Grimsby Reserve Site
Grimsby CHP.

Environmental Noise Assessment to inform potential impact of proposals

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SECTION **TITLE** **PAGE**

1. INTRODUCTION AND OVERVIEW OF PLANNING CONSENT

The Grimsby Reserve Site comprises Sites A & B, located on the site of the Combined Heat and Power Station (CHP), on the Pyewipe Industrial Estate, Grimsby. The CHP plant served the former Huntsman Tioxide Chemical Works, which is now closed, with the site demolished. The CHP plant has been de-commissioning and therefore would not form part of the Reserve Site availability.

Grimsby Site A was granted planning permission in December 2016, under application number DM/0104/16/FUL, with the scheme layout subsequently amended under a Section 73 application, to include for a configuration of a single row of 10 Containerised Generator Sets, each with a generating capacity of 2MW, resulting in a total capacity of 20MW. This site is now operational.

Planning permission for Grimsby Site B (Ref: DM/0491/18/FUL) expires on 29th June 2020 and, as the project has not been implemented during this period, RWE Generation UK are preparing to submit a new application.

The new application will include for small changes to the layout of Site B and also the as-built Site A. To reflect these changes, the original Environmental Noise Assessment (ref PJ3539/16440), prepared in support of the 2018 consented scheme, has been updated and included in this revised report. The updates include:

- Completion of an update to the computer noise model, relating to prediction of operational noise, to reflect the changes to layout of Site B and also the as-built Site A;
- Update of the noise assessments (BS 4142 and change to overall pant sound emission) to reflect the updated prediction results;
- Update to the assessment of noise relating to the Humber Estuary SAC designated site, to reflect the updated prediction results.

2. RESERVE SITE PROPOSAL

The proposal is for the Site B extension to comprise an additional row of 10 Containerised Generator Sets on an identical site to the east of Site A, providing an additional capacity of 20MW, resulting in a total Reserve Site capacity of 40MW. The existing electrical and gas infrastructure would be utilised.

The normal status of a Reserve Site is ‘not running, but ready to run’. Operating hours are dictated by market requirements, however, RWE Generation UK plc operates a number of reserve sites and can therefore estimate the likely operating scenario:

- The Reserve Site would only operate for short periods at times of peak demand or to rapidly fill a temporary shortfall of generation, while an alternative conventional power station is being brought on-line.
- When called upon to operate, runs are most often between October and March and would typically be less than 3 hours in duration, most likely occurring during the morning (07:00-10:00) and early evening (17:00-20:00) demand peaks.
- Night-time running would not normally occur and it is anticipated that the site would only be called upon to run at night under emergency conditions, such as a major grid failure.

Due to the operating scenario described, a qualitative assessment would indicate that Reserve Site operational noise is likely to provide a low risk of adverse noise impact. For the Grimsby Reserve Site, there are additional considerations that further reduce the potential for adverse noise impact:

- The Grimsby Reserve Site is located on an existing power plant site, which itself is located on the large Pyewipe Industrial Estate;
- The closest noise-sensitive property (a hotel), in Appian Way, Pyewipe, is located at significant distance (500m) from the centre of the Reserve Site;
- The closest residential properties are located to the south, with Haven Gardens being 950m from the Reserve Site. The residential areas are located to the south side of the A180 main trunk road into Grimsby, which runs between these residential areas and the Reserve Site. Daytime ambient noise levels at these properties are therefore dominated by continuous road traffic noise, together with noise from other (closer) industry;
- Grimsby Site A, comprising 10 x 2MW Containerised Generator Sets has been operating regularly at the site since December 2016, with no adverse noise impact reported.

Whilst a qualitative assessment would indicate that operational noise from the proposed Site B extension to the Grimsby Reserve Site would provide a low risk of adverse noise impact, a quantitative assessment of noise has additionally been provided to inform the planning application. This assessment, based on the cumulative noise emission from the combined A and B sites, is detailed in Section 4 of this report.

3. AMBIENT NOISE SURVEY

In order to assess operational noise, in line with BS 4142[1] assessment procedures, the noise emission from the Reserve Site needs to be compared with the existing ambient noise environment, at the nearest noise sensitive receptor locations to the site. As part of the noise assessment process, ambient noise levels have therefore been established for the normal operating periods of the Reserve Site, covering the peak demand periods of 07:00-10:00 and 17:00-20:00.

3.1 NOISE SENSITIVE RECEPTOR POSITIONS

A description of the noise sensitive receptor positions (R) chosen for the noise impact assessment is provided in Table 1. These positions were chosen as being representative of the closest residential receptor positions, the Humber Estuary Special Area of Conservation (SAC) designated site and also the Local Wildlife designated site (LWS). These positions are also illustrated on Figure 1.

[1] BS 4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound*

Receptor Position	Distance to Reserve site (m)	Description
R1 Premier Inn, Appian Way, Pyewipe	510	This position is representative of hotel accommodation at the Premier Inn, situated south of the Reserve Site, within the Industrial Estate. Ambient noise measurements were recorded in the north facing car park of the Hotel.
R2 Haven Gardens, Grimsby	925	This position is representative of the closest residential properties, situated south of the Reserve Site and south of the A180. Ambient noise measurements were recorded in a car park bay, in front of properties in Haven Gardens.
R3 Woad Lane, Great Coates	1000	This position is representative of the closest residential properties in Great Coats, situated southwest of the Reserve Site and south of the A180. Ambient noise measurements were recorded at the rear of properties, at the intersection of Woad Lane and Estate Road No. 5.
R4 Continental Tyres Training Centre/Gym	185	This position is representative of the closest commercial (training centre use) premises, situated south of the Reserve Site, and part of the Continental Tyres site. Ambient noise measurements were recorded in the car park, at the side of the building.
R5 Sea Wall	435	This position is on the sea wall north of the Reserve Site and representative of the SAC area on the mud-flats.
R6 CHP Site boundary	125	This position is on the north boundary of the CHP site (RWE ownership boundary) with the background noise at this position representative of the LWS roosting area, further to the north.

