MORAY EAST
OFFSHORE WINDFARM

Television and Radio Reception Mitigation Plan

Telford, Stevenson and MacColl Offshore Wind Farms and Associated Offshore Transmission Infrastructure

July 2018

Moray Offshore Windfarm (East) Limited

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Review / Approval

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List of Abbreviations

CIR	Carrier to Interference Ratio
COM	Commercial Multiplexes
DAB	Digital Audio Broadcast
dB	Decibel
DSLP	Development Specification and Layout Plan
FM	Frequency Modulated
FPSL	Free Path Space Loss
ITU	International Telecommunications Union
KHz	Kilo-Hertz
MHz	Mega Hertz
nm	Nautical Mile
OfTI	Offshore Transmission Infrastructure
OSP	Offshore Substation Platform
PSB	Public Service Broadcast
RCS	Radar Cross Section
TEC	Transmission Entry Capacity
TRRMP	Television and Radio Reception Mitigation Plan
WTG	Wind Turbine Generator
UHF	Ultra-High Frequency

Definitions

The following definitions have been used throughout this document with respect to the company, the consented wind farms and how these definitions have changed since submission of the Moray East Environmental Statement (ES) in 2012 and the Moray East Modified Transmission Infrastructure ES in 2014.

- **Moray Offshore Windfarm (East) Limited (formerly known as Moray Offshore Renewables Limited)** – the legal entity submitting this Television and Radio Reception Mitigation Plan (TRRMP);
- **Moray East Offshore Wind Farm** - the wind farm to be developed in the Moray East site (also referred as the Wind Farm);
- **The Moray East site** - the area in which the Moray East Offshore Wind Farm will be located. Section 36 Consents and associated Marine Licences to develop and operate up to three generating stations on the Moray East site were granted in March 2014. At that time the Moray East site was known as the "Eastern Development Area (EDA)" and was made up of three sites known as the Telford, Stevenson and MacColl offshore wind farm sites; The Section 36 Consents and Marine Licences were subsequently varied in March 2018;
- **Telford, Stevenson and MacColl wind farms** – these names refer to the three consented offshore wind farm sites located within the Moray East site;
- **Transmission Infrastructure (TI)** - includes both offshore and onshore electricity transmission infrastructure for the consented Telford, Stevenson and MacColl wind farms. Includes connection to the national electricity transmission system near New Deer in Aberdeenshire encompassing AC offshore substation platforms (OSPs), AC OSP interconnector cables, AC export cables offshore to landfall point at Inverboyndie continuing onshore to the AC collector station (onshore substation) and the additional regional Transmission Operator substation near New Deer. A Marine Licence for the offshore TI was granted in September 2014 and a further Marine Licence for two additional distributed offshore substation platforms (OSPs) was granted in September 2017.The onshore TI was awarded Planning Permission in Principle in September 2014 by Aberdeenshire Council and a Planning Permission in Principle under Section 42 in June 2015;
- **Offshore Transmission Infrastructure (OfTI)** – the offshore elements of the transmission infrastructure, comprising AC OSPs, OSP inter-connector cables and AC export cables offshore to landfall (for the avoidance of doubts some elements of the OfTI will be installed in the Moray East site);
- **Moray East ES 2012** – The ES for the Telford, Stevenson and MacColl wind farms and Associated Transmission Infrastructure, submitted August 2012;
- **Moray East Modified TI ES 2014** – the ES for the TI works in respect to the Telford, Stevenson and MacColl wind farms, submitted June 2014;
- **The Development** – the Moray East Offshore Wind Farm and Offshore Transmission Infrastructure (OfTI);
- **Design Envelope** - the range of design parameters used to inform the assessment of impacts;
- **OfTI Corridor** – the export cable route corridor, i.e. the OfTI area as assessed in the Moray East Modified TI ES 2014 excluding the Moray East site.
- **Moray East Offshore Wind Farm Consents** – are comprised of the following:

Section 36 Consents:

- Section 36 consent for the Telford Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the Telford Offshore Wind Farm assigned to Moray East on 19 June 2018.
- Section 36 consent for the Stevenson Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the Stevenson Offshore Wind Farm assigned to Moray East on 19 June 2018.
- Section 36 consent for the MacColl Offshore Wind Farm (as varied) – consent under section 36 of the Electricity Act 1989 for the construction and operation of the MacColl Offshore Wind Farm assigned to Moray East on 19 June 2018.

Marine Licences

- Marine Licence for the Telford Offshore Wind Farm (as varied) – Licence Number: 04629/18/1 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on the 19 July 2018.
- Marine Licence for the Stevenson Offshore Wind Farm (as varied) – Licence Number: 04627/18/1 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on the 19 July 2018.
- Marine Licence for the MacColl Offshore Wind Farm (as varied) – Licence Number: 04628/18/2 (as varied) - consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area transferred to Moray East on the 19 July 2018.

- **OfTI Licences** – are comprised of the following:
  - Marine Licence for the Offshore Transmission infrastructure – Licence Number 05340/14/0 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction works and deposits of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the "OfTI Marine Licence")
  - Marine Licence for two additional distributed OSPs – Licence Number 06347/17/1 – consent under the Marine (Scotland) Act 2010 & Marine and Coastal Access Act 2009, Part 4 marine licensing for marine renewables construction, operation and maintenance works and the deposit of substances or objects in the Scottish Marine Area and the United Kingdom Marine Licensing Area (referred to as the "OSP Marine Licence")

Executive Summary

The presence of Wind Turbine Generators (WTGs) in the Moray East site has the potential to result in transmission loss if placed in the direct-line of sight between transmitters and receivers. In line with the requirements of Condition 23 of the Section 36 Consents (Television and Radio Reception Mitigation Plan), Moray East has commissioned a television and radio reception desk-based study and baseline study to investigate the potential for interference to television and radio reception within the Moray Firth area as a result of constructing the Moray East Offshore Wind Farm.

Results of the desk-based assessment determined that two transmitters, Knockmore and Rumster Forrest, were within the assessment area, however there was limited or no potential for properties receiving signals from the Knockmore transmitter to experience transmission loss as a result of the Wind Farm. It was identified that there is potential for properties or dwellings which receive television from the Rumster Forrest transmitter to experience transmission loss in an area along the coast, to the east of Gardenstown. Whilst the results of survey determined some transmission loss may be experienced, topography and environmental conditions may also affect transmission to varying degrees depending on the location of the receptor. The magnitude of transmission loss as a result of the Wind Farm would vary from location to location and where any claims of transmission loss are reported, an investigation will be undertaken to identify the cause of loss and identify appropriate mitigation solutions where necessary.

1 Introduction

1.1 Background

In March 2014, Moray Offshore Windfarm (East) Limited (known as Moray East) received consents from the Scottish Ministers under Section 36 of the Electricity Act 1989 for the construction and operation of the Moray East Offshore Wind Farm. The associated Marine Licences were granted in September 2014. The Section 36 Consents and associated Marine Licences are referred to together as the Moray East Offshore Wind Farm Consents. The provision of the Television and Radar Reception Mitigation Plan (TRRMP) is a requirement of the Section 36 Consents. At that time the Moray East site was known as the "Eastern Development Area" and was made up of three sites known as Telford, Stevenson and MacColl offshore wind farm sites. The Moray East Offshore Wind Farm Consents were varied in March 2018 and this TRRMP is based on information presented in the Design Layout Specification Plan (DSLP), which was submitted in accordance with these consents.

Moray East is a joint venture partnership between EDP Renewables, Engie, and Diamond Generating and has been established to develop, finance, construct, operate, maintain and decommission the Moray East Offshore Wind Farm. The associated offshore and onshore Transmission Infrastructure will be transferred to the Offshore Transmission Owner (OFTO) within 18 months of the commissioning of the Development.

1.2 Objectives of the Document

A requirement of the Section 36 Consents is the approval of a TRMMP which identifies the potential for impacts to receptors and outlines a process for mitigation. This TRRMP considers the potential for impacts as a result of wind turbine generators (WTGs) within the Moray East Offshore Wind Farm.

The relevant condition setting out the requirement for the TRRMP approval is set out in full in Table 1-1.

This document has been prepared in compliance with Condition 23 of the Section 36 Consents by providing results of modelling and baseline survey of television and radar reception undertaken to identify potential impacts to receptors and outlining a mitigation plan to investigate and address claims of impacts to received Television or radio signals.

Table 1-1: Consent conditions to be discharged by this TRRMP

Consent Document	Condition Reference	Condition Text	Reference in this TRRMP
Section 36 Consents	23	The Company must, no later than 6 months prior to the Commencement of the Development, submit a Television and Radio Reception Mitigation Plan ("TRRMP"), in writing, to the Scottish Ministers for their written approval.	This document sets out the TRRMP for approval by Scottish Ministers
		Such approval may only be granted following consultation by the Scottish Ministers with the Highland Council.	Consultation will be undertaken with Scottish Ministers and Highland Council.
		The TRRMP must provide for a baseline television reception survey to be carried out at a location(s) to be agreed by the Scottish Ministers in consultation with the Highland Council, paid for by the Company, prior to the commencement of any WTG installation. The results of which must be submitted by the Company, in writing, to	A baseline survey has been undertaken, survey methodology and results are reported in Appendix A.

Consent Document	Condition Reference	Condition Text	Reference in this TRRMP
		the Highland Council within the time limit set in the TRRMP.	
		From Commencement of the Development until the date occurring 12 months after the Final Commissioning of the Development, any reasonable claim by any individual person regarding television picture loss or interference at their house, business premises or other building, which they claim is attributable to the Development, and which is notified to the Company, must be investigated by a qualified engineer approved by the Scottish Ministers in consultation with the Highland Council. The Company is liable for any costs incurred by any such investigation.	Protocols for investigating claims and mitigation are outlined in Section 4 of this report.
		The results of any investigation must be submitted by the Company to the Scottish Ministers and the Highland Council within 2 months of completion of the investigation. Any impairment to the television signal shall be remedied by the Company, at its own expense, as soon as practicable to provide that the standard of reception at any affected property is equivalent to the baseline television and radio reception as existing at that property before the operation of the Development.	Protocols for investigating claims and mitigation are outlined in Section 4 of this report.

1.3 TRRMP Document Structure

After the introduction, references and context sections, the TRRMP will contain the follow structure outlined in Table 2.1 below;

Table 1-2: Document Structure

Document Structure Overview		
Section	**Section Title**	**Details**
2	Project Description	Project Description
3	Methodology	Overview of methodology and conclusions undertaken, consisting of for two stage assessment.; Stage 1- Interference modelling; Stage 2- Baseline survey and assessment.
4	Television and Radar Reception Mitigation Plan	Procedures to be put in place to mitigate potential effects.
Appendix	A	Pager Power Technical Report providing detailed methodology, analysis and conclusions for the assessment of interference.

1.4 Linkages with Other Consent Plans

The TRRMP is one of a number of documents produced by Moray East to meet the requirement of the Section 36 Consents. Although a stand-alone document, it is linked to the Moray East DSLP, which sets out the final WTG layout of the Moray East site and has been used as the basis for the interference modelling, baseline survey and impact assessment used to inform the TRRMP.

2 Project Description

The Moray East site is located on the Smith Bank in the outer Moray Firth. It is located 12 nautical miles (nm) (approximately 22km) from the Caithness Coast, covers an area of 281 nm^2 or 520 km^2, and ranges from 37m - 57m in water depth.

Moray East's intention is to develop and construct the Moray East site as a single offshore wind farm (the Moray East Offshore Wind Farm) with a transmission entry capacity (TEC) of 900 MW and capacity of 950 MW. The Moray East site and OfTI location is shown in Figure 2-1.

Full details of the Development are provided within the DSLP (Moray East 2018). The Moray East site will consist of the construction of 100 wind turbine generators (WTGs), which will be installed on three legged jackets. The DSLP also identifies nine 'spare' WTG locations which will only be utilised if ground conditions are encountered during the foundation installation operations at one or more of the WTG locations that cannot be overcome by micro-siting.

The WTGs are arranged in a regular geometric pattern that permits navigation between rows of WTGs in any direction. The WTGs are spaced at a distance of 1,128 m apart in the north to south axis and at a distance of 1,547 m apart in the east to west axis. There are four turbine locations where the distance to the next turbine differ from standard separation distances. The separation distance for the four turbines will be between 1,120 m and 2,722.85 m. Micro-siting may also need to be undertaken prior to construction. The WTG locations as presented in the DSLP are provided in Figure 2-2.

The modelling undertaken for the TRRMP was based on WTGs being present in all 109 turbine locations in the Moray East layout (as presented in the approved DSLP dated August 2018) in order to cover all potential interference scenarios of this layout. In the event of a material change in layout the assumptions used in this assessment will be revisited and the TRRMP will be revised if required.

It should be noted that since the interference assessment and baseline survey was undertaken for this TRRMP, three additional spare WTG locations have been included within the Moray East site layout (as presented in the Safety Zone Application dated August 2018[1]). It is noted these three additional spare locations have not been considered in the DSLP as approved. It is confirmed that these three locations have been considered and it is concluded that they do not affect the conclusions of this TRRMP. Other project documentation including the DSLP will be updated to reflect these additional locations if required.

