Rampion Offshore Wind Farm

ES Section 27 – Noise

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27 NOISE AND VIBRATION

27.1 Introduction

27.1.1 This section of the Environmental Statement (ES) assesses the potential noise and vibration impacts of the proposed Rampion Offshore Wind Farm (the Project) at onshore receptors. The assessment identifies, establishes and quantifies the expected noise emissions associated with the construction of the onshore cable route, and the construction and operation of the onshore substation. The assessment is based upon the results of baseline noise monitoring and predictive calculations of the noise impact. The potential for noise impacts at onshore receptors as a result of the operation of the offshore turbines is also addressed.

27.2 Legislation and Policy Context

27.2.1 National Policy Statements (NPS) provide the primary basis on which the Secretary of State is required to make its decisions. The specific assessment requirements for noise, as detailed within the NPSs are set out below.

27.2.2 EN-1 sets out NPS for energy infrastructure. In relation to noise and vibration, Sections 5.11.4 to 5.11.7 of the NPS state that, *"where noise impacts are likely to arise, the applicant should include:*

- *"A description of the noise generating aspects of the development proposal leading to noise impacts including the identification of any distinctive tonal, impulsive or low frequency characteristics of the noise;*
- *Identification of noise sensitive premises and noise sensitive areas that may be affected;*
- *The characteristics of the existing noise environment;*
- *A prediction of how the noise environment will change with the proposed development;*
- *In the shorter term such as during the construction period;*
- *In the longer term during the operating life of the infrastructure;*
- *At particular times of the day, evening and night as appropriate;*
- *An assessment of the effect of predicted changes in the noise environment on any noise sensitive premises and noise sensitive area; and*
- *Measures to be employed in mitigating noise".*

27.2.3 The NPS also states that:

27.2.4 *“The nature and extent of the noise assessment should be proportionate to the likely noise impact” and “The noise impact of ancillary activities associated with the development, such as increased road and rail traffic movements, or other forms of transportation, should also be considered.*

"Operational noise, with respect to human receptors, should be assessed using the principles of the relevant British Standards and other guidance. Further information on assessment of particular noise sources may be contained in the technology-specific NPSs. In particular, for renewables (EN-3) and electricity networks (EN-5) there is assessment guidance for specific features of those technologies. For the prediction, assessment and management of construction noise, reference should be made to any relevant British Standards and other guidance which also give examples of mitigation strategies.”

27.2.5 The National Planning Policy Framework (NPPF) (published March 2012) has replaced Planning Policy Guidance (including PPG 24: Planning and Noise) as the means by which noise is considered within the planning regime. The NPPF does not contain assessment criteria, instead providing a series of policies, giving local authorities the flexibility in meeting the needs of local communities. A summary of the pertinent paragraphs is presented in Section 4 (Planning Policy Context).

27.2.6 The use of various British Standard methodologies for noise assessments have been incorporated in this assessment as follows:

BS 7445: 2003 - Description and measurement of environmental noise - guide to quantities and procedures.

27.2.7 BS 7445 provides the framework within which environmental noise should be quantified. Part 1 provides a guide to quantities and procedures and Part 2, a guide to the acquisition of data pertinent to land use. Part 3 provides a guide to the application of noise limits. The standard also refers to BS EN 61672, which prescribes the equipment necessary for such measurements.

BS 5228-1: 2009 - Calculation for noise from open and construction sites - Part 1: Noise

27.2.8 Construction noise impacts arising from equipment, vehicular movements and processes related to the construction phase of a development are assessed by calculating the change in ambient noise level (LAeq,1hr) resulting from such processes with methods described in BS5228-1.

27.2.9 The assessment predicts noise emissions from various construction activities, which are then compared against background noise levels at residential receptors. Full details of the process are contained in Annex E of the standard.

27.2.10 Annex E of the standard also provides criteria for the assessment of significance. Exceedances of threshold levels trigger a responsibility on the developer to provide noise insulation or a scheme to facilitate temporary rehousing. The standard suggests that noise insulation should be provided if trigger levels are predicted to be exceeded for a period of ten or more days of working in any fifteen consecutive days, or for a total of days exceeding 40 in any 6 month period.

BS 5228-2:2009 - Calculation for noise from open and construction sites - Part 2: Vibration

27.2.11 BS 5228 describes methods of mitigation that can be employed for construction ground-borne vibration and provides historical library data of vibration levels measured during various activities on various ground types.

27.2.12 Table 27.1 (Table B.1 from BS 5228-2) gives the likely response to various Peak Particle Velocity (PPV) vibration levels.

Table 27.1: Typical human response to different PPV levels

Vibration Level	Effect
0.14 mms-1	Vibration might just be perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mms-1	Vibration might just be perceptible in residential environments.
1.0 mms-1	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents
10 mms-1	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

27.2.13 BS 5228-2 reiterates the transient vibration guide values in the 4 – 15Hz and 15Hz and above frequency bands that lead to cosmetic damage of BS 7385. BS 5228-2 also discusses the assessment of the vulnerability of ground-related structures and services concluding that a maximum PPV for intermittent or transient vibration of 30mms^{-1} and a maximum PPV for continuous vibration of 15mms^{-1}. BS 5228 also discusses the vulnerability of building contents and activities within buildings to vibration, concluding that they too should be assessed on an individual basis.

Calculation of Road Traffic Noise (CRTN) & Design Manual for Roads and Bridges (DMRB)

27.2.14 The CRTN produced by the Department of Transport / Welsh Office provides a method for the prediction of noise from road traffic. The Highways Agency Design Manual for Roads and Bridges, Volume 11, Section 3, Part 7 Had 213/11 Noise and Vibration, provides guidance on the assessment of noise impacts from roads and contains guidance for assessing the likely impact of noise generated by road traffic. The criteria from DMRB for short term effects have been used in the assessment of changes to traffic noise as a result of proposed construction Heavy Goods Vehicle (HGV) traffic.

BS 4142: 1997 - Method for rating industrial noise affecting mixed residential and industrial areas

27.2.15 BS 4142 provides a methodology for assessing industrial noise against ambient background noise levels. A 'rating penalty' of 5dB is added to the industrial noise if it contains characteristics that are likely to increase the potential for it to cause annoyance. Such characteristics could include impulses (e.g. bangs/crashes) or tonal components (e.g. hums/whistles etc). Noise from electricity infrastructure can contain tonal components (the "mains hum"). As such a rating penalty has been applied to noise levels assessed.

27.2.16 Comparison of the difference between the industrial noise level including any rating penalty (the rating level) and the background noise level indicates the likelihood of complaint. The greater the difference, the greater the likelihood of complaints arising.

- A difference of around +10dB or more indicates that complaints are likely.
- A difference of around +5dB is of marginal significance.
- A difference of -10dB indicates that complaints are unlikely.

27.2.17 BS 4142 is not suitable for use in situations where both the industrial noise and the background noise are very low (below 35 and 30dB(A) respectively). Where this occurs, a suitable alternative assessment method (such as criteria based on World Health Organisation (WHO) guidelines) should be utilised.

WHO Night Noise Guidelines for Europe (NNG)

27.2.18 Sleep is an essential part of healthy life and is recognised as a fundamental right under the European Convention on Human Rights. The report provides guidelines and recommendations for health protection. For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than $L_{night,outside}$ = 40dB during the part of the night when most people are in bed.

27.2.19 For the purposes of assessing plant sound levels at receptor locations, as BS 4142 would be considered appropriate should plant rating noise levels at residential receptors be greater than 35dB(A) (including a tonal penalty) the effect of noise would be considered significant should plant noise at receptor be predicted to exceed 35dB(A). A level of 35dB(A) would also be within WHO recommended guidelines for night-time noise.

ETSU-R-97

27.2.20 ETSU-R-97 'The assessment and rating of noise from wind farms' is used for the assessment of onshore wind farms. However, it is also the most appropriate guidance for assessing noise from the offshore turbines at onshore receptors.

27.2.21 In general terms, ETSU-R-97 states that turbine noise levels should be limited to 5dB(A) above the prevailing background noise at each wind speed, subject to minimum limits of 35dB(A) and 43dB(A) during the day and night respectively.

27.2.22 Noise limit curves are derived based on background noise measurements taken under a variety of wind conditions. If it can be demonstrated that turbine noise levels will be below 35dB(A) at a wind speed of 10m/s, it can be concluded that there is no potential for noise from the turbines to give rise to impacts at onshore receptors.

Local Policy Planning Framework

27.2.23 Local and Development Plans for the local authorities within the scope of this assessment include planning policies for the protection against noise effects. These policies are referenced in Section 4 (Planning Policy Context).

27.3 Assessment Methodology

Scoping

27.3.1 As part of the scoping phase of the Environmental Impact Assessment (EIA), a Scoping Report (E.ON/RSK, September 2010) was prepared to set out the proposed approach to EIA in respect of the proposed development, including the identification of assessment methodologies for each of the EIA topic areas to be assessed. The Scoping Report was submitted to the infrastructure Planning Commission (IPC) in September 2010. A Scoping Opinion (IPC, October 2010) was received from the IPC in October 2010 incorporating comments from a wide range of consultees. A copy of the Scoping Report and Scoping Opinion including consultee comments are included in Appendix 5.1 and 5.2.

27.3.2 The information and advice received during the scoping process with regard to noise and vibration issues is summarised in Table 27.2.

Table 27.2: Relevant scoping responses

Date	Consultee	Summary scoping response	Where addressed
11/10/2010 & 12/10/2010	Adur District Council	EIA to include assessment of noise on land from the wind turbines. Noise from offshore construction including construction of turbines and cabling to be assessed.	Turbine Noise: Paragraphs 27.5.34-27.5.38 Offshore construction noise: Paragraphs 27.5.20-27.5.22 Cable Route Construction: Paragraphs 27.5.5- 26.5.13
12/10/2010	Brighton and Hove City Council	There is evidence to suggest off shore wind farms create low frequency noise which is able to travel long distances. The potential for offshore noise should be considered using a variety of approaches including but not limited to: EN 61400-11:2003 BS 4142:1997 ETSU –R-97 Offshore noise from construction should also be considered. In the past the construction of other offshore wind farms has attracted complaints.	Turbine Noise: Paragraphs 27.5.34-27.5.38 Offshore construction noise: Paragraphs 27.5.20-27.5.22
October 2010	IPC	Refer to comments made by above councils. Request that following are considered: • Noise along public roads and Public Rights of Way; • Vibration caused by abnormal loads; • Noise disturbance at night and other unsocial times such as weekends and public holidays; • The monitoring of noise complaints; • Noise and vibration in terms of the offshore environment.	Paragraphs 27.5.23 – 27.5.27 Predicted Impacts Section 27.5 Mitigation Measures Section 27.6 Offshore construction noise: Paragraphs 27.5.20-27.5.22

27.3.3 The Environmental Health Officer (EHO) for Mid Sussex District Council was contacted with regard to the noise monitoring locations along the cable route and close to the substation in September 2011. An email confirming agreement of these locations was received from the EHO in October 2011.

27.3.4 The scope of the assessment was modified accordingly to take account of the above consultee responses and the opinions of the IPC, the findings of which were reported in the Draft ES.

Formal Pre-application Consultation

27.3.5 As detailed in Section 5 – EIA Methodology, an extensive programme of engagement has been undertaken with regard to the Project, details of which are provided in the Consultation Report (Document 5.1). This included publication of the Draft ES as part of the Section 42 and Section 48 consultation in June 2012.

27.3.6 Following review of consultee feedback on the Draft ES, discussions with consultees and updated technical information, the following modifications have been made to the Project and overall assessment scope:

- The 'Legislation and Policy Context' Section 27.2 has been updated to include the Design Manual For Roads and Bridges and the Calculation of Road Traffic Noise. In addition, the consideration of significance when noise levels are considered very low as described in BS 4142 has been clarified.

- A criterion for the assessment of traffic noise changes taken from DMRB has been added to Section 27.3 'Assessment Methodology'.

- Further description of the existing noise environment has been included within Section 27.4 'Environmental Baseline'.

- Further discussion has been added to the assessment of offshore piling within Section 27.5 to explain that the piling would be inaudible at rural locations based on met mast piling noise measurements. An additional assessment has been added presenting a maximum sound power level for piling equipment to ensure onshore inaudibility of wind turbine piling.

- An assessment of traffic noise based on CRTN predictions and short-term DMRB criterion has replaced the previous assessment in Section 27.5, previously based only on substation construction traffic.

- Further to receiving additional information from project engineers, additional plant items (cooling radiators) have been used within predictions and Auxiliary Transformer noise has been increased to match Super Grid Transformers. The indicative spectrum data for the substation plant equipment has been included within the report. These changes have resulted in changed noise levels at receptor locations within Section 27.5. Noise contour plans have been amended with a smaller scale in order to include noise levels at all identified receptor points (Figure 27.4 and Figure 27.6).

- Several new options of offshore turbine layouts have been modelled and assessed within Section 27.5 including numerical predictions for residential and quiet leisure locations at the shoreline. A noise contour plan has been presented for the worst-case wind turbine layout Option B (Figure 27.5).

- A prediction and assessment for the offshore substation has been included within Section 27.5.

- Further discussion has been added to the Cumulative Assessment Section 27.8 incorporating noise from the construction and operation of additional plant at the existing Bolney substation.

- Appendix 27.2 has been updated to include co-ordinates for measurement points, condition of the sea during the noise survey, additional information on offshore piling noise measurements and clarification of Table 3.2.

- Computer noise modelling inputs have been presented in Appendix 27.3.

27.3.7 Full details of the consultation process and associated responses are documented in Document 5.1 (Consultation Report).

Establishment of Baseline Environment

27.3.8 A noise survey was undertaken at various locations along the proposed cable route and around the proposed substation site options between 29 February and 2 March 2012 during day and night-time periods.

27.3.9 Monitoring locations were selected to measure the ambient noise levels at sensitive human receptors that might be exposed to the noise from the construction of the onshore cabling work and the operation of the proposed onshore substation. Baseline methodology and monitoring locations were agreed with the Local Authority Environmental Health Department. Monitoring locations are presented on Figure 27.1 and Figure 27.2 and are listed in Table 27.3.

Table 27.3: Noise monitoring locations

Location	Town	Description
P 1	East Worthing	Between the east of the residential properties Seamill Park Crescent and Brooklands golf club, away from Brooklands Go Kart Circuit
P 2		At the end of St Pauls avenue (foot path)
P 3	Broadwater	At the end of Bramber Road (foot path)
P 4	Sompting	North of Titch Hill farm, at the entrance of Lychpole Farm
P 5	Coombes	Coombes Road, the west of the River Adur
P 6	Adburton	The top of Mill Hill, West Sussex
P 7	Small Dole	Oreham common, away from Horn lane
P 8	Woodmancote	To the west of Henfield Lodge
P 9	Blackstone	Twineham Lane

Location	Town	Description
P 10	Twineham	Wineham Lane, to the west of the existing Bolney substation
P 11		Further north on Wineham Lane
P 12		Bob Lane, to the east of the existing Bolney substation

27.3.10 Sound level measurements were made with the following equipment:

- Norsonic Nor-140 (serial number 1402810) with pre-amplifier and microphone protected by foam windshield; and
- Cirrus acoustic calibrator type 1251, serial number 037732.

27.3.11 Measurements were taken in free-field conditions, i.e. 1.5m above the ground and away from reflective building facades. The microphones were fitted with foam windshields to protect against extraneous wind noise. Weather conditions at the time of the survey were considered as suitable conditions for an environmental noise survey, being dry, sunny with light wind and clear sky.

27.3.12 Calibration checks for the sound level meters were made before and after each measurement using the acoustic calibrator. No significant calibration drift was noted.

27.3.13 The sound level meters used conform to the requirements of BS EN 61672-1: 2003 Electroacoustics, Sound level meters, Specifications. The calibrator used conforms to the requirements of BS EN 60942: 2003 Electroacoustics, Sound calibrators. The equipment used has a calibration history that is traceable to a certified calibration institution. Calibration certification for equipment used in the survey can be found in Appendix 27.1.

Prediction of construction and decommissioning noise impacts

27.3.14 Construction phase noise impacts arising from equipment, vehicular movements and processes have the potential for a short-term impact on noise sensitive receptors in the vicinity of the construction site. The impact is assessed by calculating the change in ambient noise level (LAeq,1hr) as a result of construction works. An example method for assessing the criteria of noise from construction activities is provided within Annex E of BS 5228-1 and described with small amendments as below. Minor changes have been made to the start of the evening Saturday period (from 13:00 to 14:00) and start of the night period (from 23:00 to 22:00) of the threshold values within the associated table of BS 5228-1 to be in line with the trigger levels as presented in Table 27.5.

27.3.15 A significant effect has been deemed to occur if the total LAeq noise level, including construction, exceeds the threshold levels presented in Table 27.4 for the category appropriate to the ambient noise level. It is considered that a significant effect would occur if the increase in total noise levels is more than 3dB above the ambient noise, should this resultant level be above threshold values.

Table 27.4: Example threshold of significant effect at dwellings

Assessment category and threshold value period (LAeq)	Threshold value, in decibels (dB)		
	Category A A)	Category B B)	Category C C)
Night-time (22.00−07.00)	45	50	55
Evenings and weekends D)	55	60	65
Daytime (07.00−19.00) and Saturdays (07.00−14.00)	65	70	75

A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are less than these values.

B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are the same as Category A values.

C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5 dB) are higher than Category A values.

D) 19.00–22.00 weekdays, 14.00–22.00 Saturdays and 07.00–22.00 Sundays.

27.3.16 Annex E of BS 5228-1 continues by providing criteria for the assessment of significance. Exceedances of noise levels presented in Table 27.5 below trigger a responsibility to provide noise insulation or temporary rehousing if levels are exceeded for a period of ten or more days of working in any fifteen consecutive days or for a total of days exceeding 40 in any 6 month period.

Table 27.5: Noise levels applicable to eligibility for noise insulation

Time	Relevant Time Period	Averaging time, *T*	Noise trigger level dB $L_{Aeq,T}$ 1)
Monday to Friday	07.00 – 08.00	1 h	70
	08.00 – 18.00	10 h	75
	18.00 – 19.00	1 h	70
	19.00 – 22.00	3 h	65
	22.00 – 07.00	1 h	55
Saturday	07.00 – 08.00	1 h	70
	08.00 – 13.00	5 h	75
	13.00 – 14.00	1 h	70
	14.00 – 22.00	3 h	65
	22.00 – 07.00	1 h	55
Sunday & Public Holidays	07.00 – 21.00	1 h	65
	21.00 – 07.00	1 h	55

Time	Relevant Time Period	Averaging time, *T*	Noise trigger level dB $L_{Aeq, T}$ 1)
Note 1) Equivalent continuous A-weighted noise level predicted or measured at a point 1m in front of the most exposed windows or doors leading directly to a habitable room (living room or bedroom) in an eligible dwelling.			

Prediction of operation noise impacts

27.3.17 Noise levels from the proposed substation site have been assessed at the locations shown on Figure 27.2 and set out below. Baseline noise measurements have been used to establish background levels in these locations. Where these receptor locations are also very close to monitoring points, these are shown in brackets.