Table 1: Description of noise sensitive receptor positions used for the assessment

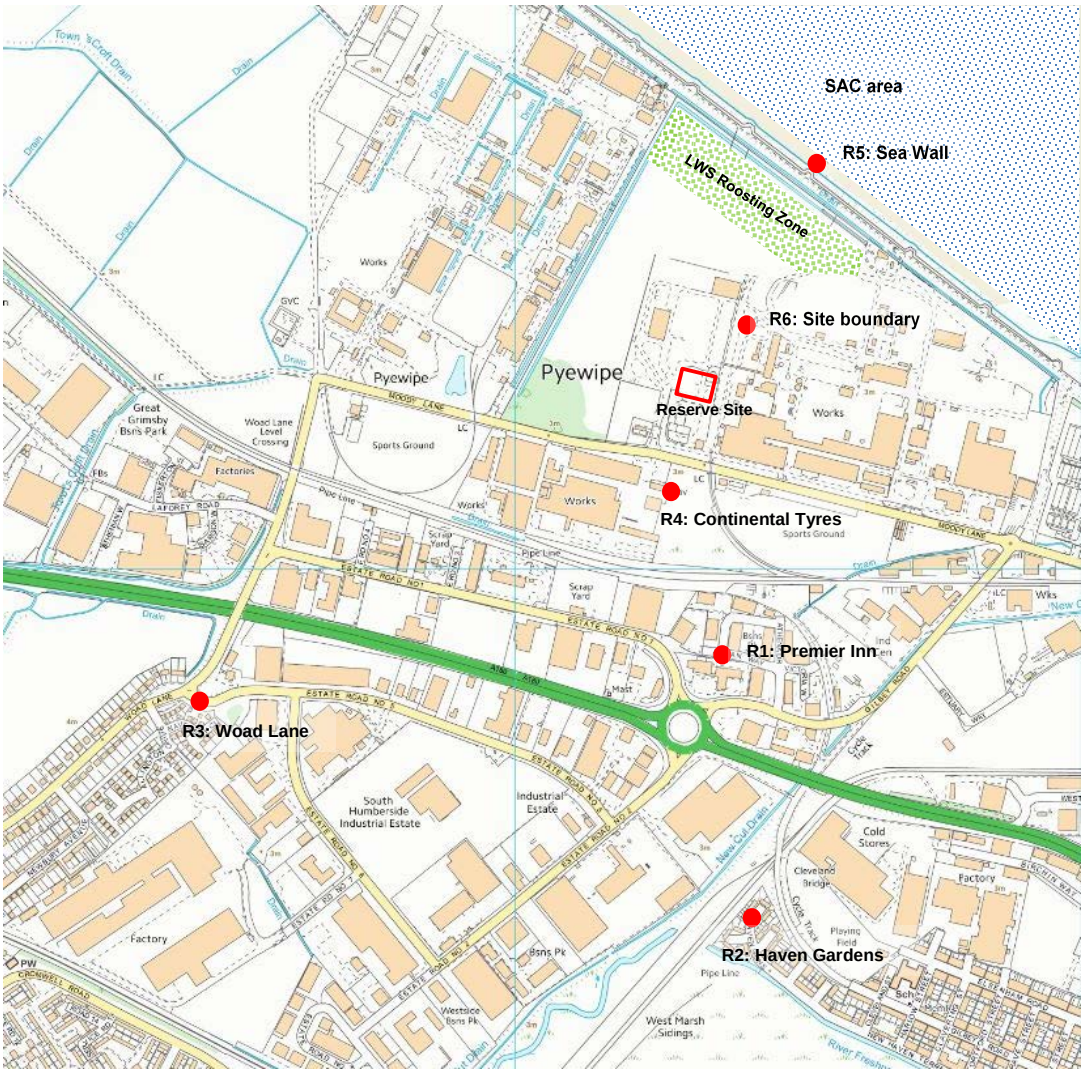

Figure 1: Plan showing Grimsby Reserve Site and noise sensitive receptor positions

3.2 NOISE SURVEY PROCEDURE AND INSTRUMENTATION

Instrumentation used to measure noise levels included the following items. All equipment is calibrated in accordance with manufacturers requirements, using equipment referenced to the British Calibration Service and the National Physical Laboratory:-

- 1 x Bruel & Kjaer Type 2260 Sound Level Analyser, serial number 1772232
- 1 x Bruel & Kjaer Type 2238 Sound Level Meter, serial number 2285767
- 1 x Bruel & Kjaer Type 4231 Acoustic Calibrator; and
- 1 x Bruel & Kjaer Outdoor microphone kit

The manned noise survey was completed during the early evening (17:00-20:00) and morning (07:00-10:00) hours of 8-9 February 2017. The measurements at the CHP site boundary (Position R6), were recorded over a 20-hour period, using a remote noise logger. During the survey period the weather was cold, dry, with light winds. The environment around the Grimsby Reserve Site has not changed since the 2017 survey, so the results taken from this survey may be deemed suitable for use in this updated 2020 assessment.

