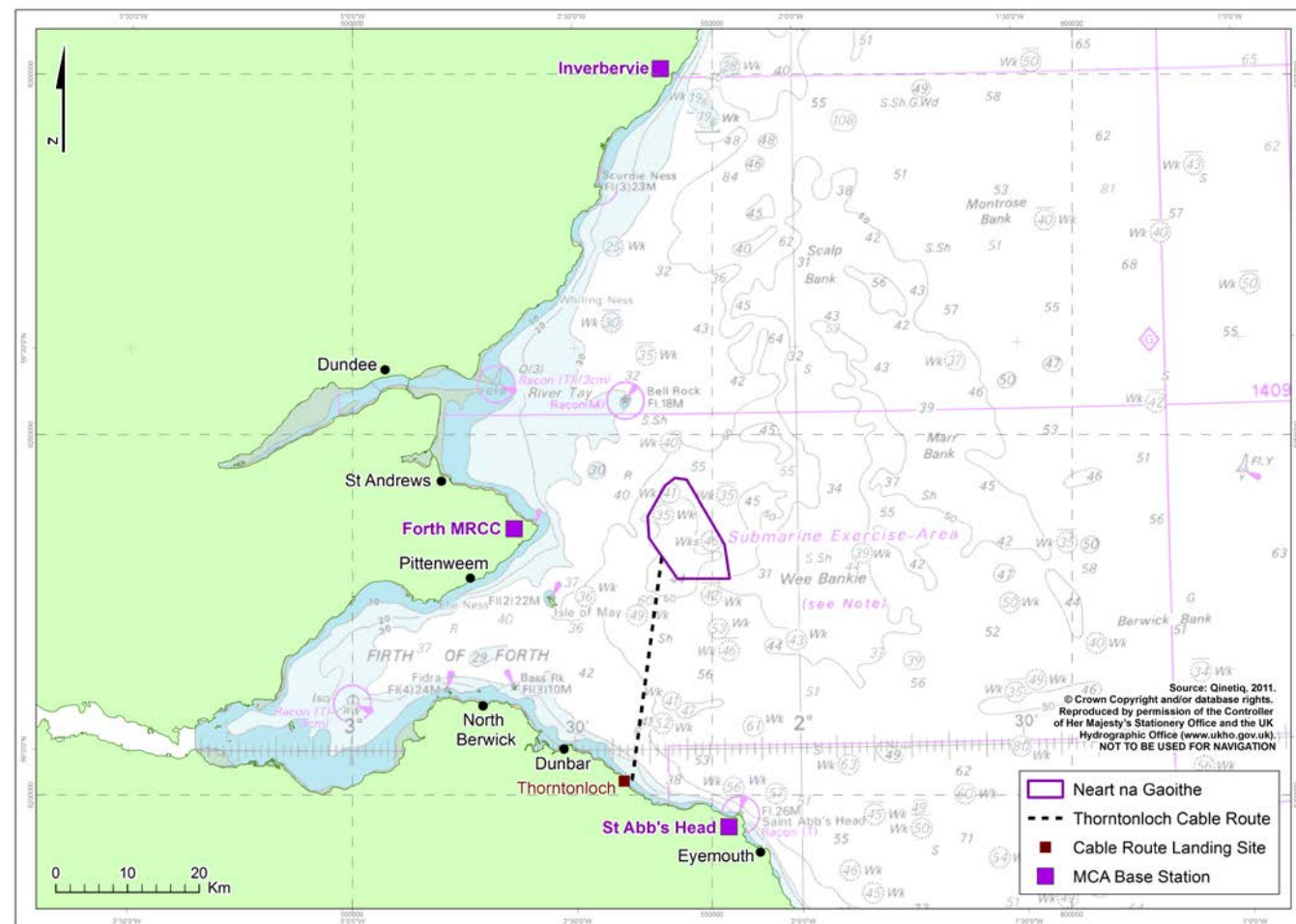


Figure 18.7: Location of MCA VHF communications and AIS base stations (Marine Rescue Co-ordination Centres (MRCC)).

Racons

56 Racons are transponder devices, which detect radar signals and transmit characteristic replies to identify themselves. The replies appear on the radar display as a characteristic set of dots and dashes representing a Morse code character that identifies the racon. Racons are typically located on offshore floats and buoys to mark navigation channels or maritime hazards. There are no racons operated by the MCA in the vicinity of Neart na Gaoithe (MCA, 2011).

Automatic Identification Systems

57 AIS is a tracking system used to identify vessels and the location of navigational aids such as floats and buoys. The system is used on marine vessels and by VTS. AIS transmitters continually transmit information such as identification and position. Because marine vessels use the system, AIS will potentially be operated anywhere in the vicinity of the proposed wind farm.

58 AIS transmissions are made from fixed navigational aids in the Firth of Forth, and also from maritime vessels that could be anywhere in the vicinity of the turbines. The location of fixed AIS base stations operated by the MCA are the same as the VHF communication base stations shown in Figure 18.7.

18.6.4.2 Global Navigation Systems

Long Range Navigation

59 LORAN is a system that allows users to determine their position on the earth's surface. The LORAN receiver can determine the direction of arrival of transmissions from LORAN transmitters at known fixed locations around the world. By comparing the direction of several LORAN transmitters, a process called triangulation, the location of the receiver can be calculated. The version of LORAN currently in use in Europe is LORAN-C. Due to the increased use of GPS as a global navigation system, the use of LORAN-C is currently in decline. The service is likely to continue in the near future, however, as a backup in the event of failure of the GPS satellite network.

60 LORAN-C transmits at low frequency with good long-range coverage. Accordingly, only a small number of transmitters are required to provide coverage, with only one in the UK at Anthon, Cumbria (LORAN-C, 2011). The Anthon transmitter is approximately 86 NM from the development site. There is LORAN-C coverage in the vicinity of the Neart na Gaoithe site as illustrated in Figure 18.8 (LORAN-C, 2011).

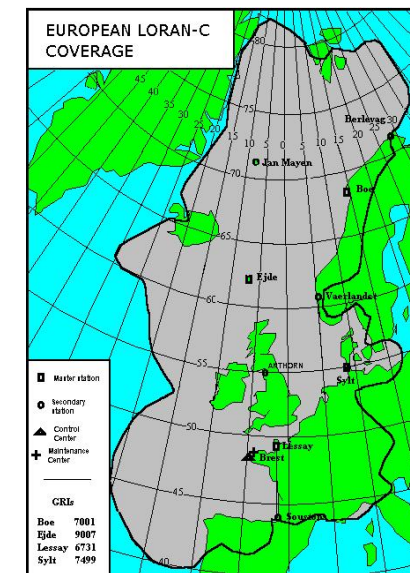


Figure 18.8: European LORAN-C coverage map. The LORAN-C coverage area is shown in grey (Source: LORAN-C, 2011)

Global Positioning System

61 GPS allows users to determine their position on the earth's surface. The method of operation is similar to LORAN but in the case of GPS, transmissions are from earth orbiting satellites. There are currently 30 satellites in the network of GPS satellites (FAA, 2010).

62 Differential GPS (DGPS) is a system that improves the positional accuracy of GPS. The accuracy of GPS is typically limited by unpredictable irregularities in propagation of signals through the atmosphere. The errors typically remain fairly constant over hundreds of kilometres. DGPS base stations broadcast the difference between their known fixed position and the position indicated by the satellites. GPS receivers then adjust their positional estimates according to the correction factor. The accuracy of the DGPS correction reduces as the range of the GPS receiver increases from the base station.

63 GPS reception is available in the vicinity of the proposed wind farm and is commonly used on virtually all maritime vessels for navigation. Accordingly, GPS can be expected to be in use anywhere around the wind farm. Some AIS systems and distress beacons rely on GPS for positional information.

64 The locations of the closest UK DGPS transmitters are shown in Figure 18.9 (Trinity House, 2011). The closest DGPS transmitter is at Girdle Ness, approximately 47 NM to the north of the proposed Neart na Gaoithe site. The DGPS system is designed to provide coverage out to at least 50 NM from the coast (Trinity House, 2011) and so there is likely to be coverage throughout the wind farm site.

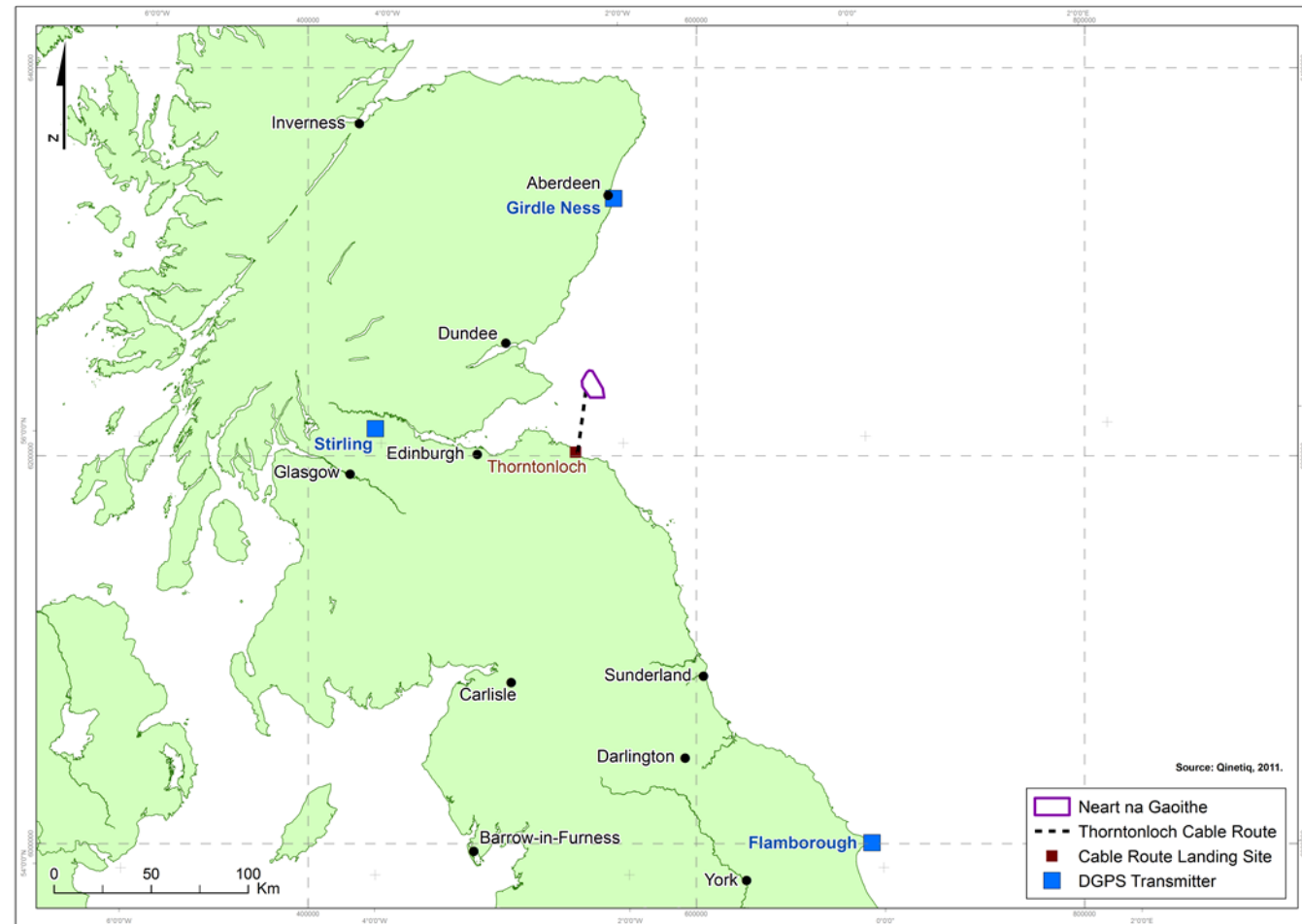


Figure 18.9: Locations of the closest UK DGPS transmitters in relation to the proposed wind farm boundary