[1] **available on the Marine Scotland website: http://marine.gov.scot/sites/default/files/moray_east_safety_zone_application_sep2018_redacted.pdf**

Figure 2-1: Geographical Location of the Development (Moray East site and OfTI Corridor)

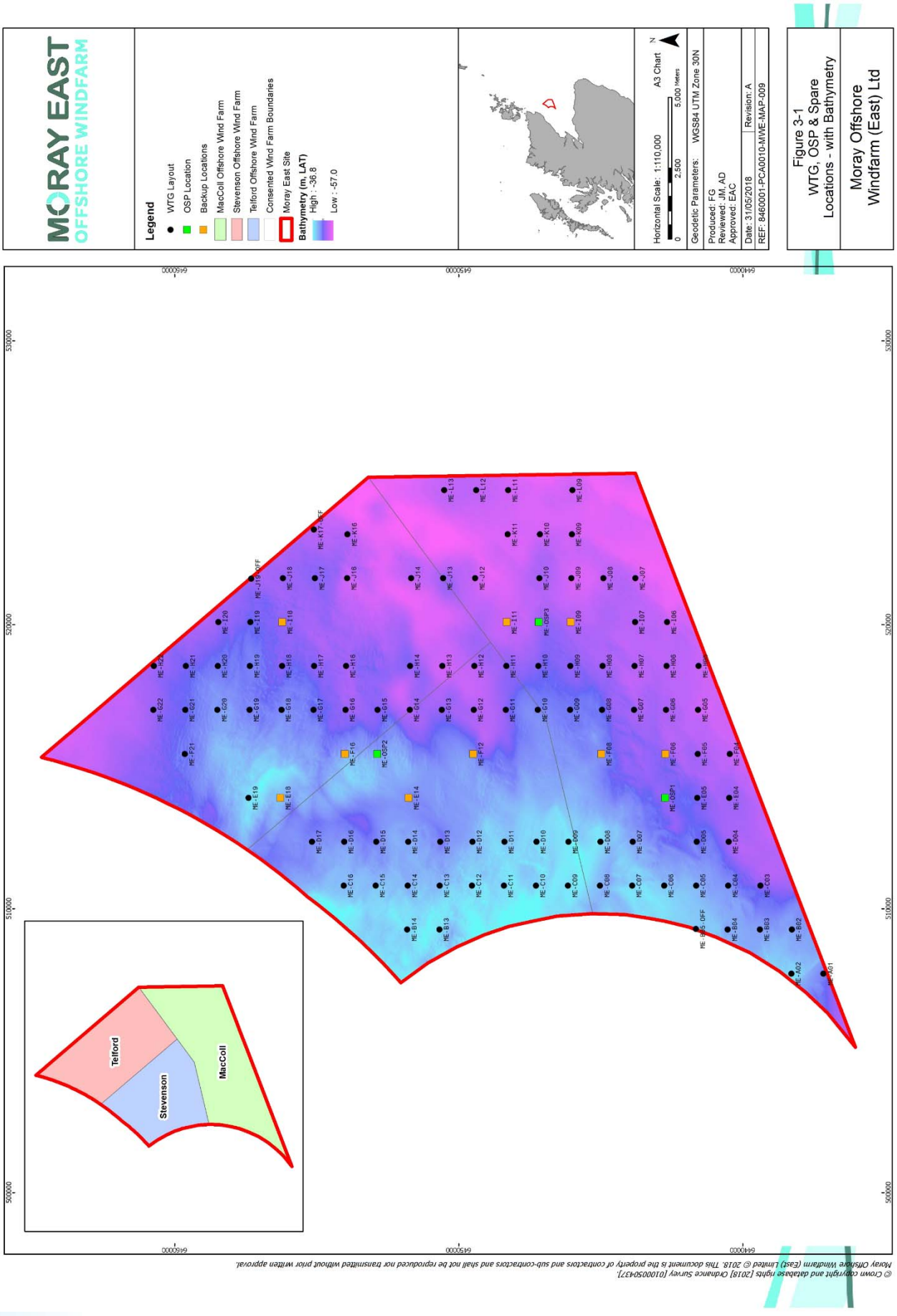

Figure 2-2 Wind Farm WTG, OSP and spare locations with site bathymetry [extracted from the Moray East DSLP (Moray East 2018].

3 Methodology

3.1 Overview

A desk-based television and radio impact assessment has been undertaken to determine the potential for interference upon broadcast signals across the Moray Firth.

The assessment of interference was undertaken following stages;

1. Stage 1 Interference Analysis informed by modelling was undertaken to identify which transmitters may be potentially affected.
2. Stage 2- Baseline survey undertaken to verify the results of desk-based modelling. Locations sampled within the baseline survey were determined by Stage 1.

A Technical Report outlining full methodologies and results for the interference assessment and baseline survey is provided in Appendix A of this TRRMP and summarised below.

3.2 Stage 1- Interference Analysis

The first stage of the desk-based assessment was to undertake modelling of potential interference effects that may arise as a result of the presence of WTGs within the Moray East Offshore Wind Farm. Modelling results were then analysed to determine whether television transmission signals maybe effected.

3.2.1 Parameters used in modelling

The following section provides a summary of parameters used to model interference effects for the Moray East Offshore Wind Farm.

3.2.1.1 Broadcast Coverage and the Assessed Area

Radio signals are more resilient to WTG interference than television signals, therefore only modelling for television interference has been completed as this represents the most conservative receptor. Interference mechanisms and mitigation requirements for both radio and television signals are similar and therefore radio baseline reception has been considered as part of the baseline survey.

Terrestrial television signals propagate from transmitters to receiving aerials which in turn are connected to television receiving equipment. Terrestrial television coverage on the land surrounding the Moray East Wind Farm is likely to be significantly influenced by local terrain, with a variety of different transmitters serving the area. Services from Knockmore and Rumster Forest transmitters were identified as being most likely to be affected, therefore the assessment has focused on theses transmitters. Each of these transmitter broadcasts digital services. The Rosemarkie transmitter does not provide coverage of areas that where there is a potential for impacts and it was determined there was no perceived pathway for potential impacts (Section 3, Appendix A).

When considering interference from wind farm developments it is usual to consider direct signals – those that pass from transmitter to receiver in a straight line and reflected, or indirect, signals. The reflected signal goes from the transmitter to a turbine and then on to the receiver.

Standard receiving aerials are directional meaning that signals from the direction of the transmitter are amplified and signals from other angles are attenuated.

3.2.1.2 Carrier to Interference Ratio

The likelihood of television interference is determined by considering the strength of the direct, or carrier, signal in comparison to the reflected, or interfering, signal. The Carrier to Interference Ratio (CIR) quantifies the relative strength of the direct and reflected signals.

A high CIR means interference is less likely. A low CIR means that interference is more likely. The CIR is normally expressed in decibels (dB).

3.2.1.3 Free Space Path Loss

Television and radio signals weaken over distance. The closer a receiver is to a transmitter the stronger its received signal will be. This reduction in signal strength due to separation distance is referred to as Free Space Path Loss (FSPL).

3.2.1.4 Electromagnetic Propagation by Diffraction

An electromagnetic signal may travel between two points, even when no direct line of sight exists between those two points. This is because transmission travels as a series of waves rather than as a direct ray. When no direct line of sight exists between the two points the signal is considerably weakened. This weakening is known as a diffraction loss.

International Telecommunications Union (ITU) Recommendation ITU-R P526-14 describes a method for calculating diffraction losses over regular terrain.

Total path loss for a specific path is determined by adding Free Space Path Loss to Diffraction Loss.

3.2.1.5 Radar Cross Section

The size of the interfering signal is dependent on the amount of energy that is reflected from a wind turbine. This reflective quality is known as the Radar Cross Section (RCS) and can be expressed in metres squared or in dBm^2.

A significant amount of work has been carried out to help determine wind turbine RCS by various parties although little work has been carried out at UHF frequencies. Values cited typically vary between 25 and 300 m^2 with instantaneous peaks reaching 3000 m^2 for a single wind turbine.

The moving and static parts of the turbine are often considered separately.

3.2.2 Modelling Approach

This section provides an overview of the modelling methods used by Pager Power to identify areas where television (and radio) reception may be reduced by the presence of WTGs within the Moray East Offshore Wind Farm. Full details of the methods used to model interference are provided in Annex 1, of Appendix A and summarised below.

Pager Power uses a compound methodology, informed through literature review and approved methodologies, including factors such as:

- Triplicate calculations accounting for tip, hub and rotor bottom;
- Accounting for actual field strength;
- Calculating interference in accordance with the Dabis method; and
- Calculating interference in accordance with the ITU method.

Following assessment by these various methods the following conclusions have been drawn:

- Although wind turbine interference appears more likely when the received signal is weak there is no direct relationship between direct signal strength and observed picture and audio interference;
- Observed picture interference is directly related to the CI Ratio;
- Analysis of the ITU-R BT805 method demonstrates this method to be significantly more accurate than the Dabis method for assessing observed interference as it is based on empirical data collected from existing wind farms;
- Summing of unwanted signals from each turbine to determine a total unwanted signal level appears to be reasonably accurate;

- The CIR threshold of 10dB cited by RES appears to be reasonable – it is certainly true that the threshold of 28-34 cited by BT805 is too high when using this method. Observations on a 32 wind turbine developments suggest that a threshold of 15 dB may be more reasonable in this case;
- Pager Power's basis for concluding that the threshold in BT805 is too high comes from experience of existing wind developments where interference effects have been modelled and recorded;
- Carrying out an assessment based on the hub height appears to be fairly representative – however there can be significant variation in CIR over the blade span. In an example with no direct line of sight between transmitter and receiver the CIR varies by 31 dB between the top and bottom of the rotor. This is a large variation and should be considered or accounted for.

It was concluded therefore that triplicate calculations at tip, hub and rotor base should be considered. The principals of this calculation are as follows:

- The interference signal calculation should be carried out three times for each turbine – at tip, hub and rotor base;
- A weighted average of the three unwanted interference signal levels should be made (of absolute levels not decibel levels);
- A signal passing through the WTG at hub height will be more greatly affected due to the increased frequency at which the signal will be intercepted compared to a signal passing through the tip or rotor base so an increased weighting should be applied to the hub signal;
- The weighting applied to rotor tip and rotor base should be identical as the proportion of the signal passing through the rotor is identical at both heights;
- A geometric calculation suggested that following weightings be used for averaging, these were then appropriately rounded (see Table 3-1) for use in further calculations

Table 3-1: Weightings calculations

Turbine Part	Weighting (%)	Rounded values used for calculation
Tip	19.55	20
Hub	60.9	60
Rotor Bottom	19.55	20

3.2.3 Interference Analysis

The quality of the image and sound on a television set is dependent on both the strength of the signal received directly from the transmitter (Carrier signal) and the strength of Interference signals from other sources. Pager Power's methods to analyse interference are based on evaluation of the CIR. Whilst this parameter is related to analogue services, the interference mechanisms for digital transmissions are similar to those for analogue transmissions.

Results from the modelling were used to inform a desk-based assessment which identified areas where affects caused by WTGs may be received. Methods used to undertake the analysis of interference are provided in Section 4 of Appendix A. Results of the assessment are provided in Section 5 and Section 6 of Appendix A. A summary is provided below.

Pager Power's modelling identified two assessment zones where signals for the Knockmore transmitter are received, and three assessment zones where signals from Rumster Forrest are received (See Section 4 of Appendix A). Beyond these areas, modelling determined that there would be no likely effect on television signals. Further analysis of these areas was undertaken to determine the likelihood of effects

on television signals within these areas. The results of the interference analysis are provided in Section 5 of Appendix A.

3.2.4 Summary of results

Full results are provided in Section 6 of Appendix A. Based on the results of the desk-based analysis, there is the potential for television signals to be affected in some locations by the presence of the Moray East Offshore Wind Farm for dwellings receiving a signal from the Rumster Forest transmitter in the assessed area only. No significant interference to Knockmore transmissions is expected.

Any dwellings receiving television signals via satellite or cable are not expected to be affected by the presence of the Moray East Offshore Wind Farm. Radio signals are unlikely to be affected.

3.3 Stage 2 -Baseline Survey

3.3.1 Overview

The results of the modelling and analysis undertaken is Stage 1) was used to inform a baseline survey.

A site survey was undertaken on 13 June 2018. The weather on the day was variable which may have resulted in subtle variations in signal strength. Detailed methodology and results are reported in Appendix A, Section 7 and Annexes B and C. The baseline survey serves three purposes, these are:

- To confirm which transmitter is serving most homes in the areas surveyed (television only);
- To provide an indication of the likelihood of interference. If current signals are of good quality, minor degradation is less likely to have a noticeable effect;
- To allow a 'before and after' comparison to be made in the event that a complaint is received.

As modelling had demonstrated that there would be no significant interference to signals from the Knockmore transmitter and that only areas of the southern Moray Firth coastline would have the potential to be affected, the baseline survey sampled nine locations along this section of coastline. Survey locations are shown in Section 7.2 and Annex B of Appendix A.

3.3.2 Summary of results

It was identified that there is potential for properties or dwellings which receive television from the Rumster Forrest transmitter to experience transmission loss in an area along the coast, to the east of Gardenstown. Whilst the results of survey determined some transmission loss maybe experienced, topography and existing environmental conditions may also affect transmission to varying degrees depending on the location of the receptor. The magnitude of transmission loss as a result of the Moray East Offshore Wind Farm would vary from location and where claims of transmission loss are reported, an investigation would need to be undertaken to identify the cause of loss and identify appropriate mitigation solutions where necessary. Please refer to section 4.3 for further information on mitigation options.

Full results from the baseline survey are reported in Section 7 of Appendix A.

3.4 Conclusions

The following section provides the conclusions that have been drawn from the results of Stage 1 (the assessment of interference) and Stage 2 (the baseline survey) as reported in Appendix A.

3.4.1 Television Reception

A comprehensive search of transmitter and coverage maps revealed that the Knockmore, Rosemarkie and Rumster Forest are the main transmitters which provide terrestrial coverage in the areas surrounding the Moray East Offshore Wind Farm. The Rosemarkie transmitter does not provide signal coverage to areas where there is a potential for impacts and was not considered further in detailed analysis. The transmissions from Knockmore and Rumster Forest transmitters have been modelled for areas where there is a potential for interference to occur. The assessed areas consist mainly of small villages with surrounding rural land. The overall result of the analysis is shown in the following sub-sections.

3.4.1.1 Rosemarkie Transmitter

- The forward scatter region lies out to sea with respect to the transmitter;
- A review of coverage has shown that the transmitter does not have coverage in areas where interference would be expected;
- Overall, no impacts upon Rosemarkie's transmissions are expected.

3.4.1.2 Knockmore Transmitter

- The forward scatter region for the transmitter is in the sea, therefore the land nearest to this area has been assessed;
- A review of coverage maps showed that coverage for this transmitter is limited to the coastline, with coverage decreasing further inland;
- Analysis of the modelling results showed that no interference is expected to be caused by the presence of the Wind Farm;
- A review of the available imagery revealed that residents within the assessed area are not expected to use the Knockmore transmitter;
- Overall, no impacts upon Knockmore's transmissions are expected.

3.4.1.3 Rumster Forest Transmitter

- The forward scatter region was assessed for Rumster Forest's transmissions. The forward scatter region lies on the north Aberdeenshire coast line, to the south of the Moray Firth;
- A review of coverage maps showed that coverage for this transmitter is limited to this coastline, with coverage decreasing further inland;
- Analysis of the modelling results showed that moderate or high interference is expected in some areas along the coastline which is likely to be due to the presence of the Wind Farm;
- Available imagery revealed that in some locations, residents have their aerials orientated north or north west towards the Rumster Forest transmitter. This was confirmed during the baseline survey;
- The baseline survey showed that received signals were, on average, moderate at best however residents within the assessed area do use Rumster Forest to provide television services;
- Considering the modelling, their relative locations and the signal strength received, there is a potential interference at a number of locations could occur, these include:

- Gardenstown;
- New Aberdour;
- Rosehearty
- Fraserburgh, and;
- Any individual dwelling receiving a signal from Rumster Forest in an area of predicted interference.