Noise samples of 15-minute duration were recorded in rotation at each measurement position, with one-sample recorded during each of the morning (0700:10:00) and early evening (17:00-20:00) periods.

Noise samples were recorded in terms of the following parameters:

- $L_{Aeq,T}$ the equivalent continuous noise level; and
- $L_{A90,T}$ percentile level.

Briefly, $L_{Aeq,T}$ the equivalent continuous noise level is used as the measure of total ambient noise, or noise from a specific source, over the reference time period T. $L_{A90,T}$ is defined in BS4142, as the measure of background noise, when it is applied to the residual noise level (the noise in the absence of the specific noise being assessed).

3.3 NOISE SURVEY RESULTS

The ambient noise measurements recorded during the early evening (17:00-20:00) and morning (07:00-10:00) assessment periods are included in Table 2.

Receptor Position	Start time	Noise sample (15 mins)		Description of Noise
		$L_{Aeq,T}$	$L_{A90,T}$	
R1 Premier Inn	19:30	51.7	48.8	Road traffic: local & A180.
Appian Way	07:20	56.3	54.4	Road traffic: local & A180
	Mean	**54**	**52**	
R2 Haven Gardens	18:30	45.5	44.0	Road traffic: local & A180.
Great Coates	08:50	51.4	48.6	Road traffic: local & A180
	Mean	**48**	**46**	
R3 Woad Lane	18:00	66.7	61.2	Road traffic local & A180.
Grimsby	08:35	67.2	62.6	Road traffic: local & A180
	Mean	**67**	**62**	
R4 Continental Tyres	19:00	56.7	47.8	Road traffic local & A180. Local industry
Moody Lane	07:50	58.8	53.0	Road traffic: local & A180. Local Industry
	Mean	**58**	**50**	
R5 Sea Wall	17:00	57.7	56.5	Waves (tide in); Local Industry; aircraft
	09:30	50.4	46.8	Waves (tide out); Local Industry; aircraft
	Mean	**54**	**52**	
R6 CHP Site boundary	17-20	46.3	43.9	Local Industry; Road traffic.
	07-10	48.1	45.5	Local Industry; Road traffic.
	Mean	**47**	**45**	

Table 2: Ambient noise measurement results

As the noise data measured at Position R6 (CHP site boundary) was recorded over a 20-hour period between 15:00-11:00, this data is also illustrated in Chart 1. The noise levels included in Table 1 represent the mean values over the periods 17:00-20:00 and 07:00-10:00

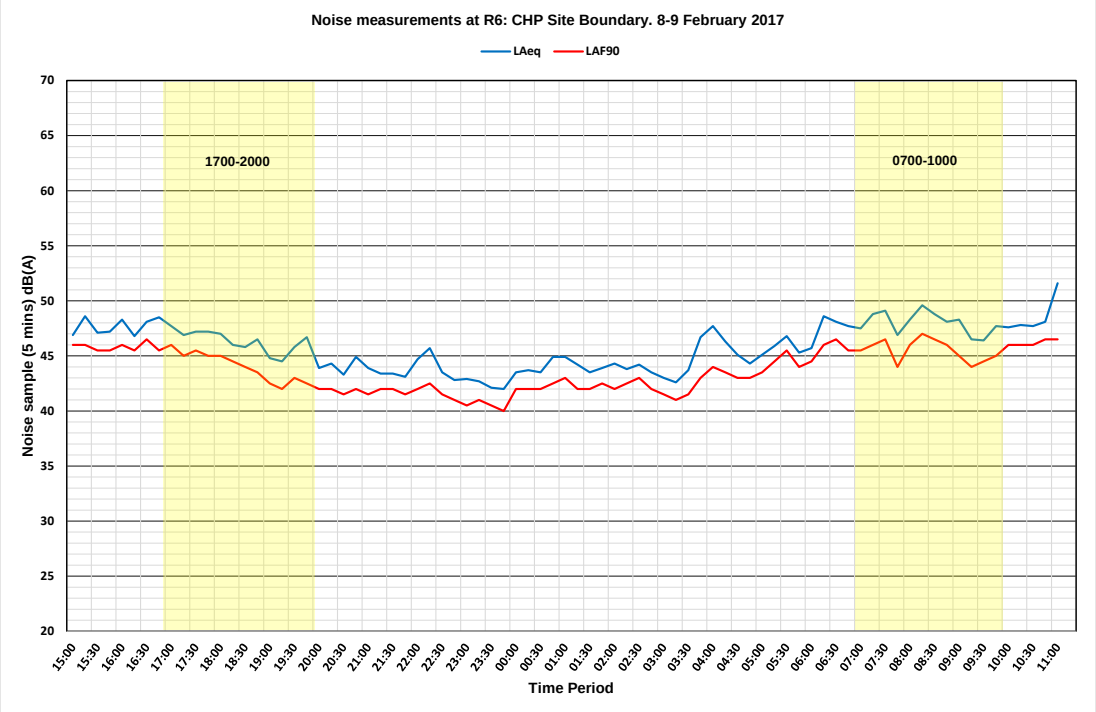

Chart 1: Ambient noise measurements at Position R6: CHP northern site boundary)

As indicated by the noise measurements included in Table 1, both ambient $L_{Aeq,T}$ and background $L_{A90,T}$ noise at the residential receptor positions are at moderately high levels during the morning and early evening assessment periods, due to high volumes of traffic both on local roads and the nearby A180.