18.6.4.3 Global Maritime Distress Safety Systems

- 65 The Global Maritime Distress Safety System (GMDSS) elements considered are distress beacons, search and rescue transponders (SARTs) and direction finding equipment. All of these systems could be used anywhere in the vicinity of the development site. The GMDSS is an internationally agreed set of procedures, equipment and protocols used for the rescue of maritime vessels and aircraft.
- 66 Distress beacons such as emergency locator transmitters (ELTs), emergency position-indicating radio beacons (EPIRBs) and personal locator beacons (PLBs) could be used in the vicinity of the wind farm. These three types of beacon are used for aircraft, maritime vessels and people respectively. The main differences are in how they are deployed. Once deployed, all three have a similar method of operation, relying on the transmission of a distress signal to a satellite network. The signal is then relayed to SAR teams. Distress beacons could be deployed anywhere in the water around a wind farm.
- 67 Search and rescue transponders are another type of distress beacon with a different method of operation. When deployed, a SART will respond to X-band radar pulses, transmitting its own characteristic reply. The reply appears as a series of dots on the X-band radar's display and helps SAR teams to locate the SART and, hence, the stricken vessel.
- 68 Search and rescue direction finding (DF) systems typically use a directional antenna to determine the direction of arrival of a signal. In simple terms, the direction of the source is determined by the direction of the antenna when the signal is strongest. DF systems are carried by many types of vessel, including lifeboats, and so could operate anywhere in the vicinity of the wind farm.

18.6.4.4 Telephony Systems

Mobile Telephones

69 Mobile telephones rely on a network of onshore base stations for coverage. The closest mobile telephone base stations are located near Crail on the east coast of Fife (Ofcom, 2011a). The closest base station (site reference 5465, operated by Vodafone) is marked in Appendix 18.1: Military and Aviation Technical Report and is approximately 18 km at its closest point, and 30 km at most from the development boundary. The coverage range of base stations can typically be less than 10 km and no more than 35 km (Ofcom, 2001), and so mobile telephone coverage within the development site is unlikely, although possible in principle. Mobile phone usage in the vicinity of the wind farm will be limited to use on maritime vessels.

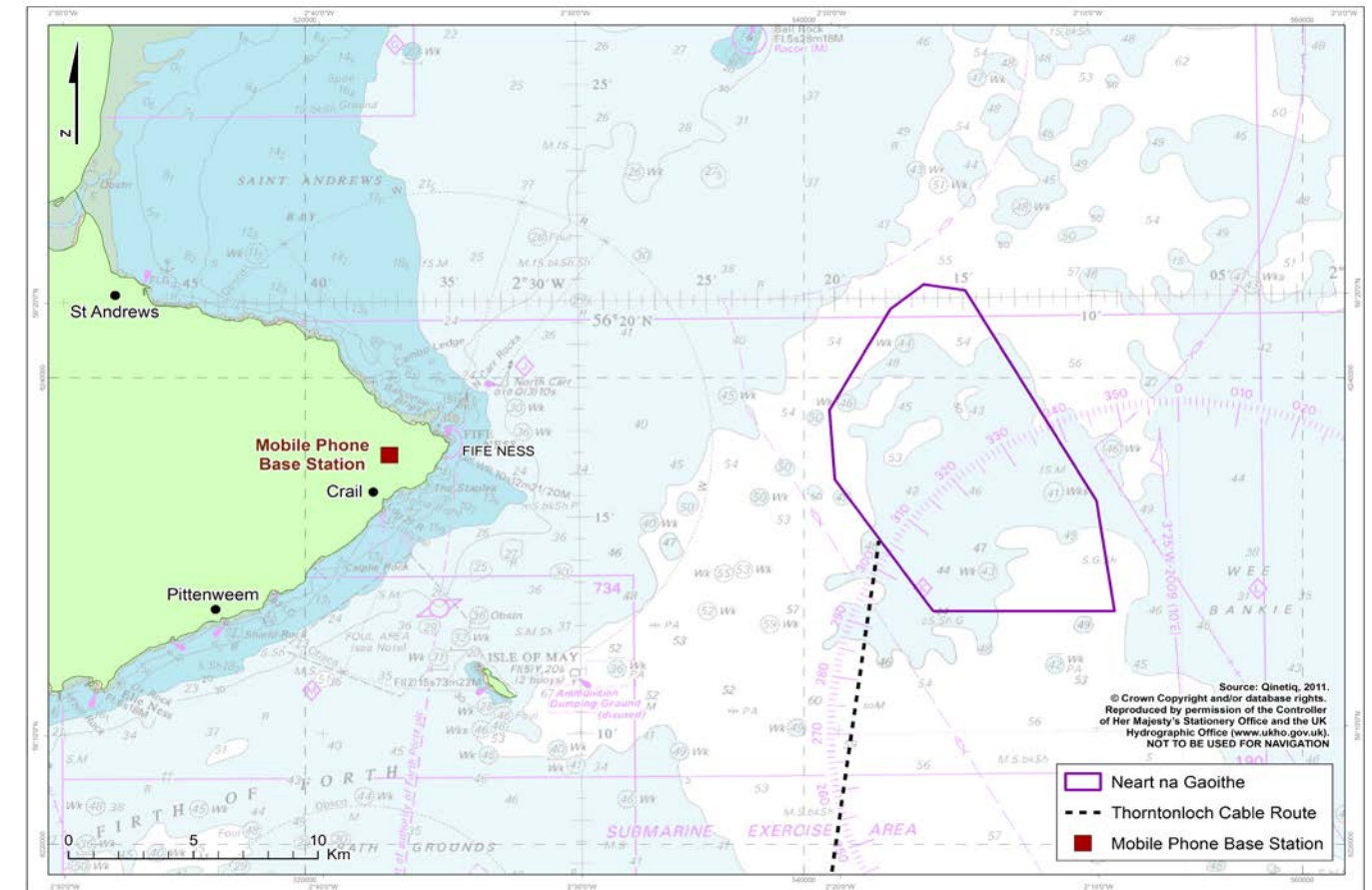


Figure 18.10: Location of the proposed wind farm and the nearest mobile phone base station

Satellite Telephones

70 Satellite telephone systems are commonly used in areas where mobile telephone coverage is not available and are routinely used on maritime vessels. Satellite telephones will potentially be used, regardless of whether mobile telephone coverage is available at any given location. Satellite telephone systems can use either geostationary satellites (always in the same position for a fixed earth observer) or orbiting satellites (whose position varies for a fixed earth observer). They can be used anywhere in the vicinity of the proposed wind farm.

18.6.4.5 Television and Public Radio Broadcasts

- 71 Television reception in the vicinity of the wind farm may be either through fixed onshore transmitters or through satellites. Satellite television in the UK is commonly provided by a network of satellites known as Astra. Onshore television reception is very unlikely to be affected by the proposed wind farm, although reception on offshore vessels in its vicinity could be potentially impacted.
- 72 Public radio broadcasts are made from onshore transmitters and reception is possible in the vicinity of the proposed wind farm.

Television

- 73 The closest main onshore television transmitters are Angus and Craigkelly (BBC, 2011), as illustrated in Figure 18.11. Television coverage at Crail (the closest onshore location from the Neart na Gaoithe site) is likely to be from the Craigkelly transmitter (DigitalUK, 2011). Both the Angus and Craigkelly transmitters are approximately 60 km from the centre of the proposed development site. Usage in the vicinity of the Neart na Gaoithe site will be limited to reception on maritime vessels.