- Overall, based on the desk-based interference charts, it is believed that the presence of the Wind Farm may affect homes in the forward scatter region where a terrestrial television signal from Rumster Forest is received.

A mitigation plan for identifying and resolving potential instances of interference loss caused by the presence of the WTGs is outlined in Section 4.

3.4.2 Radio Reception

The results of the analysis and survey for radio transmissions are as follows:

- Radio services are provided by a range of transmitters in the area. Digital and analogue service were received at all surveyed locations;
- Interference to the signal is most likely in the shadow region, this is expected to be in a similar location to where television interference is predicted. Potential impacts are limited however due to:
  - The variable signal strength of radio transmissions;
  - The robust nature of radio services.
- Overall no noticeable effects are expected for radio services.

4 Television and Radio Reception Mitigation Plan

4.1 Overview

The results of the desk-based and baseline survey identified several locations where there is the potential for a loss of signal transmitted from the Rumster Forest transmitter along the southern coastline of the Moray Firth, to the east of Gardenstown.

A range of mitigation options are available for compensating for loss of signal, and the following section outlines the protocol which will be implemented to determine whether any reported transmission loss is due to the presence of the Moray East WTGs or other factors. Where transmission loss is found to be as a result of the WTGs, a range of potential mitigation options are outlined in Section 4.3 below.

4.2 Protocol for determining claims arising from the operation of the WTGs

Notification for complaints regarding television or radio interference would be limited to a fixed period from the commencement of construction to 12 months after the final commissioning of the Wind Farm. Moray East would investigate claims made, either to the Local Planning Authority or directly to Moray East during this period. If it is found that the interference is attributable to the Moray East Offshore Wind Farm, suitable mitigation will be identified and put in place.

In the first instance, an initial investigation of any reported issues will be undertaken within one month of Moray East receiving the complaint details in writing. Moray East would provide results of the investigation and discuss suitable mitigation options with the claimant (and / or local planning authority if appropriate). Once identified, required mitigation will be implemented within two months of completion of the investigation.

The recommended process for identifying and resolving suspected interference as a result of the Wind Farm can be summarised in the following four steps.

Step 1 Consideration of the location of the reported interference with reference to the transmitters and the Wind Farm. Where the interference has been reported within an area outlined as a potential of interference in the modelling and / or baseline survey, further investigation will be undertaken.

Step 2 Carry out measurements at relevant locations (where complaints have been received). Results of these measurements will be cross checked with the desk-based modelling and the baseline survey reception data. Interference detected will be characterised to determine the source of interference. An investigation of receiving equipment may be undertaken where appropriate.

Step 3 Information gathered will be used to determine whether the interference is attributable to the Wind Farm based on steps 1 and 2. Where it is proven that interference is due to the Wind Farm, potential mitigation options will be investigated. Results of this investigation will be provided to Scottish Ministers within 2 months of the investigation.

Step 4 Once identified and agreed with the claimant (and / or local planning authority), agreed mitigation will be applied, based on step 3. The requirement for the implementation of such measures will be addressed on a case-by-case basis.

Mitigation options are likely to range from a simple re-tuning of signals at a receiver to more bespoke solutions depending on the magnitude of transmission loss and location of the claimant. In the first instance, simple mitigation solutions will be investigated. Where these are found not to be suitable, more bespoke mitigation options will be investigated. A schedule of mitigation options is provided in section 4.3 below.

4.3 Schedule of Mitigation Options

4.3.1 Television

Below is a list of standard actions to mitigate television reception issues caused by wind farm developments. The suitability of these mitigation options will be investigated on a case by case basis. Where possible, mitigation will be agreed with the claimant directly. If necessary, consultation will be undertaken with the local planning authority. The following list represents a hierarchy of mitigation options which will be investigated on a case-by case basis;

1. Repositioning the receiving aerial so that the received signal is strongest;
2. Replacement of receiving aerial with a more directional, or higher gain, aerial;
3. Directing the receiving aerial to an alternative transmitter that covers the area and retuning the television accordingly;
4. Upgrading antenna cabling and connections;
5. Installation of signal amplifiers;
6. Development of a bespoke local solution using a receiving aerial some distance from the dwelling;
7. A combination of the above;
8. Replacing terrestrial reception equipment with satellite or cable reception equipment.

Depending on the magnitude of the issue, actions 1-5 may need to be deployed in combination per residence. Some mitigation options would need to be undertaken across multiple residence or wider area basis depending on whether interference is reported over a wider area. The spatial scale of each option is presented in Table 4-1.

Table 4-1: Television Mitigation options

Actions	Basis
Combination of #1-5 aerial system upgrade	Per residence
#6 bespoke reception system	Per residence / per area
#7 combination of 1-6	Per residence / per area
#8 satellite installation	Per residence

The requirement for the implementation of such measures will be addressed on a case-by-case basis.

4.3.2 Radio

It is not anticipated that the presence of the Wind Farm will result in transmission loss of radio signals. However, if transmission interference is reported Moray East would undertake an investigation as outlined in section 7.2. If mitigation is required, it would be expected to be on a per residence basis. Below is a list of standard actions to mitigate radio reception issues caused by wind farm developments:

1. re-tuning the radio;
2. relocation of the radio;
3. upgrading the aerial or the radio itself;

4. provision of an external aerial for receiving radio services.

The requirement for the implementation of such measures will be addressed on a case-by-case basis.

5 References

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Urban & Renewables

Appendix A

Television and Radio Impact Assessment with Baseline Reception Survey

Moray Offshore Windfarm (East) Ltd

Moray East Offshore Wind Farm- August 2018

ADMINISTRATION PAGE

Job Reference:	9197B+C
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Issue	Date	Detail of Changes
1	June, 2018	Initial issue
2	August, 2018	Minor amendments

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EXECUTIVE SUMMARY

Overview

Moray Offshore Windfarm (East) Limited is developing the Moray East Offshore Wind Farm in the Moray Firth, in the North Sea, northern Scotland. The Moray East Offshore Wind Farm will consist of 100 wind turbine generators (WTG) with a maximum tip height up to 198.9m above the sea level.

A desk-based television and radio impact assessment has been undertaken to determine the potential for interference upon broadcast signals across the Moray Firth. A baseline reception survey has also been completed to support the modelling results.

Terrestrial television signals propagate from transmitters to receiving aerials which, in turn, are connected to television receiving equipment. Transmissions are in the Ultra-high frequency (UHF) range and only digital television services are broadcast. Radio services are broadcast in both analogue and digital.

It is known that WTGs can interfere with television and other radio broadcast systems. Understanding the potential impacts pre-construction is beneficial as it can assist in determining the requirement for mitigation at affected homes if interference is predicted.

A study of transmitter and coverage maps was used to identify the relevant transmitters. This was used to establish the transmitters which may be affected by the proposed Moray East Offshore Wind Farm.

Using specialised software, Pager Power has modelled the effects of the proposed WTGs on the quality of television reception in selected areas on land around the Wind Farm from the identified transmitters.

Television Results

A comprehensive search of transmitter and coverage maps revealed that Knockmore, Rosemarkie and Rumster Forest are the main transmitters which provide coverage in the areas surrounding the proposed Wind Farm. The transmissions from these transmitters have been modelled where interference could occur. The assessed areas consist mainly of small villages with surrounding rural land. The overall result of the analysis is shown in the following sub-sections.

Knockmore Transmitter

- The forward scatter region for the transmitter is in the sea, therefore the land nearest to this area has been assessed;
- A review of coverage maps showed that coverage for this transmitter is limited to the coastline, with coverage decreasing further inland;
- Analysis of the modelling results showed that no interference is expected to be caused by the presence of the Wind Farm;
- A review of the available imagery revealed that residents within the assessed area are not expected to use the Knockmore transmitter;
- Overall, no impacts upon Knockmore's transmissions are expected.

Rosemarkie Transmitter

- The forward scatter region lies out to sea with respect to the transmitter;
- A review of coverage has shown that the transmitter does not have coverage in areas where interference would be expected;
- Overall, no impacts upon Rosemarkie's transmissions are expected.

Rumster Forest Transmitter

- The forward scatter region was assessed for Rumster Forest's transmissions. The forward scatter region lies on the north Aberdeenshire coast line, to the south of the Moray Firth;
- A review of coverage maps showed that coverage for this transmitter is limited to this coastline, with coverage decreasing further inland;
- Analysis of the modelling results showed that moderate or high interference is expected in some areas along the coastline which is likely to be due to the presence of the Wind Farm;
- Available imagery revealed that in some locations, residents have their aerials orientated north or north west towards the Rumster Forest transmitter. This was confirmed during the baseline survey;
- The baseline survey showed that received signals were, on average, moderate at best however residents within the assessed area do use Rumster Forest to provide television services;
- Considering the modelling, their relative locations and the signal strength received, it is possible that interference at a number of locations could occur, these include:
    - Gardenstown;

- New Aberdour;
- Rosehearty
- Fraserburgh, and;
- Any individual dwelling receiving a signal from Rumster Forest in an area of predicted interference.

- Overall, based on the desk-based interference charts, it is believed that the presence of the Wind Farm may affect homes in the forward scatter region where a terrestrial television signal from Rumster Forest is received.

Radio Results

The results of the analysis and survey for radio transmissions are as follows;

- Radio services are provided by a range of transmitters in the area. Digital and analogue service were received at all surveyed locations;
- Interference to the signal is most likely in the shadow region, this is expected to be in a similar location to where television interference is predicted. Potential impacts are limited however due to:
  - The variable signal strength of radio transmissions;
  - The robust nature of radio services.
- Overall no noticeable effects are expected for radio services.

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1 Introduction

1.1 Overview

Moray Offshore Windfarm (East) Limited (Moray East) is proposing the development of the Moray East Offshore Wind Farm in the Moray Firth, in the North Sea, northern Scotland. The Moray East Offshore Wind Farm will consist of 100 WTGs. A desk-based television and radio impact assessment has been undertaken to determine the potential for interference upon broadcast signals across the Moray Firth. A baseline reception survey has also been completed to support the modelling results.

Terrestrial television signals propagate from transmitters to receiving aerials which, in turn, are connected to television receiving equipment. Transmissions are in the Ultra-high frequency (UHF) range and, only digital television services are broadcast. Radio services are broadcast in both analogue and digital.

WTGs can interfere with television and other radio broadcast systems. Understanding the potential impacts pre-construction is beneficial as it can assist in determining the requirement for mitigation at affected homes if interference is shown to be predicted.

A study of transmitter and coverage maps was used to identify the relevant transmitters. This was used to establish the transmitters which may be affected by the proposed Moray East Offshore Wind Farm.

Using specialised software, Pager Power has modelled the effects of the proposed WTGs on the quality of television reception in selected areas on land around the offshore Development from the identified transmitters.

Pager Power undertook a two-stage assessment approach. The first stage consisted of interference analysis (Section 4-6) using results of interference modelling. The second stage consisted of a baseline survey (Section 7) of areas identified in Stage 1.

Conclusions have then been made based on modelling and survey results.

1.2 Co-ordinates

Unless otherwise stated all coordinates used within this report are in British National Grid (OSGB36 datum) or WGS84 format. Co-ordinates used for the assessment are consistent with those outlined within the Moray East Development Specification and Layout Plan (DSLP).

2 Assessment Details

2.1 Overview

The following section presents the WTG assessment details for the proposed Wind Farm.

2.2 Proposed WTG Dimensions

A WTG with a rotor diameter of 164 m, a hub height of 116.9 m and an overall tip height of 198.9 m has been assessed. This is the largest WTG proposed and therefore is a worst-case assessment.

2.3 Proposed WTG Co-Ordinates

The Moray East Offshore Wind Farm will consist of 100 WTGs. The DSLP also included provision of nine additional WTG locations which may be used if ground conditions at primary turbine sites are found to be unsuitable. WTG coordinates used for informing this report are reported in Section 3.3 of the DSLP.

2.4 Wind Farm General Location

The proposed Wind Farm general location is shown in Figure 1 below.

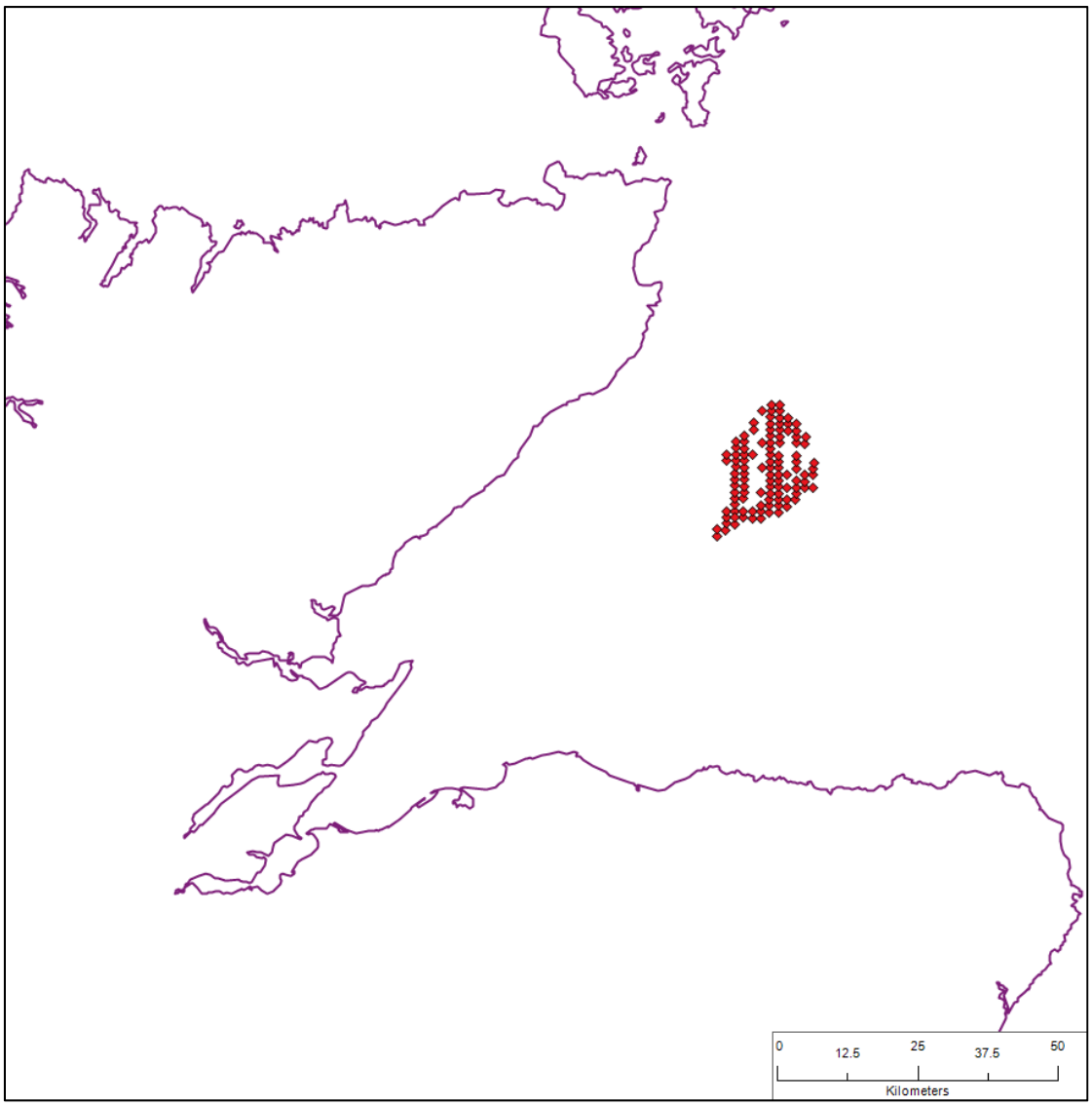

Figure 1 Proposed WTG locations (including spare locations)

2.5 Wind Farm Layout Map

Figure 2 below shows the location and layout of the proposed Wind Farm.