Noise levels were found to be particularly high at R3: Woad Lane, Great Coates ($L_{Aeq,}$ 67dB / $L_{A90,}$ 62dB) due to regular HGV movements along the Industrial Estate road. Lower noise levels were found to be present at R2: Haven Gardens ($L_{Aeq,}$ 48dB / $L_{A90,}$ 46dB), as this position is at further distance from both the A180 and busy local roads.

At the Continental Tyres premises (Training Centre) ambient noise levels were also found to be at a moderately high level of $L_{Aeq,}$58dB, again due to road traffic noise and also noise from nearby Local Industry.

On the Sea Wall (Position R5), representative of noise levels inside the SAC area along the coastline, ambient noise levels were shown to be heavily influenced by wave noise, with levels increasing from $L_{Aeq,T}$ 50-58dB when the tide was in, i.e. with waves breaking close to the sea wall.

At the CHP site boundary (Position R6), ambient noise levels were found to be influenced by noise from Local Industry and distant traffic. With these sources being at further distance, ambient $L_{Aeq,T}$ levels of 47dB were lower than at the Sea Wall (54dB).

4. ASSESSMENT OF RESERVE SITE OPERATIONAL NOISE

4.1 METHODOLOGY

For the purpose of confirming the qualitative assessment, which indicates that there would be a low risk of adverse noise impact from operation of the proposed Grimsby Reserve Site development, the noise impact appraisal additionally provides a quantitative assessment comprising:

- Assessment of change to total plant sound power level (L_{wA}) by comparing the total sound power from the plant associated with the former Huntsman Tioxide CHP operation, with the total sound power from operation of the Reserve Site Generator Sets.
- Completion of a detailed predictive noise model, using sound power data applicable to the generation equipment being considered for the scheme and based on proposed A & B site layouts, together with screening provided by local buildings and terrain.
- Predicted specific sound levels produced by operation of the Reserve Site Generator Sets compared with measured background sound levels at the closest residential receptors, located to the south of the site.
- Predicted specific sound levels produced by operation of the Reserve Site Generator Sets, compared with measured ambient sound levels at:
    a) the Humber Estuary Special Area of Conservation (SAC), designated site, located along the south bank of the Humber Estuary, some 450m north of the Reserve Site and on the far side of the sea-wall embankment.
    b) the Local Wildlife designated site (LWS) to the west and north of the Reserve Site, with the assessment focussed on the northern part of the LWS, where curlews have been identified as roosting in the area of grassland south of the sea wall.

4.2 ASSESSMENT CRITERIA

4.2.1 Residential receptors

The assessment of noise at the residential receptor positions will be based on guidance provided by the following Standards and guidelines:

BS 4142, which provides an assessment procedure based on the comparison between specific operational sound and background sound.

BS 8233[2], which provides guidance for noise levels in outdoor amenity areas, indicating that it is desirable for noise levels in gardens to not exceed $L_{Aeq,T}$ 50dB and that 55dB should be seen as an upper limit.

WHO Guideline for Community Noise[3], which provides guidance on desirable levels of ambient (total) noise, citing values of $L_{Aeq,8\ hour}$ 45dB(A), for outside bedroom windows (of dwellings) at night, and $L_{Aeq,16\ hour}$ 50dB(A), for the external amenity areas of residential properties (an upper value of $L_{Aeq,16\ hour}$ 55dB advised for noisier environments).

[2] *BS 8233:2014: Guidance on sound insulation and noise reduction for buildings*
[3] *Guidelines for Community Noise - World Health Organization, 1999 (WHO)*

4.2.2 SAC and LWS receptors

More comprehensive notes covering guidance on the assessment of anthropogenic noise on wildlife and in particular bird populations, including a literature study of relevant documents, is included in Appendix C of the report. In summary, guidance indicates that in relation to steady noise an observed behavioural response in bird populations is more likely than not at noise above $L_{Aeq,T}$ 65dB, with flight with abandonment being the most likely response at noise levels above $L_{Aeq,T}$ 75dB. Thresholds of significance for impulsive character noise (bangs and clatters) are likely to be lower, due to the increased startle effect with levels of LAmax 50dB(A) being suggested.

Based on a wide ranging review of relevant research literature, the threshold of significant noise impact is commonly cited as being $L_{Aeq,T}$ 65dB(A), for a largely continuous noise emission, with this figure accounting for more sensitive species reactions, which concurs with the Habitats Directive 'precautionary principle' mentioned in the introduction. This level may therefore be used as the basic threshold level for the significance of noise impact on bird populations at a specific site of interest.

4.3 PREDICTION OF RESERVE SITE OPERATIONAL NOISE

To assess the potential impact of Reserve Site operational noise, at the noted residential and SAC/LWS receptor locations, it is necessary to predict the specific operational noise level produced at these locations.

The sound power levels of the individual components of the Containerised Generator Set are provided in Table 3. The information has been based on test data supplied by the Generator Set supplier, commensurate with meeting an average sound pressure level of 73dB(A) at 1m from each component of the Set, resulting in a level of <80dB(A) around the 1m surface of the overall package.

Generator Set Component	dB(A)	Octave band centre frequency (Hz)								
		31	63	125	250	500	1k	2k	4k	8k
Container casing	**95**	103	106	108	97	90	80	69	88	60
Air intake louver (with attenuator)	**87**	95	97	102	86	68	54	54	78	57
Air discharge louver (with attenuator)	**88**	100	105	102	83	66	57	57	80	64
Exhaust (on roof)	**85**	77	77	80	77	79	76	80	79	66
Cooling radiator and fans (on roof)	**85**	75	82	86	85	77	77	78	79	70
Total (1 Set)	**97**	105	108	110	97	90	82	82	89	72

Table 3: Sound power level of main components of Containerised Generator Set

The sound power level of each Generator Set is used as the starting point for the purpose of predicting noise levels in the surrounding environment and at the specified receptor locations, using an environmental noise propagation model.