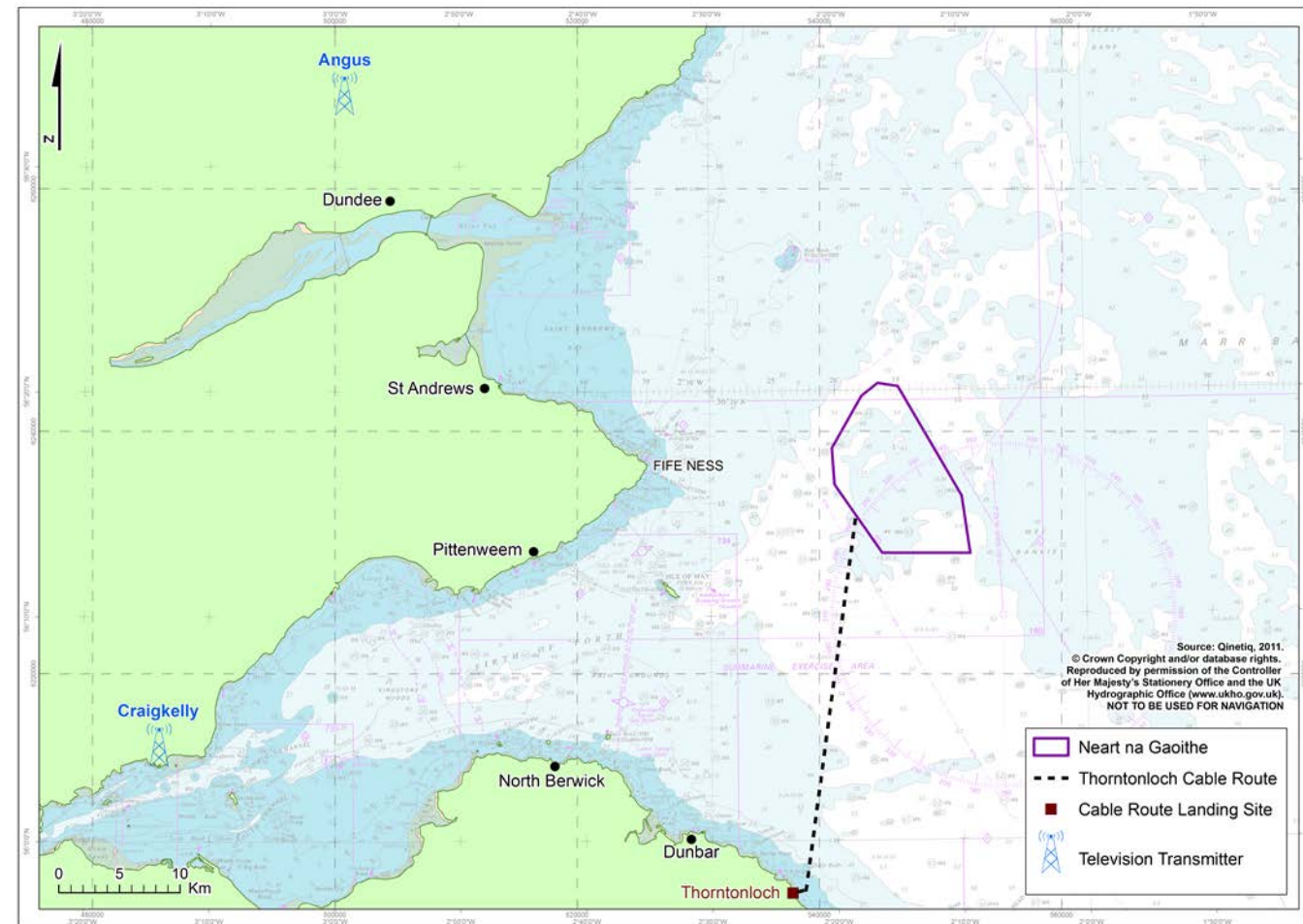


Figure 18.11: Location of Angus and Craigkelly transmitters and the proposed wind farm boundary

Public Broadcast Radio

- 74 There is a variety of onshore public broadcast radio transmitters in the vicinity of the proposed wind farm. The main transmitter sites are shown in Figure 18.12. It is not known which transmitters offer coverage within the development area. Based on the typical maximum coverage ranges of analogue and digital radio broadcasts of many tens of kilometres (MB21, 2011), it is likely that radio reception is available at the Neart na Gaoithe site.

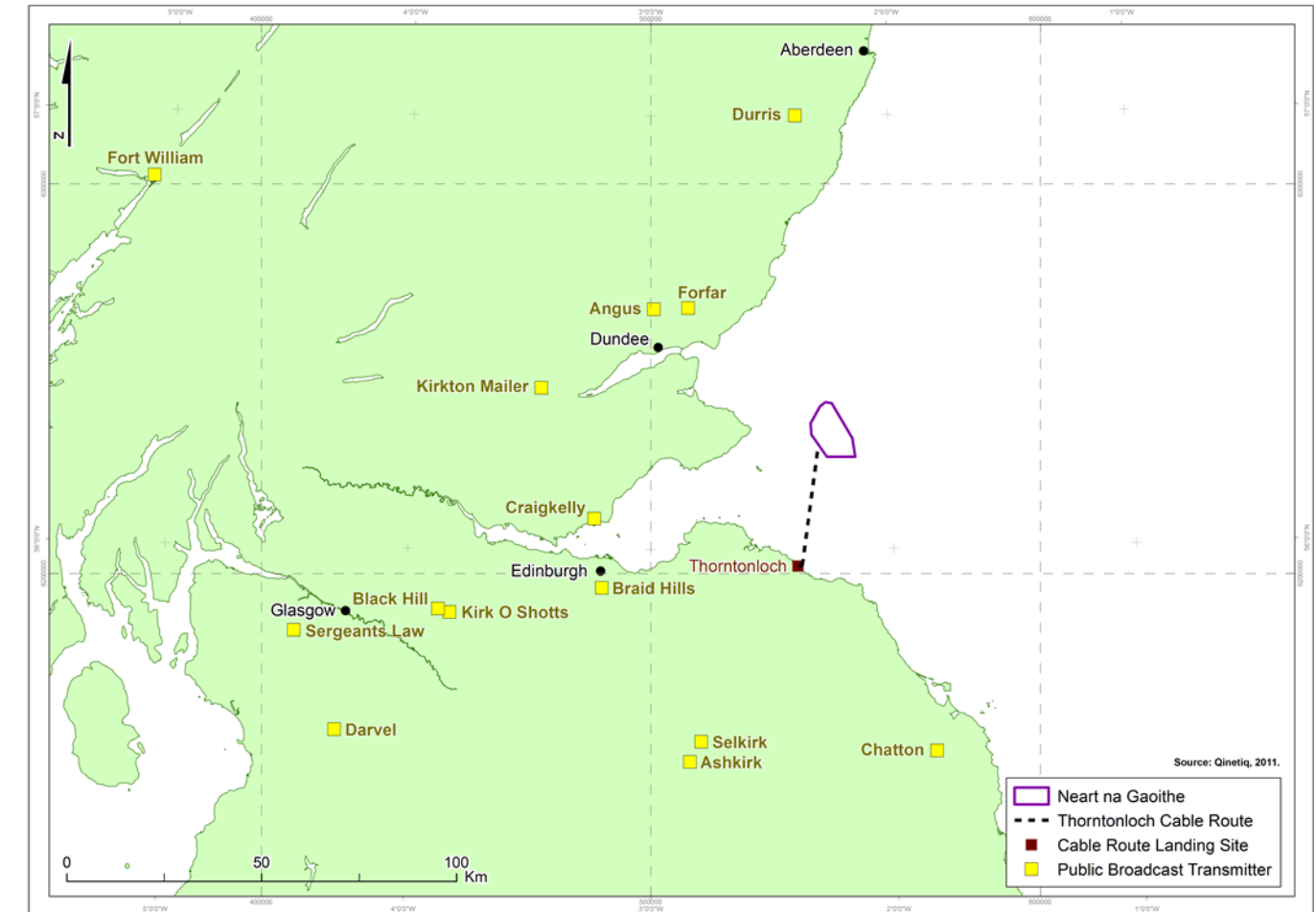


Figure 18.12: Main public broadcast transmitter sites, also showing the location of the proposed wind farm boundary

18.6.4.6 Line of Sight Links

- 75 LoS links are communication links between two fixed locations, sometimes referred to as point-to-point links or microwave links. Directional antennae are normally used to ensure signals are not transmitted in unwanted directions. Offshore LoS links are normally maintained by oil and gas operators, exchanging information between onshore antennae and offshore platforms. LoS links are normally limited to transmissions of tens of nautical miles in range.
- 76 No LoS links have been identified in the vicinity of the Neart na Gaoithe site. Because no offshore structures have been identified within tens of nautical miles to the east of the development site, it is unlikely that there are any LoS links crossing the site. In addition, no potentially affected LoS links were identified through consultation with Ofcom. Due to this, LoS is not taken forward to the assessment phase.

18.6.5 Physical Obstruction to Aviation

18.6.5.1 Obstacle Limitation Surfaces

77 Wind turbines can also present a physical obstruction for certain aviation activities, such as airport arrival and departures, navigational aid calibration and military low-flying. Aircraft activity around aerodromes is normally safeguarded using OLS. These are surfaces defined around runways, typically extending no more than 20 km in range from them. If a proposed wind turbine lies inside the boundary of one of the surfaces and exceeds its minimum height, the aerodrome may object on the basis that the structure is a physical obstruction and poses an unacceptable risk of collision.

18.6.5.2 Military Low-Flying

78 The MOD publishes a UK LFA map (refer to Figure 18.3) for the purpose of providing wind farm developers guidance on the likely impact on low-flying activities (MOD, 2011b). The map is supplied only for guidance about locations likely to be problematic and is not intended as a binding statement of MOD procedure or policy (MOD, 2011b).

79 The development area lies outside of the LFA and as such military low-flying activities are not taken forward to the assessment phase.

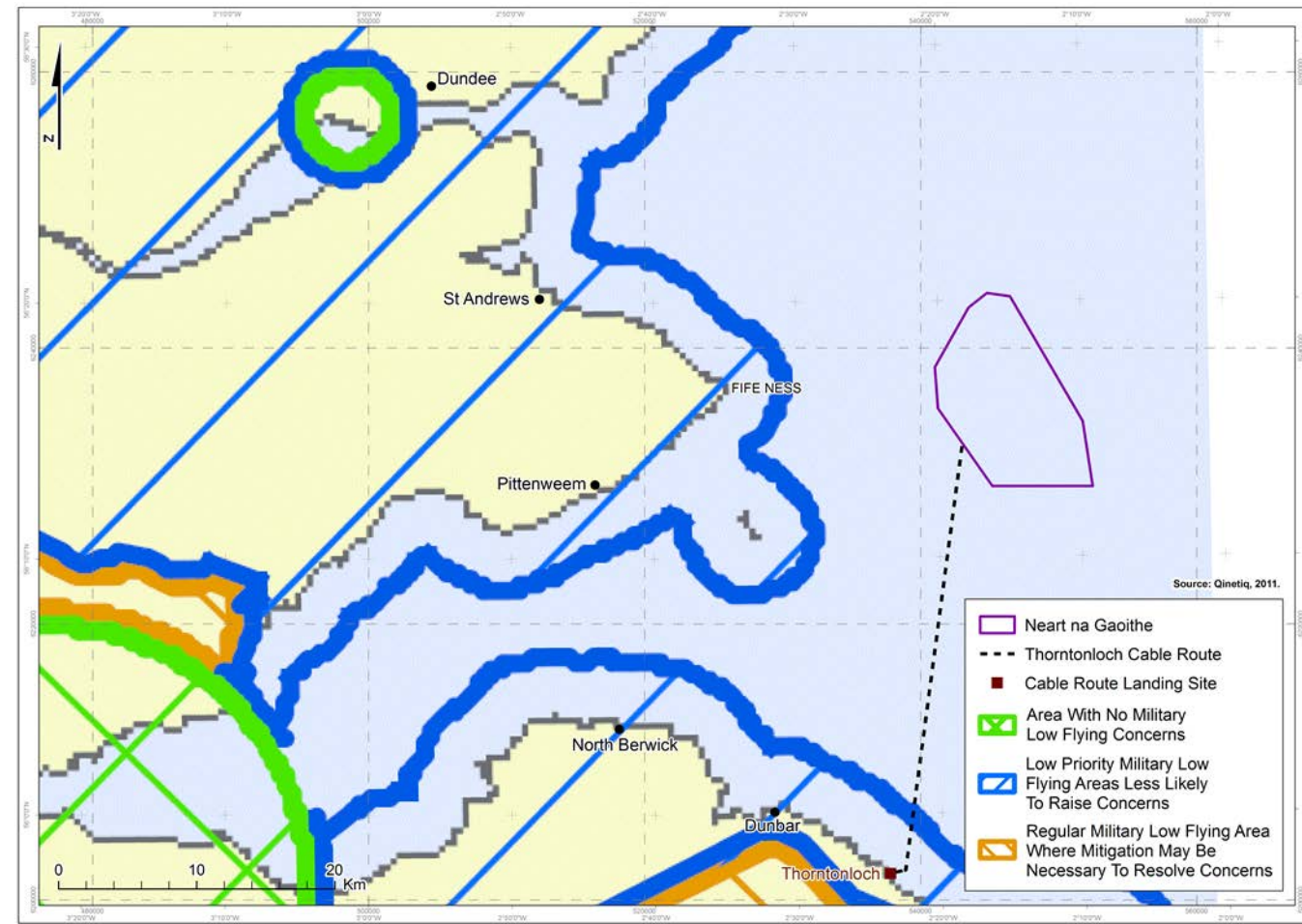


Figure 18.13: MOD LFA safeguarding map showing the location of the proposed wind farm boundary

80 The proposed wind farm does not lie within any of the low-flying consultation zones published by the MOD (MOD, 2011a). In February 2010, the MOD indicated that the impact on low-flying would be manageable (EMU, 2010b).