- R1 Twineham Court Farm;
- R2 The Coach House;
- R3 Coombe Farm (P12);
- R4 Coombe House;
- R5 Dawe's Farm;
- R6 Eastridge Lodge (P11);
- R7 Westridge Place; and
- R8 Residence to west (P10); and
- R9 Woodpeckers / Downsview (P12).

27.3.18 Predictions for the substation have been undertaken using CadnaA computer noise modeling software, which incorporates prediction methodology in ISO 9613:1996 *'Acoustics - Attenuation of sound during propagation outdoors'*.

27.3.19 CadnaA noise software has been used to predict noise levels from the offshore wind turbine options at wind speeds of 10m/s. Predications have been calculated at receptors across the shoreline including urban and rural locations. An assessment has been undertaken based on the absolute level of 35dB(A) as considered appropriate protection of amenity by ETSU-R-97.

27.3.20 A conservative calculation has been made of offshore substation noise with reference to distance attenuation, downwind conditions, a conservative assumption of air absorption attenuation and taking into account sound reflection from the water. Predicted noise from the offshore substations has been assessed at the closest onshore location.

Identification and Assessment of Impacts and Mitigation Measures

27.3.21 The magnitude of a noise impact has been assessed using the criteria set out in Table 27.6.

Table 27.6: Impact magnitude

Potential Impact	Negligible	Minor	Moderate	Major
Noise from construction	Less than BS 5228 significance criteria	Above the BS 5228 significance criteria for less than one month	Noise levels and duration exceed BS 5228 significance criteria for more than 1 month	Noise levels and duration exceed 'noise mitigation eligibility' criteria of BS 5228
Noise from construction traffic	0.1-0.9dB Short-term change in traffic noise level $L_{A10,18hr}$	1-2.9dB Short-term change in traffic noise level $L_{A10,18hr}$	3-4.9dB Short-term change in traffic noise level $L_{A10,18hr}$	>5dB Short-term change in traffic noise level $L_{A10,18hr}$
Vibration from construction	Vibration undetectable by humans (as defined by BS 5228)	Vibration just detectable but not intrusive (as defined by BS 5228)	Vibration levels likely to lead to complaint (as defined by BS 5228)	Vibration levels intolerable (as defined by BS 5228)
Noise from operation of substations	Noise level more than 10dB(A) below existing background	Noise level less than 'Marginal significance' as defined by BS 4142 or no more than 35dB(A) if background noise levels considered 'very low'	Noise level between 'Marginal Significance' and 'complaints likely' as defined by BS 4142 or > 35dB(A) if background noise levels considered 'very low'	Noise level exceeds 'complaints likely' criteria as defined by BS 4142
Onshore noise from turbines	Turbine noise imperceptible	Turbine noise level below 35dB(A)	Turbine noise level between 35dB(A) and 43dB(A).	Turbine noise level above 43dB(A)

27.3.22 While other types of receptor are considered, such as users of beaches and green spaces, this assessment focuses on residential receptors, considered to be the most sensitive receptor type, and therefore the sensitivity for all receptors identified are considered equal. As a result the significance of effect is only related to magnitude and not cross-referenced with sensitivity.

27.3.23 The significance of a noise impact has been assessed using the criteria set out in Table 27.7.

Table 27.7: Significance of Effect

Potential Impact	Not Significant	Significant
Noise from construction	Negligible or minor effect	Moderate or major effect
Noise from construction traffic	Negligible or minor effect	Moderate or major effect
Noise from operation of substation components	Negligible or minor effect	Moderate or major effect
Vibration from construction	Negligible or minor effect	Moderate or major effect
Onshore noise from turbines	Negligible or minor effect	Moderate or major effect

Uncertainty and Technical Difficulties Encountered

27.3.24 The noise emission levels, both for the construction and operational phases, are based on assumptions, as a detailed design of the scheme is not yet available. Where uncertainties exist, worst-case assumptions have been made, and as a result impacts may be slightly overstated.

27.4 Environmental Baseline

27.4.1 Attended measurements were undertaken at selected monitoring locations during day and night time periods and the results of measurements are summarised in Table 27.8.

Table 27.8: Summary of measurements

Period	Location	Date	Time	Duration	$L_{Aeq, T}$ dB	$L_{A90, T}$ dB	Dominant noise source
Day	P 1	01/03/12	11:19	00:15:02	50.6	45.5	Distant road traffic noise
	P 2	01/03/12	11:45	00:15:00	50.8	41.0	Road traffic noise, bird song, dogs barking
	P 3	01/03/12	12:17	00:15:00	46.4	42.6	Road traffic noise, bird song, dogs barking
	P 4	01/03/12	12:49	00:15:00	60.6	35.7	Distant farming noise and road traffic noise
	P 5	01/03/12	15:11	00:15:00	55.7	40.3	Livestock
	P 6	01/03/12	15:53	00:15:00	47.3	34.7	Bird song
	P 7	01/03/12	16:43	00:16:03	46.2	40.0	Distant farming noise and road traffic noise
	P 8	01/03/12	17:26	00:15:00	43.5	35.8	Distant road traffic noise and bird song
	P 9	29/02/12	17:41	00:15:00	62.1	41.8	Road traffic noise
	P 10	29/02/12	15:50	00:15:00	63.7	43.8	Bird song and construction noise from the existing site just audible
	P 11	29/02/12	16:28	00:15:00	64.2	41.7	Road traffic noise and bird song
	P 12	29/02/12	16:58	00:15:00	54.8	37.6	Road traffic noise and bird song
Night	P 1	02/03/12	02:04	00:15:00	43.0	41.3	Distant road traffic noise
	P 2	02/03/12	02:27	00:15:00	39.5	37.3	Distant road traffic noise
	P 3	02/03/12	02:52	00:15:00	48.2	37.5	Distant road traffic noise
	P 4	-	-	-	-	-	-
	P 5	02/03/12	03:21	00:15:00	42.6	34.2	Distant road traffic noise
	P 6	-	-	-	-	-	-
	P 7	29/02/12	23:42	00:12:32	35.3	30.5	Distanced Road traffic noise
	P 8	01/03/12	00:31	00:15:00	52.8	30.5	Road traffic noise
	P 9	01/03/12	01:13	00:15:00	34.2	28.6	Distanced Road traffic noise and bird song
	P 10	01/03/12	02:14	00:15:00	34.2	31.9	Noise from electric cable (pylon)
	P 11	01/03/12	01:48	00:13:17	33.5	30.4	Operational noise from the existing site just audible
	P 12	01/03/12	02:37	00:15:00	34.9	29.3	Distant road noise

27.4.2 The general noise climate at sensitive receptors along the proposed cable route and around the proposed substation are affected by road traffic noise and animal noise (bird song, dogs barking and livestock).

27.4.3 The ambient noise levels (LAeq) in the area along the proposed cable route are in the range of 44dB(A) to 65dB(A) during day time.

27.4.4 The ambient noise levels in the area along the proposed cable route are in the range of 34dB(A) to 53dB(A) during night time.

27.4.5 The dominant noise sources affecting the monitoring locations are the noise from the adjacent roads, house stock and nature (i.e. bird song).

27.4.6 For the purpose of the BS 5228 assessment the lowest ambient noise levels, LAeq, measured at monitoring locations are 44dB(A) and 35dB(A) for day and night time periods at sensitive receptors along the cable route, and 55dB(A) and 34dB(A) for day and night time periods at sensitive receptors around the proposed substation. The lowest target threshold levels of 65dB(A) and 45dB(A) for day and night time (from Table 27.4 Category A) have been used for the assessment as a 'worst-case' for both cable trenching works and the construction of the substation. Target threshold values for the purposes of assessing HDD works are identified on a site specific basis.

27.4.7 The background noise levels in the area surrounding the substation site are in the range of 29dB(A) to 32dB(A) during the night time.

27.5 Predicted Impacts

Rochdale Envelope Principles

27.5.1 In line with the use of the "Rochdale Envelope" (see Section 5 – EIA Methodology), the assessment in this section has been based on a development scenario, which is considered to be the worst case in terms of noise emissions. Rochdale Envelope principles relating to noise relate to the noise emissions associated with the entire Project.

Onshore Cable Route & Onshore Substation

27.5.2 Worst-case construction noise levels have been assumed for each aspect of cabling construction works as detailed in Section 27.5.7. For substation construction, it has been assumed that all of the plant is operating on the closest part of the site to the receptor as a worst case.

27.5.3 For substation operation, maximum sound power levels for major equipment within the proposed substation have been assumed as a worst case as detailed in Table 27.17. In addition, the assessment has assumed that all plant is operating continuously.

Onshore Wind Farm

27.5.4 For turbine operation, eight indicative turbine layouts have been assessed as part of the Rochdale Envelope for the Project and these are presented in Section 2a: Project Description (Offshore). Turbine layout option B has been adopted as the worst case scenario in terms of noise at onshore receptors.

Construction

Construction noise – Cable Route

27.5.5 Equipment likely to be used during cabling construction work has been assumed for activities based on information provided as set out in Table 27.9. The noise level data has been taken from Annex C of BS 5228-1: 2009. All sound pressure levels are given at a distance of 10m from the measured plant.

Table 27.9: Noise levels of construction equipment - cabling

Activity	Plant	No#	BS 5228 ref.	Operational hours	A-weighted SPL dB(A) at 10m
Topsoil strip	Tracked excavator (22t)	2	C.2.3	90 %	73
	Dozer	3	C.2.1	90 %	75
Construction of temporary site access road	Wheeled backhoe loader (8t)	1	C. 2.8	90 %	68
	Dumper (5t)	2	C. 4.7	90 %	78
	Vibratory roller (3t)	1	C. 2.40	90 %	73
Trench excavation	Tracked excavator (16t)	1	C. 2.5	90 %	76
	Tracked mobile crane	1	C.3.29	90 %	70
	Sheet Piling – Hydraulic jacking	1	C.3.9	90 %	63
	Power Pack	1	C.3.10	90 %	68
Duct work	Side boom (Use tracked mobile crane data)	3	C.3.28	90 %	67
	Water pump	1	C. 4.88	90 %	68
	Wheeled backhoe loader (8t)	1	C. 2.8	90 %	68
Backfilling trench	Wheeled backhoe loader (8t)	1	C. 2.8	90 %	68
	Tracked excavator (16t).	1	C. 2.5	90 %	76
	Dumper (5t)	2	C. 4.7	90 %	78
	Vibratory roller (3t)	2	C. 2.40	90 %	73
Reinstatement	Dumper (5t)	2	C. 4.7	90 %	78
	Wheeled backhoe loader (8t)	1	C. 2.8	90 %	68
Cable pulling	Conveyor drive unit	1	C.10.20	90 %	77
	Field conveyor (rollers)	2	C.10.23	90 %	53
Horizontal Directional Drilling	Power Auger (Crawler Mounted Rig)	1	C.3.21	100 %	79

27.5.6 Noise levels at the sensitive receptors have been calculated according to the method presented within BS 5228. Noise propagation is affected by distance between the source and receiver, any noise screening and the duration of activity. For the purposes of predicting noise from cable construction work the following have been considered:

- Soft ground condition between source and receiver;
- No screening;
- The likely nearest distance from the sources to receptor; and
- Operational hours of equipment have been assumed as maximum uses.

27.5.7 Based upon the predicted plant type, number and percentage 'on-time' Table 27.10 to Table 27.12 provides calculated 'worst-case' construction noise levels for each aspect of cabling construction works in terms of distance from the works at distances of 20m, 50m, and 100m from the works respectively.

Table 27.10: Assessment of cable construction work – distance at 20m

Time period	Construction aspect	Predicted construction noise level dB(A)	Ambient noise level dB(A)	Combined noise level dB(A)	Target threshold level dB(A)	Increases over threshold dB
Day time	Topsoil strip	74.1	44	74.1	65	9
	Construction of temporary site access road	76.5		76.5		12
	Trench excavation	74.7		74.7		10
	Duct work	69.5		69.5		4
	Backfilling trench	78.1		78.1		13
	Reinstatement	75.4		75.4		10
	Cable pulling	74.0		74.0		9

Table 27.11: Assessment of cable construction work – distance at 50m

Time period	Construction aspect	Predicted construction noise level dB(A)	Ambient noise level dB(A)	Combined noise level dB(A)	Target threshold level dB(A)	Increases over threshold dB
Day time	Topsoil strip	64.2	44	64.2	65	-1
	Construction of temporary site access road	66.6		66.6		2
	Trench excavation	64.7		64.7		0
	Duct work	59.5		59.7		-5
	Backfilling trench	68.2		68.2		3
	Reinstatement	65.5		65.5		1

Time period	Construction aspect	Predicted construction noise level dB(A)	Ambient noise level dB(A)	Combined noise level dB(A)	Target threshold level dB(A)	Increases over threshold dB
	Cable pulling	64.1		64.1		-1

Table 27.12: Assessment of cable construction work – distance at 100m

Time period	Construction aspect	Predicted construction noise level dB(A)	Ambient noise level dB(A)	Combined noise level dB(A)	Target threshold level dB(A)	Increases over threshold dB
Day time	Topsoil strip	56.7	44	56.9	65	-8
	Construction of temporary site access road	59.1		59.2		-6
	Trench excavation	57.2		57.4		-8
	Duct work	52.0		52.6		-12
	Backfilling trench	60.7		60.7		-4
	Reinstatement	58.0		58.1		-7
	Cable pulling	56.6		56.8		-8

27.5.8 The results show that for the majority of receptors noise levels have the potential to exceed the target threshold levels when works are within 50m of a property, which accounts for 21 properties along the cable route, but the noise levels would not exceed the target threshold levels when works were 100m from the property.

27.5.9 However, it should be noted that, as the works are transient and individual items of plant or machinery assigned to complete different tasks will move along the cable route as works progress, the time over which these worst-case noise levels would be experienced at an individual receptor is likely to be less than ten days of working in any fifteen consecutive days or for a total of days not exceeding 40 in any 6 month period.

27.5.10 Worst-case noise levels from trenching of the cable route would result in a minor impact, which is not significant.

27.5.11 Noise from the Horizontal Directional Drilling (HDD) has been assessed based on a duration of works between 7.5 to 13.5 weeks and a worst case scenario that drilling would be required 24 hours a day. Table 27.13 presents the results of HDD noise predictions at the nearest residential receptor to the anticipated drill end of the HDD transit. Where the project description is uncertain as to which end that the drill rig will be operational, a worst-case approach based on proximity to residences has been assumed. The location of the HDD has been taken as the centre point of the working width.

Table 27.13: Assessment of HDD works

HDD location	Approximate Distance to nearest receptor (m)	LAeq Noise Levels (dB(A))					
		Ambient Measured	Target Threshold	Predicted HDD	Combined Ambient + HDD	Increase over target	Increase over Trigger Threshold (55 dBA)
Landfall	200	43	50	51	52	+2	-3
Railway	100	40	45	59	59	+14	+4
Sompting Bypass	75	48	55	62	62	+7	+7
River Adur	375	43	50	44	47	-3	-8
A281	100	53	56	59	60	+4	+5
B2116	100	34	45	59	59	+14	+4

27.5.12 The results show a predicted negligible impact from HDD noise at the River Adur site, which would not be significant. The results show a moderate impact from HDD noise at the landfall and a major impact from HDD at the railway, Sompting Bypass, A281 and B2116, which would be considered significant.

Construction vibration – Cable Route

27.5.13 The construction equipment that is anticipated to be used for the cable route is not considered to generate significant levels of vibration more than 10m from the equipment. All construction works would occur significantly more than 10m from buildings. Effects of vibration would therefore be considered negligible and not significant.

Construction noise – Substation

27.5.14 The noise levels of equipment likely to be used for the construction of the substation have been provided and are shown in Table 27.14.

Table 27.14: Noise level of construction equipment – substation

Plant	No# of vehicles	Operational hours	A-weighted SPL (dB(A) at 10m
Front end loaders (wheeled)	1	90 %	82
Tracked excavator	1	90 %	77
Wheeled backhoe loader	1	90 %	68
Wheeled loader	1	90 %	79
Dozer	1	90 %	80
Articulated dump truck	1	90 %	74
Road roller	1	90 %	80
Graders	1	90 %	75
Material Handling	1	90 %	86
Cement mixer truck	1	90 %	75

Plant	No# of vehicles	Operational hours	A-weighted SPL (dB(A) at 10m
Truck mounted concrete pump and boom arm	1	90 %	80
Wheeled mobile telescopic crane	1	90 %	78
Diesel generator for site cabins	1	100 %	65

27.5.15 Noise emission levels at the nearest residential receptor from the construction work of the substation have been calculated according to the method presented within BS 5228.

27.5.16 The closest receptor to the substation site is 130m from the substation boundary. Resultant worst-case noise levels would be 64dB(A). This is below the BS 5228 target threshold of 65dB(A), and as such would result in a negligible impact which is not significant.

27.5.17 The results show that the predicted construction noise would exceed the target threshold level during daytime within 100m from the site boundary. It should be noted that the predicted levels are worst-case, as it is assumed that all of the plant is operating on the closest part of the site to the receptor. Actual noise levels are likely to be lower, as in reality some of the plant is likely to operate further away from the receptor.

Construction vibration – Substation

27.5.18 The large distances (in vibration terms) between the site and sensitive receptors means that there is no potential for vibration from these works to affect sensitive receptors. The impact of vibration will therefore be negligible and not significant.

Construction noise – Offshore Piling

27.5.19 Noise from piling offshore was assessed during piling of the offshore meteorological (met) mast monopile foundation at the Project site on 13 April 2012. Similar offshore piling equipment will be used for installation of the turbine bases, it can be concluded that the piling of turbine bases offshore does not have the potential to disturb receptors onshore as piling was inaudible onshore during the met mast piling, 13.5km from the shoreline.

27.5.20 The findings of the met mast noise assessment are provided in Appendix 27.2. The measurement locations were undertaken in the towns of Shoreham, Worthing and Littlehampton. In rural areas, such as Peacehaven, it is possible that the background noise levels will be less than measured. However, noise levels from piling would be inaudible, regardless of the existing background noise level. This is because predicted piling noise was, at most, 13dB(A) at the shoreline. This is below the threshold of normal human hearing (around 20dB(A)).

27.5.21 The pile size for the turbines would be up to a maximum diameter of 6.5m in comparison with the 2.5m pile used for the met mast. Potentially this could result in higher noise level during the turbine piling than that measured for the met mast. However, there would not necessarily be an increase in noise level as a different pile technique or equipment could result in lower noise levels despite the increased size of pile. The maximum sound power level of the piling in order that noise levels would be inaudible onshore (20dB(A)) has been calculated at 148dB(A). This is based on distance attenuation, reflections from water (+3dB), favourable wind conditions (+3dB) and air absorption (-3dB per 1,000m). As a comparison, the average sound power level from the piling calculated from the noise measurements was 130dB(A). A level of 148dB(A) is considered achievable with existing piling types.

Construction noise and vibration - Traffic

27.5.22 The changes in noise levels along road links for construction traffic is presented in Table 17.15. The 'Without Construction' scenario consists of baseline traffic in addition to predicted traffic changes as a result of committed development. Speeds have been based on guidance within CRTN as follows (it is assumed that construction traffic is limited to 80km/h):

- 50km/h for single carriage roads subject to a speed limit of less than 50mph;
- 70km/h for single carriage roads subject to a speed limit of 50mph); and
- 80km/h for dual carriage roads subject to a speed limit of 50mph.