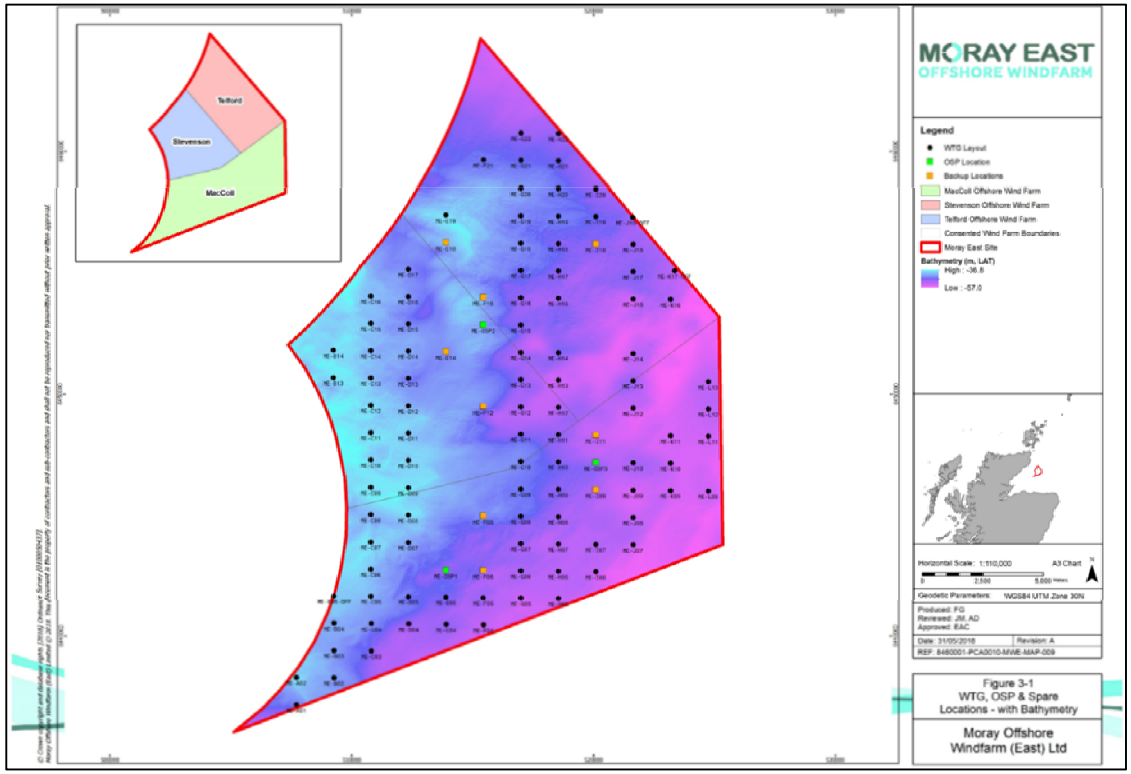

Figure 2 Wind Farm WTG, OSP and spare locations with site bathymetry (extracted from the Moray East DSLP (Moray East 2018)).

3 Transmitter Details

3.1 Overview

A comprehensive search of transmitter and coverage maps was undertaken to determine the relevant transmitters in the area. The following section presents the relevant information.

3.2 Television Transmitters

The results revealed that the Knockmore and Rumster Forest main transmitters are most likely to be affected by the proposed Development due to the transmitters having coverage over the proposed Wind Farm and on the coastline behind the Wind Farm with respect to the transmitter. It was determined that the Rosemarkie transmitter does not provide coverage to areas with the potential to receive interference from the Moray East Offshore Windfarm.

The digital switchover has been completed all over the UK and therefore only digital services are broadcast. The relevant transmitter information is presented in the sub-sections below.

3.3 Knockmore Transmitter

The Knockmore transmitter is one of the main transmitters within the STV[2] North transmitter network in northern Scotland. It is located approximately 70 km south west of the proposed Wind Farm. The published British National Grid co-ordinates for its location are NJ32134970. The published digital services[3] provided are shown below.

	Public (PSB)			Commercial (COM)		
Service	BBC A	Digital 3&4	BBC B	SDN	Arqiva A	Arqiva B
Channel	26	23	29	53	57	60-
Power	20kW	20kW	20kW	10kW	10kW	10kW
Average Frequency	634 MHz					
Power	20kW			10kW		

Table 3-1 Knockmore Public Service Broadcaster (PSB) and Commercial multiplexes (COM)

[2] **Scottish Television.**
[3] **Source: Ofcom, UK digital television transmitter details – DSO multiplexes. Last accessed 21/08/2018.**

3.4 Rosemarkie Transmitter

The Rosemarkie transmitter does not have coverage in areas where interference would be expected. Therefore no impact is expected and this transmitter is therefore not discussed further.

3.5 Rumster Forest Transmitter

The Rumster Forest transmitter is one of the transmitters within the STV North transmitter network in northern Scotland. It is located approximately 30km north west of the proposed Wind Farm. The published British National Grid co-ordinates for its location are ND19783854. The published digital services[4] provided are shown below.

	Public (PSB)			Commercial (COM)		
Service	BBC A	Digital 3&4	BBC B	SDN	Arqiva A	Arqiva B
Channel	27	24	21+	30-	59	55
Power	20kW	20kW	20kW	20kW	20kW	20kW
Average Frequency	601 MHz					
Power	20kW			10kW		

Table 3-2 Rumster Forest Public Service Broadcaster (PSB) and Commercial multiplexes (COM)

3.6 Radio Transmissions

Radio services in the UK are broadcast from a variety of main and local transmitters. Services are currently broadcast as both analogue and digital transmissions.

Receivers are typically mobile or portable devices with omnidirectional aerials. The relevant transmitter is dependent on the receiver's exact position and the radio channel that is being received.

Whilst it is not practical to record every possible radio channel at every location, the following approach was taken:

- Select survey locations in close proximity to the proposed Development;
- Measurement of the D1 National digital radio service (225.6 MHz);
- Measurement of other prominent peaks in the spectrum at digital radio frequencies;
- Measurement of sample channels within the 88 – 106 MHz band (FM radio).

In this way, an understanding of the availability and quality of radio services in potentially affected areas has been achieved.

[4] **Source: Ofcom, UK digital television transmitter details – DSO multiplexes. Last accessed 21/08/2018.**

3.7 Transmitters and Wind Farm Location

Figure 3 below shows the location of the Wind Farm and the transmitters[5] on an outline map of the UK coastline.

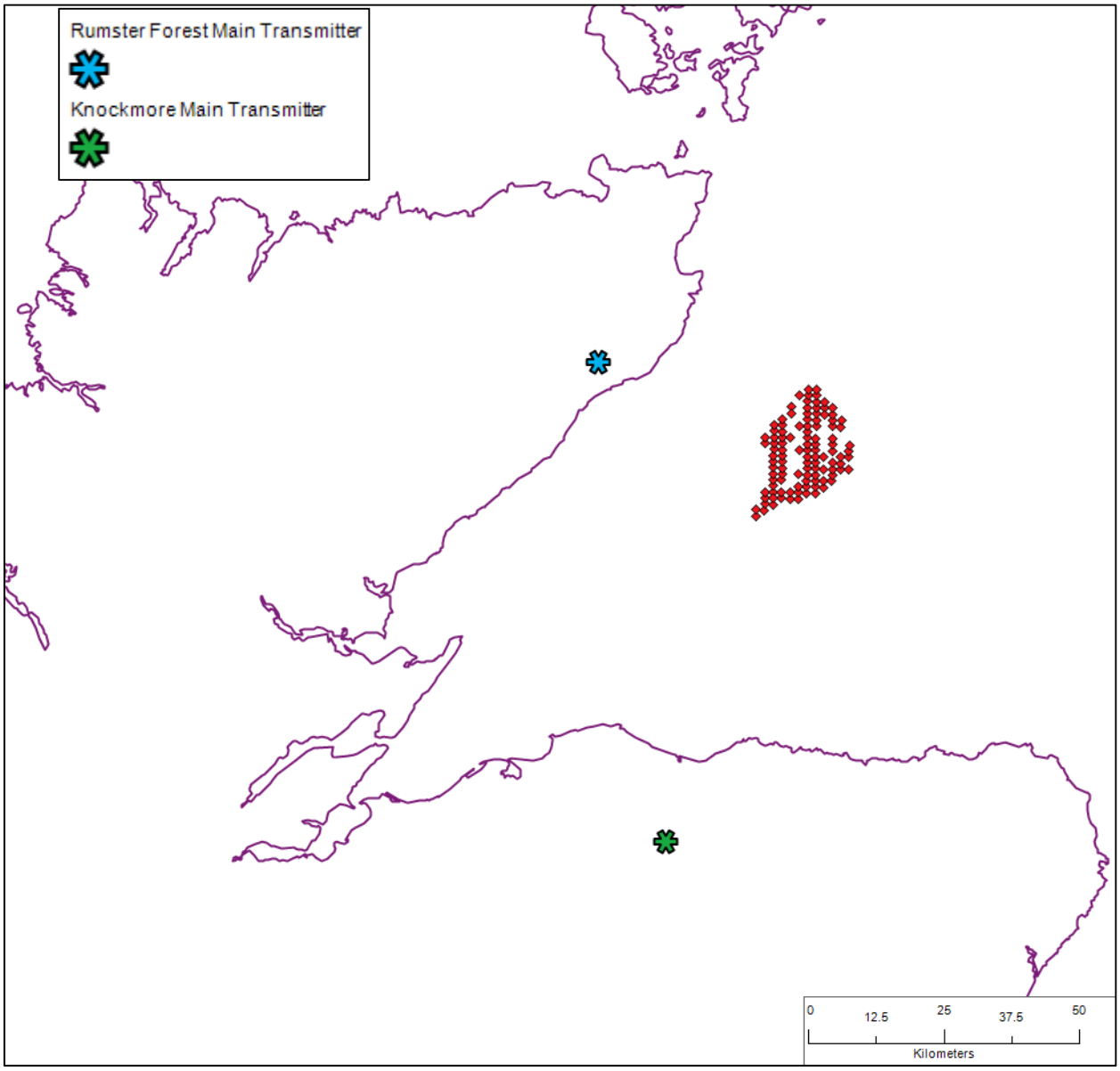

Figure 3 Television transmitter and proposed WTGs (including spare locations) map

[5] **For which effects are deemed possible.**

4 Interference Analysis

4.1 Technical Overview - Television

Terrestrial television services are provided by means of UHF Radio waves which propagate from transmitters to receiving aerials which then relay the signal to a television set.

The quality of the image and sound on a television set is dependent on both the strength of the signal received directly from the transmitter (Carrier signal) and the strength of Interference signals from other sources. In this case the interference signals are modelled as reflections of the Carrier signal by WTGs.

Pager Power's methodology for assessment of interference effects was developed based on evaluation of the predicted Carrier to Interference Ratio (CIR). Whilst this parameter is related to analogue services, the interference mechanisms for digital transmissions are similar to those for analogue transmissions. The main difference is the manner in which the interference is manifested on the television screen. Analogue signals may suffer degradation that reduces the signal quality by causing various effects such as ghosting or flickering. Digital transmissions tend to be robust to small amounts of interference, but are drastically affected by more severe interference. Even though the digital switchover has taken place over all of the UK, the interference zones modelled here are, to the best of Pager Power's knowledge, equally applicable to digital transmissions as analogue transmissions.

To achieve good quality reception an aerial must receive a strong Carrier signal but weak Interference signals. The standard characterisation of this condition is the Carrier to Interference Ratio, (CIR). The CIR is interpreted as presented in Table 4.1 below.

Colour	CIR (dB)	Interference Level	Likelihood of Interference
Red	<5	High	Likely
Yellow	5 – 15	Medium	Possible
None	>15	Low	Unlikely

Table 4-1 Interpreting the CIR

The CIR is evaluated by taking the ratio of the predicted signal strength (provided directly from the transmitter) to the predicted interference signal strength (reflections from the WTGs). It should be noted that the television interference model used for the analysis is considered to be conservative.

4.1.1 Television Interference Modelling for Knockmore

Interference analysis has been undertaken for Knockmore transmissions in the areas bound by the co-ordinates presented in Table 4.2 below.

Assessment Area	West	East	North	South
1	320500	340500	956000	936000
2	320500	340500	976000	956000

Table 4-2 Boundary co-ordinates for Knockmore

4.1.2 Television Interference Modelling for Rumster Forest

Interference analysis has been undertaken for Rumster Forest transmissions in the areas bound by the co-ordinates presented in Table 4.3 below.

Assessment Area	West	East	North	South
3	352000	372000	869000	849000
4	372000	392000	869000	849000
5	392000	412000	869000	849000

Table 4-3 Boundary co-ordinates for Rumster Forest

4.2 Interference Areas – Radio Services

Due to the number of potential transmitters and the nature of most radio receivers (portable or mobile), the potential interference areas are less well defined than for television services. In general terms, interference is more likely closer to the WTGs. This is because the signal does not have the chance to reform when located close to a wind turbine. Survey locations were therefore selected in accordance with the television survey locations, with television signals being more susceptible to interference. Those survey locations were chosen based on their proximity to the coast line, the population and the modelling results.