18.6.5.3 Military Practice and Exercise Areas

81 A number of PEXA have been identified in the vicinity of the proposed wind farm. The PEXA are shown in Figure 18.14, indicated by their MOD serial numbers. In the serial numbers, the prefix “X” means activities are generally undertaken at the sea surface or beneath the surface; the prefix “D” indicates activities are generally undertaken above the sea surface. The boundaries of areas X5613, X5614, X5641, X5642 and D609 are approximate (Mainstream, 2009; DTI, 2004). The remaining boundaries are exact (MOD, 2010a). The name of each area and the activities undertaken are listed in Table 18.4.

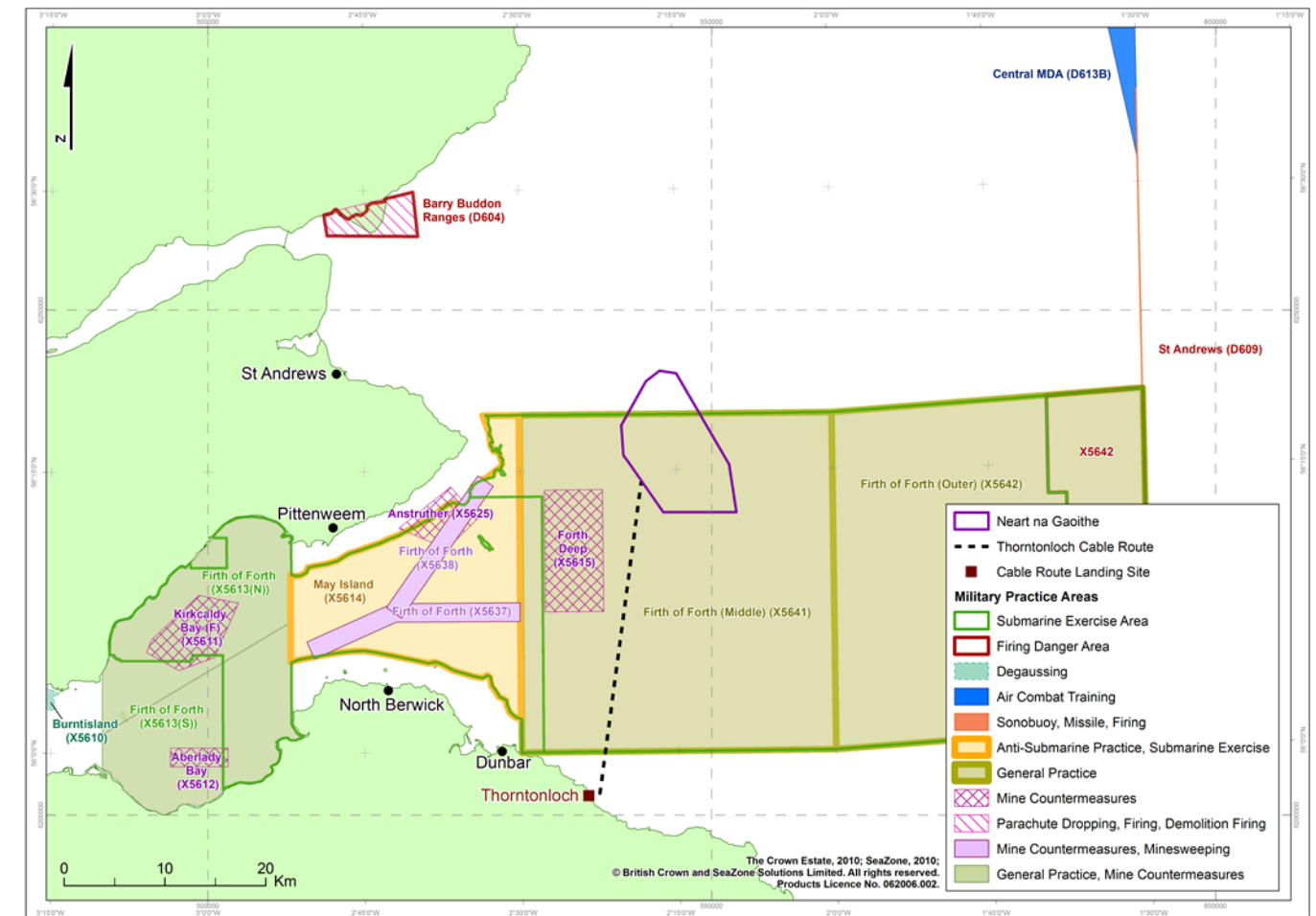


Figure 18.14: Locations of PEXA in the vicinity of the proposed wind farm. The boundaries of X5613, X5614, X5641, X5642 and D609 are approximate

82 In addition to the activities listed for each of the PEXA, hydrographic charts (e.g., UKHO, 2002) indicate that much of the Firth of Forth is a submarine exercise area but the boundary of this area is not marked on the charts. It is likely that the exercise area extends to the vicinity of the wind farm. The majority of the proposed wind farm lies inside X5641, Firth of Forth (middle), where the principal activity is firing practice (UKHO, 2004).

| PEXA Serial Number | Name | Activities |
|--------------------|--|--|
| D609 | St Andrews | Sonobuoys, missiles, firing (DTI, 2004) |
| X5611 | Kirkcaldy Bay | Mine countermeasures (DTI, 2004) |
| X5612 | Aberlady Bay | Mine countermeasures (DTI, 2004) |
| X5613 | Firth of Forth | General practice, mine countermeasures (DTI, 2004) |
| X5614 | May Island | Submarine and anti-submarine exercises (DTI, 2004; UKHO, 2002) |
| X5615 | Forth Deep | Mine countermeasures (DTI, 2004) |
| X5625 | Anstruther | Mine countermeasures (DTI, 2004) |
| X5637 | Firth of Forth Minesweeping Corridor (MOD, 2010a) | Minesweeping (MOD, 2010a) |
| X5638 | Firth of Forth Northern Minesweeping Corridor (MOD, 2010a) | Minesweeping (MOD, 2010a) |
| X5641 | Firth of Forth (middle) (UKHO, 2004) | Firing practice area (UKHO, 2004) |
| X5642 | Firth of Forth (outer) (UKHO, 2004) | Firing practice area (UKHO, 2004) |

Table 18.4: PEXA details

18.6.6 Summary of the Baseline

83 The baseline assessment has identified those radar or communications systems which have the potential to interact with the proposed development. Those with no identifiable interaction are not taken forwards to the assessment phase. The following table (Table 18.5) highlights those systems which are considered in the impact assessment.

| Group | Function | System | Taken Forward to Assessment Phase |
|--------------------------|---------------------------------------|--|---------------------------------------|
| Military and Civil Radar | Primary Surveillance Radar Systems | ATC | Yes |
| | | AD | No (none identified) |
| | | PAR | Yes |
| | | VTS | Yes |
| | | Offshore early warning | No (none identified) |
| | | Meteorological | Yes |
| | Other Radar Systems | SSR | Yes |
| Telecommunications | Marine Navigation Aids | Radio beacons | Yes |
| | | VHF communications | Yes |
| | | AIS | Yes |
| | Global Navigation Satellite System | LORAN | Yes |
| | | GPS | Yes |
| | Telephony | Mobile telephones | Yes |
| | | Satellite | Yes |
| | Television and Public Broadcast Radio | Television | Yes |
| | | Public broadcast radio | Yes |
| | Physical Obstruction to Aviation | OLS | No (project does not overlap any OLS) |
| Low-flying | | No (project does not lie in any MOD LFA) | |
| Military Practice Areas | PEXA | No (no potential impacts identified) | |

Table 18.5: Summary of the military and civil passage systems being taken forward to assessment

18.7 Impact Assessment

18.7.1 Impact Assessment – Construction

18.7.1.1 Site-Specific Assessment

84 The impacts on radar and telecommunications systems arise due to their physical presence, mainly as a result of reflections from turbines causing interference, or by the blockage of signals (shadowing). All of the potential impacts due to the turbines can, therefore, occur during the construction phase. Any impacts will increase throughout the construction phase as more turbines are built, until reaching the maximum level when the wind farm is complete.

85 A technical assessment of each radar and telecommunications system is given in Appendix 18.1: Military and Aviation Technical Report. Using the methodology defined in Section 18.5 – Impact Assessment Methodology, a summary of the technical findings is given in the remainder of this section.