Table 27.15: Construction traffic noise results

	Without Construction		With Construction			$L_{A10,\ 18\ Hr}$ Result		
Road	**Total flows**	**% HGV**	**Total flows**	**% HGV**	**Speed (km/hr)**	**Without Construction (dBA)**	**With Construction (dBA)**	**Increase (dBA)**
A272	16132	8	16256	8	80	73.4	73.6	0.2
Wineham Lane	1014	7	1411	14	50	58.8	61.6	2.8
B2116	3808	8	3877	9	50	64.5	64.9	0.3
A2037	8059	0	8355	0	50	65.4	65.5	0.2
Edburton Road	1760	7	1853	10	50	61.2	62.1	0.9
A283	21811	7	22277	8	70	73.8	74.0	0.2
A27 (East of A283)	69157	15	69471	16	80	80.9	81.0	0.1
A27 (between A2025 and A283)	57622	15	58115	15	80	80.1	80.1	0.0
Western Rd	11815	8	11880	8	50	69.5	69.6	0.1
A259	35599	7	35650	7	50	74.1	74.1	0.0

27.5.23 The results show that short-term changes to traffic noise levels on the road system affected by construction would negligible (<0.9dBA) to minor (1-2.9dBA) magnitude of impact and not significant.

27.5.24 CRTN states that the prediction methodology is not suitable for traffic flows less than 50 per hour. Both predicted baseline traffic and construction traffic on St Paul's Avenue would be lower than 50 vehicular trips per hour. Therefore, the methodology and criteria within BS 5228 has been utilised for construction traffic movements along St Paul's Avenue, assuming an HGV traffic flow of 34 vehicles (worst case flow estimated to only occur at most for 2 days during construction) averaged over an 8 hour day and based on a sound power level for a wheeled loader (BS 5228, Annex C, Table C.2, Ref # 27).

Table 27.16: Construction traffic noise on St Paul's Avenue

Sound power level LAw dB(A)	Hourly flows*	Distance to receptor, m	Speed (km/h)	Sound pressure level, dB(A)
111	4	10	48	57

27.5.25 The results (see Table 27.16) show that noise levels would be below the BS 5228 threshold for daytime and therefore the noise impact would be considered negligible.

27.5.26 In the majority of circumstances HGV traffic is not considered a significant source of vibration. However, higher peaks of vibration can be caused by HGV driving over cracks and holes within the road. HGV traffic will largely be using A and B classified roads that are likely to be well maintained. Where it is planned that HGV traffic uses unclassified roads or newly constructed access routes (the two side accesses shown on Figure 2b.1), residences are at sufficient distances (>10m) from these routes so that vibration caused by HGV would not result in a significant impact. Some routes to access the cable route corridor are yet to be determined and will be assessed for potential vibration impacts when identified.

Operation

Operational Noise - Substation

27.5.27 The proposed onshore substation has been modelled using CadnaA noise software. The detailed design for the substation has not yet been completed, so an indicative design has been used to assess potential noise impact. The key components consist of the noise sources set out in Table 27.17. The location of the noise sources as modelled is presented in Figure 27.3.

Table 27.17: Sound power levels of major equipment within the onshore substation

Equipment	Number of Plant	Point Source Height (m)	Sound Power Level, dB(A)	Mitigation Sound Reduction Levels, dB(A)
Super Grid Transformer	4	3.5	90	25
Auxiliary Transformer	4	3.5	90	25
Reactor[1]	12	3.0	78	15
STATCOM unit	4	4.0	84	15
Harmonic Filter Compound	4	4.0	91	20
Cooling Unit (Transformers and STATCOM)	12	6.0	75	0
Note 1: includes reactive compensation equipment Note 2: assumes that noise levels from capacitors do not significantly contribute to noise levels from the substation				

27.5.28 Given the distance between sources and receptors, it was considered appropriate to model the various plant as point sources, with the height of point relating to 2/3 of the height of plant. Indicative spectrum data for the plant has been used (based on a reasonable worst-case assumption of low frequency dominance within the 125Hz Octave Band). Details of computer noise modeling are presented in Appendix 27.3.

27.5.29 Resultant noise levels from the substation site during operation without mitigation are presented as a noise contour map in Figure 27.4, and noise levels at each receptor are presented in Table 27.18. Table 27.18 also shows the BS 4142 assessment noise level, and is based on night time background noise levels as worst-case. A 5dB 'rating penalty' has been applied to the modelled noise levels to take account of the potential for the substation to generate noise containing tonal components.

Table 27.18: Substation BS 4142 assessment (without mitigation)

Receptor			Plant		Assessment		
ID	Name	L_{A90} (dB)	SPL (dBA)	Rating Level (dBA)	BS 4142 Applicable	Rating Level Over L_{A90}	Impact Magnitude
R1	Twineham Court Farm	30	45	50	Yes	20	Major
R2	The Coach House	30	40	45	Yes	15	Major
R3	Coombe Farm	30	39	44	Yes	14	Major
R4	Coombe Farm	30	38	43	Yes	13	Major
R5	Receptor to North	30	37	42	Yes	12	Major
R6	Eastridge Lodge	30	34	39	Yes	9	Moderate
R7	Farm to West	30	34	39	Yes	9	Moderate
R8	Residence to west	32	35	40	Yes	8	Moderate
R9	Woodpeckers / Downsview	30	39	44	Yes	14	Major

27.5.30 The results in Table 27.18 show that at all locations, the rating level without mitigation applied is more than 5-10dB(A) above the existing background noise level. This would result in a moderate to major impact, which would be significant.

27.5.31 However, it should be noted that the noise models assume all plant is operating continuously. This may not be the case, particularly at night, because it is generally cooler and the cooling plant is unlikely to be operating at its highest capacity.

Operational Vibration - Substation

27.5.32 There are no sources on site with the potential to generate vibration that is perceptible at the nearest receptors. Therefore the impact of vibration from the operation of the substation would be negligible and not significant.

Operational Noise -Turbines

27.5.33 Operational noise from the turbines has been predicted using CadnaA noise modelling software, incorporating ISO-9613 methodology. Wind farm layout options A - D have been modeled with a 7MW wind turbine and options E-H modelled with a 3MW wind turbine. Details of computer noise modeling are provided in Appendix 27.3. The predicted noise from the proposed wind turbines at 10m/s wind speed for each layout option is presented in Table 27.19. Receptor locations have been chosen at intervals along the nearest coastline to the proposed wind turbines.

Table 27.19: Wind farm noise levels at receptor locations

Receptor	Predicted Noise Levels (L_{A90}) at Receptor Locations from Wind Turbine Options							
	A	B	C	D	E	F	G	H
Worthing	27	27	28	28	24	24	24	25
Littlehampton	23	23	23	24	20	20	20	20
Brighton	27	27	27	27	24	24	24	24
Peacehaven	26	26	25	25	23	23	22	22
Newhaven	25	25	24	24	22	22	21	21
Sleaford	23	23	22	22	20	20	19	19

27.5.34 Turbine layout option B is considered the worst case overall and the predicted noise contours are presented in Figure 27.5. For all wind farm layout options, the results show that noise levels at the coastline are not predicted to exceed an LA90 of 35dB(A). The ETSU R-97 methodology states that background noise monitoring is not required for a wind farm development if turbine noise levels are predicted to be less than 35dB(A) at all receptors for a wind speed of 10m/s.

27.5.35 It is unlikely that the wind farm would be audible, even at very quiet coastal locations, as at 10m/s the background noise at onshore locations would be raised by wind conditions. At lower wind speeds, the predicted noise level from the wind farm would be lower or, as on calm days, not operational. It is therefore considered that noise from the wind turbines would not result in a disturbance to residential amenity, would be of negligible impact and therefore not significant.

27.5.36 The predictions will need to be revised should testing of the 7MW turbine (the V164-7MW) in accordance with EN 61400-11:2003 show that the sound spectrum or sound power levels for the wind turbines is significantly different from that used in predictions.

27.5.37 Should revised predictions at onshore receptors be in excess of 35dB(A), a full ETSU R-97 assessment (including background noise monitoring) will be required for the onshore receptors.

Operational Noise - Offshore Substations

27.5.38 It is expected that there will be two offshore substations installed at the northern boundary of the Project site to serve the development. It is anticipated that each substation will consist of 2 transformers, considered to be the dominant noise source on each substation. Noise levels from the two substations have been predicted assuming a likely maximum sound power level of 105dB(A) for each transformer and the nearest residential receptor along the shoreline at 13km from the northern boundary of the site. Predictions have taken into account distance attenuation, atmospheric absorption (estimated at 3dB per 1,000m), reflection from the water (+3dB) and a tonal penalty of 5dB. The resulting calculated noise level, including a tonal penalty, is 10dB(A).

27.5.39 The resulting noise level predicted from the two substations would not be audible and therefore a negligible impact and not significant.

Decommissioning

27.5.40 At decommissioning it is anticipated that the onshore cables will be left buried in situ, unless lifted to be replaced by new cables to be run along the same route as part of future developments or wind farm repowering. It is likely that ducting will remain in place; however, the cables may be pulled out of the ducts via the jointing bays. Decommissioning would be quieter than construction as there would be no trenching and HDD operations undertaken.

27.5.41 No decision has been made regarding the final decommissioning policy for the proposed substation, as it is recognised that industry best practice, rules and legislation change over time. The onshore substation may continue to be used as a substation site after the Project has been decommissioned. It is quite possible that the substation will be upgraded for use by future offshore renewable developments. The decommissioning methodology cannot be finalised until immediately prior to decommissioning; the substation will be decommissioned in line with relevant policy at that time.

27.5.42 Decommissioning for offshore elements of the project would be quieter than construction as there would be no piling operations undertaken.

27.6 Mitigation Measures

During Construction

27.6.1 Best practice construction noise methods will be used to minimise noise generated throughout the construction of the cable route and the substation. Methods will include the following:

- Consideration of noise levels when selecting construction methods and equipment used;
- Training of construction workers on site to ensure noise is considered through all stages of the construction works;
- Careful timing of any particularly noisy activities;
- Development area layouts to minimise or avoid vehicle reversing;
- Locating highest noise emitting plant and activities farthest away from residences;
- Use of modern, quiet equipment to minimise noise generation;
- Ensuring engines are switched off when machines are idle;
- Registration with the ‘Considerate Constructors Scheme’, which includes independent inspection of the environmental performance of development areas;
- Use of a construction management plan detailing the mitigation to be used throughout each stage of construction;
- Regular communication with residents close to the cable route and substation, particularly where the route is close to houses. The communication will include details of expected work schedules and activities taking place, and contact details in case of query or complaint; and

- Noise measurements will be undertaken in the event of complaints in order to assess the level of disturbance and requirements for further mitigation.

27.6.2 In addition to the above general construction management measures, in order to reduce noise from HDD, screening should be provided to block line of sight between the notable noise emitting element of the HDD rig and associated plant and effected residential receptors.

27.6.3 It is planned that the construction mitigation measures will be incorporated into a noise management scheme.

During Operation - Substation

27.6.4 Without mitigation, there is potential for the operation of the onshore substation to give rise to disturbance at night to neighbouring properties. To reduce noise levels to 'less than marginal', mitigation will be incorporated into the design of the substation to ensure that 'rating levels' are less than 35dB(A) at the closest properties. An example mitigation package is set out below; however it may be possible to mitigate noise using an alternative package of mitigation. Other mitigation measures that could be used include modifying the site layout, construction of noise barriers or enclosures, or selection of quieter equipment.

27.6.5 The example mitigation package assessed comprises:

- Applying noise mitigation to all transformers (SGT and Auxiliary) to reduce noise levels by 25dB(A);
- Applying noise mitigation to all reactors to reduce noise levels by 15dB(A);
- Applying noise mitigation to all filters to reduce noise levels by 20dB(A); and
- Applying noise mitigation to all STATCOM units to reduce noise levels by 15dB(A).

27.6.6 It is considered that the required sound level reductions can be achieved with appropriate enclosures over the identified equipment.

27.6.7 In addition to the above, noise measurements will be undertaken in the event of complaints in order to assess the level of disturbance and requirements for further mitigation.

27.6.8 It is planned that the substation operation mitigation measures will be incorporated into a noise management scheme.

During Operation - Wind Turbines

27.6.9 As assessed, the wind turbines are predicted to be inaudible at the shoreline. Prior to the construction of wind turbines, a review of noise predictions would be undertaken with guaranteed sound power levels (as calculated in accordance with EN 61400-11:2003) for the chosen wind turbine type. Construction of the wind farm would not take place unless the predicted noise levels satisfied the requirements within ETSU R-97. Although all of the predictions indicate that noise from the turbines will not be audible onshore, if justified complaints due to potential noise from the turbines are made, noise measurements will be undertaken in order to assess the level of disturbance and any requirements for mitigation.

During Decommissioning

27.6.10 Mitigation during decommissioning would utilise best practice methods as described for construction.

27.7 Significance of Residual Effects

During Construction

27.7.1 Construction noise and vibration effects for trenching works and the construction of the substation remain negligible to minor and not significant.

27.7.2 It is considered that with appropriate screening at the HDD sites in addition to the use of low noise machinery and good construction practice, noise levels could be reduced such that BS 5228 threshold values were not exceeded. The residual noise from HDD sites would be considered a minor effect on the nearest residential receptors and not significant.

During Operation

27.7.3 Residual noise levels from the substation site are presented as a noise contour map in Figures 27.6 and noise levels at each receptor are presented in Table 27.20 shows the BS4142 assessment noise level and is based on night time background noise levels as worst-case. A 5dB ‘rating penalty’ has been applied to the modelled noise levels to take account of the potential for the substation to generate noise containing tonal components.

Table 27.20: Residual substation BS 4142 assessment (with mitigation)

Receptor			Plant		Assessment		
ID	Name	$L_{A90\ (dB)}$	SPL (dBA)	Rating Level (dBA)	BS4142 Applicable	Rating Level Over L_{A90}	Impact Magnitude
R1	Twineham Court Farm	30	29	34	No	4	Minor
R2	The Coach House	30	24	29	No	-1	Minor
R3	Coombe Farm	30	24	29	No	-1	Minor
R4	Coombe Farm	30	23	28	No	-2	Minor
R5	Receptor to North	30	22	27	No	-3	Minor
R6	Eastridge Lodge	30	19	24	No	-6	Minor
R7	Farm to West	30	19	24	No	-6	Minor
R8	Residence to west	32	21	26	Yes	-6	Minor
R9	Woodpeckers / Downsview	30	24	29	No	-1	Minor

27.7.4 The results in Table 27.20 show that at all locations, the rating level is either below the background noise level where BS 4142 would be considered applicable or below 35dB(A) (and therefore below WHO night-time guideline limits) where BS 4142 would not be considered applicable. The predicted noise levels would result in a minor effect, which would not be significant.

27.7.5 Impacts from the operation noise from the offshore wind farm and offshore substations remain negligible and not significant.

27.7.6 Operational vibration effects remain negligible and not significant.

During Decommissioning

27.7.7 Construction noise and vibration effects remain negligible to minor and not significant.

Table 27.21: Summary of residual effects and mitigation measures

Aspect	Impact	Magnitude of Impact	Proposed Mitigation Measures	Residual Effect
Construction Phase				
Noise	Disturbance to receptors from trenching works	Negligible to minor	Good practice construction management	Negligible to minor
	Disturbance to receptors from HDD works	Negligible to major	Good practice construction management / screening	Negligible to minor
	Disturbance to receptors from traffic noise increases	Negligible to minor	None required	Negligible to minor
Vibration	Disturbance / structural damage	Negligible	Good practice construction management	Negligible
Operational Phase				
Noise from substation	Disturbance to receptors	Moderate to major	Incorporation of noise control measures into detailed design of substation	Minor
Noise from offshore substations	Disturbance to receptors	Negligible	None required	Negligible
Noise from turbines	Disturbance to receptors	Negligible	None required	Negligible
Decommissioning Phase				
Noise	Disturbance to receptors	Negligible to minor	Good practice construction management	Negligible to minor
Vibration	Disturbance/ structural damage	Negligible	Good practice construction management	Negligible

27.8 Cumulative Impacts

27.8.1 If the works associated with the Teville Stream restoration coincide with cable route construction works in similar locations, there is potential for noise levels to be generated over and above those predicted for the cable route construction works alone. At this stage, there is insufficient information to enable the resultant noise levels to be calculated, but any periods of high noise levels at any one location would be likely to be short as the cable route works are transient. As such, the durations of construction in any one location would not exceed the BS 5228 time thresholds and the cumulative impact is therefore likely to be limited to negligible to minor and not significant.

27.8.2 The following planned developments are noted in the vicinity of the proposed substation:

- Modifications to the existing National Grid Bolney substation (associated with Rampion connection).
- Modifications to the existing National Grid Bolney substation (not associated with Rampion).

27.8.3 Four 400kV feeder bays are required within the NGET substation compound at Bolney to connect the new Rampion substation to the existing NGET Bolney substation. Recent discussions between National Grid and E.ON have indicated that these works would fall outside NGET's permitted development rights and therefore planning consent would be required, E.ON intends to apply for planning permission from Mid Sussex District Council.

27.8.4 Detailed environmental assessment reports have not yet been completed for the National Grid Bolney modifications.

27.8.5 The construction works at the existing Bolney substation are likely to include earthworks, foundations and installation. The nearest residential receptor to the construction works for the existing substation is 110m from the anticipated site boundary. This residence is 580m from the site boundary for the proposed Rampion substation. If a worst case scenario occurs (all construction equipment operational at the same time for both sites as assessed in Section 27.5), the contribution of the Project construction noise would be at least 15dB(A) below the construction noise from the existing Bolney substation works. The overall noise levels would therefore be the same as the existing Bolney substation works alone, and there would not be a cumulative effect.

27.8.6 The nearest residence to the proposed Rampion substation works at 130m is 330m from the anticipated nearest works at the existing substation site. If a worst case scenario occurs (all equipment operational at the same time for both sites as assessed in Section 27.5), the contribution of the Bolney equipment would be 8dB(A) below the predicted noise from the proposed Project substation works. This would increase the predicted noise level in Section 27.5 of 64dB(A) by 1dB. The resultant noise level would still be below the threshold for significant effect as described within BS 5228.

27.8.7 The cumulative noise effect of construction works at both the existing Bolney substation and proposed Rampion substation would be considered negligible and not significant.

27.8.8 The notable noise emitting plant to be proposed at the existing Bolney substation site (works not associated with Rampion) includes a Mechanically Switched Capacitor (MSC) compound (including reactors) and Static VAR Compensator (SVC) Compound (including reactors, cooling fans, filters and transformer with radiator). It is understood that National Grid (the site developer) will mitigate noise levels for new plant at the existing Bolney substation, if required, such that background noise levels will not be exceeded (inclusive of appropriate tonal penalties). A noise level from the existing Bolney substation equaling the background noise level at residential receptors would result in the following cumulative noise levels with the proposed Rampion substation.