4.3 Assessment Zones Map

Figure 4 below shows the modelled interference zones for each transmitter. Zones 1-2 were modelled for the Knockmore transmitter and Zones 3-5 were modelled for the Rumster Forest transmitter.

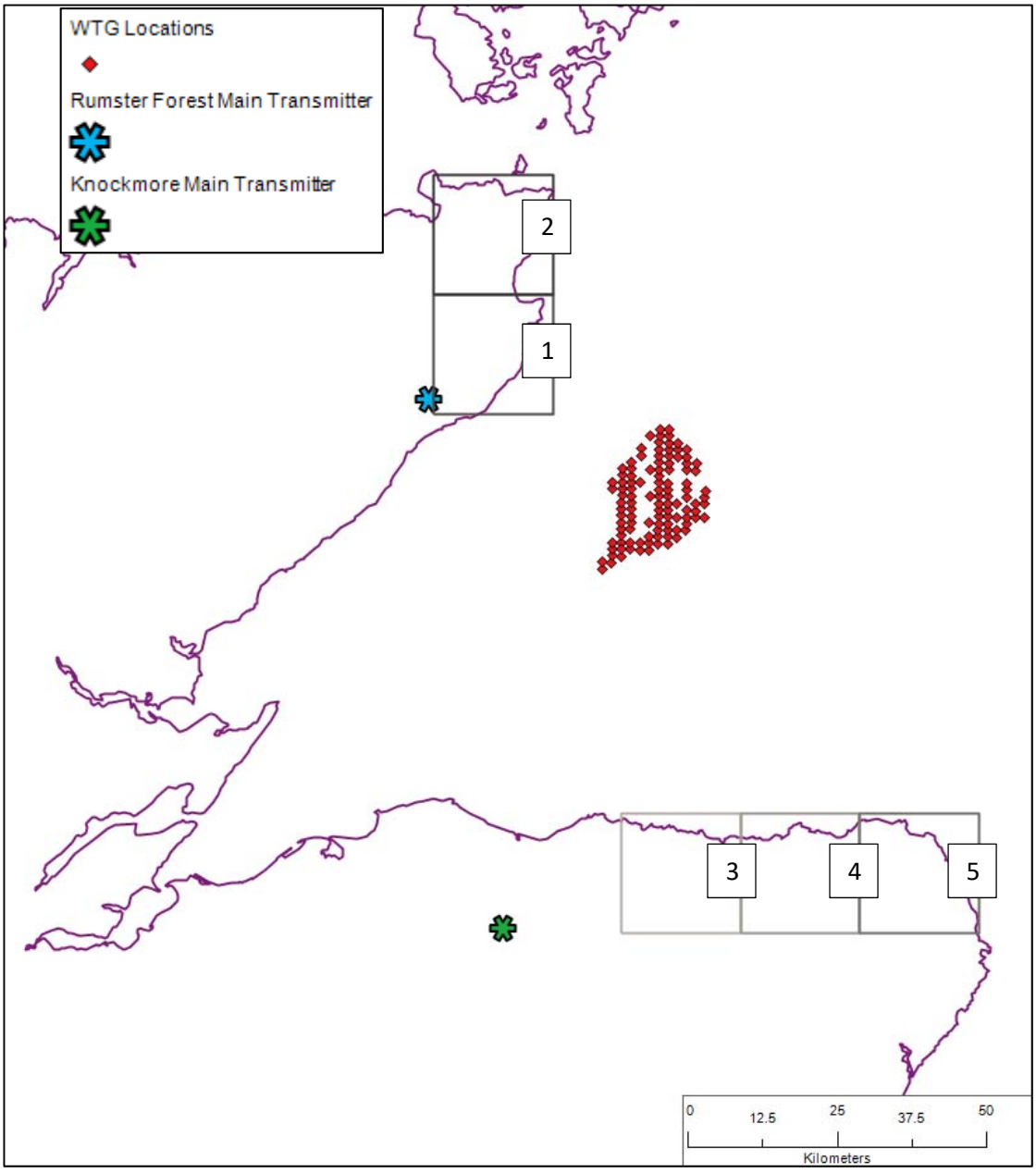

Figure 4 Assessment zones

The assessment zones have been chosen based on their location behind the Wind Farm in relation to the transmitters. It would be unlikely for any other area on land to be affected. All of the assessment areas are considered to be rural.

5 Interference Charts

5.1 Overview

The following section presents the interference charts and maps for the two assessed areas of the identified television transmitters.