Military and Civil Radar

86 A summary of the impacts of the Neart na Gaoithe wind farm on each military and civil radar receptor is given in Table 18.6.

| Source | Pathway | Receptor | Magnitude of effect | Vulnerability of receptor | Significance of impact | Qualification of significance |
|--|--|--------------------------|---------------------|---------------------------|------------------------|---|
| Radar signals reflected by turbines | Inconvenience or risk due to clutter on radar display | RAF Leuchars PSR | Moderate | High | Major significance | Significance of impact could reduce if the provision of radar services reduces at RAF Leuchars but the future of the base is not yet known. |
| Shadowing of radar signals behind turbines | Reduced detectability of aircraft behind turbines | RAF Leuchars PSR | Low | High | Moderate significance | Shadowing will occur, so vulnerability is high. Height of shadowing is limited to approximately 1000 m AMSL. Significance of impact could reduce if the provision of radar services reduces at RAF Leuchars but the future of the base is not yet known. |
| Radar signals reflected by turbines | Inconvenience or risk due to clutter on radar display; tracking affected | RAF Leuchars PAR | Negligible | Low | Minor significance | The developer has committed to ensuring that no turbines will be built within the PAR exclusion zone. There is a residual likelihood that turbines could have an impact on coverage inside the PAR cone. Any impacts would occur at the edges of the cone and would have a negligible operational impact. |
| Provision of NERL En-route services | Inconvenience or risk due to clutter on radar display | Any NERL en-route PSRs | Moderate | Negligible | Minor significance | NATS self-assessment maps confirm they do not have coverage, so vulnerability is negligible. |
| Provision of VTS services | Inconvenience or risk due to clutter on radar display | Any VTS radar | Low | Negligible | Minor significance | Response from MCA indicates that vulnerability is negligible. |
| Quality of meteorological data | Inconvenience or risk due to clutter on radar display | Any meteorological radar | Moderate | Negligible | Minor significance | Turbines fall outside stakeholder's exclusion zones. |
| Offshore platform radar services | Inconvenience or risk due to clutter on radar display | Any offshore radar | Negligible | Negligible | Not significant | Even if the turbines were detectable, the turbines would have a negligible impact on the role of the radar. |
| SSR data quality | Degradation of positional accuracy | Any SSR | Low | Negligible | Minor significance | All SSRs fall outside consultation zones so vulnerability is negligible. |

Table 18.6: Impact assessment conclusions of construction phase on military and civil radar

Telecommunications

87 A summary of the impacts of the Neart na Gaoithe wind farm on each telecommunications receptor is given in Table 18.7.

| Source | Pathway | Receptor | Magnitude of effect | Vulnerability of receptor | Significance of impact | Qualification of significance |
|--|---|----------------------|---------------------|---------------------------|------------------------|--|
| Interference/ shadowing | Reduction in voice quality or loss of signal | VHF communications | Low | Low | Minor significance | Emergency radio communications for stricken vessels is critical but likely to be able to contact multiple vessels, all of which will not be impacted. The likelihood of any vessel being close to a turbine is low. Impacts are likely to be transitory due to vessel motion. Construction or maintenance vessel operators will be well informed of potential impacts. |
| Triggering via reflections from turbines | Apparent location of racon is incorrect | Racons | Negligible | Negligible | Not significant | Consultation indicates there are no racons near the development, so vulnerability is negligible. |
| Interference/ shadowing | Reduction or loss of service | AIS | Low | Low | Minor significance | The likelihood of any vessel operating AIS being close to a turbine is low; impacts are likely to be transitory due to vessel motion. Impact on the system is likely to be negligible as the system will continue to operate with latest received information. |
| Interference/ shadowing | Reduction in positional accuracy | Loran | Low | Low | Minor significance | LORAN operation is unlikely to be affected. |
| Interference/ shadowing | Reduction in positional accuracy | GPS | Negligible | Moderate | Minor significance | Moderate likelihood of vessels using GPS close to turbines but the operational significance of impacts is likely to be negligible. |
| Interference/ shadowing | More difficult for SAR services to locate | Distress beacons | Low | Low | Minor significance | Any impacts are likely to be short lived due to relative motion of beacon and SAR vehicles. |
| Obscuration of signal | More difficult for SAR services to locate | SARTs | Low | Low | Minor significance | Any impacts are likely to be short lived due to relative motion of beacon and SAR vehicles. |
| Interference/ shadowing | Reduction in bearing estimation accuracy | Direction finding | Low | Low | Minor significance | The likelihood of any vessel being close to a turbine is low. Impacts are likely to be transitory due to vessel motion. SAR operators using DF will be well informed of potential impacts. |
| Interference/ shadowing | Reduction or loss of coverage | Mobile telephones | Low | Low | Minor significance | Mobile phone coverage is unlikely in the vicinity of the turbines. |
| Interference/ shadowing | Reduction or loss of coverage | Satellite telephones | Negligible | Moderate | Minor Significance | Moderate likelihood of vessels using satellite telephones close to turbines but the operational significance of impacts is likely to be negligible. |
| Interference/ shadowing | Reduction of picture quality or loss of picture | Television | Low | Low | Minor Significance | Television coverage is unlikely to be important in the area of the wind farm. |
| Interference/ shadowing | Reduction of sound quality of loss of signal | Public radio | Low | Low | Minor Significance | Public radio coverage is unlikely to be important in the area of the wind farm. |
| Interference/ shadowing | Intermittent or complete loss of data | LoS links | Negligible | Negligible | Not significant | No LoS links have been identified. |

Table 18.7: Impact assessment conclusions of construction phase on telecommunications

Physical Obstruction to Aviation

88 A summary of the impacts of the Neart na Gaoithe wind farm on each physical obstruction to aviation receptor is given in Table 18.8.

| Source | Pathway | Receptor | Magnitude of effect | Vulnerability of receptor | Significance of impact | Qualification of significance |
|----------------------|--|---------------------------|---------------------|---------------------------|------------------------|--|
| Physical obstruction | Increased risk of collision around airfields | Airfield protected by OLS | Negligible | Negligible | Not significant | Magnitude of impact is negligible because no turbine lies within the OLS of any airfield. |
| Physical obstruction | Restrictions on low-flying activities | Military LFA | Low | Low | Minor significance | Although the turbines lie outside any marked low-flying zones, low-flying activities do take place from RAF Leuchars, so vulnerability is low. The impact is to inconvenience and restrict activities. |

Table 18.8: Impact assessment conclusions of construction phase for physical obstructions to aviation

Military Practice Areas

89 A summary of the impacts of the Neart na Gaoithe wind farm on PEXA is given in Table 18.9.

| Source | Pathway | Receptor | Magnitude of effect | Vulnerability of receptor | Significance of impact | Qualification of significance |
|----------------------|--|---------------|---------------------|---------------------------|------------------------|--|
| Physical obstruction | Restrictions on activities carried out in PEXA | Military PEXA | Low | Low | Minor significance | Feedback from the MOD to date indicates the impact would be low. |

Table 18.9: Impact assessment conclusions of construction phase for military practice areas

18.7.1.2 Cable Route

90 The types of vessel employed during the construction of the cable route are likely to be similar to the types of vessel already operating in that area. No additional impacts due to the construction process have been identified.

18.7.2 Impact Assessment – Operation and Maintenance

18.7.2.1 Site-Specific Assessment

91 All of the potential impacts of the turbines occur as a result of their physical presence, and are the same as identified for the construction phase. No additional impacts have been identified that could occur during the operation and maintenance phase.

18.7.2.2 Cable Route Assessment

92 The types of vessel employed during the operation and maintenance of the cable route are likely to be similar to the types of vessel already operating in that area. No additional impacts due to the operation and maintenance process have been identified.

18.7.3 Impact Assessment - Decommissioning

18.7.3.1 Site-Specific Assessment

93 All of the potential impacts of the turbines occur as a result of their physical presence, and are the same as identified for the construction phase. No additional impacts have been identified that could occur during the decommissioning phase. At the completion of decommissioning, assuming no part of any structure associated with the wind farm breaks the sea surface, there will be no remaining impacts on radar or telecommunications systems.

18.7.3.2 Cable Route Assessment

94 The types of vessel employed during the decommissioning of the cable route are likely to be similar to the types of vessel already operating in that area. No additional impacts due to the decommissioning process have been identified.

18.8 Cumulative and In-combination Impacts

18.8.1 Construction

95 No significant cumulative or in-combination impacts have been identified during the construction phase.

18.8.2 Operation and Maintenance

Cumulative Assessment

96 The location of Neart na Gaoithe and the other proposed wind farm developments in the Firth of Forth are shown in Figure 18.15. This figure is based on the current project statuses for the Inch Cape and Firth of Forth Round 3 Zone 2 wind farm developments. The Inch Cape wind farm development is located to the north of Neart na Gaoithe, approximately 5.5 NM at its nearest point. The proposed Inch Cape turbines have a maximum blade tip height of 215 m and are distributed throughout the development boundary. The Rochdale Envelope for Inch Cape and the Round 3 Zone 2 is detailed in Chapter 5: Project Description. The Firth of Forth Round 3 Zone 2 development consists of seven projects, identified Alpha to Golf in Figure 18.15. The proposed Firth of Forth Round 3 Zone 2 turbines have a maximum blade tip height of 199 m; a provisional layout was not available but for the purpose of the study it is assumed turbines will be distributed evenly over the seven projects.