Table 27.22: Cumulative substation BS 4142 assessment (with mitigation)

Receptor			Rating Level (dBA)			Assessment		
ID	Name	$L_{A90\,(dB)}$	Existing Substation - New Plant	Proposed Substation	Cumulative Effect	BS 4142 Applicable	Rating Level Over L_{A90}	Impact Magnitude
R1	Twineham Court Farm	30	30	34	35	No	5	Minor
R2	The Coach House	30	30	29	33	No	3	Minor
R3	Coombe Farm	30	30	29	33	No	3	Minor
R4	Coombe Farm	30	30	28	32	No	2	Minor
R5	Receptor to North	30	30	27	32	No	2	Minor
R6	Eastridge Lodge	30	30	24	31	No	1	Minor
R7	Farm to West	30	30	24	31	No	1	Minor
R8	Residence to west	32	32	26	33	Yes	1	Minor
R9	Woodpeckers / Downsview	30	30	29	33	No	3	Minor

27.8.9 The results show that cumulative noise levels would constitute a minor impact and not significant.

27.9 References

BS 4142: 1997 - Method for rating industrial noise affecting mixed residential and industrial areas

BS 5228-1: 2009 - Calculation for noise from open and construction sites - Part 1: Noise

BS 5228-2:2009 - Calculation for noise from open and construction sites - Part 2: Vibration

BS 7385-1:1990 Evaluation and measurement for vibration in buildings - Guide for measurement of vibrations and evaluation of their effects on buildings

BS 7445: 2003 - Description and measurement of environmental noise - guide to quantities and procedures

BS 60942: 2003 Electroacoustics Sound Calibrators – Specifications

BS 61672: 2003 Electroacoustics. Sound Level Meters – Specifications

Calculation of Road Traffic Noise (DTI & Welsh Office, 1988)

Design Manual For Roads and Bridges Volume 11, Section 3, part 7 HD213/11 (Highways Agency, Updated 2011)

EN 61400-11: 2003 Wind turbine generator systems - Acoustic noise measurement techniques

National Planning Policy Framework

World Health Organisation (WHO) Night Noise Guidelines for Europe (NNG)

Rampion Offshore Wind Farm

ES Section 27 – Noise

Figures 27.1 -27.6

RSK Environmental Ltd | **Document 6.2.27**

December 2012 | **APFP Regulation 5(2)(a)**

Revision A

E.ON Climate & Renewables UK Rampion Offshore Wind Limited

Rev	Date	Description	Drn	Chk	App
02	27.11.12	New Development Area	AJ	ME	DW
01	22.10.12	Development Area	DL	ME	DW
00	20.04.12	First Draft	NH	ME	DW

Rampion Wind Farm

Title :

Figure 27.1: Noise Monitoring Locations Along Cable Route

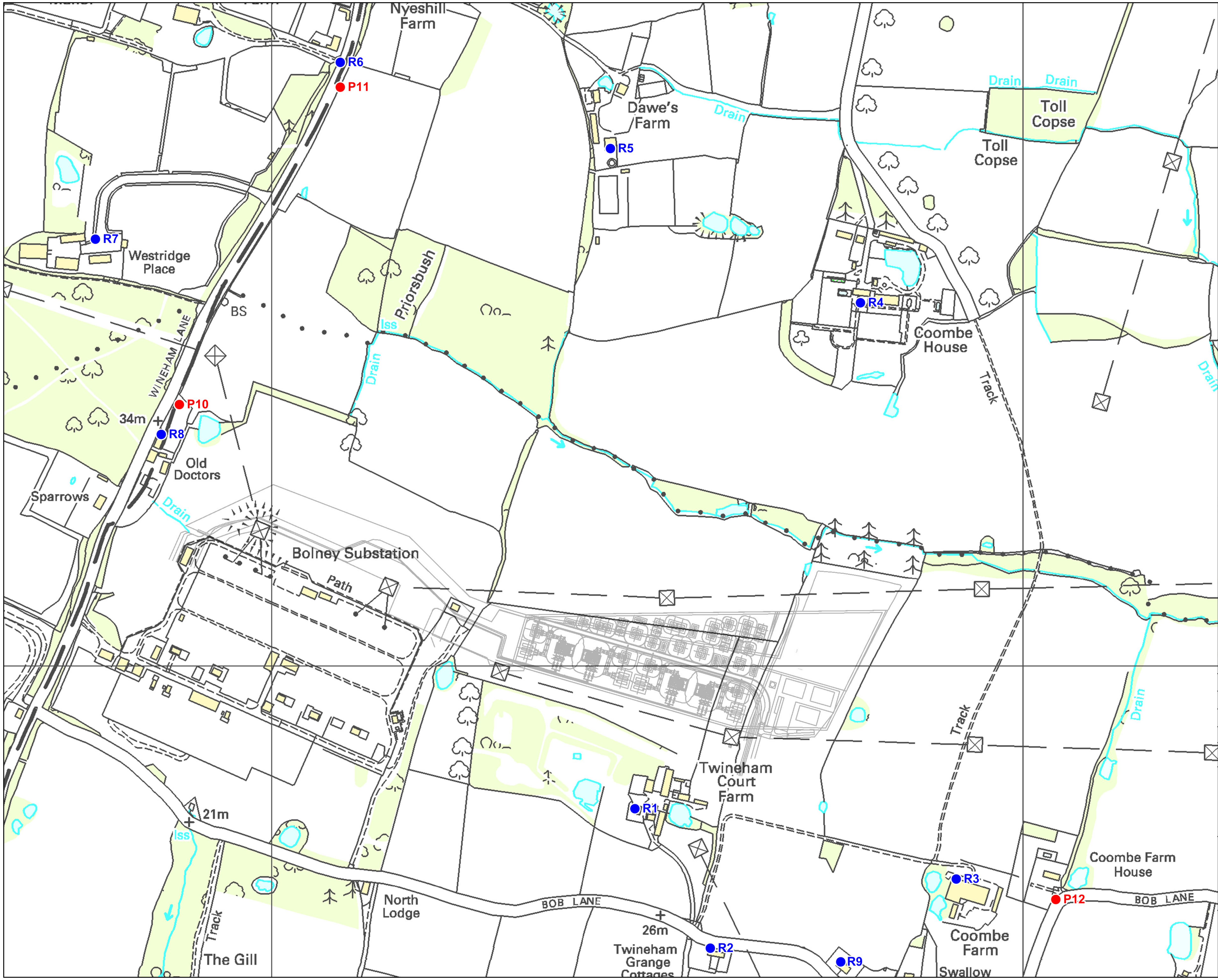
0 1 2 kilometres

Scale = 1:75,000 @ A3

N W E S

REV 02

FILE NAME: P41318 \05 - GIS\ES_Fig27-1 - Noise Location Plan.wor



Legend

- Noise Monitoring Locations
- Noise Receptor Locations

Rev	Date	Description	Drn	Chk	App
01	22.10.12	Revised Layout	DL	ME	DW
00	20.04.12	First Draft	NH	ME	DW

Rampion Wind Farm

RSK e·on

Title :

Figure 27.2: Monitoring and Receptor Locations Around Substation Options

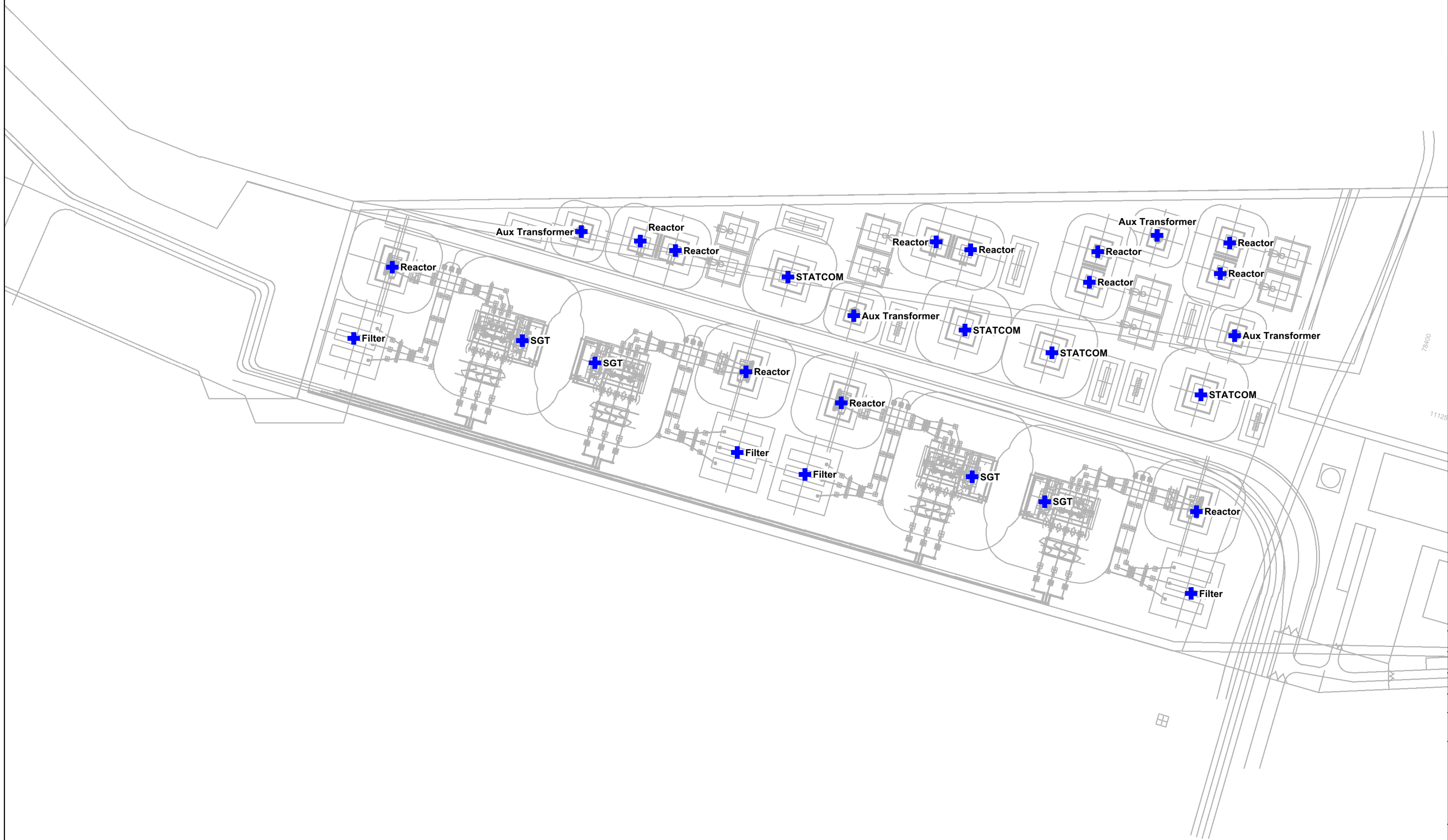
0 100 200
metres

Scale = 1:5,000 @ A3

N W E S

REV 01

FILE NAME: P41318 05 - GISES_Fig 27-2 - Noise Monitoring and Receptor Locations.wor



Legend

Noise Sources

Rev	Date	Description	Drn	Chk	App
02	15.11.12	Label changes	NH	ME	DW
01	22.10.12	Revised Layout	DL	ME	DW
00	24.04.12	First Draft	NH	ME	DW

Rampion Wind Farm

RSK e·on

Title :

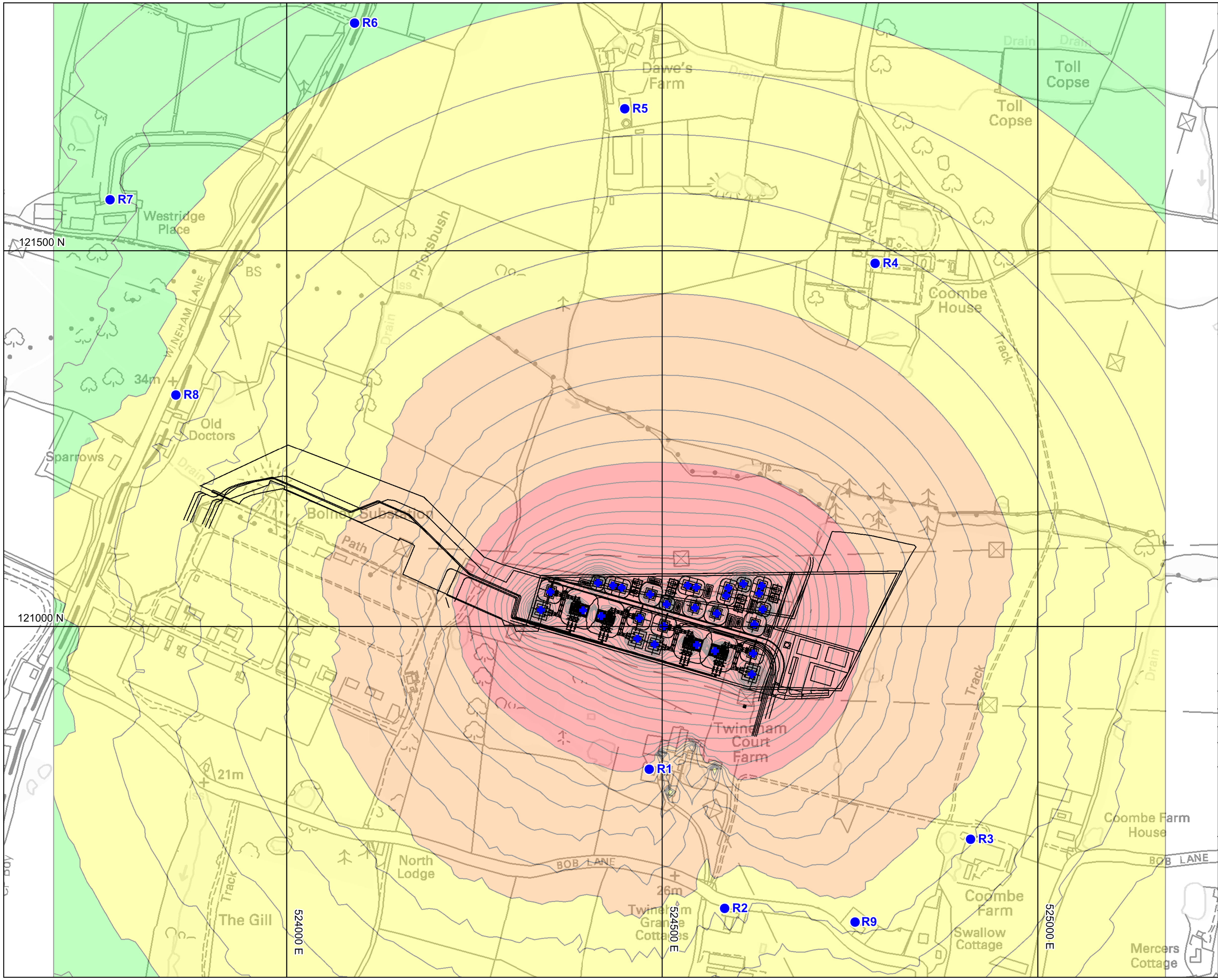
Figure 27.3: Substation Noise Sources

0 25 50
metres
Scale = 1:1500 @ A3

N W E S

REV 02

FILE NAME: P41318 I05 - GISES_Fig27-3 - Option A Noise Sources.wor



Legend

- Noise Sources
- Receptor Locations
- 35-40 dB(A)
- 40-45 dB(A)
- 45-50 dB(A)
- >50 dB(A)

Rev	Date	Description	Drn	Chk	App
00	13.11.12	Noise Levels	NH	ME	DW

Rampion Wind Farm

RSK e.on

Title :

Figure 27.4: Substation Rating Noise Levels

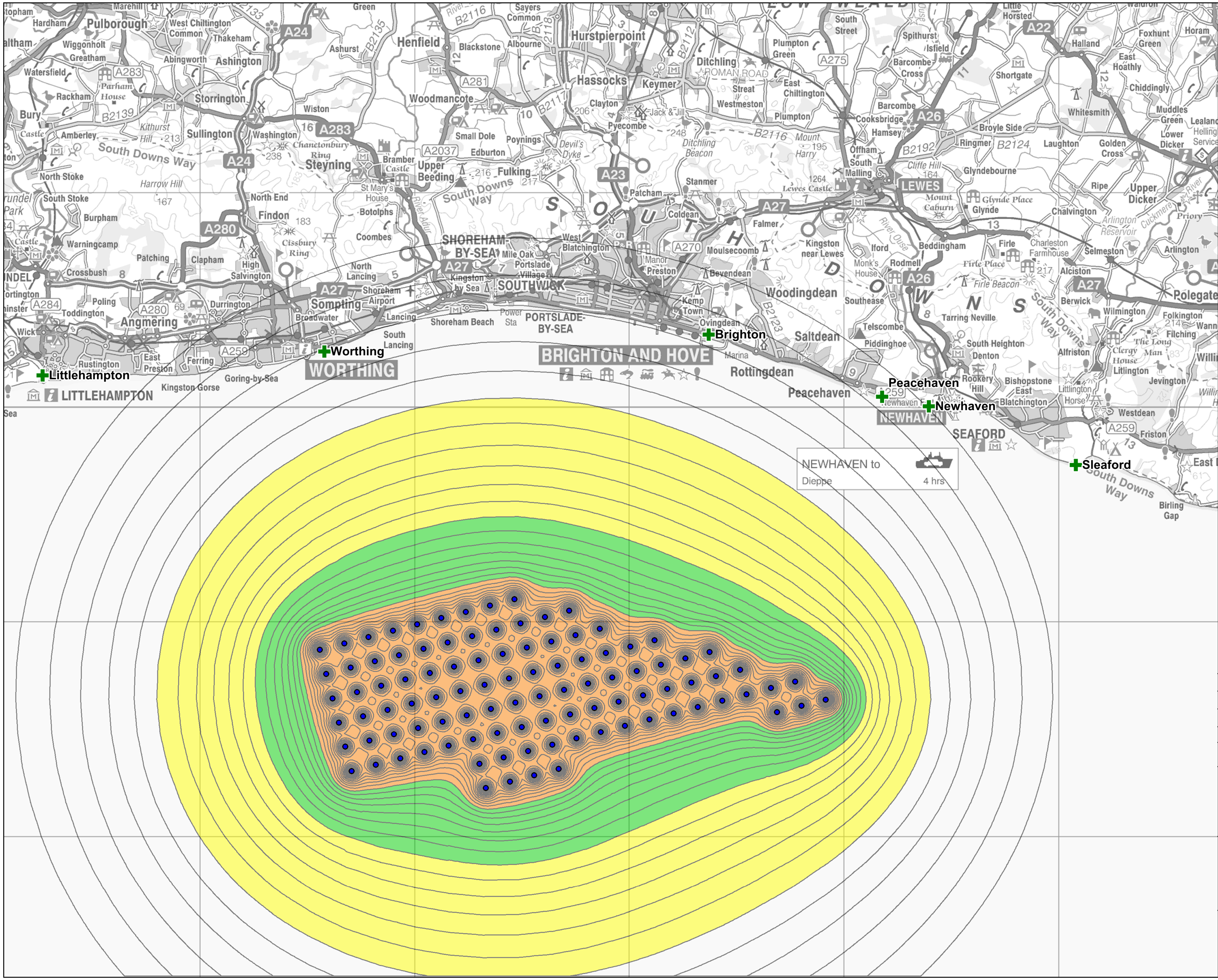
0 50 100 metres

Scale = 1:5000 @ A3

N W E S

REV 00

FILE NAME: P41318 05 - GISES_Fig 27-4 Substation Rating Noise Levels.wor



Legend

- Proposed Turbine Locations
- Receiver Location
- Within Limits, 20-25dB(A)
- Within Limits, 30-35dB(A)
- ETSU Day Min Limit >35dB(A)
- ETSU Night Min Limit >43dB(A)