For the purpose of this assessment a proprietary noise model, the Bruel and Kjaer, 'Predictor', has been used. This model is based upon noise propagation corrections (including distance attenuation, ground effects, topographical screening and atmospheric absorption), as advised in ISO 9613[4], to determine numeric results. This model calculates levels around a site simultaneously and allows the reporting of the results visually through the construction of noise contours.

[4] ISO 9613. Part 2 1996. Acoustics – Attenuation of sound during propagation outdoors. General method of calculation.

The following set-up parameters have been included in the noise model:

- Ground Factor = 0.5 (moderately soft ground).
- Downwind conditions (C=0)
- Temperature = 10°C
- Receiver heights = 1.5m
- Humidity 60%
- Source height: As per the source location on the surface of the Generator Set Container.

The noise map, showing noise contours projected for Reserve Site operation (total of A & B sites), is provided in Figure 1. Specific noise sensitive receptor (R) co-ordinates can be included in the noise propagation model, to obtain results at example locations. Predicted levels at a sample of the closest residential receptor positions, south of the Reserve Site, are included in Table 4. Whilst not residential, a further position has been included to represent the Continental Tyres premises, located on the south side of Moody Lane. It is understood these premises are occasionally used for meeting/training courses, with the upper floor used as a Gym.

Receptor Position		dB(A)	A-weighted octave band sound pressure Levels (dB)							
			63	125	250	500	1k	2k	4k	8k
R1	Premier Inn, Appian Way	**34**	27	33	24	18	-	-	-	-
R2	Haven Gardens, Grimsby	**33**	24	32	25	21	17		-	-
R3	Woad Lane, Great Coates	**31**	22	29	22	16	-	-	-	-
R4	Continental Tyres premises	**52**	40	50	41	39	38	40	39	-

Table 4: Predicted specific L_{Aeq} noise level from Reserve Site operation (A & B sites) at closest sensitive receptor positions

The SAC and LWS are receptor areas, rather than receptor points, so reference is best made to the noise contours crossing this area (see Figure 1). The typical noise level range across these areas is summarised in Table 5.

Receptor Area	$L_{Aeq,T}$ Range dB
SAC	**35-40**
LWS (North Roosting Zone)	**40-48**

Table 5: Predicted specific L_{Aeq} noise level from Reserve Site operation (A & B sites) at SAC and LWS receptor positions