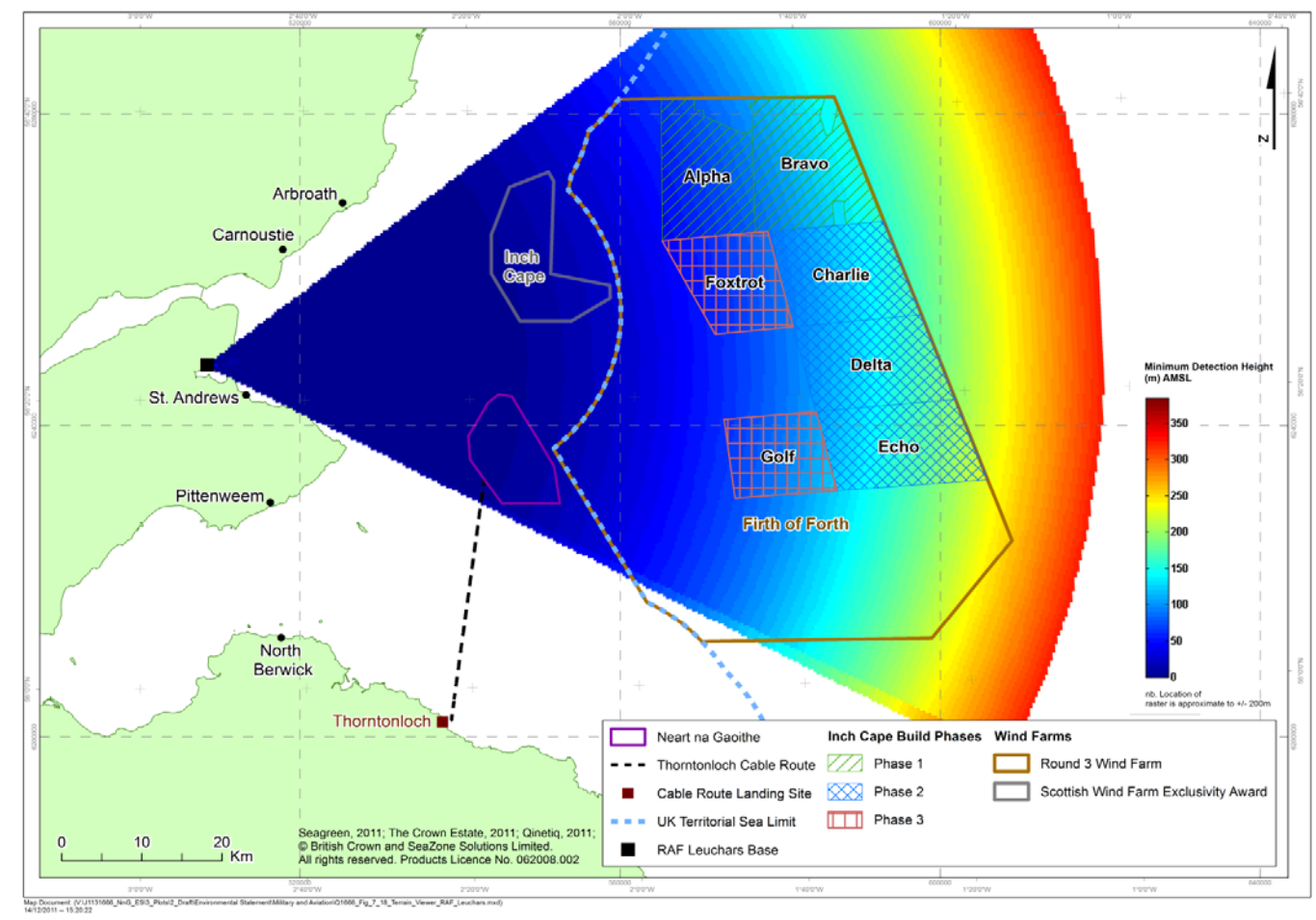
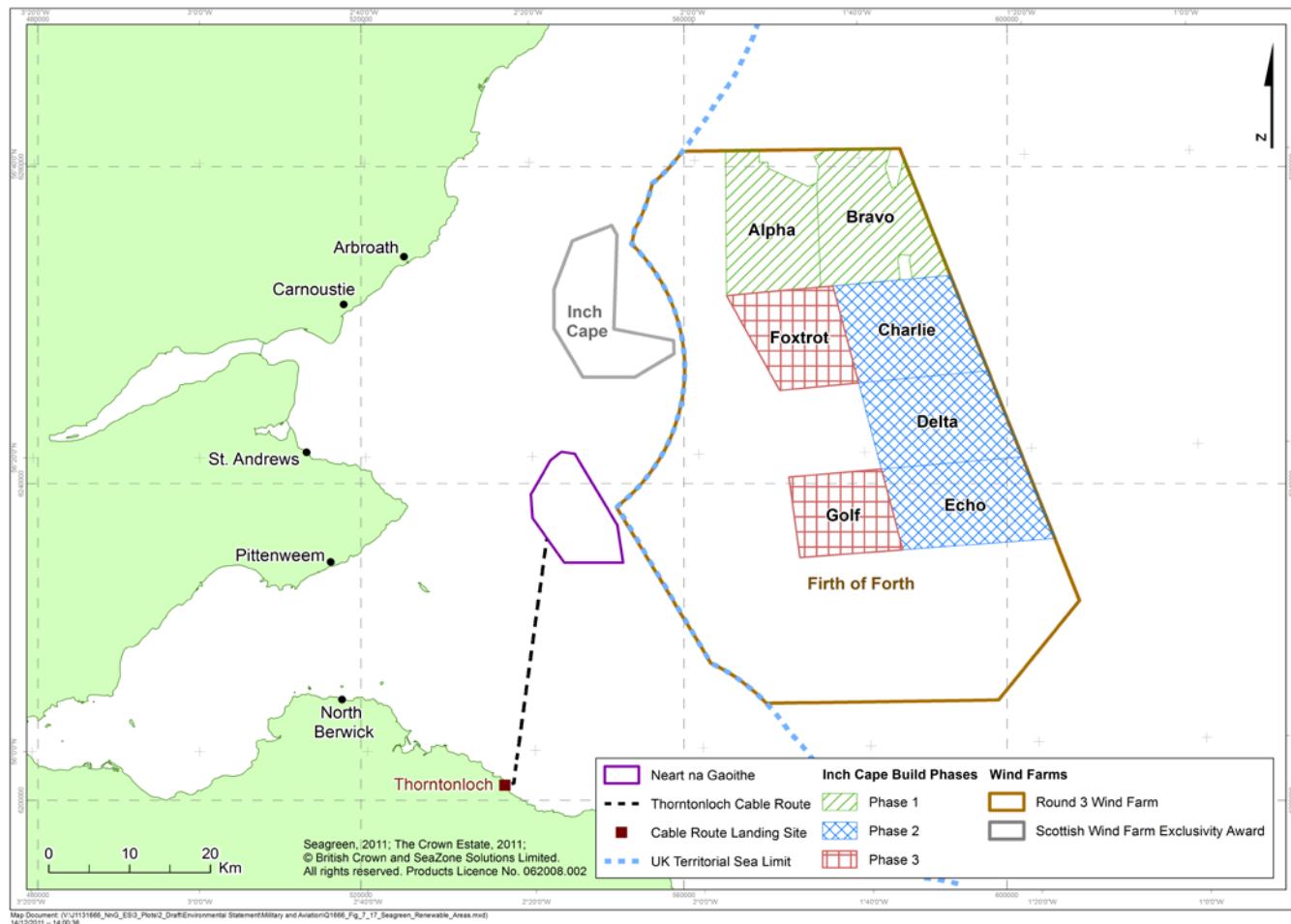


Figure 18.15: Location of Neart na Gaoithe and other proposed Firth of Forth wind farms

Figure 18.16: Estimate of the RAF Leuchars PSR BoC in the vicinity of the proposed Firth of Forth wind farms. The colour shows the minimum detection height, based on radar LoS, in metres AMSL

97 The only significant cumulative impact of the projects shown in Figure 18.15 is on the RAF Leuchars PSR. Figure 18.16 shows an estimate of the base of cover (BoC) (minimum available coverage heights), based on radar LoS calculations. The BoC in the vicinity of the Neart na Gaoithe and Inch Cape wind farms is between 20-50 m, and so turbines are very likely to be detected. The BoC over the seven FoF projects varies from approximately 100-300 m; turbines to the west of the projects are very likely to appear as clutter, some turbines to the east of the projects may not appear as clutter.

RAF Leuchars PSR

98 Figure 18.17 shows the location of the proposed Firth of Forth wind farms overlaid on UK ATS airspace classifications chart (CAA, 2011). The locations of RAF Leuchars and Dundee Airport are also shown. Because the majority of the proposed wind farms are in LoS to the radar, they would create, in effect, a large area within which significant clutter can be expected. All of the proposed wind farms are located in areas where controllers using the Leuchars radar can be expected to need to see aircraft, depending on the service provided at each location. It is evident that, as larger areas are covered and the extent of the clutter increases, the options for the controller reduce. For example, even if a controller were to guide their aircraft between the two areas at Inch Cape and Neart na Gaoithe and a potential conflict emerged with an aircraft under their control, they would have insufficient time to react.

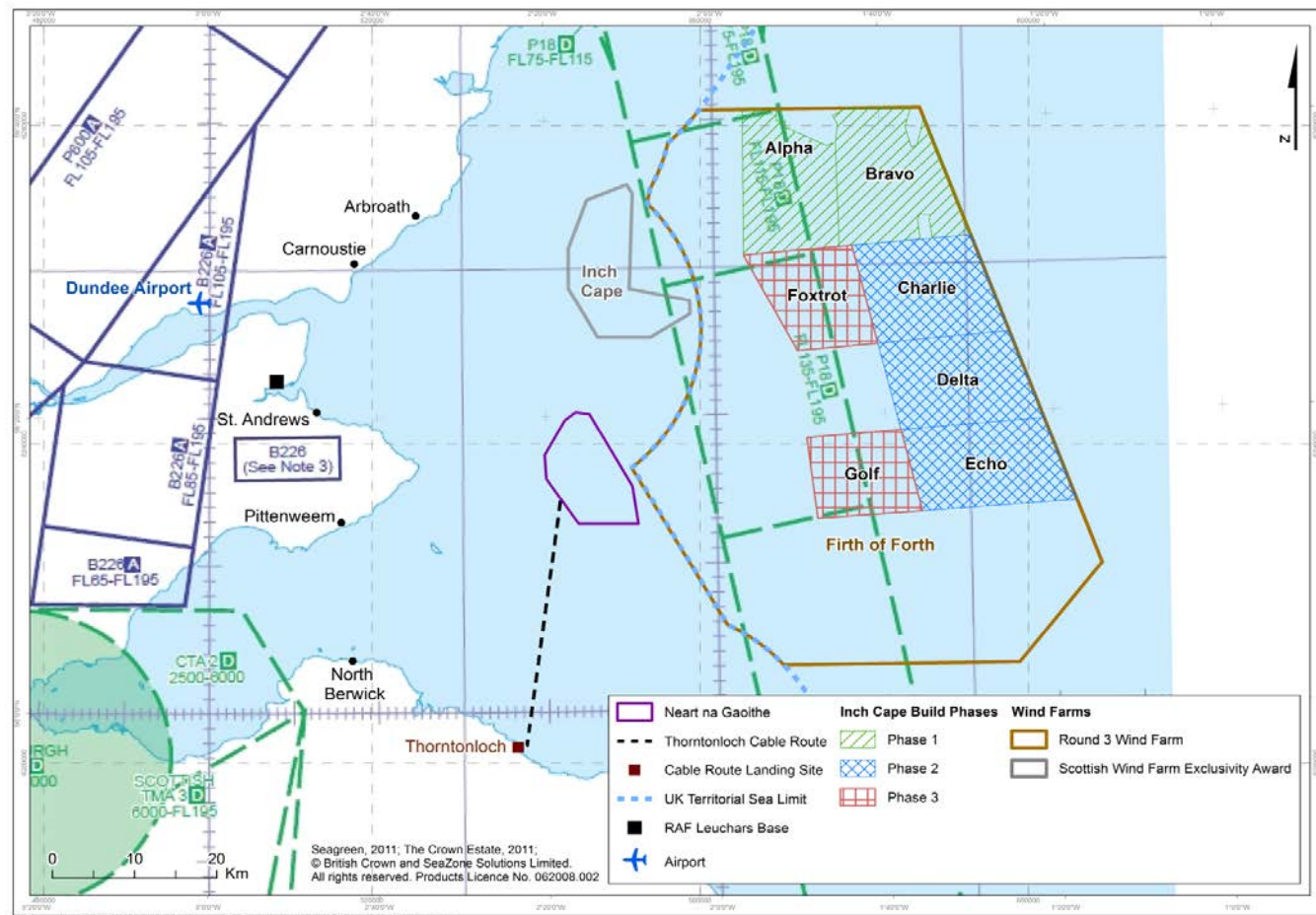


Figure 18.17: Proposed wind farms in the Firth of Forth overlaid on UK ATS airspace classifications chart (CAA, 2011)

99 As the majority of the proposed wind farms are in LoS to the radar at Leuchars it is implicit that the more sites that are proposed or built, the greater the impact on the provision of ATC radar services. Neart na Gaoithe and Inch Cape are the greatest contributors as they are closer to RAF Leuchars than the Firth of Forth Round 3 Zone. With Neart na Gaoithe being the closest site to RAF Leuchars, it is likely that it would raise the greatest concern since:

- It is closest to the Leuchars radar patterns, and so could conceal potentially conflicting traffic closest to the majority of traffic under the control of Leuchars ATC. This would be less of an issue, were flying operations at Leuchars to cease;
- Aircraft performing general handling over the sea tend only to fly over the sea as far as necessary, and consequently areas closer to the shore are likely to be operationally preferable; and
- The area is located outside airway P18, the approximately north-south channel marked in green in Figure 18.17, passing between Inch Cape and the Round 3 Zone 2 Firth of Forth wind farm. Since aircraft descending into and climbing out of the low-flying system are generally under the control of military ATC agencies, they will usually be outside controlled airspace. Since they are also descending to an overland point, they would usually be descended to the west of the airway, placing them closer to the Neart na Gaoithe and Inch Cape sites.