Rev	Date	Description	Drn	Chk	App
02	16.11.12	Title	DL	ME	DW
01	24.10.12	Revised Contours	DL	ME	DW
00	23.04.12	First Draft	NH	ME	DW

Rampion Wind Farm

RSK e.on

Title :

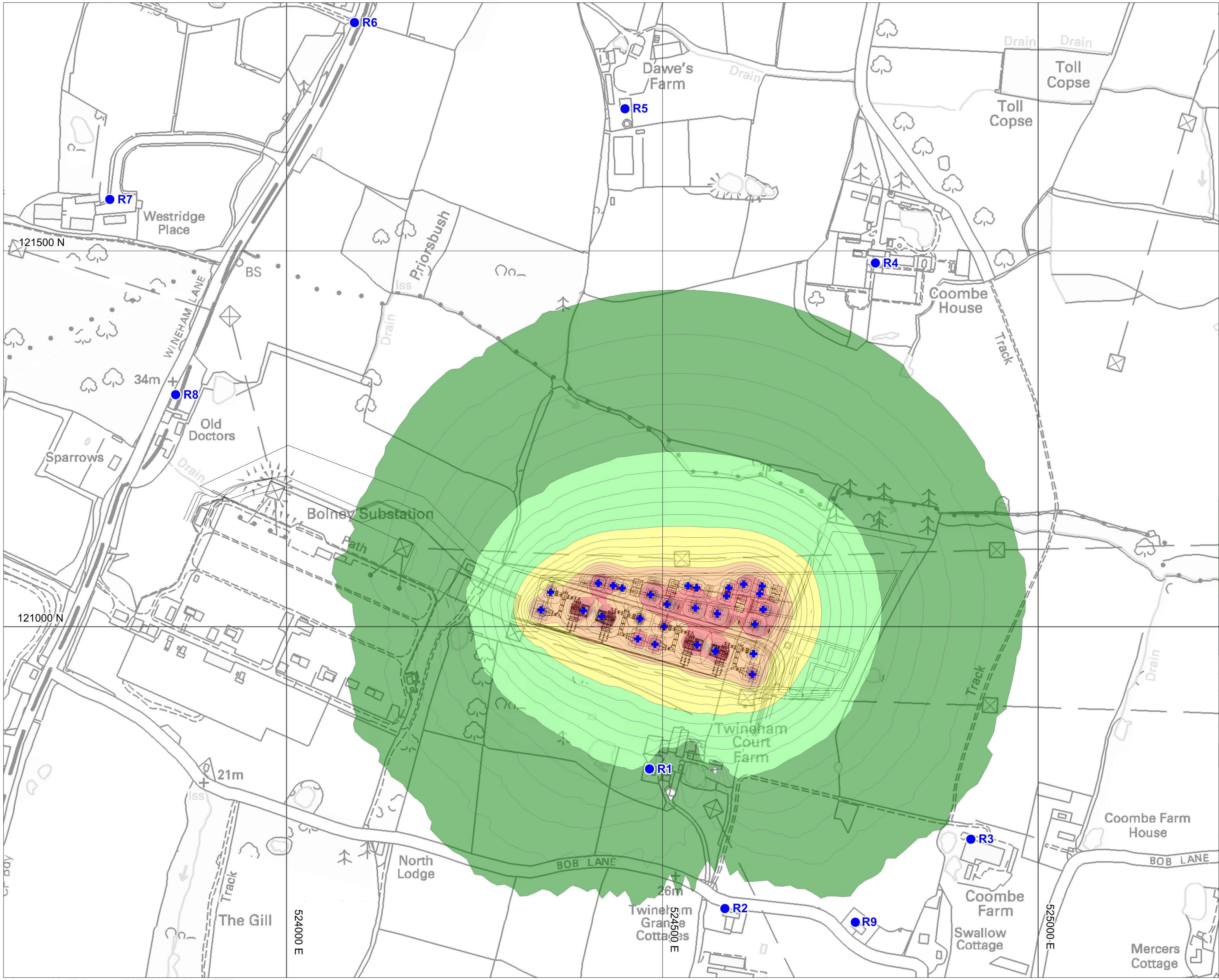
Figure 27.5 :
Turbine Layout Option B Noise Levels at 10m/s

0 2 4
kilometres

Scale = 1:175,000 @ A3

REV 02

FILE NAME: P41318 05 - GISIES Fig 27.5 Option B Noise Contours at 10ms.wor



Legend

- Noise Sources
- Receptor Locations
- 30-35 dB(A)
- 35-40 dB(A)
- 40-45 dB(A)
- 45-50 dB(A)
- >50 dB(A)

Rev	Date	Description	Drn	Chk	App
00	13.11.12	Noise Levels	NH	ME	DW

Rampion Wind Farm

RSK e·on

Title :

Figure 27.6: Substation Rating Noise Levels with Mitigation

0 50 100 metres

Scale = 1:5000 @ A3

REV 00

FILE NAME: P41318 05 - GISIES_Fig 27-6 Substation Rating Noise Levels with Mitigation.wor

Rampion Offshore Wind Farm

ES Section 27 – Noise

Appendices 27.1

ACSL **Document 6.3.27i**

December 2012 **APFP Regulation 5(2)(a)**

Revision A

E.ON Climate & Renewables UK Rampion Offshore Wind Limited

Acoustic Calibration Services Limited,
Unit 6F, Diamond Industrial Centre,
Works Road, Letchworth Garden City,
Hertfordshire SG6 1LW

Tel: 01462-610085/87 Fax: 01462-610087
e-mail: cal@acousticcalibration.co.uk
web: www.acousticcalibration.co.uk

ACSL
Acoustic Calibration Services Limited

CERTIFICATE OF CALIBRATION

Model: Norsonic 140 **Serial No:** 1402810

Organisation: RSK Environment Limited, 18 Frogmore Road, Hemel Hempstead
Hertfordshire HP3 9RT

Job Number: 2013 **Customer Order Reference:** G Youn

The Sound Level Meter was assessed for conformance with International Standards *IEC 60651* and *IEC 60804* using test procedures described in *BS 7580* Part 1. The meter claims Type 1 accuracy conformance and it was against these requirements that all the results were evaluated.

The sound level meter was fitted with a Norsonic 1225 measurement microphone Serial No. 72943 and a Norsonic 1209 preamplifier Serial No. 12227. The microphone has a nominal capacitance of 20 pF and the device used to apply electrical signals to the preamplifier was of the same nominal capacitance.

A Cirrus CR:511E Acoustic Calibrator Serial No: 037732 was supplied with the meter and was utilised in establishing the initial acoustic calibration setting.

The sound level meter passed all applied tests with no deviations from Type 1 specification, in accordance with *IEC 60651* and *IEC 60804*. Accordingly, the meter meets the requirements of *BS 7580* Part 1.

The sound level meter should be set to read 93.8dB when used with the associated acoustic calibrator, microphone and preamplifier as detailed above at reference atmospheric pressure.

All ACSL's calibration instrumentation is fully traceable to National Standards. The acoustic references are calibrated by laboratories which are UKAS accredited for the purpose.

Certificate No: **13841**
Date of Issue: **8th November 2011**

Signature:
Print Name: **Trevor Lewis**

Acoustic Calibration Services Limited,
Unit 6F, Diamond Industrial Centre,
Works Road, Letchworth Garden City,
Hertfordshire SG6 1LW

Tel: 01462-610085/87 Fax: 01462-610087
e-mail: cal@acousticcalibration.co.uk
web: www.acousticcalibration.co.uk

ACSL
Acoustic Calibration Services Limited

CERTIFICATE OF CALIBRATION

Model: Cirrus 511E **Serial Number:** 037732

Organisation: RSK Environment Limited, 18 Frogmore Road, Hemel Hempstead
Hertfordshire HP3 9RT

Job Number: 2013 **Customer Order Reference:** G Youn

The acoustic calibrator was run for a period of time until a stable level was measured. The output level was compared to the certified level of the laboratory measurement references. The measurements were repeated 5 times and the average value calculated.

The ambient temperature during calibration was 24.0 ± 1°C.
The barometric pressure was 100.8 to 100.9 kPa.

The output of the acoustic calibrator when applied to the Norsonic 1225 is 93.8dB

The output frequency of the acoustic calibrator is 1000Hz.

All ACSL's calibration instrumentation is fully traceable to National Standards. The acoustic references are calibrated by laboratories which are UKAS accredited for the purpose.

Certificate No: **13841**
Date of Issue: **8th November 2011**

Signature:
Print Name: **Trevor Lewis**

Norsonic 140 (Type 1) : Calibration Results

Customer Name: **RSK Environment Limited**

Service Reference Number: **2013**

Date of Calibration: **8th November 2011**

Instrument Details:

	Model	Serial Number
SLM	Norsonic 140	1402810
Preamplifier	Norsonic 1209	12227
Microphone	Norsonic 1225	72943
Acoustic Calibrator	Cirrus 511E	037732

Preliminary Inspection:

BS EN 60651: Type 1I BS EN 60804: Type 1 Instrument Functional Checks: **PASS**

Setting Up:

Reference B&K 4231 Calibrator – Serial No: **1883557** T/E No: **005**

B&K 4231 Calibrator SPL: **114.11 dB** Microphone Correction: -0.2 **dB**

Initial Reading: 93.7 dB

Adjusted Readings:

1) 93.9 dB 2) 93.9 dB 3) 93.9 dB 4) 93.9 dB 5) 93.9 dB

Average Reading: 93.9 dB Total Spread: 0.0 dB Test: **PASS**

Self Generated Noise:

Time Constant: SLOW Measurement Range: (-10) – 70dB

A (dB)	C (dB)	Lin(dB)
10.5	14.1	26.2

Test: **PASS**

Linearity:

Linearity Range: 24 – 137 dB

Linearity Leq:

Difference from REFERENCE	Instrument Reading (dB)	Error (dB)
-90.0	24.0	0.0
-89.0	25.0	0.0
-88.0	26.0	0.0
-87.0	27.0	0.0
-86.0	27.9	-0.1
-85.0	28.9	-0.1
-80.0	33.9	-0.1
-75.0	38.9	-0.1
-70.0	43.9	-0.1
-65.0	49.0	0.0
-60.0	54.0	0.0
-55.0	59.0	0.0
-50.0	64.0	0.0
-45.0	69.0	0.0
-40.0	74.0	0.0
-35.0	79.0	0.0
-30.0	84.0	0.0
-25.0	89.0	0.0
-20.0	94.0	0.0
-15.0	99.0	0.0
-10.0	104.0	0.0
-5.0	109.0	0.0
REF	**114.0**	**0.0**
5.0	119.0	0.0
10.0	124.0	0.0
15.0	129.0	0.0
18.0	132.0	0.0
19.0	133.0	0.0
20.0	134.0	0.0
21.0	135.0	0.0
22.0	136.0	0.0
23.0	137.0	0.0

Test: **PASS**

Linearity:

Reference Range: 24 – 137 dB

Linearity SPL:

Difference from REFERENCE	Instrument Reading (dB)	Error (dB)
-90.0	24.0	0.0
-89.0	25.0	0.0
-88.0	26.0	0.0
-87.0	27.0	0.0
-86.0	27.9	-0.1
-85.0	28.9	-0.1
-80.0	33.9	-0.1
-75.0	38.9	-0.1
-70.0	43.9	-0.1
-65.0	49.0	0.0
-60.0	54.0	0.0
-55.0	59.0	0.0
-50.0	64.0	0.0
-45.0	69.0	0.0
-40.0	74.0	0.0
-35.0	79.0	0.0
-30.0	84.0	0.0
-25.0	89.0	0.0
-20.0	94.0	0.0
-15.0	99.0	0.0
-10.0	104.0	0.0
-5.0	109.0	0.0
REF	**114.0**	**0.0**
5.0	119.0	0.0
10.0	124.0	0.0
15.0	129.0	0.0
18.0	132.0	0.0
19.0	133.0	0.0
20.0	134.0	0.0
21.0	135.0	0.0
22.0	136.0	0.0
23.0	137.0	0.0

Test: **PASS**

Random Incidence Check:

Initial SLM setting: 114.0 dB

Frequency (Hz)	Instrument Reading (dB)	Instrument Reading – L_0
8,000	116.2	2.2
12,500	118.6	4.6

Test: **PASS**

Frequency Weightings:

Reference Level: 114 dB / 1 kHz

Frequency (Hz)	Instrument Range	Instrument Reading dB (A)	Instrument Reading dB (C)	Instrument Reading dB (Lin)
1,000	24 – 137	114.0	114.0	114.0
31.5	24 – 137	74.5	111.0	113.9
63	24 – 137	87.8	113.2	114.0
125	24 – 137	97.8	113.8	114.0
250	24 – 137	105.3	114.0	114.0
500	24 – 137	110.7	114.0	114.0
2,000	24 – 137	115.2	113.8	114.0
4,000	24 – 137	114.9	113.1	114.0
8,000	24 – 137	112.8	110.9	114.0
12,500	24 – 137	109.8	107.8	113.9

Test: **PASS**

Time Weightings - Fast and Slow:

Initial SLM setting: 113.0 dB

Time Weighting	Instrument Reading (dB)
FAST	111.9
SLOW	108.9

Test: **PASS**

Time Weighting – Impulse:

Initial SLM setting: 117.0 dB

Tone Burst Type	Instrument Reading (dB)
Single	107.7
Repeated	113.8

Test: **PASS**

RMS Accuracy:

Initial SLM setting: 115.0 dB

Attenuator Setting	Instrument Reading (dB)
- 6.6 dB	114.9
-17.0 dB	114.5

Test: **PASS**

Overload Indicator:

	Instrument Reading (dB)	Difference
1 dB below overload	135.1	3.0
4 dB below overload	132.1	

Test: **PASS**

Time Averaging:

Initial SLM setting: 107 dB

Repetition Period	Instrument Reading (dB)
04×10^3	106.9
04×10^4	96.9

Test: **PASS**

Pulse Range:

Test: **PASS**

Sound Exposure Level:

Test: **PASS**

Peak Response:

Frequency Weighting used: LINEAR

	Frequency (Hz)	Instrument Reading (dB)	Difference between Readings
Positive Pulse	50 Hz	116.0	0.0
	5 kHz	116.0	
Negative Pulse	50 Hz	116.0	0.0
	5 kHz	116.0	

Test: **PASS**

Comments:

OVERALL : **PASS**

Calibration Certificate Number:	**13842**

Issued By:	**T J Lewis**

Date:	**8th November 2011**

Rampion Offshore Wind Farm

ES Section 27 – Noise

Appendices 27.2 – 27.3

RSK Environment Ltd **Document 6.3.27ii**

December 2012 **APFP Regulation 5(2)(a)**

Revision A

E.ON Climate & Renewables UK Rampion Offshore Wind Limited

E.ON Climate & Renewables

Onshore Noise from Offshore Piling

Noise Assessment

41318

OCTOBER 2012

RSK GENERAL NOTES

Project No.: 41318

Title: Noise Assessment of Offshore Piling

Client: E.ON Climate & Renewables

Date: 25h October 2012

Office: Manchester

Author	Mark Evans	**Technical reviewer**	Ian Holmes
Date:	25th October 2012	Date:	25th October 2012

RSK Environment (RSK) has prepared this report for the sole use of the client, showing reasonable skill and care, for the intended purposes as stated in the agreement under which this work was completed. The report may not be relied upon by any other party without the express agreement of the client and RSK. No other warranty, expressed or implied, is made as to the professional advice included in this report.

Where any data supplied by the client or from other sources have been used, it has been assumed that the information is correct. No responsibility can be accepted by RSK for inaccuracies in the data supplied by any other party. The conclusions and recommendations in this report are based on the assumption that all relevant information has been supplied by those bodies from whom it was requested.

No part of this report may be copied or duplicated without the express permission of RSK and the party for whom it was prepared.

Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK Environment.

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APPENDICES

Appendix A – Graphs Of Onshore Monitoring Data
Appendix B – Offshore Monitoring Data

1 INTRODUCTION

A programme of monitoring has been undertaken in order to assess the potential noise impacts at the residential receptors on the south coast of England, as a result of piling works for the Rampion Offshore Wind Farm. The closest receptors to the piling works will be properties along the coast, and will vary as different turbine bases are installed. The closest piling works for construction of the wind farm bases will be taking place approximately 13.5km offshore.

The base for the meteorological mast was installed on 13 April 2012, using similar piling techniques to those that will be employed for construction of the turbine bases. Noise monitoring was undertaken on shore and on a boat close to the piling operations immediately before, during, and after the piling operation, and noise level changes as a result of the piling have been assessed.

2 METHODOLOGY AND MONITORING

The noise monitoring assessment was undertaken in two stages:

1. Onshore, attended noise monitoring on the seafront at the identified residential areas
2. Offshore, attended monitoring at various distances around the piling rig during operation between 07:00 and 08:00 (undertaken by Subacoustic).

The results of the monitoring will be combined to calculate the noise level expected onshore at the receptors. Figure 1 shows the monitoring locations.

2.1 Onshore Monitoring

The monitoring assessment was undertaken on the morning of the 13th April 2012, from approximately 04:45 until 08:30. Attended measurements were undertaken as follows:

- Littlehampton (17.13km from piling): 05:05 – 08:35 (RION NL-32, 00503253)
  Co-ordinates: Easting, 505,392; Northing 101,438
  The ambient noise sources were waves on the beach, seagulls and passing cars and people. Piling was not audible at the monitoring location.
- Worthing (13.59km from piling): 05:00 – 08:34 (RION NL-32, 00503257)
  Worthing A Co-ordinates: Easting, 514,509; Northing 102,262

  Worthing B Co-ordinates: Easting, 515,268; Northing 102,453
  The ambient noise sources were waves on the beach, seagulls, waste removal activities, aircraft and passing cars and people. The monitoring location was changed at approximately 06:35 due to noise being made by a passer-by. The new location (Worthing B) is 13.66km from the piling works. Piling was not audible at either monitoring location.
- Shoreham (16.29km from piling): 04:43 – 08:08 (RION NL-32, 01013661)
  Co-ordinates: Easting, 521,834; Northing 104,513

  The ambient noise sources were waves on the beach, seagulls, increasing levels of traffic, occasional trains and pedestrians talking.

During the monitoring period, the weather was noted to be, clear sky, cool and a light north to south breeze. Sea conditions were calm.

Noise survey measurements were undertaken in accordance with BS 7455. The equipment used, conforming to the requirements of BS EN 61672. Calibration of each SLM took place before and after the monitoring period using a Norsonic Type 1251 Calibrator (Serial number 32194), no drift was observed.

2.2 Offshore Monitoring

Consultants 'Subacoustic' undertook monitoring from a boat during the piling works. The data supplied is presented in Appendix B. The data supplied covers the period 07:00 – 08:00 on the morning of the 13th April 2012. Measurements were taken at various distances from the piling works, ranging from 39m to 2.38km.