5.2 Interference Chart for the Knockmore Main Transmitter (Areas 1 & 2)

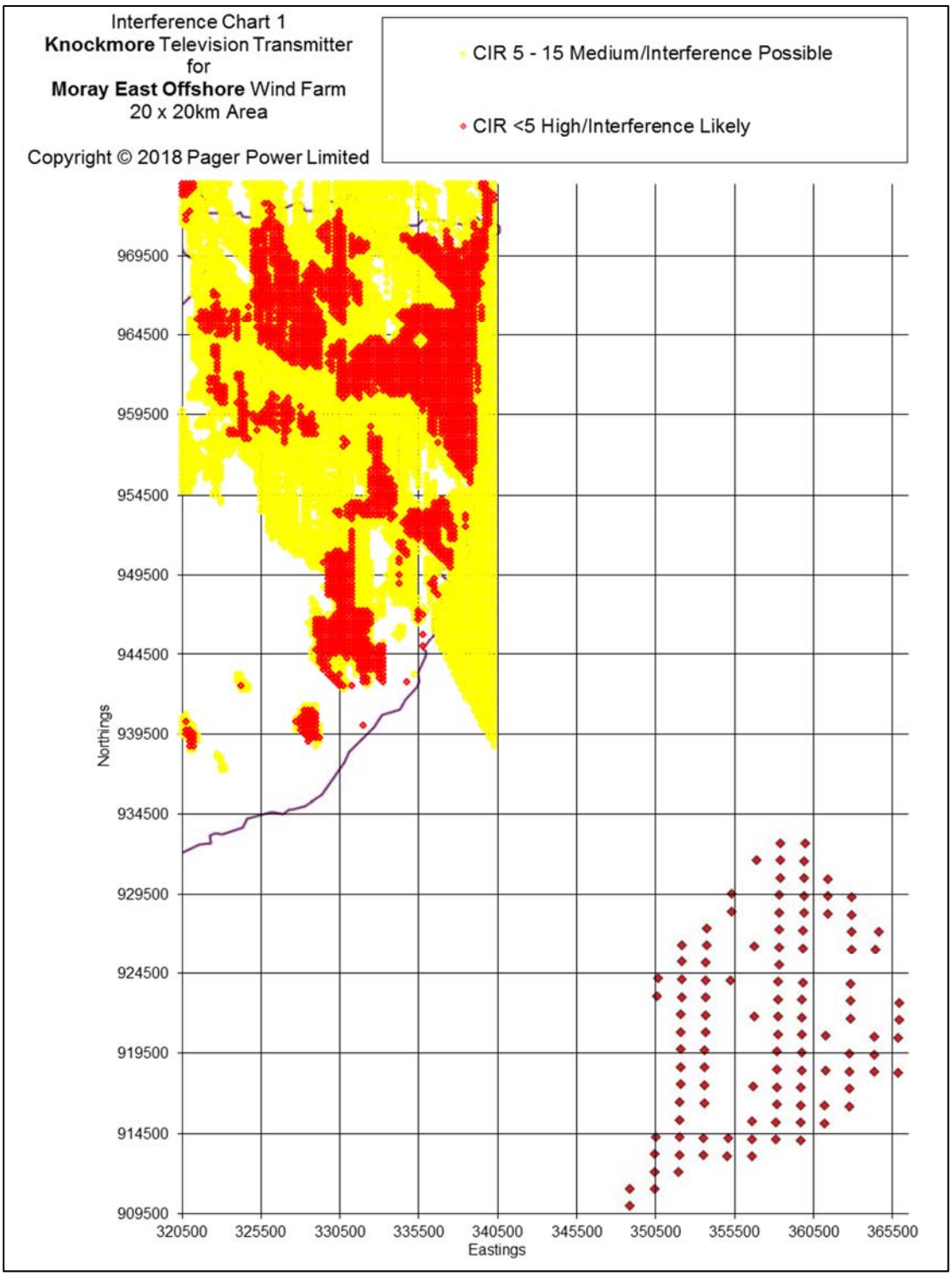

Figure 5 Interference chart for the Knockmore main transmitter

5.3 Interference Map for the Knockmore Main Transmitter (Areas 1 & 2) – Zoomed with Map

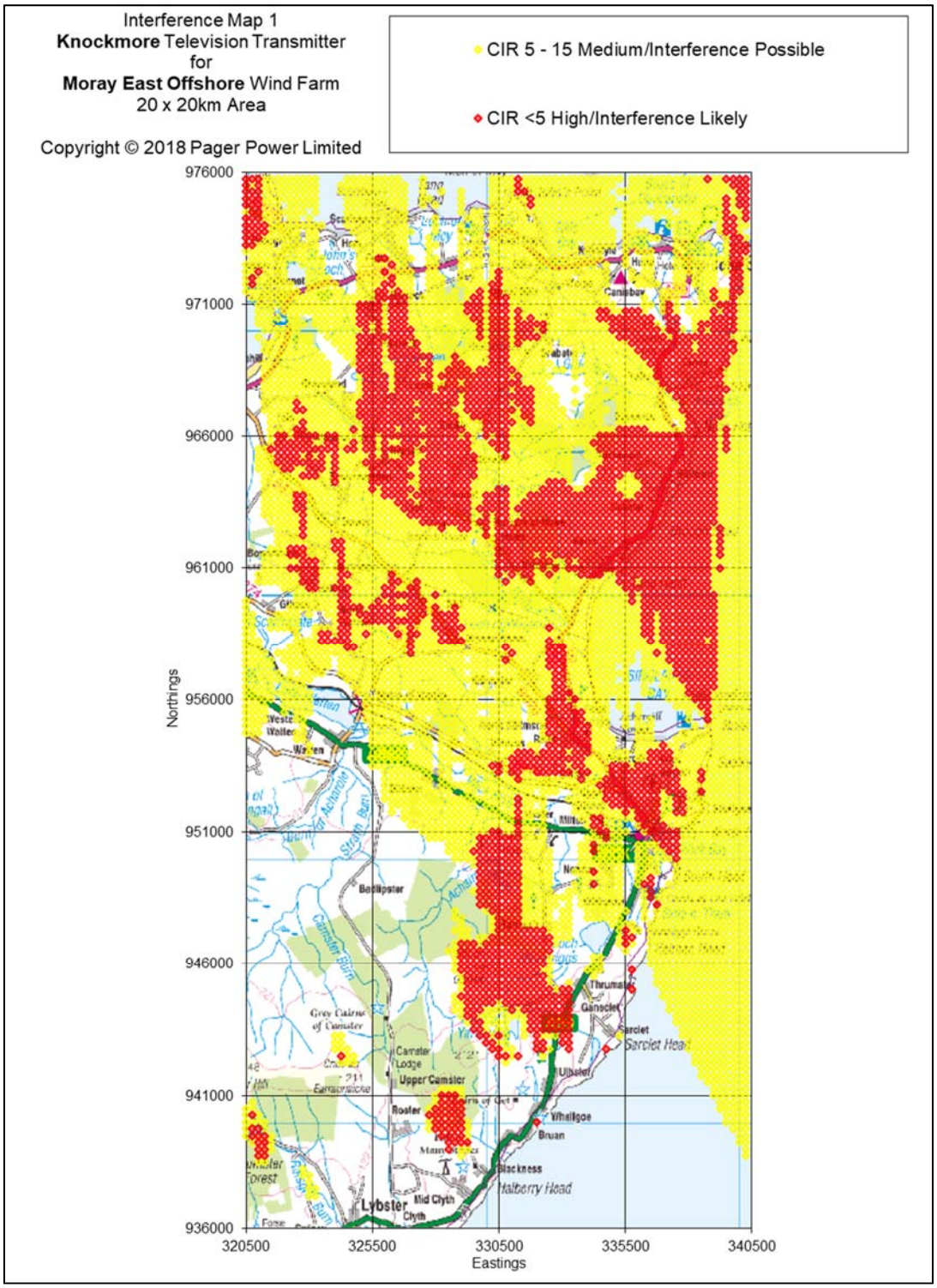

Figure 6 Interference map for the Knockmore main transmitter – Zoomed

5.4 Interference Chart for the Rumster Forest Main Transmitter (Areas 3, 4 and 5)

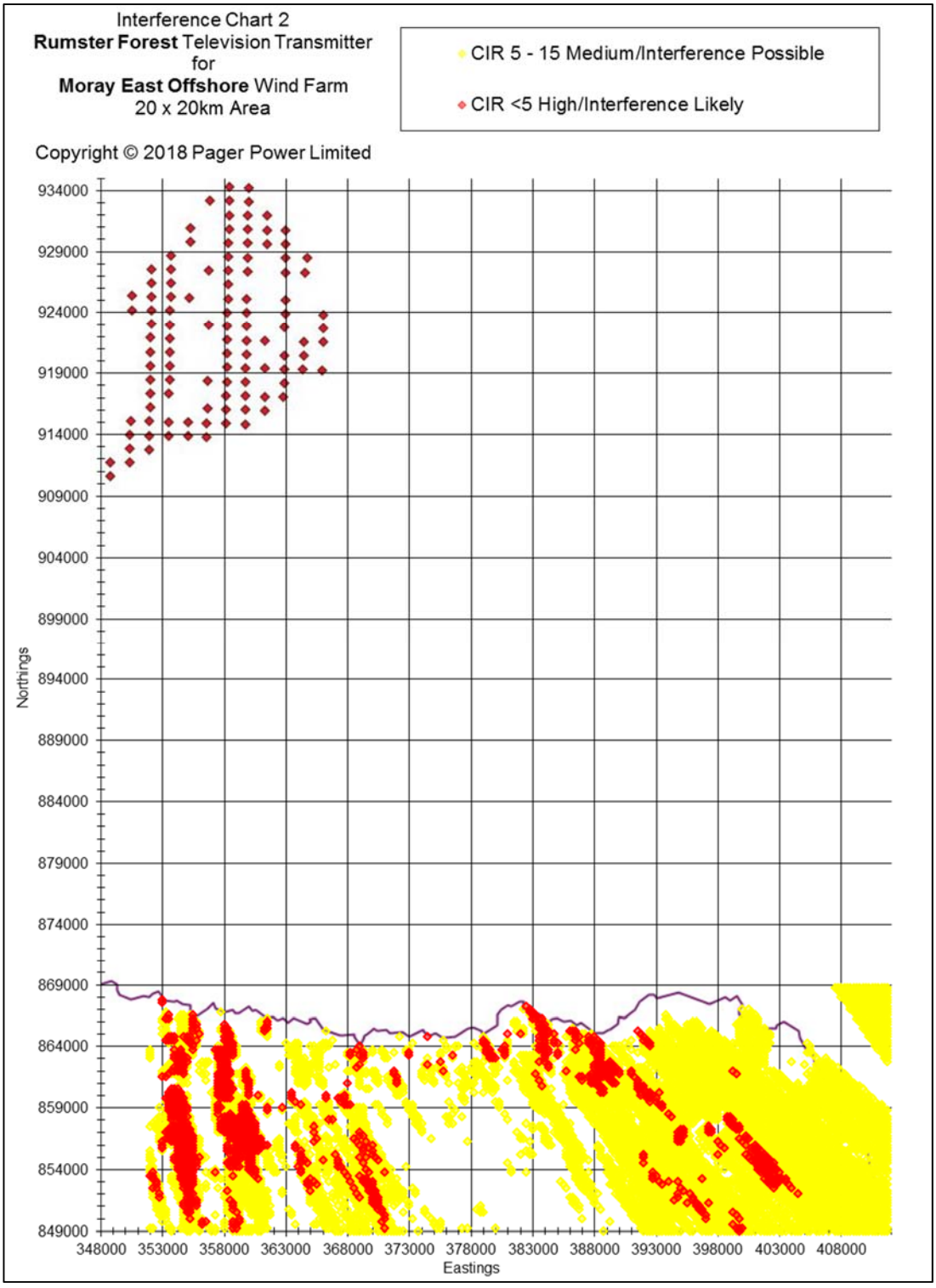

Figure 7 Interference chart for the Rumster Forest main transmitter

5.5 Interference Map for the Rumster Forest Main Transmitter (Areas 3, 4 and 5) – Zoomed with Map

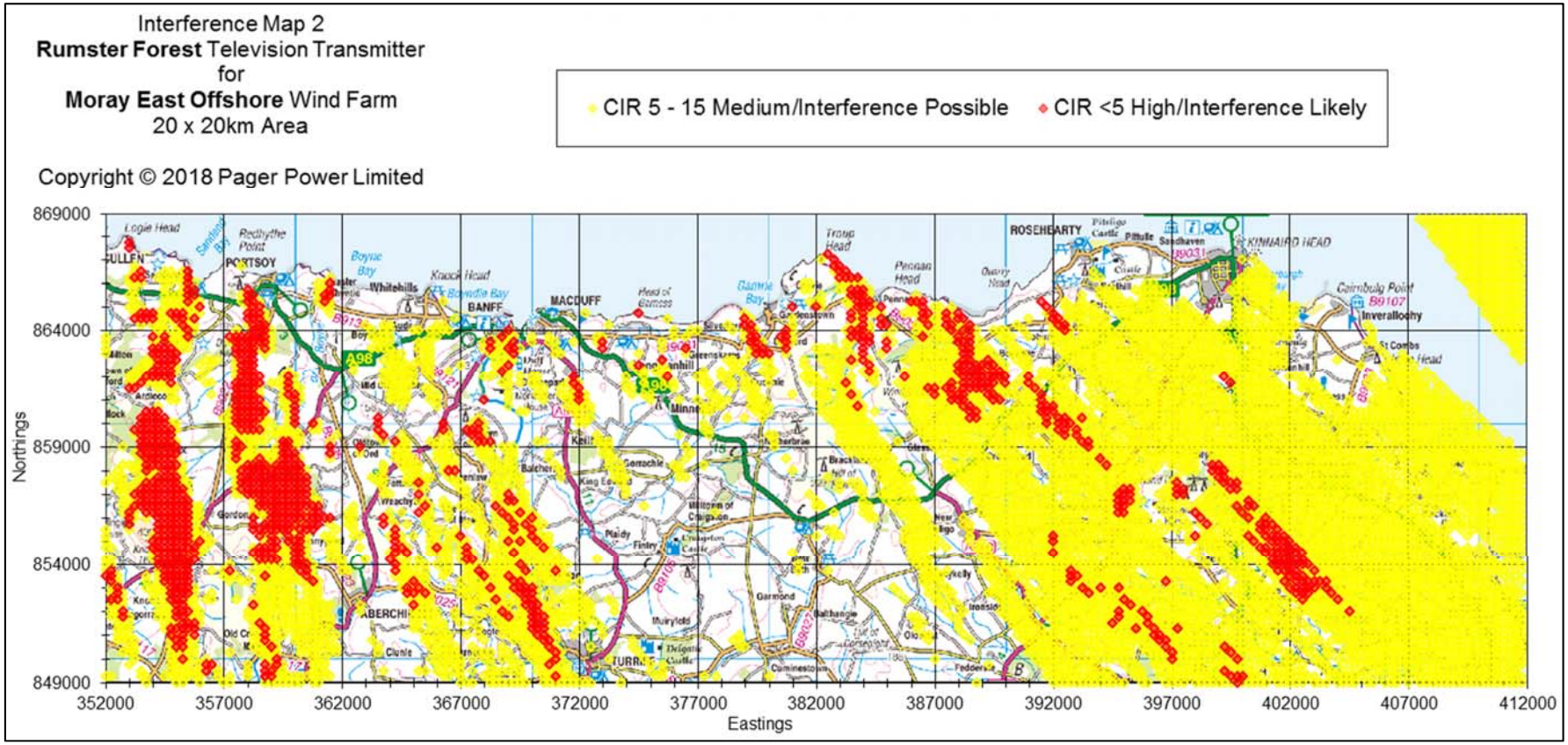

Figure 8 Interference map for the Rumster Forest main transmitter

6 Interference Quantification Assessment

6.1 Overview

Using aerial photography, Google Street View Imagery[6], OS mapping, the interference patterns produced and Pager Power's experience of electromagnetic propagation, an initial assessment has been made regarding the possible television interference effects caused by the presence of the Wind Farm.

Worst case interference will occur where the WTGs interfere with a signal which then goes on to be received by an aerial. This is likely to be in an area known as the forward scatter region (the area behind the WTGs relative to the transmitter). The distance to which this area extends beyond the WTGs depends on the size and layout of the WTGs, as well as the heights of the broadcasting transmitter. Interference analysis has been undertaken for the land in the forward scatter region of the proposed Wind Farm, or on the land nearest this area. This means that land on the opposite side of the Moray Firth has been assessed for each relevant transmitter.

The modelling shows that the majority of the assessed area for each transmitter will encounter high or medium interference. In some cases this will be because the terrain in the surrounding area does not permit a direct line of sight between the transmitters and the aerials and, thus, there is no signal coverage. In other cases it may be due to the presence of the Wind Farm interfering with the transmitted signal.

High and medium interference produced by the presence of the Wind Farm can cause significant problems if it is expected in populated areas and the signal is already received. It is therefore important to determine what is located within these areas of interference, which transmitter signal is being received and what signal the aerials in the area are directed to receive. The interference charts for each transmitter have therefore been analysed to determine whether any interference is expected. The results are presented in the following sub-sections.

6.2 Knockmore Interference Assessment

Based on a review of the available imagery, it can be assumed that most dwellings receive a signal from the Rumster Forest Transmitter (or local relays) in the most susceptible area of interference for Knockmore transmissions. The assessed area is to the west of the forward scatter region with respect to Knockmore, and therefore in an area which is less susceptible to interference.

A review of coverage maps has revealed that it is likely that the Knockmore transmitter does have coverage to the south of the assessed area (along the coastline to the south). The coverage of the transmitter decreases with distance inland. As stated, it is not believed that dwellings here will use a signal from the Knockmore transmitter.

[6] It important to note that satellite and street view imagery may not provide the most up to date images of the assessed area.

The interference patterns produced are believed to be caused by the terrain which affects the coverage. It is not thought that the WTGs will affect the signal coverage in this area.

Overall it is not thought that any dwellings in the areas to the north of the Moray Firth receive a signal from the Knockmore transmitter, nor will the signal be affected. Therefore no impact upon Knockmore transmissions is expected.

6.3 Rumster Forest Interference Assessment

Based on a review of the available imagery, it is assumed that dwellings receive a signal from the Knockmore or Durris main transmitters or local relays within the assessed area. Some properties along the coastal villages also appear to have a horizontally polarised aerial orientated north westerly, which is likely to be towards the Rumster Forest transmitter.

A review of coverage maps has revealed that the Rumster Forest transmitter has coverage along the southern coastline of the Moray Firth with coverage decreasing further inland (south).

The modelling has predicted moderate and high interference at points along the coastline. This is likely to be because the assessed area is (mostly) within the forward scatter area relative to the Rumster Forest transmitter. If the Rumster forest transmitter is received in areas where interference is predicted, then the signal may be affected and mitigation may be required. This could be achieved by re-orientating the aerials towards an alternate transmitter[7] (if available) or via the installation of satellite television services. The areas where effects are most likely are:

- Banff;
- Macduff;
- Gardenstown;
- New Aberdour;
- Rosehearty;
- Fraserburgh: and
- Any individual dwelling receiving a signal from Rumster Forest in an area of predicted interference.

[7] **Local broadcast services may however be affected.**

6.4 Interference Overall Conclusions

Based on the results of the desk-based analysis, it is expected that television signals may be affected in some locations by the presence of the Moray East Offshore Wind Farm for dwellings receiving a signal from the Rumster Forest transmitter in the assessed area only. No significant interference to Knockmore transmissions is expected.

A baseline survey helps to confirm where interference may be expected based on the current signal strength in the relevant locations. The results of the baseline survey are presented in the following section, the locations of which have been informed by the modelling output.

Any dwellings receiving television signals via satellite or cable are not expected to be affected by the presence of the Wind Farm.

7 Baseline Survey

7.1 Overview

A site survey was undertaken on 13 June 2018. The weather on the day was variable. The baseline survey serves three purposes, these are:

- It confirms which transmitter is serving most homes in the areas surveyed (television only);
- It provides an indicator regarding the likelihood of interference. If current signals are of good quality, minor degradation is less likely to have a noticeable effect;
- It allows a 'before and after' comparison to be made in the event that a complaint is received.

7.2 Survey Locations

Those receiving their television signal by satellite dishes will not be affected. Figure 9[8] below shows the survey locations chosen as a result of the modelling completed.

Figure 9 Survey locations

[8] **Source: © 2018 Google.**

The strength of the recorded signals has been categorised in accordance with Table 7.1 below for television.

Average Signal Strength (dB)	Subjective Signal Strength Definition
<35	Low
35-45	Moderate
46-55	Good
55+	Very Good

Table 7-1 Terrestrial television signal strength categories

7.3 Survey Results

An overview of the results is presented in the following section.

7.3.1 Television

The survey confirmed that the Rumster Forest transmitter is the main transmitter serving the assessed areas. Some dwellings did not have external aerials and some had satellite dishes.

7.3.2 Radio

Digital and analogue (FM) services were received at all locations.

7.3.3 Results

Table 7.2 on the following page summarises the results of the reception survey. The following abbreviations are used:

- MUX – multiplex (group of television channels);
- DAB – Digital Audio Broadcast (digital radio);
- FM – Frequency Modulated (analogue radio).

The average signal strength is given separately for the main television multiplexes, digital radio and FM radio. This is because the difference in power for these transmissions is significant, such that a single average figure would not be meaningful.

For digital radio signals, the signal strength shown is the strength for that particular channel. For analogue radio, the signal strength was highly varied across the frequency range, such that a single value is not meaningful. A maximum value was noted for reference purposes.

Detailed survey results are shown in Annex A. Photos taken at the individual survey locations are shown in Annex B.

The likelihood of interference is given based on the survey results and the interference modelling.

Location	Average Measured Signal Strength	Remarks	High Level Conclusion
01	Knockmore Main TV MUX: - Rumster Main TV MUX: 25.6 dB DAB: Up to 20dB FM: Up to 40 dB	External aerials were directed orientated south west. A small number orientated north west towards Rumster Forest. Satellite dishes were also observed. No television signals for Knockmore or Rumster Forest were decoded.	This location is not with the shadow area for Rumster Forest. Television signal quality is also poor at this location. Further significant degradation of the signal is unlikely. **Interference to television or radio services is not expected.**
02	Knockmore Main TV MUX: 25.5 dB Rumster Main TV MUX: 42.8 dB DAB: Up to 30 dB FM: Up to 30 dB	Aerials orientated towards Rumster Forest to the north. Satellite dishes observed. Three of the six Rumster Forest channels decoded with fine picture and sound.	This location is not with the shadow area for Rumster Forest. Only three of the six Rumster Forest services decoded with the average signal strength deemed moderate. Significant degradation of the signal is unlikely. **Interference to television or radio services is not expected.**

Location	Average Measured Signal Strength	Remarks	High Level Conclusion
03	Knockmore Main TV MUX: 25.7 dB Rumster Main TV MUX: 38.6 dB DAB: Up to 40 dB FM: Up to 30 dB	Aerials orientated towards Rumster Forest to the north. Satellite dishes observed. Three of the six Rumster Forest channels decoded with fine picture and sound.	This location is not with the shadow area for Rumster Forest. Only three of the six Rumster Forest services decoded with the average signal strength deemed moderate. Significant degradation of the signal is unlikely. **Interference to television or radio services is not expected.**
04	Knockmore Main TV MUX: 25.9 dB Rumster Main TV MUX: 25.7 dB DAB: Up to 30 dB FM: Up to 20 dB	One aerial seen orientated towards Knockmore, other aerials orientated towards Rumster Forest. No television signals for Knockmore or Rumster Forest were decoded.	This location is not with the shadow area for Rumster Forest. Television signal quality is also poor at this location. Further significant degradation of the signal is unlikely. **Interference to television or radio services is not expected.**

Location	Average Measured Signal Strength	Remarks	High Level Conclusion
05	Knockmore Main TV MUX: 25.9 dB Rumster Main TV MUX: 34.6 dB DAB: Up to 20 dB FM: Up to 20 dB	Aerials orientated towards Rumster Forest. Satellite dishes observed. Three of the six Rumster Forest channels decoded with fine picture and sound.	This location is not with the shadow area for Rumster Forest. Only three of the six Rumster Forest services decoded with average signal strength deemed low. Significant degradation of the signal is unlikely. **Interference to television or radio services is not expected.**
06	Knockmore Main TV MUX: 26.4 dB Rumster Main TV MUX: 35.5 dB DAB: Up to 30 dB FM: Up to 30 dB	Some aerials observed orientated towards Rumster Forest. Big fluctuations observed for those channels decoded. Channels 32-34 and 35 also decoded with strength 40-50, likely from a local relay. Three of the six Rumster Forest channels decoded however large fluctuations were observed which caused pixilation and stuttering. No other channels decoded.	This location is just outside the shadow area for Rumster Forest. Only three of the six Rumster Forest services decoded however the signal fluctuated significantly. Further degradation of the signal is possible. **Interference to television or radio services is possible**.