AIS and VHF Communications

100 Shadowing effects from Neart na Gaoithe and other wind farms can, in principle, have a cumulative impact on AIS and VHF communication transmissions. This is unlikely to be significant in terms of routine communications due to the separation of Neart na Gaoithe from other wind farms.

18.8.3 Decommissioning

101 No significant cumulative or in-combination impacts have been identified during the decommissioning phase.

18.9 Mitigation and Residual Impacts

102 Table 18.10 summarises any impacts identified in Section 18.7: Impact Assessment, where significance is moderate or major. In each case, available mitigation options are discussed and the residual impact significance is assessed. The mitigation options are discussed in more detail below.

103 It is important to note that any mitigation options must be accepted by the MOD and discussions are ongoing between the MOD and the Forth and Tay Offshore Wind Developers Group to identify suitable mitigation.

| Source | Pathway | Receptor | Significance pre-mitigation | Mitigation | Residual impact significance | Qualification of significance |
|---|---|------------------|-----------------------------|---|------------------------------|--|
| Radar signals reflected by turbines (clutter) | Inconvenience or risk due to clutter on radar display | RAF Leuchars PSR | Major Significance | Change airspace by designating area over the wind farm as a Transponder Mandatory Zone (TMZ). | Minor Significance | SSR is used as mitigation by establishing a TMZ, similar to the proposed solution for the Greater Wash Regional Scheme (GWRS). |
| | | | | Infill radar (single onshore system or multiple offshore systems local to turbines). | Minor Significance | This assumes that the MOD requirements for seamless integration can be met. |
| Shadowing of radar signals behind turbines | Reduced detectability of aircraft behind turbines | RAF Leuchars PSR | Moderate Significance | Infill radar system. | Minor Significance | Currently the response from the MOD identifies reduced detectability due to shadowing as a concern. . When considering how clutter is mitigated with an in-fill radar, the extent to which this also mitigates shadowing should be considered. |

Table 18.10: Example mitigation and reassessment process

18.9.1 Technical Mitigation of Effects on RAF Leuchars

18.9.1.1 New Radar

104 Replacing the existing RAF Leuchars Watchman ATC radar with a system that is more robust to wind farm clutter could mitigate the impact of clutter from Neart na Gaoithe. Given the likely extent of the clutter, especially when considered cumulatively with the other proposed Firth of Forth wind farms, a wind farm resilient radar may not provide complete mitigation.

18.9.1.2 Infill Radar

105 Any region of radar coverage impacted by the presence of strong clutter can be mitigated through the use of additional radar to supplement the radar coverage. This infill radar should be located in an area where the wind farm is out of radar coverage, either over the horizon or terrain shielded but still able to detect aircraft flying above the turbines. A simplistic representation, showing the basic premise of the infill approach, is shown in Figure 18.18.

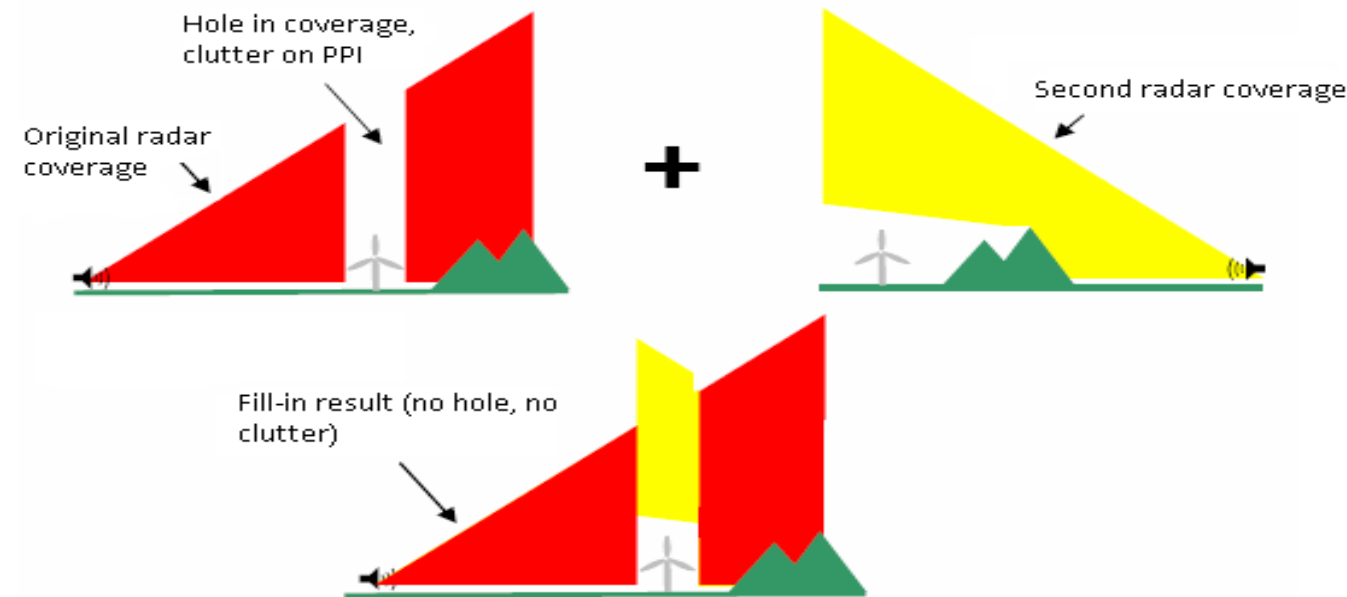


Figure 18.18: Simplified side on representation of infill radar

106 An infill radar system could either take the form of a new onshore system, if a suitable location can be found, or a system local to the wind farm. Any infill system would need to meet the MOD seamless integration policy, where seamless integration is defined as: *“The insertion of data into an air traffic control radar video display to provide a radar picture over a wind turbine development within a specific designated area that appears to have smooth boundaries with no visible seams or obvious joins to an MoD Air Traffic Controller. The infill patch must not display any form of boundary corruption for transponding or non-transponding aircraft which could lead to an MoD Air Traffic Controller being unable to provide safe air traffic control services”* (MOD, 2010b).

107 It is desirable that any infill solution would form part of a regional solution, to mitigate the other proposed Firth of Forth wind farm developments. Given the likely extent of the cumulative area of clutter, it is unlikely that any one new onshore radar will fully mitigate the effect. Local infill solutions could, in principle, fulfil this requirement. Current local infill solutions include:

- Cambridge Solutions *Aveillant*, based on holographic radar methods, whereby the airspace around the wind farm is continually scanned using a three dimensional radar that can discriminate between turbines and aircraft;
- C Speed *Lightwave*, a solid state PSR that uses a high pulse repetition frequency to differentiate between wind farm clutter and real aircraft; and
- QinetiQ *VERIFEYE*, a novel solution using multiple navigation radars as a low cost, high redundancy solution that is readily integrated with existing radar set ups.

108 In addition to mitigating the impacts of clutter, infill radar solutions can potentially mitigate the impact of shadowing on the RAF Leuchars PSR, should this be considered necessary.

18.9.2 Operational Mitigation of Effects on the RAF Leuchars PSR

18.9.2.1 Airspace Change

109 The proposed site is currently located in Class-G airspace, which means that most class of airspace user can fly there with a minimum level of equipment. There is currently no requirement for aircraft to be equipped with an SSR transponder, when operating at lower levels. This has three main consequences:

- The activity levels around Neart na Gaoithe are unpredictable;
- ATC authorities cannot deny access to the airspace above Neart na Gaoithe to any airspace user; and
- ATC agencies controlling traffic near the proposed site cannot guarantee that the probability of detection of conflicting traffic will be improved through the use of SSR.

110 It would be possible to increase the level of predictability over the site by means of an airspace change process. For example, the area could be designated a TMZ, which would require aircraft to be equipped with transponders. Without a TMZ, SSR cannot be considered an effective mitigation. The implementation of a TMZ is a proposed mitigation for the impact of offshore wind farms in The Greater Wash, as part of the GWRS.

111 There are other more constrictive types of airspace that could also be considered, however, it is recognised that the authority for classifying airspace in the UK, the Directorate of Airspace Policy within the CAA, has a remit to ensure access to airspace equitably to all airspace users, and it would be unlikely to sanction proscriptive airspace classification simply to permit the development of a wind farm. Moreover, the ACP process is lengthy and expensive, requiring consultation with all affected stakeholders.

18.9.2.2 Procedure Change

112 Where formal instrument flight rules (IFR) procedures exist, it is sometimes possible to explore the modification of these procedures to ensure that aircraft can be safely separated from wind-turbine clutter. In this case, all the activities that directly affect the proposed site take place in Class-G airspace without prescribed routes and altitudes. Consequently there are no formal procedures to assess.

113 The radar patterns associated with RAF Leuchars, whilst not formally published IFR procedures, take place to the south of the extended centreline of Leuchars main runway, which runs approximately east-west. These patterns cannot be moved to the north of the airfield due to noise-abatement and terrain issues, as well as the need to avoid a formal Site of Specific Scientific Interest (SSSI) (refer to Chapter 4: Site Selection, Project Alternatives and Design Evolution and Chapter 11: Nature Conservation). Consequently, these radar patterns cannot be significantly altered to clear the site.