A Larson Davies Model 831 type 1 integrating sound level meter was installed on board the survey vessel. The meter was situated in the work area for control and monitoring, with the preamp and microphone connected at the end of an extension lead, fixed to the antenna framework.

The system was calibrated using a Larson Davies Type 200 calibrator before and after measurements. No significant drift in calibration was detected. The microphone was fitted with a heavy duty windshield. There was an unobstructed 360 degree view around the vessel. The weather during the survey was dry with light winds, which made conditions suitable for the measurement of environmental noise.

The noise was sampled as consecutive 1-minute files. Measurements were taken between 05.49 on 13th April 2012 as the vessel left port, to 08.04 after the piling operation was completed. Measurements were taken continuously throughout the foundation piling, including periods before and after piling where ambient noise was sampled. All relevant metrics were sampled, including LAeq, LAmax, LCpeak and LA90 with the fast time weighting.

2.3 Assessment

The data gathered from the offshore monitoring will be used to predict the noise level at the residential receptors. These noise levels have been compared to the measured background noise levels at each monitoring location to determine the likelihood of impact due to piling works.

3 RESULTS

3.1 Onshore Measurements

Attended measurements of background noise levels onshore were measured with a resolution of 1 minute. The results of the measurements at each location are shown graphically in Appendix A. Piling activities took place between 07:00 and 08:00. A summary of the measured ambient noise levels is displayed in Table 3.1.

Table 3.1: Summary of Onshore Monitoring Results

Location	Time Period	LAeq	LA90
Littlehampton	Before	46.6	43.2
	During	50.1	42.1
	After	55.9	40.2
Worthing	Before (A)	55.4	45.9
	Before (B)	53.2	48.1
	During	51.8	47.4
	After	51.8	48.5
Shoreham	Before	48.0	45.8
	During	50.6	45.4
	After	48.0	45.1

3.2 Offshore Measurements

Attended measurements of piling rig noise levels were measured with a resolution of 1 minute form a boat at various distances from the rig. The results of the measurements at each distance are displayed in Table 3.2.

3.3 Attenuation Calculations

Noise levels from the piling rig activities will be greatly reduced when they reach the receptors on the seafront at the locations where monitoring has been undertaken. The reduction will be as a result of both distance attenuation and atmospheric absorption. Distance attenuation is calculated using the formula:

$$20 \times \log_{10}\left(\frac{R_2}{R_1}\right)$$

whilst the attenuation due to the atmosphere can be conservatively calculated as 3dB per kilometre.

The total attenuation at the receptors due to these factors is shown in Table 3.2.

Table 3.2: Offshore Monitoring and Attenuation

Time	Distance (d) of Offshore Measurement to Piling [m]	SPL Measured Offshore at Distance (d) [dBA]	Attenuation Via Distance (d) & Atmospheric Absorption / Resultant Calculated Noise Level at Onshore Receptor [dBA]							
			Littlehampton		Worthing A		Worthing B		Shoreham	
07:11:00	74	83.6	98.7	<0	85.9	<0	86.3	<0	95.7	<0
07:12:00	74	82.8	98.7	<0	85.9	<0	86.3	<0	95.7	<0
07:13:00	72	83.0	98.9	<0	86.2	<0	86.5	<0	96.0	<0
07:14:00	70	79.0	99.2	<0	86.4	<0	86.8	<0	96.2	<0
07:15:00	70	78.9	99.2	<0	86.4	<0	86.8	<0	96.2	<0
07:16:00	70	76.5	99.2	<0	86.4	<0	86.8	<0	96.2	<0
07:17:00	70	94.3	99.2	<0	86.4	7.9	86.8	7.5	96.2	<0
07:18:00	70	67.7	99.2	<0	86.4	<0	86.8	<0	96.2	<0
07:26:00	58	98.1	100.8	<0	88.1	10.1	88.4	9.7	97.8	0.3
07:27:00	50	98.4	102.1	<0	89.3	9.1	89.7	8.7	99.1	<0
07:29:00	39	91.4	104.2	<0	91.5	<0	91.9	<0	101.3	<0
07:32:00	228	72.9	88.9	<0	76.2	<0	76.5	<0	85.9	<0
07:33:00	209	72.6	89.7	<0	76.9	<0	77.3	<0	86.7	<0
07:35:00	242	73.9	88.4	<0	75.6	<0	76.0	<0	85.4	<0
07:36:00	245	70.5	88.3	<0	75.5	<0	75.9	<0	85.3	<0
07:39:00	563	61.9	81.1	<0	68.3	<0	68.7	<0	78.1	<0
07:41:00	606	62.7	80.4	<0	67.7	<0	68.0	<0	77.5	<0
07:47:00	686	64.1	79.3	<0	66.6	<0	67.0	<0	76.4	<0
07:48:00	722	62.9	78.9	<0	66.2	<0	66.5	<0	75.9	<0
07:49:00	722	61.6	78.9	<0	66.2	<0	66.5	<0	75.9	<0
07:50:00	761	78.5	78.4	0.1	65.7	12.8	66.1	12.5	75.5	3.0
08:00:00	2380	54.0	68.5	<0	55.8	<0	56.2	<0	65.6	<0

4 ASSESSMENT

Table 4.1 shows the maximum predicted noise level reached by the piling operation at each location, compared to the measured LA90 background noise level for the same time period.

Table 4.1: Comparison of noise levels

Location	Time [hh:mm]	Predicted Level at receptor [dBA]	LA90 [dBA]	Difference [dBA]
Littlehampton	07:50	0.1	42.5	-42.4
Worthing B	07:50	12.5	48.6	-36.1
Shoreham	07:50	3.0	44.8	-41.8

The table shows that that even at the loudest part of the piling operations, the noise at the receptors is well below the background level and can therefore be considered to be of no impact.

The consultants conducting the monitoring at the receptor locations all noted that the piling operations were inaudible at the locations during the works. This observation is backed up by the attenuation calculations, which demonstrate that the levels from the piling rig should be inaudible above the background noise at each location.

5 CONCLUSION

Provided that the piling technique to employed during construction of the wind turbine bases is similar to that used during construction of the met mast base, it can be concluded that there is no potential for offshore piling noise to cause disturbance to sensitive receptors onshore.

FIGURES

Figure 1 – Noise Monitoring and Piling Rig Locations

APPENDIX A
GRAPHS OF ONSHORE MONITORING DATA

APPENDIX B
OFFSHORE MONITORING DATA

Time	Range (m)	LAeq	LAFmax	LCpeak (max)	LAF1.00	LAF10.00	LAF90.00
07:00:00		65.8	69.1	99.6	68.6	67.1	65.0
07:01:00		66.0	71.0	99.0	70.4	67.1	65.1
07:02:00		65.9	70.4	99.2	69.6	67.6	64.7
07:03:00		65.0	72.3	93.4	66.4	65.4	64.4
07:04:00		65.2	68.8	97.4	67.3	65.6	64.6
07:05:00		66.4	77.8	101.1	70.4	68.0	64.6
07:06:00		65.9	80.1	101.4	74.3	68.3	60.3
07:07:00		62.5	73.1	95.1	67.9	63.4	60.6
07:08:00		67.9	74.3	101.7	71.0	69.9	65.0
07:09:00		64.0	65.6	93.1	65.0	64.6	63.3
07:10:00		65.8	72.5	100.9	71.9	68.2	63.5
07:11:00	74	83.6	101.6	119.5	98.9	68.6	58.5
07:12:00	74	82.8	102.4	119.5	97.7	71.3	58.4
07:13:00	72	83.0	99.9	116.9	97.8	77.8	58.5
07:14:00	70	79.0	96.6	113.9	93.4	77.4	57.6
07:15:00	70	78.9	96.1	113.1	93.9	72.3	57.0
07:16:00	70	76.5	94.8	110.5	90.6	75.0	55.8
07:17:00	70	94.3	103.0	119.6	101.8	98.9	80.2
07:18:00	70	67.7	90.5	113.8	82.3	60.6	56.0
07:19:00		60.2	81.0	101.1	72.0	60.0	53.7
07:20:00		68.0	74.7	102.3	70.8	70.1	60.6
07:21:00		64.5	68.4	97.9	67.7	65.0	63.6
07:22:00		65.0	69.8	99.8	68.6	66.9	63.8
07:23:00		64.8	67.6	99.8	67.1	66.4	63.5
07:24:00		64.6	67.5	99.1	67.1	65.0	63.9
07:25:00		74.9	97.7	114.6	85.9	66.1	63.6
07:26:00	58	98.1	105.3	123.0	104.3	102.2	87.7
07:27:00	50	98.4	106.6	124.4	105.5	102.4	88.2
07:28:00		95.6	106.2	124.4	105.0	100.4	80.7
07:29:00	39	91.4	98.4	117.8	97.6	95.8	79.1
07:30:00		87.7	95.7	114.0	94.3	92.4	76.8
07:31:00		77.0	84.7	104.4	83.7	81.0	67.6
07:32:00	228	72.9	79.9	98.2	78.4	76.7	63.5
07:33:00	209	72.6	79.8	97.9	78.2	76.8	62.1
07:34:00		72.9	84.0	102.6	78.6	77.1	61.6
07:35:00	242	73.9	79.8	103.4	78.9	77.2	63.0
07:36:00	245	70.5	75.9	100.2	74.8	73.2	67.3
07:37:00		67.2	75.5	103.4	74.0	71.1	55.1
07:38:00		63.3	70.0	88.6	68.9	67.3	54.2
07:39:00	563	61.9	68.0	87.9	67.0	65.8	54.2

Time	Range (m)	LAeq	LAFmax	LCpeak (max)	LAF1.00	LAF10.00	LAF90.00
07:40:00		62.0	68.2	90.1	67.3	66.0	54.3
07:41:00	606	62.7	81.4	106.8	68.4	66.0	53.7
07:42:00		61.9	73.4	93.3	69.3	66.0	53.0
07:43:00		63.1	73.0	92.6	70.3	67.1	54.1
07:44:00		65.3	73.4	92.7	72.5	69.6	54.7
07:45:00		64.2	71.8	91.1	70.9	68.6	53.4
07:46:00		62.9	69.5	90.8	68.8	67.2	52.4
07:47:00	686	64.1	79.1	97.9	71.1	67.9	52.6
07:48:00	722	62.9	72.1	90.5	70.1	67.3	50.9
07:49:00	722	61.6	69.7	90.7	68.6	65.9	50.8
07:50:00	761	78.5	83.3	109.1	82.9	81.8	68.1
07:51:00		79.8	84.1	107.8	83.5	82.5	65.7
07:52:00		82.4	84.0	107.3	83.6	83.1	81.6
07:53:00		82.0	84.0	107.4	83.5	82.9	81.1
07:54:00		63.9	74.4	101.9	73.9	67.4	42.0
07:55:00		50.4	60.1	90.4	58.3	54.9	41.3
07:56:00		57.5	63.9	93.9	62.4	59.9	53.8
07:57:00		54.4	61.0	91.0	59.6	57.6	48.5
07:58:00		53.5	59.9	91.0	58.5	56.4	48.5
07:59:00		51.3	64.1	87.3	56.2	53.6	47.0
08:00:00	2380	54.0	62.6	89.4	59.5	56.8	48.5

E.ON Climate & Renewables Ltd.

Noise Prediction Methodology

Appendix 27.3.

NOVEMBER 2012

RSK GENERAL NOTES

Project No.: P41318

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Author	Mark Evans	**Technical reviewer**	Ian Holmes
Date:	7th November 2012	Date:	7th November 2012

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This work has been undertaken in accordance with the quality management system of RSK Environment Ltd.

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Glossary

1. Sound Pressure Level (L_p)

The basic unit of sound measurement is the sound pressure level, which is measured on a logarithmic scale and expressed in decibels (dB). The logarithmic scale makes it easier to manage the large range of audible sound pressures, and also more closely represents the way the human ear responds to differences in sound pressure:

$L_p = 20 \log_{10} (p/p_o)$

where p = RMS (root mean square) sound pressure; and

p_0 = reference sound pressure 2×10^{-5} Pa.

2. Sound Power Level (L_W)

The sound power level is the sound power output of a source, also measured on a logarithmic scale and expressed in decibels (dB).

$L_W = 10 \log_{10} (W/W_o)$

where W = sound power; and

W_o = reference sound power 1×10^{-12} W.

Sound power level can be calculated from a sound pressure level measured at a known distance from a sound source. For sound radiating uniformly and hemispherically from a point source on a flat reflecting surface such as hard ground, the equation is:

$L_W = L_p + 20 \log_{10} r + 8$ $\quad L_W = L_p + 20\log_{10} r + 8$

where r = distance from the source in m.

3. Equivalent Continuous Sound Level (L_{eq})

Sound levels tend to fluctuate, and as such an 'instantaneous' measurement like sound pressure level cannot fully describe many real-world situations. A summation can be made of the measured sound energy over a certain period, and a notional steady level can be calculated which would contain the same total energy as the fluctuating sound. This notional level is termed the equivalent continuous sound level L_{eq}. L_{eq} can be determined over any time period, which is indicated as $L_{eq,T}$ where T is the time period (e.g. $L_{eq,24h}$).

In mathematical terms, for n discrete sound level measurements, L_{eq} is given by:

$$L_{eq,T} = 10 \log_{10} (t_1 \times 10^{L1/10} + t_2 \times 10^{L2/10} + \ldots t_n \times 10^{Ln/10})/T$$

where t_1 = time at level L_1 dB;

t_2 = time at level L_2 dB;

and T = total time

4. Frequency Weighting Networks

Frequency weighting networks, which are generally built into sound level meters, attenuate the signal at some frequencies and amplify it at others. The A-weighting network approximately corresponds to human frequency response to sound. Sound levels measured with the A-weighting network are expressed in dB(A). Other weighting networks also exist, such as C-weighting which is nearly linear (i.e. unweighted) and other more specialised weighting networks. Variables such as L_p and L_{eq} that can be measured using such weightings are expressed as L_{Ap} / L_{Cp}, L_{Aeq} / L_{Ceq} etc.

5. Percentile or Statistical Levels (L_N)

Sometimes it is useful to calculate the level which is exceeded for a certain percent of a total period. Background noise is often defined as the A-weighted sound pressure level exceeded for 90% of the specified period T, expressed $L_{90,T}$. Road traffic noise is often characterised in terms of $L_{A10,18h}$.

1 NOISE PREDICTION METHODOLGY

1.1 Introduction

- This document outlines the noise prediction methodology followed for the assessment of the operation of the onshore substation and offshore turbines associated with the proposed Rampion Offshore Wind Farm. This document forms Appendix 27.3 to *Section 27* of the Environmental Statement and should be read alongside this section, which also presents elements of the noise prediction methodology.

1.2 Operational Predictions –Receptor Points

1.2.1 Onshore Substation

Receptor points have been identified that may be affected by the operation of the Onshore Substation. These are detailed in Table 1.

Name	ID	Height (m)	Coordinates (m)	
			X	Y
Twineham Court Farm	R1	4.5	524485.66	120813.94
The Coach House	R2	4.5	524583.67	120622.35
Coombe Farm	R3	4.5	524910.16	120725.67
Coombe House	R4	4.5	524796.26	121490.70
Receptor to North	R5	4.5	524449.85	121692.12
Eastridge Lodge	R6	4.5	524089.18	121804.20
Farm to West	R7	4.5	523767.22	121584.13
Residence to south-west	R8	4.5	523852.82	121315.99
Woodpeckers / Downsview	R9	4.5	524753.07	120608.32

Table 1 Receptor points for Onshore Substation model

Receptor points have been identified which are considered to represent the shoreline that may be affected by the operation of the Offshore Turbines have been identified in Table 2.

Name	Height (m)	Coordinates (m)	
		X	Y
Worthing	4.5	515786.7	102668.0
Littlehampton	4.5	502656.0	101546.1
Brighton	4.5	533693.5	103449.9
Peacehaven	4.5	541769.5	100551.9
Newhaven	4.5	543946.7	100116.8
Sleaford	4.5	550784.0	97375.35

Table 2 Receptor points for Offshore Turbine models

1.3 Operational Predictions – Onshore Substation

1.3.1 Prediction Method

Modelling of the onshore substation for the Rampion Offshore Wind Farm development has been undertaken using CadnaA noise modelling software, which incorporates prediction methodology within ISO 9613: 1993 Acoustics - Attenuation of sound during propagation outdoors. The ISO 9613 method predicts a long-term equivalent continuous A-weighted sound pressure level (L_{Aeq}) under meteorological conditions favourable to propagation at distances from a variety of sources of known emission. The method is defined for octave bands for 63 Hz to 8 kHz.

1.3.2 Prediction parameters

The model assumes downwind propagation. The following parameters have been used within the modelling:

- No screening considered due to the flatness of the land surrounding the substation;
- 0.1 absorption coefficient on site ground assuming concrete and 0.7 absorption coefficient outside of site as per Datakustik methodology for fields/grassland/arable; and
- Temperature of 10°C and humidity of 70% for worst case sound propagation.

1.3.3 Noise Source Parameters

The following section describes the noise sources as they have been modelled within the CadnaA computer noise model representing the main noise emitting plant for an onshore substation of the type proposed for the Rampion Offshore Wind Farm development. Sources of data used in the modelling were as follows:

- Super Grid Transformer x 4
- Auxiliary Transformer x 4
- Reactor x 12
- STATCOM unit x 4
- Harmonic Filter Compound x 4
- Cooling Units (Transformers and STATCOM) x 12

Each source has been modeled using the indicative frequency spectrum shown in Table 3. The indicative spectrum was considered to represent a reasonable worst case assumption of low frequency dominance in the 125 Hz octave band. A full list of the individual point sources used within the model is presented in Table 4. Heights for point sources were based on 3/4 height of equipment.