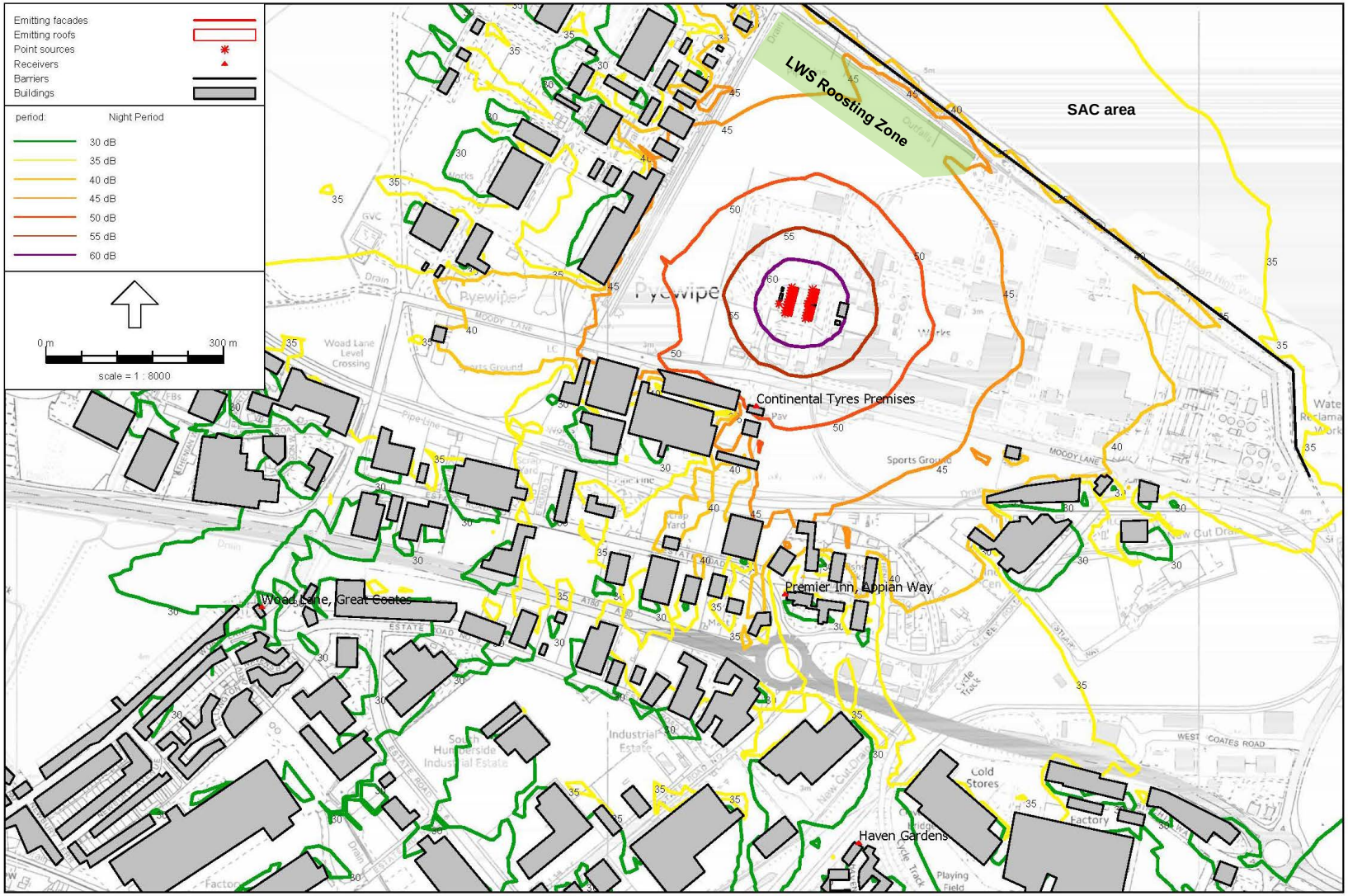

Figure 1: Grimsby Reserve Site. Predicted Operational Sound Contours

4.4 ASSESSMENT OF CHANGE TO OVERALL PLANT SOUND EMISSION

The equipment list, including the sound power level of each item of equipment applicable to the operation of the original CHP plant is included in Table A1 of Appendix A. This data was taken from the design concept document applicable to the CHP project, as included in the project Environmental Statement (ES). Equipment sound power data was taken from supplier information or based on test data on similar equipment items.

A comparison between the sound power emission associated with the operation of the former CHP plant and that associated with operation of the Reserve Site Generator Sets, is provided in Table 6. The sound power level applicable to operation of the 20 x Containerised Generator Sets is calculated from the sound power level of L_{wA} 97dB, applicable to each Generator Set (as detailed in Table 3).

Plant Detail	No. Off.	dB(A)	Octave band centre frequency (Hz)								
			31	63	125	250	500	1k	2k	4k	8k
Original CHP Plant		**113**	131	126	115	108	108	108	105	105	101
Reserve Site											
Generator Set (1 Set (for information))	1	**97**	105	108	110	97	90	82	82	89	72
Total Reserve Site (A & B sites)	20	**110**	118	121	123	110	103	95	95	102	85
Sound Power (Emission) Change		**-3**	-13	-5	+8	+2	-5	-13	-10	-3	-16

Table 6: Sound power emission relating to original CHP plant operation and proposed Reserve Site operation (A & B sites)

As indicated in Table 6, the site sound power assessment has indicated that the Reserve Site, operating with all 20 Gas Engines together on Sites A & B, would provide a noise change of -3dB(A) to the total power plant sound emission, in comparison to the former CHP operation. Essentially, this represents a beneficial noise change, resulting in a small positive impact.

Moreover, the former CHP Plant operated in conjunction with the large Huntsman Tioxide chemical plant and the cessation of operations on this parent site has removed a significant contributing source of environmental noise, resulting in an overall reduction in noise level, should the site be taken as a whole.

4.5 ASSESSMENT OF OPERATIONAL NOISE AT RESIDENTIAL RECEPTORS

For each residential receptor position selected for the assessment, Table 7 provides a comparison of predicted Reserve Site operational noise, with the average $L_{A90,T}$ background sound level, taken from the morning (07:00-10:00) and early evening (17:00-20:00) daytime assessment periods. Comparison with the WHO/BS 8223 advised daytime outdoor criterion of $L_{Aeq,T}$ 50dB is also included.

Receptor Position		Specific sound level $L_{Aeq,T}$ (dB)	Background sound level (Day) $L_{A90,T}$ (dB)	BS4142 Assessment Level (dB)	Comparison with WHO/BS 8233 50dB criterion
R1	Premier Inn, Appian Way	34	52	-18	-16
R2	Haven Gardens, Grimsby	33	46	-13	-17
R3	Woad Lane, Great Coates	31	62	-31	-19

Table 7: Predicted specific L_{Aeq} noise level from Reserve Site operation, at the closest residential receptor positions, compared with measured daytime background L_{A90} noise levels

As shown in Table 7, the projected specific operational noise level from the Reserve Site, at the closest residential receptor positions, is between $L_{Aeq,T}$ 31-34dB. Projected noise levels are low, due to the significant separation distance and also the screening benefit provided by other intervening industrial and commercial buildings.

The specific sound level from operation of the Generator Sets would be steady and expected to provide no tonal, or impulsive, character at the distant receptor positions. The rating level would therefore be the same as the specific noise level, resulting in a BS 4142 assessment level of between -13dB to -31dB.

BS 4142 states *'the lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound level will have an adverse impact, or significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact'.*

Clearly with the rating level for operational noise being between 13-31dB below background noise this would be a positive indication that operational noise from the Reserve Site would provide a negligible adverse impact.

Operational noise levels are also well within the BS 8233 and WHO advised 'desirable level' of $L_{Aeq,T}$ 50dB, applicable to daytime and evening enjoyment of outdoor amenity areas of residential properties.

Operational noise from the Reserve Site is therefore unlikely to provide a significant contribution to community noise levels, which are dominated by road traffic and other local industry, during the daytime and evening hours.

Whilst night-time operation of the Reserve Site is not envisaged, other than under emergency conditions, it may be noted that the predicted level of operational noise at the nearest dwellings is well within (by at least 10dB(A)) the WHO advised value of $L_{Aeq,8\ hour}$ 45dB, applicable to outside bedroom windows at night.