Location	Average Measured Signal Strength	Remarks	High Level Conclusion
07	Knockmore Main TV MUX: 25.7 dB Rumster Main TV MUX: 34.1 dB DAB: Up to 30 dB FM: Up to 30 dB	Horizontally and vertically polarised aerials observed looking north west and north east respectively. Satellite dishes observed. Three of the six Rumster Forest channels decoded with fine picture and sound.	This location is within the shadow area for Rumster Forest. Only three of the six Rumster Forest services decoded with average signal strength deemed low. Further degradation of the signal is possible. **Interference to television or radio services is possible**.
08	Knockmore Main TV MUX: 25.9 dB Rumster Main TV MUX: 27.4 dB DAB: Up to 30 dB FM: Up to 32 dB	Few horizontally polarised aerials observed. Satellite dishes observed. No television signals for Knockmore or Rumster Forest were decoded.	This location is within the shadow area for Rumster Forest however many dwellings are unlikely to use its signal. If a dwelling does currently have a useable Rumster Forest signal further significant degradation of the signal is possible. **Interference to television or radio services is possible**.

Location	Average Measured Signal Strength	Remarks	High Level Conclusion
09	Knockmore Main TV MUX: - Rumster Main TV MUX: 25.4 DAB: Up to 20 dB FM: Up to 20 dB	Vertically polarised aerials orientated west, likely towards Rosehearty. Satellite dishes observed. No television signals for Knockmore or Rumster Forest were decoded.	This location is within the shadow area for Rumster Forest however many dwellings are unlikely to use its signal. If a dwelling does currently have a useable Rumster Forest signal further significant degradation of the signal is possible. **Interference to television or radio services is possible**.

Table 7-2 Survey results

7.4 Modelling and Survey Overall Conclusions

Considering the modelling results, relative location and signal strength received, it is possible that interference at a number of locations could occur, these include:

- Gardenstown;
- New Aberdour;
- Rosehearty;
- Fraserburgh; and
- Any individual dwelling receiving a signal from Rumster Forest in an area of predicted interference.

Overall, based on the desk-based interference charts, it is believed that the presence of the Wind Farm may affect homes in the forward scatter region where a terrestrial television signal from Rumster Forest is received.

8 Mitigation

8.1 Mitigation Requirement

If an adverse effect on television or radio services occurs and is attributable to the Development, mitigation will be required.

8.2 Mitigation Scheme

A separate document presents the television and radio mitigation scheme in the event that interference is encountered. Please see this Section 4 of the TRRMP for mitigation details.

9 Overall Conclusions

9.1 Television Results

A comprehensive search of transmitter and coverage maps revealed that the Knockmore, Rosemarkie and Rumster Forest are the main transmitters which provide coverage in the areas surrounding the proposed Wind Farm. The transmissions from these transmitters have been modelled where it is thought interference could occur. The assessed areas consist mainly of small villages with surrounding rural land. The overall result of the analysis is shown in the following sub-sections.

9.1.1 Knockmore Transmitter

- The forward scatter region for the transmitter is in the sea, therefore the land nearest to this area has been assessed;
- A review of coverage maps showed that coverage for this transmitter is limited to the coastline, with coverage decreasing further inland;
- Analysis of the modelling results showed that no interference is expected to be caused by the presence of the Wind Farm;
- A review of the available imagery revealed that residents within the assessed area are not expected to use the Knockmore transmitter;
- Overall, no impacts upon Knockmore's transmissions are expected.

9.1.2 Rosemarkie Transmitter

- The forward scatter region lies out to sea with respect to the transmitter;
- A review of coverage has shown that the transmitter does not have coverage in areas where interference would be expected;
- Overall, no impacts upon Rosemarkie's transmissions are expected.

9.1.3 Rumster Forest Transmitter

- The forward scatter region was assessed for Rumster Forest's transmissions. The forward scatter region lies on the north Aberdeenshire coast line, to the south of the Moray Firth;
- A review of coverage maps showed that coverage for this transmitter is limited to this coastline, with coverage decreasing further inland;
- Analysis of the modelling results showed that moderate or high interference is expected in some areas along the coastline which is likely to be due to the presence of the Wind Farm;
- Available imagery revealed that in some locations, residents have their aerials orientated north or north west towards the Rumster Forest transmitter. This was confirmed during the baseline survey;
- The baseline survey showed that received signals were, on average, moderate at best however residents within the assessed area do use Rumster Forest to provide television services;

- Considering the modelling, their relative locations and the signal strength received, it is possible that interference at a number of locations could occur, these include:
    - Gardenstown;
    - New Aberdour;
    - Rosehearty;
    - Fraserburgh; and
    - Any individual dwelling receiving a signal from Rumster Forest in an area of predicted interference.
- Overall, based on the desk-based interference charts, it is believed that the presence of the Wind Farm may affect homes in the forward scatter region where a terrestrial television signal from Rumster Forest is received.

9.2 Radio Results

The results of the analysis and survey for radio transmissions are as follows

- Radio services are provided by a range of transmitters in the area. Digital and analogue service were received at all surveyed locations;
- Interference to the signal is most likely in the shadow region, this is expected to be in a similar location to where television interference is predicted. Potential impacts are limited however due to:
    - The variable signal strength of radio transmissions;
    - The robust nature of radio services.
- Overall no noticeable effects are expected for radio services.

ANNEX A – TELEVISION INTERFERENCE

Television Interference

Introduction

Terrestrial television signals propagate from transmitters to receiving aerials which in turn are connected to television receiving equipment. Transmissions are in the UHF frequency range and may be either analogue or digital. Television channels have a bandwidth of 8 MHz.

When considering interference from buildings or wind farms it is usual to consider direct signals – those that pass from transmitter to receiver in a straight line and reflected, or indirect, signals. The reflected signal goes from transmitter to WTG (or building) to receiver.

Standard receiving aerials are directional meaning that signals from the transmitter direction are amplified and signals from the sides and rear of the aerial are attenuated.

Carrier to Interference Ratio

The likelihood of television interference is determined by considering the strength of the direct, or carrier, signal in comparison to the reflected, or interfering, signal. The Carrier to Interference Ratio (CIR) quantifies the relative strength of the direct and reflected signals.

A high CIR means interference is less likely. A low Carrier to Interference ratio means that interference is more likely. The CIR is normally expressed in decibels (dB).

Free Space Path Loss

Television signals weaken over distance. The closer a receiver is to a transmitter the stronger its received signal will be. This reduction in signal strength due to separation distance is referred to a Free Space Path Loss (FSPL).

Electromagnetic Propagation by Diffraction

An electromagnetic signal may travel between two points, even when no direct line of sight exists between those two points. This is because transmission travels as a series of waves rather than as a direct ray. When no direct line of sight exists between the two points the signal is considerably weakened. This weakening is known as a diffraction loss.

International Telecommunications Union (ITU) Recommendation ITU-R P526-7 describes a method for calculating diffraction losses over regular terrain.

Total path loss for a specific path is determined by adding Free Space Path Loss to Diffraction Loss.

Radar Cross Section

The size of the interfering signal is dependent on the amount of energy that is reflected from the WTG. This reflective quality is known as the Radar Cross Section (RCS) and can be expressed in metres squared or in dBm^2.

A lot of work has been carried out to help determine WTG RCS by various parties although little work has been carried out at UHF frequencies. Values cited typically vary between 25 and 300 m^2 with instantaneous peaks reaching 3000 m^2 for a single WTG.

The moving and static parts of the WTG are often considered separately.

Nature of Television Interference from WTGs

Determining whether a television picture is impaired by WTGs or whether the impairment is significant enough to cause picture quality to become unacceptable is considered a subjective matter. The level of effect is determined by looking at the picture when the WTG is operating.

There is a subjective system for grading television picture impairment with grades from 5 down to 1 described in ITU-R 500. The impairments are shown in the table below.

Impairment Grade	Description
5	Imperceptible
4	Perceptible, but not annoying
3	Slightly annoying
2	Annoying
1	Very Annoying

Table 9-1 Grading Table

Where interference is marked it is generally clear that it is being caused by WTGs. The picture regularly distorts with a time base matching the passing of WTG blades. This means that it is fairly easy to determine whether a viewer's interference problem is related to a WTG.

Conditions for WTG Interference

Simplistically the television picture is likely to be unacceptably affected by WTG interference when the CI Ratio is low. In practice interference is most noticeable when some or all of the following conditions are satisfied:

1. The received signal strength is weak.
2. The direct signal path between transmitter and receiver is physically obscured.
3. There is a clear signal path between transmitter and WTG.
4. There is a clear signal path between WTG and receiver.
5. The WTG lies directly between the transmitter and receiver.

Pager Power Approach

Having reviewed many relevant published works, a synopsis of which is included at the end of this text, Pager Power has arrived at a compound methodology including some additional factors such as:

- Triplicate calculations accounting for tip, hub and rotor bottom.
- Accounting for actual field strength
- Calculating interference in accordance with the Dabis Method
- Calculating interference in accordance with the ITU method

Following assessment by these various methods the following conclusions have been drawn:

- Although it is true that wind farm interference appears more likely when the received signal is weak there is no direct relationship between direct signal strength and observed picture interference.
- Observed picture interference is directly related to the CIR.
- Analysis of the ITU-R BT805 method demonstrates this method to be significantly more accurate than the Dabis method for assessing observed interference.
- Summing of unwanted signals from each WTG to determine a total unwanted signal level appears to be reasonably accurate.
- The CIR threshold of 10dB cited by RES appears to be reasonable – it is certainly true that the threshold of 28-34 cited by BT805 is too high when using this method. Observations on a 32 WTG development suggest that a threshold of 15dB may be more reasonable in this case.
- Carrying out an assessment based on the hub height appears to be fairly representative – however there can be significant variation in CIR over the blade span. In an example with no direct line of sight between transmitter and receiver the CIR varies by 31dB between the top and bottom of the rotor. This is a large variation and should be considered or accounted for.

It was concluded therefore that triplicate calculations at tip, hub and rotor base should be considered. The principals of this calculation are as follows:

- The interference signal calculation should be carried out three times for each WTG – at tip, hub and rotor base.
- A weighted average of the three unwanted interference signal levels should be made (of absolute levels not decibel levels).
- A signal passing through the WTG at hub height will be more greatly affected due to the increased frequency at which the signal will be intercepted compared to a signal passing through the tip or rotor base so an increased weighting should be applied to the hub signal.
- The weighting applied to rotor tip and rotor base should be identical as the proportion of the signal passing through the rotor is identical at both heights.

- A geometric calculation suggested that following weightings be used for averaging:

WTG Part	Weighting (%)	Rounded values used for calculation
Tip	19.55	20
Hub	60.9	60
Rotor Bottom	19.55	20

Table 9-2 Weighting for calculation

Pager Power Assessment Methodology

Having considered the various published works, exploring knowledge of real interference caused by wind farms, and modelling interference in various ways Pager Power has developed an effective modelling method for mapping likely television interference from wind farms. The process involves the following stages:

1. Acquire terrain data in digital format.
2. Determine the following for modelling:
    a. Transmitter location and height.
    b. WTG locations and hub heights.
    c. Single Blade Area.
    d. Blade Width for modelling purposes.
    e. Television signal wavelength for modelling purposes.
3. Area of interest for interference modelling – this will be a rectangular area defined by top-right and bottom-left coordinate pair.
4. Determine the sample point spacing for modelling purposes – this is currently a fixed value for the entire area.
5. Determine the receiver aerial height for modelling purposes.
6. Calculate coordinates of each Receiver Sample Point in the area of interest.
7. Calculate Free Space Path Losses for the following paths:
    a. Transmitter to each WTG FSPL_TW.
    b. Transmitter to each Receiver Sample Point FSPL_TR.
    c. Each WTG to each Receiver Sample Point FSPL_WR.
8. Build electronic terrain profile for each of the above paths. The number of points in the profile is determined dynamically based on the source terrain data resolution and the particular path length.
9. Determine additional diffraction losses for each of the above paths using ITU-R 526 method. These losses are DL_TW, DL_TR and DL_WR respectively. These calculations are carried out for the WTG tip, WTG hub and WTG rotor.
10. Calculate a WTG Reflection Factor (RF) in accordance with ITU-R BT805.

11. Calculate an adjustment factor (ADJ) to compensate for the 1km free space path loss built into the Relative Amplitude (RA) calculation defined in ITU-R BT805. This is 88.662dB.
12. Determine the following for each WTG – sample point pair:
    a. Horizontal Angle (alpha) at the WTG between extended path from transmitter and path to sample point.
    b. Horizontal Angle (beta) at sample point between WTG and transmitter.
    c. Calculate Relative Amplitude (RA) based in accordance with ITU-R BT805. If RA is calculated to be smaller than -10 it is changed to -10 (as described in BT805).
    d. Calculate Loss due to Antenna Directivity (AL) based on angle beta and the curves in ITU-R BT419.
13. Calculate Interference Signal Magnitude for each WTG Receiver Sample Point Pair at WTG tip, hub and rotor base by summing the following:
    a. - FSPL_TW
    b. - DL_TW
    c. - FSPL_WR
    d. - DL_WR
    e. RF
    f. RA
    g. ADJ
    h. –AL
14. The above absolute values are summed for each WTG sample point and converted back into decibel values and saved as Summed Interference Values (I). Summing occurs with a 20/60/20 respective weighting split for tip, hub and rotor base.
15. Carrier Signal Magnitude (C) is then determined for each Receiver Sample Point by summing:
    a. – FSPL_TR
    b. – DL_TR
16. CIR is then calculated for each point by subtracting I from C.
17. CIR for each sample point is then recorded on an interference map.