Point Source	Octave Band (Hz) Sound Levels, dB(A)									Broadband Total, dB(A)
	31.5	63	125	250	500	1000	2000	4000	8000	
STATCOM	76.6	78.6	80.6	72.6	56.6	50.6	50.6	48.6	46.6	84.0
SGT	82.6	84.6	86.6	78.6	62.6	56.6	56.6	54.6	52.6	90.0
Filter	83.6	85.6	87.6	79.6	63.6	57.6	57.6	55.6	53.6	91.0
Aux Transformer	82.6	84.6	86.6	78.6	62.6	56.6	56.6	54.6	52.6	90.0
30 MV Reactor	70.6	72.6	74.6	66.6	50.6	44.6	44.6	42.6	40.6	78.0
15 MV Reactor	70.6	72.6	74.6	66.6	50.6	44.6	44.6	42.6	40.6	78.0
Cooling	67.6	69.6	71.6	63.6	47.6	41.6	41.6	39.6	37.6	75.0

Table 3 Model spectrum noise levels for substation sources

Name	With mitigation correction (dBA)	Height (m)	Coordinates (m)	
			X	Y
STATCOM	-15	4	524543.67	121024.8
STATCOM	-15	4	524484.23	121042.5
STATCOM	-15	4	524572.78	121017.1
STATCOM	-15	4	524622.92	121002.9
SGT	-25	3.5	524386.02	121024.3
SGT	-25	3.5	524428.7	121010.3
SGT	-25	3.5	524536.82	120978.6
SGT	-25	3.5	524579.52	120964.9
Filter	-20	4	524338.23	121022
Filter	-20	4	524467.22	120983.6
Filter	-20	4	524489.87	120976.3
Filter	-20	4	524619.51	120936.2
Aux Transformer	-25	3.5	524506.25	121029.5
Aux Transformer	-25	3.5	524414.75	121057.7
Aux Transformer	-25	3.5	524634.12	121022.9
Aux Transformer	-25	3.5	524608.14	121056.5
Reactor	-15	3	524351.27	121045.9
Reactor	-15	3	524470.14	121010.7
Reactor	-15	3	524502.08	121000.2
Reactor	-15	3	524621.36	120963.8
Reactor	-15	3	524434.52	121054.6
Reactor	-15	3	524446.39	121051.4
Reactor	-15	3	524534	121054.3
Reactor	-15	3	524545.56	121051.7
Reactor	-15	3	524588.24	121051.1
Reactor	-15	3	524585.35	121040.8
Reactor	-15	3	524632.53	121054
Reactor	-15	3	524629.32	121043.7
Cooling	0	6	524571.44	120967.8
Cooling	0	6	524545.36	120975.9
Cooling	0	6	524419.81	121013.2
Cooling	0	6	524395.08	121021.2
Cooling	0	6	524627.15	121001.7
Cooling	0	6	524577.42	121015.8
Cooling	0	6	524639.4	121021.5
Cooling	0	6	524614.03	121054.3
Cooling	0	6	524548.11	121024
Cooling	0	6	524510.62	121028.8
Cooling	0	6	524418.75	121056.8
Cooling	0	6	524488.4	121041.2

Table 4 Substation sources used in model

1.4 Operational Predictions – Offshore Turbines

1.4.1 Prediction Method

Modelling of the offshore turbines for the Rampion Offshore Wind Farm development has been undertaken using CadnaA noise modelling software, which incorporates prediction methodology within ISO 9613: 1993 Acoustics - Attenuation of sound during propagation outdoors. The ISO 9613 method predicts a long-term equivalent continuous A-weighted sound pressure level (L_{Aeq}) under meteorological conditions favourable to propagation at distances from a variety of sources of known emission. The method is defined for octave bands for 63 Hz to 8 kHz.

1.4.2 Prediction parameters

The model assumes downwind propagation. The following parameters have been used within the modelling:

- Ground absorption for the models is set to 0 to account for the reflective nature of the surface of the water.
- Temperature of 10°C and humidity of 70% for worst case sound propagation.

1.4.3 Noise Source Parameters

The following section describes the noise source data used within the CadnaA computer noise model. A sound power level of 112 dB(A) at a 10m high 10 m/s wind speed has been provided by Vestas Wind Systems Ltd for the V164-7MW (Vestas, 0011-5675 V00). The Vestas V164 had not been tested at the time of writing and therefore it was necessary to utilise an indicative sound spectrum. The sound spectrum for the Vestas V90-3MW turbine was used as a basis for the shape of the spectrum, with decibels added to each octave band frequency to bring the total noise level up to 112 dB(A).

The same spectrum has been used for the 3MW turbine in options E-F but with shape decreased in order for the total to equal the Vestas 112 3MW sound power level at 10 m/s of 106.5 dB(A).

The resulting sound power level used for the V164-7MW and V112-3MW is set out in Table 5.

Point Source	Octave Band (Hz) Sound Levels, dB(A)									Broadband Total, dB(A)
	31.5	63	125	250	500	1000	2000	4000	8000	
V164	93.6	99.1	100.5	103.6	105	106.7	103.0	100.2	97.0	112.0
V112	88.0	93.5	94.9	98.0	99.4	101.4	97.4	94.4	91.4	106.5

Table 5 Model spectrum for turbine sources

Location and height data for each of the modeled options A-H are provided in Tables 6-13. Options A-D use V90 spectrum data. Options E-H use V112 spectrum data

Turbine sources for option A were modeled using 7 MW turbines, spectrum data V90.

Height (m)	Coordinates (m)	
	X	Y
107	515578.4	88708.48
107	518093.8	89363.55
107	520609.2	90018.63
107	523125.1	90673.27
107	516962.1	88552.29
107	519477.5	89207.35
107	521992.9	89862.42
107	524508.9	90516.98
107	515830.3	87741.02
107	518345.7	88396.09
107	520861.1	89051.15
107	523376.5	89706.22
107	525891.9	90361.28
107	517214	87584.85
107	519729.4	88239.89
107	522244.8	88894.96
107	524760.2	89550.03
107	527275.6	90205.1
107	516082.3	86773.56
107	518597.7	87428.64
107	521113.1	88083.71
107	523628.5	88738.77
107	526143.9	89393.84
107	528659.2	90048.88
107	517465.9	86617.37
107	519981.4	87272.44
107	522496.8	87927.5
107	525012.1	88582.56
107	527527.5	89237.64
107	516334.2	85806.08
107	518849.6	86461.18
107	521365	87116.25
107	523880.4	87771.3
107	526395.8	88426.37
107	528911.2	89081.44
107	517717.9	85649.9
107	520233.3	86304.98
107	522748.7	86960.05

Height (m)	Coordinates (m)	
	X	Y
107	525264.1	87615.11
107	527779.5	88270.17
107	530294.8	88925.23
107	516586.2	84838.61
107	519101.6	85493.72
107	521617	86148.78
107	524132.4	86803.86
107	526647.8	87458.91
107	529163.1	88113.98
107	531678.5	88769.04
107	517969.9	84682.42
107	520485.3	85337.52
107	523000.7	85992.59
107	525516	86647.66
107	528031.4	87302.72
107	530546.8	87957.78
107	533062.1	88612.85
107	516838.1	83871.13
107	519353.5	84526.23
107	521869	85181.33
107	524384.3	85836.41
107	526899.7	86491.49
107	529415.1	87146.55
107	531930.4	87801.59
107	534445.8	88456.65
107	518221.8	83714.95
107	520737.2	84370.06
107	523252.6	85025.14
107	525768	85680.22
107	528283.4	86335.28
107	530798.7	86990.35
107	533314.1	87645.39
107	517090.1	82903.68
107	519605.5	83558.76
107	522120.9	84213.86
107	524636.3	84868.96
107	527151.7	85524.03
107	529667	86179.11
107	532182.4	86834.15
107	534697.7	87489.21
107	523504.6	84057.68
107	526019.9	84712.77

Height (m)	Coordinates (m)	
	X	Y
107	528535.3	85367.82
107	531050.7	86022.92
107	533566	86677.95
107	536081.4	87333.02
107	524888.2	83901.49
107	527403.6	84556.59
107	529919	85211.66
107	532434.3	85866.71
107	534949.7	86521.76
107	537465.6	87176.32
107	523756.5	83090.2
107	526271.9	83745.31
107	528787.3	84400.38
107	531302.6	85055.46
107	533818	85710.52
107	536333.3	86365.59
107	525140.2	82934.03
107	527655.6	83589.12
107	535201.6	85554.34
107	537716.9	86209.39

Table 6 Turbine sources used in model option A

Turbine sources for option B were modeled using 7 MW turbines, spectrum data V90.

Height (m)	Coordinates (m)	
	X	Y
107	515578.4	88708.48
107	516710.3	89003.27
107	517842.2	89298.05
107	518974.2	89592.83
107	520106.1	89887.62
107	521238	90182.39
107	522370.9	90476.44
107	523502	90771.88
107	524635.7	91065.23
107	515873.2	87576.56
107	517005.1	87871.35
107	518137	88166.12
107	519269	88460.89
107	520400.9	88755.67
107	521532.8	89050.45
107	522664.8	89345.23
107	523796.7	89640.02

Height (m)	Coordinates (m)	
	X	Y
107	524928.6	89934.8
107	526060.5	90229.58
107	527192.5	90524.32
107	516167.9	86444.6
107	517299.9	86739.41
107	518431.8	87034.2
107	519563.7	87328.97
107	520695.7	87623.76
107	521827.6	87918.53
107	522959.5	88213.32
107	524091.4	88508.08
107	525223.4	88802.86
107	526355.3	89097.66
107	527487.2	89392.43
107	528619.1	89687.2
107	516462.7	85312.67
107	517594.7	85607.47
107	518726.6	85902.26
107	519858.5	86197.06
107	520990.5	86491.83
107	522122.4	86786.6
107	523254.3	87081.39
107	524386.2	87376.16
107	525518.2	87670.92
107	526650.1	87965.72
107	527782	88260.49
107	528913.9	88555.29
107	530045.8	88850.06
107	531177.7	89144.83
107	516757.5	84180.73
107	517889.5	84475.53
107	519021.4	84770.31
107	520153.3	85065.12
107	521285.2	85359.9
107	522417.2	85654.68
107	523549.1	85949.48
107	524681	86244.25
107	525812.9	86539.03
107	526944.8	86833.81
107	528076.8	87128.58
107	529208.7	87423.37
107	530340.6	87718.14

Height (m)	Coordinates (m)	
	X	Y
107	531472.5	88012.91
107	532604.4	88307.7
107	533736.3	88602.47
107	517052.3	83048.81
107	518184.2	83343.58
107	519316.2	83638.38
107	520448.1	83933.17
107	521580	84227.96
107	522712	84522.75
107	523843.9	84817.55
107	524975.8	85112.34
107	526107.7	85407.12
107	527239.6	85701.91
107	528371.5	85996.67
107	529503.5	86291.48
107	530635.4	86586.25
107	531767.3	86881.02
107	532899.2	87175.78
107	534031.1	87470.55
107	535163	87765.34
107	523006.8	83390.83
107	524138.7	83685.61
107	525270.6	83980.41
107	526402.5	84275.21
107	527534.4	84569.98
107	528666.3	84864.76
107	529798.2	85159.55
107	530930.1	85454.34
107	532062.1	85749.1
107	533194	86043.87
107	534325.9	86338.66
107	535457.8	86633.42
107	536589.7	86928.21
107	537722.4	87222.26
107	523301.5	82258.9
107	524433.4	82553.68
107	525565.4	82848.47
107	526697.3	83143.26
107	536884.4	85796.34
107	538016.4	86091.09
107	539148.5	86385.63

Table 7 Turbine sources used in model option B

Turbine sources for option C were modeled using 7 MW turbines, spectrum data V90.

Height (m)	Coordinates (m)	
	X	Y
107	515578.4	88708.48
107	517803.5	89287.96
107	520028.7	89867.46
107	522254.6	90446.34
107	524480.5	91025.18
107	516799.3	88582.22
107	519024.5	89161.7
107	521249.6	89741.18
107	523474.8	90320.63
107	525700.2	90899.91
107	515795.1	87876.46
107	518020.2	88455.95
107	520245.4	89035.43
107	522470.6	89614.92
107	524695.7	90194.36
107	517016	87750.21
107	519241.1	88329.68
107	521466.3	88909.16
107	523691.5	89488.64
107	525916.6	90068.14
107	516011.7	87044.45
107	518236.9	87623.95
107	520462.1	88203.41
107	522687.2	88782.9
107	524912.4	89362.38
107	527137.5	89941.86
107	517232.6	86918.2
107	519457.8	87497.67
107	521683	88077.16
107	523908.1	88656.63
107	526133.3	89236.12
107	528358.4	89815.59
107	516228.4	86212.41
107	518453.6	86791.93
107	520678.7	87371.42
107	522903.9	87950.88
107	525129	88530.36
107	527354.2	89109.84
107	529579.3	89689.33
107	517449.3	86086.17
107	519674.5	86665.66

Height (m)	Coordinates (m)	
	X	Y
107	521899.7	87245.14
107	524124.8	87824.62
107	526350	88404.09
107	528575.1	88983.58
107	530800.2	89563.04
107	516445.1	85380.39
107	518670.3	85959.91
107	520895.4	86539.4
107	523120.6	87118.87
107	525345.7	87698.34
107	527570.9	88277.83
107	529796	88857.31
107	517666	85254.15
107	519891.2	85833.65
107	522116.4	86413.12
107	524341.5	86992.61
107	526566.6	87572.08
107	528791.8	88151.57
107	531016.9	88731.04
107	516661.8	84548.37
107	518886.9	85127.88
107	521112.1	85707.38
107	523337.3	86286.88
107	525562.4	86866.34
107	527787.5	87445.82
107	530012.7	88025.3
107	532237.8	88604.79
107	517882.7	84422.11
107	520107.9	85001.63
107	522333	85581.11
107	524558.2	86160.61
107	526783.3	86740.1
107	529008.4	87319.56
107	531233.6	87899.03
107	533458.7	88478.51
107	516878.4	83716.34
107	519103.6	84295.84
107	521328.8	84875.35
107	523553.9	85454.86
107	525779.1	86034.34
107	528004.2	86613.83
107	530229.3	87193.31

Height (m)	Coordinates (m)	
	X	Y
107	532454.5	87772.76
107	534679.6	88352.24
107	518099.4	83590.08
107	520324.5	84169.6
107	522549.7	84749.1
107	524774.8	85328.6
107	527000	85908.09
107	529225.1	86487.57
107	531450.2	87067.05
107	533675.4	87646.51
107	535900.9	88225.66
107	517095.1	82884.34
107	519320.3	83463.83
107	521545.5	84043.34
107	523770.6	84622.85
107	525995.8	85202.35
107	518316.1	82758.07

Table 8 Turbine sources used in model option C

Turbine sources for option D were modeled using 7 MW turbines, spectrum data V90.

Height (m)	Coordinates (m)	
	X	Y
107	515578.4	88708.48
107	516691	88998.23
107	517803.5	89287.96
107	518916.1	89577.72
107	520028.7	89867.46
107	521141.3	90157.2
107	522254.6	90446.34
107	523366.7	90736.47
107	524480.5	91025.18
107	515795.1	87876.46
107	516907.6	88166.21
107	518020.2	88455.95
107	519132.8	88745.69
107	520245.4	89035.43
107	521358	89325.17
107	522470.6	89614.92
107	523583.1	89904.64
107	524695.7	90194.36
107	525808.3	90484.08
107	516011.7	87044.45

Height (m)	Coordinates (m)	
	X	Y
107	517124.3	87334.21
107	518236.9	87623.95
107	519349.5	87913.67
107	520462.1	88203.41
107	521574.7	88493.15
107	522687.2	88782.9
107	523799.8	89072.64
107	524912.4	89362.38
107	526025	89652.13
107	527137.5	89941.86
107	528250.1	90231.59
107	516228.4	86212.41
107	517341	86502.18
107	518453.6	86791.93
107	519566.2	87081.66
107	520678.7	87371.42
107	521791.3	87661.16
107	522903.9	87950.88
107	524016.5	88240.62
107	525129	88530.36
107	526241.6	88820.1
107	527354.2	89109.84
107	528466.8	89399.58
107	529579.3	89689.33
107	516445.1	85380.39
107	517557.7	85670.16
107	518670.3	85959.91
107	519782.8	86249.66
107	520895.4	86539.4
107	522008	86829.13
107	523120.6	87118.87
107	524233.1	87408.61
107	525345.7	87698.34
107	526458.3	87988.09
107	527570.9	88277.83
107	528683.4	88567.58
107	529796	88857.31
107	530908.5	89147.04
107	516661.8	84548.37
107	517774.4	84838.13
107	518886.9	85127.88
107	519999.5	85417.64

Height (m)	Coordinates (m)	
	X	Y
107	521112.1	85707.38
107	522224.7	85997.11
107	523337.3	86286.88
107	524449.8	86576.62
107	525562.4	86866.34
107	526675	87156.09
107	527787.5	87445.82
107	528900.1	87735.56
107	530012.7	88025.3
107	531125.2	88315.03
107	532237.8	88604.79
107	533350.3	88894.52
107	516878.4	83716.34
107	517991	84006.08
107	519103.6	84295.84
107	520216.2	84585.62
107	521328.8	84875.35
107	522441.4	85165.1
107	523553.9	85454.86
107	524666.5	85744.61
107	525779.1	86034.34
107	526891.6	86324.09
107	528004.2	86613.83
107	529116.8	86903.58
107	530229.3	87193.31
107	531341.9	87483.04
107	532454.5	87772.76
107	533567	88062.51
107	534679.6	88352.24
107	517095.1	82884.34
107	518207.7	83174.08
107	519320.3	83463.83
107	520432.9	83753.59
107	521545.5	84043.34
107	522658.1	84333.09
107	523770.6	84622.85
107	524883.2	84912.59
107	525995.8	85202.35

Table 9 Turbine sources used in model option D

Turbine sources for option E were modeled using 3 MW turbines, spectrum data V112.