4.6 ASSESSMENT OF OPERATIONAL NOISE AT CONTINENTAL TYRES PREMISES (TRAINING CENTRE)

A BS 4142 assessment is not applicable to the Continental Tyres training premises, as occupancy is non-residential.

However, the predicted level of Reserve Site operational noise at these premises ($L_{Aeq,T}$ 52dB) is 6dB below the existing ambient $L_{Aeq,T}$ level of 58dB and consequently would provide only a small 1dB increase to the existing level (to 59dB).

Such a modest daytime noise level and small noise change would be unlikely to cause any adverse impact to the Training Centre use, particularly when consideration is given to the beneficial -3dB(A) noise change between the former CHP and proposed Reserve Site operations.

4.7 ASSESSMENT OF NOISE AT SAC AND LWS AREAS

A review of the noise contour map (Figure 2), together with the noise level ranges included in Table 3 shows that Reserve Site operational noise levels across all areas of the Humber Estuary SAC designated site, are in the range $L_{Aeq,T}$ 35-40dB. Noise levels are low due to the significant distance separation and, in this case, the screening benefit offered by the sea wall embankment.

The projected low noise levels across all areas of the SAC are therefore below existing ambient noise levels of between $L_{Aeq,T}$ 50-58dB (depending on tidal conditions) and also well below the $L_{Aeq,T}$ 65dB threshold level for the significance of noise impact on bird populations at a specific site of interest.

A similar review would indicate that Reserve Site operational noise levels across the northern zone of the LWS area (where roosting birds have been identified), are in the range $L_{Aeq,T}$ 40-47dB. The projected low noise levels across this zone of the LWS are therefore below, or at a similar level, to the existing mean ambient noise level of $L_{Aeq,T}$ 47dB and well below the $L_{Aeq,T}$ 65dB threshold level for the significance of noise impact on bird populations at a specific site of interest.

4.8 MITIGATION

The Generator Sets are to be housed in Containers, which have been specifically designed to act as acoustic enclosures, to meet an average noise level of <80dB(A) around the 1m surface of the Container.

To meet the overall level of <80dB(A), the external elements of the package, including the Cooling Radiator; Air intake/Discharge openings; and Engine Exhaust, are fitted with attenuators, or silencer (in the case of the exhaust), each designed to meet a sound pressure level of 73dB(A), at 1m from each component. The assessment has indicated that no further mitigating measures would be required,

5. ASSESSMENT OF CONSTRUCTION NOISE

The Containerised Generator Sets would be pre-assembled off site, delivered by lorry and offloaded and positioned using a mobile crane. No abnormal loads are anticipated. Such operations would not be expected to produce significant noise.

The noisiest potential construction operations would be site foundation works, with the requirements for these works not finalised at this stage. However, with the closest residential receptor positions being over 500m from the Reserve Site, this would provide a significant buffer distance for the purpose of avoiding adverse impact from construction related noise, where the indicative significant effect threshold for normal working hours is $L_{Aeq,T}$ 65 dB(A).

For example, the noisiest plant associated with foundation preparation works would be a concrete breaker (mounted on an excavator), with a typical sound pressure level[5] of L_{pA} 90dB at 10m, or a hydraulic piling (using a hammer rig), with a typical sound pressure level[6] of L_{pA} 89dB at 10m, At 500m, the noise loss for the distance alone would be at least 34dB(A), resulting in a maximum level of 56dB(A), well below the $L_{Aeq,T}$ 65 dB significant effect threshold for normal working hours.

[5] *BS 5228-1:2009 Code of practice for noise and vibration control on open sites – Part 1 Noise. Annex C1, Ref. No. 9*
[6] *BS 5228-1:2009 Code of practice for noise and vibration control on open sites – Part 1 Noise. Annex C3, Ref. No. 1*

5.1 CONSTRUCTION NOISE IMPACT ON LOCAL ECOLOGY

Due to concerns expressed by Natural England (NE), over potential construction noise impact on local ecology, Condition 5 of the previous planning permission (DM/0491/18/FUL) details the restrictions placed on construction operations:

Condition 5: *No demolition or construction works shall be carried out from the 16th to 31st of October and during the months of November, December, January, February and March unless otherwise agreed in writing by the Local Planning Authority and the development hereby approved shall be constructed in accordance with the noise mitigation measures prescribed in the Spectrum Acoustic Consultants – Grimsby B Construction Noise Mitigation Proposals dated 8th May 2018 and details shown on plan CGD/T10/0077/BP1."*

The document referenced in this condition *Spectrum Acoustic Consultants – Grimsby B Construction Noise Mitigation Proposals reference PJ3706/16440, dated 8th May 2018* is included in Appendix A of this report. The mitigation measures detailed in this document would be put in place prior to the commencement of construction works.