Formulae

Term	Unit	Description
A	m^2	Blade Area
AL	dB	Antenna Loss due to angle between signal source and antenna direction
Ave aC	dB	Carrier signal strength (based on inverse of losses)
CIR	dB	Carrier to Interference Ratio
d	M	Length of signal path
dkm	km	Length of signal path
DL	dB	Diffraction Loss
FSPL	dB	Free Space Path Loss
FSWT	dBV/m	Field Strength at WTG
I	dB	Interference signal strength
Iabs	-	Interference signal strength (absolute)
Ih	dB	Interference signal strength due to a single WTG calculated at hub height
Ir	dB	Interference signal strength due to a single WTG calculated at bottom of rotor
It	dB	Interference signal strength due to a single WTG calculated at tip height
Iw	dB	Interference due to a single WTG
Iwf	dB	Interference due to a wind farm
RA	dB	Relative Amplitude in forward scatter region
RF	dB	Reflection factor for a WTG including free space path loss for 1km

Term	Unit	Description
TW	suffix	Denotes path from transmitter to WTG
TR	suffix	Denotes path from transmitter to receiver
TXFIELD	dBV/m	Transmitter field strength at 1 metre
V	-	Diffraction Parameter
W	m	Width of blade
WR	suffix	Denotes path from WTG to receiver
A	Radians	Horizontal angle at WTG between extended path from transmitter and path to receiver
B	Degrees	Horizontal angle between path to signal source and direction receiving antenna is pointing
Λ	m	Wavelength

1 Antenna Loss

AL = 0 when β<20

AL = (β-20) x 0.4 when β between 20 and 60

AL = 16 when β>60

From Figure 1 of ITU-R BT419 Bands IV and V (UHF)

2 Reflection Factor

RF = 20log(A/λ)-60 (From Annex 1 of ITU-R BT805).

3 Relative Amplitude

RA=20log sin(π×W/λ×sinα)/(π×W/λ×sinα) (From Annex 1 of ITU-R BT805).

4 Carrier to Interference Ratio

CIR = C – I (From first principles by definition when values expressed in dB)

5 Free Space Path Loss

FSPL = 20log(4πd/λ) (From Dabis paper and by definition)

6 Interference – Single WTG – Hub Height

Formulae for a single path at hub height:

Ih = FSWT + RF + max(-10,RA) - 20log(dkm) [**a**]

From ITU-R BT805 for an unobscured path from WTG to transmitter

FSWT = TXFIELD - FSPL_TW - DL_TW [**b**]

From first principles

Ih = TXFIELD - FSPL_TW - DL_TW + RF + max(-10,RA) - 20log(dkm) [**c**]

Combining [**b**] and [**a**]

Ih = TXFIELD-FSPL_TW-DL_TW+RF+max(-10,RA)-20log(dkm)-DL_WR [**d**]

Accounts for additional diffraction losses between WTG and receiver

20log(dkm) = 20log(d/1000) = 20log(d) - 60 [**e**]

From first principles

FSPL = 20log(4π/λ) + 20log(d)

20log(d) = FSPL - 20log(4π/λ) [**f**]

From [**e**] and first principles

20log(dkm) = FSPL - 20log(4π/λ) - 60 [**g**]

Combining [**f**] and [**e**]

Ih = TXFIELD - FSPL_TW - DL_TW + RF + max(-10,RA) - FSPL_WR + 60 + 20log(4π/λ) - DL_WR [**h**]

Combining [**d**] and [**g**]

7 Interference Single WTG

Interference for a single WTG is calculated by taking a weighted average of interferences at tip, hub and rotor base.

It, Ih and Ir are all calculated as detailed in 6 above. These values will differ due to diffraction loss differences.

Iw = 20log((0.2*10^(It/20))+(0.6*10^(Ih/20))+(0.2*10^(Ir/20)))

Absolute averaging of signals with a 20/60/20 weighting – Pager Power Methodology

8 Interference Multiple WTGs

Multiple WTGs based on calculations at hub height.

Interference signals from multiple sources are calculated by summing absolute values. The following formulae apply:

Iw = 20log(Iabs)

Iabs =10^(Iw/20)

By definition Iwf=20log(Σ(10^(Iw/20)))

Direct summing of absolute values – Pager Power and RES methodologies

9 Diffraction – Single Knife Edge

DL = 6.9 + 20log(sqrt(((v-0.1)^2)+1)+v-0.1) when v > -0.7

DL = 0 when v <= -0.7

Equation 17 of ITU-R P526 (DL ≈ 0 when v<= -0.7 from the graph at Figure 7)

10 Diffraction – Path over Irregular Terrain

The general method is described in Section 4.5 of ITU-R P526.

Up to three peaks are considered as specified by the method.

An effective Earth Radius (to account for atmospheric refraction) of 8,494,678 metres is used for calculation purposes.

Review of Published Works

A number of documents relate to the interference effects of WTGs on television and radio systems. These include:

1. BBC, The impact of large buildings and structures (including wind farms) on terrestrial televisions reception
2. International Telecommunications Union, Assessment of impairment caused to television reception by a wind turbine, Recommendation ITU-R BT805*, 1992
3. Bacon, DF, A proposed method for establishing an exclusion zone around a terrestrial fixed radio link outside of which a wind turbine will cause negligible degradation of the radio link performance, Radio Communications Agency, 2002
4. Hall, SH, The assessment and avoidance of electromagnetic interference due to wind farms, Wind Engineering Vol 16 No 6, 1992
5. Dabis, HS, The provision of guidelines for the installation of wind turbines near aeronautical radio stations, Civil Aviation Authority, CAA Paper 99002, 1999
6. ETSU, Feasibility of mitigating the effects of wind farms on primary radar, ETSU W/14/00623/REP, 2003
7. Dabis, HS, The establishment of guidelines for the installation of wind turbines near radio systems, Proceedings of the eighteenth BWEA Wind Energy Conference, 1996
8. FES, Wind farms impact on aviation interests – final report, FES W/16/00614/00/REP, 2003
9. S Vila-Moreno, A Methodology to Assess Interference to TV Reception due to Wind Farms, RES, 2005

The two Dabis papers describe a method for determining the likely interference from a WTG based on it behaving like a reflector. This methodology is generally used for interference predictions. The methodology in these papers does not address the significant increase in the level of interference observed when the WTG is on the direct path between transmitter and receiver and in addition a method for accounting for multiple WTGs is not provided.

The ITU-R BT805 paper is quite useful and applies to a single WTG. It suggests:

- A CIR in excess of 28-34 dB is required to attain a good analogue picture quality having impairment grade 4 or above.
- Interference levels directly behind the WTG are 10dB higher than interference levels to the side of the WTG.
- Interference levels in flat terrain are unlikely at distances of more than 500m from the WTG site.
- Investigation of interference levels is not required at distances of more than 5km from the site.
- The paper refers to the ratio of the wanted signal to the unwanted signal which the Dabis papers refer to as CI Ratio. This document uses the term CI Ratio or CIR.

Radar studies have shown that reflected or scattered signals are much stronger immediately beyond the WTG. This is normally accounted for in interference calculations by using a higher RCS for scenarios where the WTG lies between transmitter and receiver.

The RES document describes a similar approach but includes a method for accounting for the effects of multiple WTGs by summing the unwanted reflected signals (absolute not decibel). The RES document also suggests:

- a study area of 20km x 20km centered on the wind farm
- allowing for a standard receiving antenna characteristic

- summing unwanted signals directly
- a CIR threshold of 10db – Interference being likely when CIR is less than 10dB.

ANNEX B – DETAILED SURVEY RESULTS

Overview

Baseline reception survey results are presented in the following section.

Location 1

Knockmore Main Transmitter: (GPS coordinates: NJ 55408 65983 +/- 9ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.1-25.2	-	DND[9]	
23	BBC A	25.1-25.2	-	DND	
29	BBC B	25.4-25.5	-	DND	
53	Arqiva B	25.6-25.9	-	DND	
57	SDN	25.8-25.9	-	DND	
60-	Digital 3&4	25.7-25.8	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	25.3-25.4	-	DND	
24	BBC A	24.9-25.0	-	DND	
21+	BBC B	25.4-25.5	-	DND	
30-	Arqiva B	25.7-25.8	-	DND	
59	SDN	25.9-26.0	-	DND	
55	Digital 3&4	25.8-25.9	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 40	Fine
Digital	Up to 20	Fine

[9] **Did not decode.**

Location 2

Knockmore Main Transmitter: (GPS coordinates: NJ 59061 65979 +/- 27ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.1-25.2	-	DND	
23	BBC A	25.0-25.1	-	DND	
29	BBC B	25.4-25.5	-	DND	
53	Arqiva B	25.7-25.8	-	DND	
57	SDN	25.8-25.9	-	DND	
60-	Digital 3&4	25.8-25.9	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	58.2-58.5	1*10-9	Fine	Fine
24	BBC A	55.6-55.8	1*10-7	Fine	Fine
21+	BBC B	56.2-56.5	0%	Fine	Fine
30-	Arqiva B	25.6-25.8	-	DND	
59	SDN	26.0-26.2	-	DND	
55	Digital 3&4	26.2	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 30	Fine
Digital	Up to 30	Fine

Location 3

Knockmore Main Transmitter: (GPS coordinates: NJ 65709 65330 +/- 29ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.3-25.4	-	DND	
23	BBC A	25.0-25.1	-	DND	
29	BBC B	25.6-25.7	-	DND	
53	Arqiva B	25.8-25.9	-	DND	
57	SDN	26.0-26.1	-	DND	
60-	Digital 3&4	26.0-26.1	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	56.7-26.8	1*10-7	Fine	Fine
24	BBC A	56.5-56.5	1*10-7	Fine	Fine
21+	BBC B	55.8-55.9	0%	Fine	Fine
30-	Arqiva B	25.6-25.7	-	DND	
59	SDN	25.9-26.1	-	DND	
55	Digital 3&4	26.0-26.1	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 40	Fine
Digital	Up to 30	Fine

Location 4

Knockmore Main Transmitter: (GPS coordinates: NJ 68903 63752 +/- 14ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.6-25.7	-	DND	
23	BBC A	25.5-25.6	-	DND	
29	BBC B	25.8-25.9	-	DND	
53	Arqiva B	26.0-26.1	-	DND	
57	SDN	26.2-26.3	-	DND	
60-	Digital 3&4	26.2-26.3	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	25.6-25.7	-	DND	
24	BBC A	25.5-25.6	-	DND	
21+	BBC B	25.1-25.2	-	DND	
30-	Arqiva B	25.6-25.7	-	DND	
59	SDN	26.1-26.2	-	DND	
55	Digital 3&4	26.0-26.3	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 30	Fine
Digital	Up to 20	Fine

Location 5

Knockmore Main Transmitter: (GPS coordinates: NJ 70860 64216 +/- 10ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.5-25.6	-	DND	
23	BBC A	25.2-25.4	-	DND	
29	BBC B	26.0-26.1	-	DND	
53	Arqiva B	26.0-26.1	-	DND	
57	SDN	26.1-26.2	-	DND	
60-	Digital 3&4	26.2-26.3	-	DND	

Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	42.9-43.1	1*10-7	Fine	Fine
24	BBC A	45.6-46.0	1*10-8	Fine	Fine
21+	BBC B	41.0-41.3	0%	Fine	Fine
30-	Arqiva B	25.5-25.6	-	DND	
59	SDN	25.9-26.0	-	DND	
55	Digital 3&4	25.9-26.0	-	DND	

Radio	**Signal Strength (dBµV)**	**Sound**
Analogue	Up to 20	Fine
Digital	Up to 20	Fine

Location 6

Knockmore Main Transmitter: (GPS coordinates: NJ 80202 64653 +/- 12 ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.5-25.6	-	DND	
23	BBC A	25.1-25.2	-	DND	
29	BBC B	27-32	-	DND	
53	Arqiva B	25.9-26.0	-	DND	
57	SDN	26.0-26.1	-	DND	
60-	Digital 3&4	26.0-26.1	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	40-50	Fluctuations caused large variations	Picture fine with some pixilation. Sound fine.	
24	BBC A	40-50		Fine but stuttered on occasion. Sound fine.	
21+	BBC B	40-50		Decoded but stopped.	
30-	Arqiva B	25.7-25.8	-	DND	
59	SDN	26.0-26.1	-	DND	
55	Digital 3&4	26.0-26.1	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 30	Fine
Digital	Up to 30	Fine

Location 7

Knockmore Main Transmitter: (GPS coordinates: NJ 88437 63088 +/- 21ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.4-25.5	-	DND	
23	BBC A	25.1-25.2	-	DND	
29	BBC B	25.4-25.5	-	DND	
53	Arqiva B	25.9-26.0	-	DND	
57	SDN	26.0-26.1	-	DND	
60-	Digital 3&4	26.1-26.2	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	42.6-42.8	1*10-7	Fine	Fine
24	BBC A	41.8-42.0	4*10-8	Fine	Fine
21+	BBC B	41.0-43.0	0%	Fine	Fine
30-	Arqiva B	25.6-25.7	-	DND	
59	SDN	26.1-26.2	-	DND	
55	Digital 3&4	26.0-26.1	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 30	Fine
Digital	Up to 30	Fine

Location 8

Knockmore Main Transmitter: (GPS coordinates: NJ 93052 67265 +/- 9ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.6-25.7	-	DND	
23	BBC A	25.3-25.4	-	DND	
29	BBC B	25.7-25.8	-	DND	
53	Arqiva B	26.0-26.1	-	DND	
57	SDN	26.1-26.3	-	DND	
60-	Digital 3&4	26.1-26.2	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	29.4-29.7	-	DND	
24	BBC A	29.6-29.8	-	DND	
21+	BBC B	27.4-27.5	-	DND	
30-	Arqiva B	25.5-25.6	-	DND	
59	SDN	26.1-26.2	-	DND	
55	Digital 3&4	26.1-26.2	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 20	Fine
Digital	Up to 32	Fine

Location 9

Knockmore Main Transmitter: (GPS coordinates: NJ 99712 66726 +/- 42ft)					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
26	Arqiva A	25.3-25.4	-	DND	
23	BBC A	25.2-25.3	-	DND	
29	BBC B	25.4-25.5	-	DND	
53	Arqiva B	26.0-26.1	-	DND	
57	SDN	26.1-26.2	-	DND	
60-	Digital 3&4	26.1-26.2	-	DND	

Rumster Forest Main Transmitter					
Channel	**Service**	**Signal Strength (dBµV)**	**BER**	**Picture**	**Sound**
27	Arqiva A	25.4-25.5	-	DND	
24	BBC A	25.1-25.2	-	DND	
21+	BBC B	24.8-24.9	-	DND	
30-	Arqiva B	25.4-25.5	-	DND	
59	SDN	25.8-25.9	-	DND	
55	Digital 3&4	25.8-25.9	-	DND	

Radio	Signal Strength (dBµV)	Sound
Analogue	Up to 20	Fine
Digital	Up to 20	Fine

ANNEX C – SURVEY PHOTOS

Overview

The survey photos taken at each survey location are presented on the following pages.

Location 1

Location 2

Location 3


PAGERPOWER
Urban & Renewables


PAGERPOWER
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Location 4


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Location 5


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PAGERPOWER
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Location 6

Location 7

Location 8


PAGERPOWER
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