Height (m)	Coordinates (m)	
	X	Y
94	515578.4	88708.48
94	517513.3	89212.37
94	519448.2	89716.29
94	521383.2	90220.15
94	523318.4	90723.82
94	516640.3	88597.64
94	518575.2	89101.53
94	520510.2	89605.43
94	522445.1	90109.33
94	524380.7	90612.66
94	515767.3	87982.88
94	517702.3	88486.79
94	519637.2	88990.68
94	521572.1	89494.58
94	523507	89998.47
94	525442.2	90502.14
94	516829.3	87872.05
94	518764.2	88375.93
94	520699.1	88879.82
94	522634.1	89383.73
94	524569	89887.64
94	526503.9	90391.52
94	515956.3	87257.29
94	517891.2	87761.21
94	519826.2	88265.08
94	521761.1	88768.98
94	523696	89272.88
94	525630.9	89776.79
94	527565.8	90280.65
94	517018.2	87146.45
94	518953.2	87650.34
94	520888.1	88154.25
94	522823	88658.14
94	524757.9	89162.04
94	526692.8	89665.93
94	528627.7	90169.82
94	516145.2	86531.68
94	518080.2	87035.61
94	520015.1	87539.5
94	521950	88043.4
94	523885	88547.28
94	525819.9	89051.19

Height (m)	Coordinates (m)	
	X	Y
94	527754.8	89555.08
94	517207.2	86420.84
94	519142.1	86924.76
94	521077.1	87428.66
94	523012	87932.54
94	524946.9	88436.43
94	526881.8	88940.33
94	528816.7	89444.24
94	516334.2	85806.08
94	518269.1	86310.01
94	520204.1	86813.91
94	522139	87317.8
94	524073.9	87821.69
94	526008.8	88325.59
94	527943.7	88829.49
94	529878.6	89333.38
94	517396.2	85695.25
94	519331.1	86199.17
94	521266	86703.07
94	523200.9	87206.96
94	525135.9	87710.84
94	527070.8	88214.74
94	529005.7	88718.64
94	530940.5	89222.52
94	516523.2	85080.48
94	518458.1	85584.41
94	520393.1	86088.31
94	522328	86592.2
94	524262.9	87096.12
94	526197.8	87599.99
94	528132.7	88103.89
94	530067.6	88607.79
94	532002.5	89111.69
94	517585.1	84969.65
94	519520.1	85473.56
94	521455	85977.47
94	523389.9	86481.37
94	525324.8	86985.26
94	527259.7	87489.15
94	529194.6	87993.05
94	531129.5	88496.94
94	516712.1	84354.87

Height (m)	Coordinates (m)	
	X	Y
94	518647.1	84858.8
94	520582	85362.71
94	522516.9	85866.61
94	524451.8	86370.53
94	526386.7	86874.41
94	528321.7	87378.31
94	530256.5	87882.19
94	532191.4	88386.1
94	517774.1	84244.03
94	519709	84747.96
94	521644	85251.87
94	523578.9	85755.78
94	525513.8	86259.68
94	527448.7	86763.57
94	529383.6	87267.48
94	531318.5	87771.35
94	533253.4	88275.25
94	516901.1	83629.27
94	518836.1	84133.19
94	520771	84637.12
94	522705.9	85141.02
94	524640.8	85644.94
94	526575.7	86148.84
94	528510.6	86652.74
94	530445.5	87156.63
94	532380.4	87660.51
94	534315.3	88164.39
94	517963.1	83518.43
94	519898	84022.35
94	521832.9	84526.27
94	523767.8	85030.18
94	525702.7	85534.1
94	527637.6	86038
94	529572.6	86541.91
94	531507.4	87045.78
94	533442.3	87549.66
94	535377.2	88053.55
94	517090.1	82903.68
94	519025	83407.59
94	520960	83911.52
94	522894.9	84415.43
94	524829.8	84919.35

Height (m)	Coordinates (m)	
	X	Y
94	526764.7	85423.25
94	528699.6	85927.14
94	530634.5	86431.06
94	532569.3	86934.92
94	534504.2	87438.82
94	536439.1	87942.72
94	518152.1	82792.84
94	520087	83296.75
94	523956.8	84304.59
94	525891.7	84808.51
94	527826.6	85312.4
94	529761.5	85816.31
94	531696.4	86320.2
94	533631.3	86824.07
94	535566.2	87327.97
94	523083.8	83689.83
94	525018.7	84193.75
94	526953.6	84697.65
94	528888.5	85201.55
94	530823.4	85705.48
94	532758.3	86209.34
94	534693.2	86713.23
94	536628.1	87217.12
94	524145.8	83579
94	526080.7	84082.92
94	528015.6	84586.82
94	529950.5	85090.72
94	531885.4	85594.62
94	533820.2	86098.5
94	535755.1	86602.39
94	537690.6	87105.77
94	523272.8	82964.23
94	525207.7	83468.16
94	527142.6	83972.06
94	529077.5	84475.97
94	531012.4	84979.89
94	532947.3	85483.77
94	534882.2	85987.67
94	536817	86491.56
94	524334.7	82853.39
94	526269.6	83357.31
94	528204.5	83861.23

Height (m)	Coordinates (m)	
	X	Y
94	530139.4	84365.13
94	532074.3	84869.04
94	534009.2	85372.93
94	535944.1	85876.83
94	537878.9	86380.7
94	523461.8	82238.65
94	525396.7	82742.55

Table 10 Turbine sources used in model option E

Turbine sources for option F were modeled using 3 MW turbines, spectrum data V112.

Height (m)	Coordinates (m)	
	X	Y
94	515578.4	88708.48
94	516429.7	88930.21
94	517281.1	89151.92
94	518132.5	89373.63
94	518983.9	89595.35
94	519835.2	89817.08
94	520686.6	90038.79
94	521538.1	90260.41
94	522390.2	90481.46
94	523241.1	90703.6
94	524092.8	90925
94	524945.2	91145.9
94	515800.1	87857.11
94	516651.5	88078.85
94	517502.8	88300.55
94	518354.2	88522.26
94	519205.6	88743.98
94	520056.9	88965.69
94	520908.3	89187.4
94	521759.7	89409.13
94	522611	89630.84
94	523462.4	89852.55
94	524313.8	90074.28
94	525165.3	90295.85
94	526016.5	90517.7
94	516021.8	87005.75
94	516873.2	87227.48
94	517724.5	87449.21
94	518575.9	87670.9
94	519427.3	87892.61

Height (m)	Coordinates (m)	
	X	Y
94	520278.6	88114.33
94	521130	88336.04
94	521981.4	88557.76
94	522832.7	88779.47
94	523684.1	89001.18
94	524535.5	89222.9
94	525386.8	89444.62
94	526238.2	89666.34
94	527089.5	89888.06
94	527940.9	90109.76
94	516243.5	86154.38
94	517094.9	86376.09
94	517946.3	86597.82
94	518797.6	86819.54
94	519649	87041.25
94	520500.4	87262.98
94	521351.7	87484.69
94	522203.1	87706.39
94	523054.5	87928.11
94	523905.8	88149.83
94	524757.2	88371.53
94	525608.5	88593.24
94	526459.9	88814.97
94	527311.3	89036.68
94	528162.6	89258.4
94	529014	89480.12
94	529865.3	89701.81
94	516465.2	85303
94	517316.6	85524.73
94	518168	85746.45
94	519019.4	85968.17
94	519870.7	86189.9
94	520722.1	86411.61
94	521573.5	86633.32
94	522424.8	86855.04
94	523276.2	87076.76
94	524127.5	87298.46
94	524978.9	87520.17
94	525830.3	87741.88
94	526681.6	87963.6
94	527533	88185.32
94	528384.3	88407.03

Height (m)	Coordinates (m)	
	X	Y
94	529235.7	88628.75
94	530087	88850.46
94	530938.4	89072.17
94	531789.7	89293.9
94	516687	84451.63
94	517538.3	84673.34
94	518389.7	84895.08
94	519241.1	85116.8
94	520092.4	85338.53
94	520943.8	85560.25
94	521795.2	85781.95
94	522646.5	86003.67
94	523497.9	86225.41
94	524349.3	86447.11
94	525200.6	86668.82
94	526052	86890.53
94	526903.3	87112.25
94	527754.7	87333.96
94	528606	87555.68
94	529457.4	87777.39
94	530308.7	87999.1
94	531160.1	88220.81
94	532011.4	88442.52
94	532862.8	88664.25
94	516908.7	83600.25
94	517760	83821.97
94	518611.4	84043.69
94	519462.8	84265.43
94	520314.2	84487.15
94	521165.5	84708.87
94	522016.9	84930.59
94	522868.3	85152.31
94	523719.6	85374.04
94	524571	85595.76
94	525422.3	85817.47
94	526273.7	86039.19
94	527125	86260.92
94	527976.4	86482.62
94	528827.8	86704.33
94	529679.1	86926.06
94	530530.5	87147.76
94	531381.8	87369.46

Height (m)	Coordinates (m)	
	X	Y
94	532233.2	87591.18
94	533084.5	87812.88
94	533935.9	88034.59
94	534787.2	88256.31
94	517130.4	82748.9
94	517981.8	82970.6
94	518833.1	83192.33
94	519684.5	83414.05
94	520535.9	83635.78
94	523090	84300.95
94	523941.3	84522.67
94	524792.7	84744.39
94	525644.1	84966.12
94	526495.4	85187.84
94	527346.8	85409.55
94	528198.1	85631.26
94	529049.5	85852.98
94	529900.8	86074.71
94	530752.2	86296.43
94	531603.5	86518.12
94	532454.9	86739.82
94	533306.2	86961.53
94	534157.6	87183.24
94	535008.9	87404.96
94	535860.3	87626.67
94	523311.7	83449.58
94	524163	83671.31
94	525014.4	83893.03
94	525865.8	84114.75
94	526717.1	84336.48
94	527568.5	84558.19
94	528419.8	84779.9
94	529271.2	85001.63
94	530122.5	85223.34
94	530973.9	85445.07
94	531825.2	85666.77
94	532676.6	85888.48
94	533527.9	86110.19
94	534379.3	86331.9
94	535230.6	86553.6
94	536082	86775.33
94	536933.4	86996.94

Height (m)	Coordinates (m)	
	X	Y
94	537785.6	87218
94	523533.4	82598.22
94	524384.8	82819.93
94	525236.1	83041.66
94	526087.5	83263.39
94	526938.8	83485.11
94	527790.2	83706.83
94	528641.6	83928.54
94	529492.9	84150.27
94	530344.3	84371.99
94	531195.6	84593.71
94	532047	84815.42
94	532898.3	85037.14
94	533749.6	85258.85
94	534601	85480.58
94	535452.3	85702.28
94	536303.7	85924
94	537155	86145.7
94	538006.4	86367.4

Table 11 Turbine sources used in model option F

Turbine sources for option G were modeled using 3 MW turbines, spectrum data V112.

Height (m)	Coordinates (m)	
	X	Y
94	515578.4	88708.48
94	517223.1	89136.8
94	518867.8	89565.12
94	520512.4	89993.44
94	522157.8	90421.23
94	523802.1	90849.78
94	516482.6	88608.23
94	518127.3	89036.52
94	519772	89464.85
94	521416.7	89893.16
94	523061.6	90321.3
94	524707.3	90748.76
94	515742.1	88079.63
94	517386.8	88507.94
94	519031.5	88936.25
94	520676.2	89364.58
94	522320.9	89792.9
94	523965.6	90221.16

Height (m)	Coordinates (m)	
	X	Y
94	525610.5	90649.3
94	516646.4	87979.39
94	518291.1	88407.68
94	519935.7	88835.99
94	521580.4	89264.3
94	523225.1	89692.62
94	524869.8	90120.93
94	526514.5	90549.24
94	515905.9	87450.8
94	517550.6	87879.1
94	519195.3	88307.4
94	520840	88735.71
94	522484.7	89164.04
94	524129.3	89592.35
94	525774	90020.67
94	527418.8	90448.89
94	516810.1	87350.53
94	518454.8	87778.83
94	520099.5	88207.14
94	521744.2	88635.46
94	523388.9	89063.78
94	525033.6	89492.08
94	526678.2	89920.39
94	516069.7	86821.93
94	517714.4	87250.26
94	519359.1	87678.57
94	521003.7	88106.89
94	522648.4	88535.19
94	524293.1	88963.49
94	525937.8	89391.81
94	527582.4	89820.13
94	516973.9	86721.68
94	518618.6	87149.98
94	520263.3	87578.3
94	521908	88006.61
94	523552.6	88434.93
94	525197.3	88863.23
94	526842	89291.55
94	528486.7	89719.86
94	516233.4	86193.07
94	517878.1	86621.4
94	519522.8	87049.72

Height (m)	Coordinates (m)	
	X	Y
94	521167.5	87478.04
94	522812.2	87906.35
94	524456.9	88334.65
94	526101.5	88762.97
94	527746.2	89191.28
94	529390.9	89619.58
94	517137.7	86092.82
94	518782.4	86521.14
94	520427	86949.46
94	522071.7	87377.76
94	523716.4	87806.08
94	525361.1	88234.37
94	527005.8	88662.69
94	528650.4	89091.02
94	530295.1	89519.31
94	516397.2	85564.22
94	518041.9	85992.54
94	519686.6	86420.87
94	521331.3	86849.19
94	522976	87277.5
94	524620.6	87705.79
94	526265.3	88134.11
94	527910	88562.43
94	529554.7	88990.75
94	531199.3	89419.04
94	517301.4	85463.96
94	518946.1	85892.29
94	520590.8	86320.61
94	522235.5	86748.92
94	523880.2	87177.24
94	525524.9	87605.53
94	527169.5	88033.84
94	528814.2	88462.16
94	530458.8	88890.46
94	516561	84935.37
94	518205.7	85363.7
94	519850.4	85792.03
94	521495.1	86220.34
94	523139.7	86648.66
94	524784.4	87076.95
94	526429.1	87505.26
94	528073.7	87933.58

Height (m)	Coordinates (m)	
	X	Y
94	529718.4	88361.9
94	531363.1	88790.2
94	517465.2	84835.1
94	519109.9	85263.43
94	520754.6	85691.75
94	522399.3	86120.07
94	524044	86548.4
94	525688.6	86976.69
94	527333.3	87405.01
94	528978	87833.32
94	530622.6	88261.62
94	532267.3	88689.93
94	516724.7	84306.5
94	518369.4	84734.83
94	520014.1	85163.17
94	521658.8	85591.49
94	523303.5	86019.82
94	524948.2	86448.12
94	526592.8	86876.43
94	528237.5	87304.74
94	529882.2	87733.06
94	531526.8	88161.35
94	533171.5	88589.67
94	517629	84206.24
94	519273.7	84634.58
94	520918.4	85062.91
94	522563	85491.22
94	524207.7	85919.55
94	525852.4	86347.85
94	527497.1	86776.18
94	529141.7	87204.49
94	530786.4	87632.78
94	532431	88061.09
94	534075.7	88489.4
94	516888.5	83677.65
94	518533.2	84105.96
94	520177.9	84534.31
94	521822.6	84962.63
94	523467.3	85390.97
94	525111.9	85819.28
94	526756.6	86247.6
94	528401.3	86675.91

Height (m)	Coordinates (m)	
	X	Y
94	530045.9	87104.24
94	531690.6	87532.51
94	533335.2	87960.82
94	534979.9	88389.13
94	517792.8	83577.38
94	519437.4	84005.71
94	521082.1	84434.05
94	522726.8	84862.38
94	524371.5	85290.71
94	526016.2	85719.02
94	527660.8	86147.33
94	529305.5	86575.66
94	530950.1	87003.95
94	532594.8	87432.25
94	534239.4	87860.56
94	517052.3	83048.81
94	518697	83477.12
94	520341.7	83905.46
94	521986.4	84333.79
94	523631	84762.12
94	525275.7	85190.44
94	526920.4	85618.76
94	517956.5	82948.54
94	519601.2	83376.86
94	522890.6	84233.53
94	524535.3	84661.86
94	526179.9	85090.18
94	517216.1	82419.96
94	518860.8	82848.28
94	523794.8	84133.28
94	525439.5	84561.6

Table 12 Turbine sources used in model option G

Turbine sources for option H were modeled using 3 MW turbines, spectrum data V112.

Height (m)	Coordinates (m)	
	X	Y
94	515578.4	88708.48
94	516400.7	88922.65
94	517223.1	89136.8
94	518045.4	89350.95
94	518867.8	89565.12
94	519690.1	89779.28

Height (m)	Coordinates (m)	
	X	Y
94	520512.4	89993.44
94	521334.8	90207.57
94	522157.8	90421.23
94	522980.1	90635.38
94	523802.1	90849.78
94	524626	91062.73
94	515771.2	88087.19
94	516593.5	88301.36
94	517415.9	88515.51
94	518238.2	88729.65
94	519060.6	88943.81
94	519882.9	89157.98
94	520705.2	89372.13
94	521527.6	89586.3
94	522349.9	89800.44
94	523172.3	90014.6
94	523994.7	90228.71
94	524817.5	90442.45
94	525639.5	90656.87
94	515934.9	87458.35
94	516757.3	87672.51
94	517579.6	87886.67
94	518402	88100.81
94	519224.3	88314.97
94	520046.7	88529.12
94	520869	88743.28
94	521691.3	88957.44
94	522513.7	89171.59
94	523336	89385.75
94	524158.4	89599.9
94	524980.7	89814.07
94	525803	90028.23
94	526625.4	90242.39
94	527447.8	90456.44
94	516098.7	86829.48
94	516921	87043.66
94	517743.4	87257.82
94	518565.7	87471.98
94	519388.1	87686.12
94	520210.4	87900.28
94	521032.8	88114.44
94	521855.1	88328.59

Height (m)	Coordinates (m)	
	X	Y
94	522677.5	88542.75
94	523499.8	88756.9
94	524322.1	88971.06
94	525144.5	89185.21
94	525966.8	89399.38
94	526789.1	89613.53
94	527611.5	89827.68
94	528433.8	90041.84
94	516262.4	86200.63
94	517084.8	86414.79
94	517907.1	86628.96
94	518729.5	86843.12
94	519551.8	87057.28
94	520374.2	87271.44
94	521196.5	87485.6
94	522018.9	87699.75
94	522841.2	87913.89
94	523663.5	88128.06
94	524485.9	88342.2
94	525308.2	88556.36
94	526130.6	88770.52
94	526952.9	88984.68
94	527775.2	89198.84
94	528597.6	89412.99
94	529419.9	89627.14
94	516426.2	85571.77
94	517248.6	85785.94
94	518070.9	86000.11
94	518893.3	86214.27
94	519715.6	86428.44
94	520538	86642.59
94	521360.3	86856.76
94	522182.7	87070.9
94	523005	87285.05
94	523827.3	87499.21
94	524649.7	87713.35
94	525472	87927.51
94	526294.3	88141.67
94	527116.7	88355.83
94	527939	88569.99
94	528761.3	88784.16
94	529583.7	88998.3

Height (m)	Coordinates (m)	
	X	Y
94	530406	89212.44
94	531228.3	89426.6
94	516590	84942.91
94	517412.4	85157.09
94	518234.7	85371.25
94	519057	85585.43
94	519879.4	85799.58
94	520701.7	86013.74
94	521524.1	86227.9
94	522346.4	86442.05
94	523168.8	86656.22
94	523991.1	86870.37
94	524813.4	87084.52
94	525635.8	87298.67
94	526458.1	87512.83
94	527280.4	87726.98
94	528102.8	87941.13
94	528925.1	88155.3
94	529747.4	88369.45
94	530569.7	88583.6
94	531392.1	88797.76
94	532214.4	89011.93
94	516753.8	84314.06
94	517576.1	84528.22
94	518398.5	84742.39
94	519220.8	84956.57
94	520043.2	85170.73
94	520865.5	85384.89
94	521687.8	85599.04
94	522510.2	85813.21
94	523332.5	86027.37
94	524154.9	86241.54
94	524977.2	86455.68
94	525799.5	86669.83
94	526621.9	86884
94	527444.2	87098.15
94	528266.5	87312.3
94	529088.9	87526.46
94	529911.2	87740.61
94	530733.5	87954.75
94	531555.8	88168.9
94	532378.2	88383.07

Height (m)	Coordinates (m)	
	X	Y
94	533200.5	88597.23
94	534022.8	88811.38
94	516917.5	83685.2
94	517739.9	83899.35
94	518562.2	84113.53
94	519384.6	84327.7
94	520206.9	84541.88
94	521029.3	84756.03
94	521851.6	84970.2
94	522674	85184.36
94	523496.3	85398.52
94	524318.6	85612.68
94	525141	85826.84
94	525963.3	86041
94	526785.6	86255.16
94	527608	86469.33
94	528430.3	86683.47
94	529252.6	86897.64
94	530075	87111.78
94	530897.3	87325.92
94	531719.6	87540.07
94	532541.9	87754.23
94	533364.3	87968.39
94	534186.6	88182.53
94	535008.9	88396.7
94	517081.3	83056.36
94	517903.7	83270.52
94	518726	83484.68
94	519548.4	83698.85
94	520370.7	83913.02
94	521193.1	84127.18
94	522015.4	84341.35
94	522837.7	84555.51
94	523660.1	84769.67
94	524482.4	84983.83
94	525304.7	85198.01
94	526127.1	85412.16
94	526949.4	85626.32
94	527771.7	85840.47
94	517245.1	82427.52
94	518067.5	82641.67
94	518889.8	82855.83

Height (m)	Coordinates (m)	
	X	Y
94	519712.1	83070

Table 13 Turbine sources used in model option H

1.4.4 Assessment Results

The results of the CadnaA predictions based on the L_w calculated through the methodology above were compared to project criteria. The results of this assessment are presented in *Section 27* of the Environmental Statement.