18.9.2.3 Tactical Intervention

114 When controlling aircraft, controllers can always seek to re-route aircraft away from potentially hazardous areas. In this case, options for doing this are limited for the following reasons:

- Aircraft performing GH generally do so under visual flight rules (VFR) and are, therefore, not always willing or able to accept re-routes;
- In Class-G airspace, controllers cannot mandate a re-route;
- Other wind farm sites and proximate controlled airspace limit the options for re-route;
- Controller workload: resources may not be available to meet additional workload to accommodate re-routing; and
- Other traffic: in Class-G airspace, there could be other unidentified traffic, and a proposed re-route may take an aircraft under control into the path of other unidentified aircraft.

115 Despite these limitations , it should be considered that any aerial activities where the pilot refuses to accept a re-route would only normally occur when the aircraft is operating VFR, or IFR in Visual Meteorological Conditions . When operating under a full IFR service, in Visual Meteorological Conditions or Instrument Meteorological Conditions, the pilot would normally accept the instructions of the controller or risk being in breach of the terms of the service.

116 Since it is not possible to guarantee that a controller will be able to ensure an aircraft can re-route around the proposed site, this cannot be considered reliable mitigation.

18.10 Monitoring

117 No monitoring requirements have been identified.

18.11 Summary and Conclusions

118 In conclusion, Neart na Gaoithe has been identified as having a potential major impact on PSR radar, specifically the Watchman ATC radar located at RAF Leuchars. This interaction is likely to be common to all offshore wind farms proposed for the Firth of Forth and Tay area. Mitigation measures discussed in Section 18.9 – Mitigation and Residual Impacts, would alleviate this issue; however, such measures are currently in development and have not yet been tested in a real life situation and passed as acceptable by the MOD.

119 A summary of the potential radar and telecommunications impacts is given in Table 18.11. Only impacts with a pre-mitigation moderate or major significance are listed in the table. For each impact the identified mitigation approaches are listed along with the post-mitigation and cumulative significance.

| Source | Pathway | Receptor | Significance | Qualification of significance | Mitigation | Significance post-mitigation | Cumulative/in-combination impact significance | Qualification of significance |
|---|---|------------------|-----------------------|-------------------------------|--|------------------------------|---|---|
| Radar signals reflected by turbines | Inconvenience or risk due to clutter on radar display | RAF Leuchars PSR | Major significance | Mitigation is needed | Change airspace by designating area over the wind farm as a TMZ. | Minor significance | Minor significance | TMZ could mitigate all proposed wind farms in the Firth of Forth, similar to the solution proposed for the GWRS. |
| Radar signals reflected by turbines | Inconvenience or risk due to clutter on radar display | RAF Leuchars PSR | Major significance | Mitigation is needed | Infill radar (single onshore system or multiple offshore systems local to turbines). | Minor significance | Minor significance | No significant additional cumulative impact, assuming the infill solution can be applied to all proposed Firth of Forth wind farms. |
| Shadowing of radar signals behind turbines | Reduced detectability of aircraft behind turbines | RAF Leuchars PSR | Moderate significance | Mitigation may be needed | Infill radar system. | Minor significance | Minor significance | None. |

Table 18.11: Summary significance table

18.12 References

- ADATS (Air Defence and Air Traffic Services), 2009. *Investigation into the interference effects of wind turbines on the PAR system*, WR 80026.054, 1630/09, 6 October 2009.
- BBC (British Broadcasting Corporation), 2011. *UK television transmitters*. Available online from: <http://www.bbc.co.uk/reception/transmitters/tv> [accessed 18 Jan 2011].
- BWEA (British Wind Energy Association), MOD (Ministry of Defence), DTI (Department of Trade and Industry) and CAA (Civil Aviation Authority), 2002. *Wind Energy and Aviation Interests - Interim Guidelines*, ETSU W/14/00626/REP.
- CAA (Civil Aviation Authority), 2009. *CAA Policy and Guidelines on Wind Turbines (CAP 764)*.
- CAA, 2010a. *Licensing of Aerodromes (CAP 168)*.
- CAA, 2010b. *Air Navigation: The Order and the Regulations (CAP 393)*.
- CAA, 2010c. *CAA memo CAA advice for pre-planning*, 20 December 2010.
- CAA, 2011. *Chart of United Kingdom ATS Airspace Classifications – SFC-FL195, ENR 6-1-4-1*, 30 June 2011.
- DAB Digital Radio, 2011. *DAB Digital Radio Scottish transmitter information*. Available online from: <http://www.ukdigitalradio.com/coverage/currenttransmitters/default.asp?id=1> [accessed 24 Feb 2011].
- Dearman, S., 2010. *Neart na Gaoithe wind farm assessment proposal*, version 4, 140510-0138_UUU.
- DigitalUK, 2011. *Digital television switchover information*. Available online from: <http://www.digitaluk.co.uk/postcodechecker/main/display/basic> [accessed 24 Feb 2011].
- DTI (Department of Trade and Industry), 2004. *Existing Users and Management Initiatives relevant to SEA 5, Final Report*.
- EMU, 2010a. *Minutes of meeting between MOD, EMU Limited, SeaEnergy and Mainstream*, London, 3 June 2010.
- EMU, 2010b. *Minutes of meeting between MOD, EMU Limited and Mainstream*, Birmingham, 12 Feb 2010.
- EMU, 2010c. *Forth and Tay Developers Group Radar Summary Document*, J/1/06/1664.
- FAA (Federal Aviation Authority), 2010. *Global positional system FAQs*. Available online from: http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/faq/gps [accessed 21 Feb 2011].
- Forth Ports Plc., 2011. *Forth Ports radar service description*. Available online from: <http://www.forthports.co.uk/ports/marine> [accessed 23 Feb 2011].
- LORAN-C, 2011. *European LORAN-C network description*. Available online from: <http://www.loran-europe.eu/news.php> [accessed 23 Feb 2011].
- Mainstream (Mainstream Renewable Power), 2009. *Neart na Gaoithe Proposed Offshore Wind Farm, Scoping Report* November 2009, 09/J/1/06/1419/0848.
- Maisey, R., 2010. *Response to scoping opinion request for Neart na Gaoithe wind farm*, DE/C/SUT/43/10/1/7840, 29 January 2010.
- Marico Marine, 2007. *Investigation of Technical and Operational Effects on Marine Radar Close to Kentish Flats Offshore Wind Farm*.
- MB21, 2011. *MB21 transmission gallery*. Available online from: <http://tx.mb21.co.uk/mapsys/fm/bbcnationalfm.php?mapid=16> [accessed 24 Feb 2011].
- MCA (Maritime and Coastguard Agency), 2005. *Offshore wind farm helicopter search and rescue trials undertaken at North Hoyle wind farm* MSA 10/6/239.
- MCA, Robert.Townsend@mcga.gov.uk, 2011, *RE: Request for parameters for Neart na Gaoithe offshore Windfarm* [email] Message sent to Savage, V. (vsavage@qinetiq.com). Sent 12 May 2011.
- Met Office, 2011. *National Meteorological Library and Archive, Fact Sheet 15 – Weather Radar*. Available online from: <http://www.metoffice.gov.uk/weather/uk/radar/tech.html> [accessed 23 Feb 2011].
- MOD (Ministry of Defence), 2005a. *The Effects of Wind Turbine Farms on ATC Radar*, Air Warfare Centre, AWC/WAD/72/665/TRIALS, 10 May 2005.
- MOD, 2005b. *The Effects of Wind Turbine Farms on AD radars*, Air Warfare Centre, AWC/WAD/72/652/TRIALS, 6 January 2005.
- MOD, 2010a. *Mine-laying and mine countermeasures exercises – waters around the British Isles*. Available online from: <http://www.ukho.gov.uk/ProductsandServices/MartimeSafety/AnnualNm/10.pdf> [accessed 22 Jan 2011].
- MOD, 2010b. *Defence Estates, MoD policy on Air Traffic Control infill patch mitigation solutions, Safeguarding/Egmts/Policy/20101104*, 4 November 2010.
- MOD, 2010c. David.Jones2@de.mod.uk, *RE: Firth of Forth Minutes*. [email]. Message to Duncan, A. (alison.duncan@emulimited.com). Sent 10 December 2010.
- MOD, 2011a. *Meteorological station safeguarding zones*, map reference DE080013, version 001, production date 23rd December 2009. [online] Available online from: <https://restats.decc.gov.uk/cms/aviation-safeguarding-maps> [accessed 18 Jan 2011].
- MOD, 2011b. *Low-flying areas map*, map reference DE090071, version 006, 15 December 2010. Available online from: <https://restats.decc.gov.uk/cms/aviation-safeguarding-maps> [accessed 18 Jan 2011].
- MOD, 2011c. *Safeguarding response DE reference 7840*, NEART NA GAOITHE OFFSHORE ROUND 3, DE/C/SUT/43/10/1/7840, 18 December 2011.
- MOD, DIOOpsNorth-LMS7a1b1@mod.uk, 2011d. 20111206 *RE: 20111101- RE: Amendment to DE/C/SUT/43/10/1/7840 (Neart Na Gaoithe)-U*, [email] Message to Savage, V. (vsavage@qinetiq.com), 6 December 2011
- NATS (National Air Traffic Service), 2011. *Radar impact self-assessment maps*. [online] Available online from: <http://www.nats.co.uk/environment/windfarms/nerl-self-assessment-maps> [accessed 18 Jan 2011].
- Ofcom, 2001. *Mobile phone base stations – how mobile phone networks work*. Available online from: <http://www.ofcom.org.uk/static/archive/ra/topics/mpsafety/school-audit/mobilework.htm> [accessed 24 Feb 2011].
- Ofcom, 2011a. *Sitfinder mobile phone base station database*. Available online from: <http://www.sitfinder.ofcom.org.uk> [accessed 24 Feb 2011].
- Ofcom, 2011b. *64-66GHz, 71-76GHz and 81-86GHz fixed link self-coordination databases*. Available online from: <http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/fixed> [accessed 30 September 2011].
- Trinity House, 2011. *List of United Kingdom DGPS transmitters*. Available online from: http://www.trinityhouse.co.uk/aids_to_navigation/the_task/satellite_navigation.html# [accessed 24 Feb 2011].
- QinetiQ and MCA, 2004. *Results of the electromagnetic investigations and assessments of marine radar, communications and positioning systems undertaken at the North Hoyle wind farm by QinetiQ and the Maritime and Coastguard Agency*, MCA MNA 53/10/366.].
- UKHO (United Kingdom Hydrographic Office), 2002. *Admiralty chart, Firth of Forth – Isle of May to Inchkeith*, edition 3, July 2000.
- UKHO, 2004. *Admiralty charts and publications, admiralty notices to mariners*, section 2, weekly edition 12, 18 March 2004.

Appendices

Appendix 18.1: Military and Aviation Technical Report

Appendix 18.2: Aviation Lighting and Marking Requirements