6. CONCLUDING SUMMARY

The quantitative assessment of operational noise from the Grimsby Reserve Site has provided the following information:

- Prediction of Reserve Site operational noise (Sites A & B operating together), at the closest residential positions, has demonstrated that the specific sound level at these receptor positions would be at a low level of between $L_{Aeq,T}$ 31-34dB(A) and well within the WHO / BS 8233 advised daytime $L_{Aeq,T}$ level of 50dB, applicable to outdoor amenity areas. The resulting BS 4142 assessment level of between -13dB to -31dB, provides a positive indication that operational noise from the Reserve Site would provide a negligible adverse impact.
- Prediction of Reserve Site operational noise, at the Humber Estuary SAC designated site, has demonstrated that the specific sound level across this area would be in the range $L_{Aeq,T}$ 35-40dB. This range is well below existing ambient noise levels of between $L_{Aeq,T}$ 50-58dB (depending on tidal conditions) and also well below the $L_{Aeq,T}$ 65dB threshold level for the significance of noise impact on bird populations at a specific site of interest.
- Prediction of Reserve Site operational noise, across the northern zone of the LWS area (where roosting birds have been identified), has demonstrated that the specific sound level across this area would be in the range $L_{Aeq,T}$ 40-47dB. This range is below, or at a similar level to the existing mean ambient noise level of $L_{Aeq,T}$ 47dB and well below the $L_{Aeq,T}$ 65dB(A) threshold level for the significance of noise impact on bird populations at a specific site of interest.
- Prediction of Reserve Site operational noise at the Continental Tyres premises (Training Centre), has demonstrated that the specific sound level at this position is $L_{Aeq,T}$ 52dB, which is 6dB below the existing ambient $L_{Aeq,T}$ level of 58dB and which would provide only a small 1dB increase to the existing level. Such a modest daytime noise level and small noise change would be unlikely to cause any adverse impact to the Training Centre use, particularly when consideration is given to the positive noise change between the former CHP and proposed Reserve Site operations.

- The quantitative assessment has therefore confirmed that operational noise from the proposed Grimsby Reserve Site (A & B sites) would present a negligible adverse impact on the closest residential, commercial and SAC/LWS receptors.
- A qualitative assessment of noise from construction operations would indicate that, with the closest residential receptor positions being over 500m from the Reserve Site, this would provide a significant buffer distance for the purpose of avoiding adverse impact from construction related noise, where the indicative significant effect threshold for normal working hours is $L_{Aeq,T}$ 65 dB(A).
- In accordance with the requirements of Condition 5 of the previous planning permission (DM/0491/18/FUL), construction works associated with the development would be completed in accordance with the noise mitigation measures prescribed in the Spectrum Acoustic Consultants – Grimsby B Construction Noise Mitigation Proposals dated 8th May 2018. This document, along with detail of the mitigation measures which would be put in place prior to commencement of construction works, is included in Appendix A.

APPENDIX A

Grimsby Site B Construction: Noise Mitigation Proposals

Grimsby B Construction: Noise Mitigation Proposals

Description	Grimsby Site B extension to Reserve Site. Revised construction noise mitigation proposals
Date	08 May 2018
Issued by	Peter Jackson MSc MIOA. Principal Consultant
Issued to	RWE Generation UK plc
Ref No	PJ3706/16440

1. INTRODUCTION

RWE Generation UK plc has been granted planning permission, subject to conditions, for the construction and operation of the Grimsby B-site extension to the Reserve Site, located at its existing power plant site, on the Pyewipe Industrial Estate, Grimsby.

Due to concerns expressed by Natural England (NE), over potential construction noise impact on local ecology, a condition of the planning permission restricts construction operations to the 4-month period April to July.

The objective of this technical document is to provide detail on the construction activities relating to the development of the Grimsby B site, together with the proposed noise mitigation measures, to provide NE sufficient information and confidence that the construction activities are such that conditional planning permission is relaxed to allow:

- Construction and demolition to be undertaken throughout the year with no percussive piling undertaken in the period 2 hours either side of high water in the period August to March.

- Should this not be agreeable, then the minimum requirement would be for conditional planning permission to be relaxed to allow:

construction and demolition to be permitted April to mid-October.

The request for relaxation of the time restriction would also bring this more in line with the less restrictive condition on construction and demolition connected with the adjacent Tioxide site import/export parking development (DM/0304/17/FUL). This Condition requires that no percussive piling will be undertaken in the period 2 hours either side of high water in the period August to March inclusive, albeit with an additional agreement in place to provide earth-bunding to the area of ecological sensitivity to the north of the development site (see Figure 1).

2. DESCRIPTION OF CONSTRUCTION WORKS

Table 1 provides a description of the various construction and installation activities, required for developing the Grimsby B site. Detail of the plant and equipment likely to be used for each activity is also listed.

Whilst the construction and installation programme is not finalised, the potential period for each activity is also noted in the table.

Activity	Construction Period	Plant list
Construction: Site Foundation Works: Piling & Concreting	April to August	Piling rig; Concrete mixers (2); Tracked Excavator; Dump Truck; Site Generator
Installation of Generator Sets Including installation of gas, pipes, cables and cable ducts.	September to mid-October	HGV's (deliveries); Crane; Concrete Breakers, Concrete Core Drill
Finishing Works Paving, including gravel & stone laying	Mid-September to mid-October	Paving (concrete) cutter.

Table 1 Description of construction activities

The works would be similar to those carried out for the A-site construction. A photo of the construction plant used for the main site foundation works is included below:

Photo 1: Construction plant operating during A-site works

3. ECOLOGICAL SENSITIVITY

The main ecological sensitivity identified by Natural England is Curlew usage on parts of the former Huntsman Tioxide site, which is currently cleared vacant land. The land is subject to planning permission being approved for an import/export parking development (DM/0304/17/FUL). The area of land, indicating Curlew roosts and showing the RWE power plant site, is illustrated on Figure 1.

Table 2 describes the Curlew usage, of the land.

Period	Numbers	Sensitivity
Passage Periods		
August	Highest passage numbers	Medium sensitivity
September – mid October	Decreasing passage numbers	Low sensitivity
Over-wintering period		
Mid October - March	Largest assemblage of birds	High sensitivity

Table 2: Curlew land usage and sensitivity

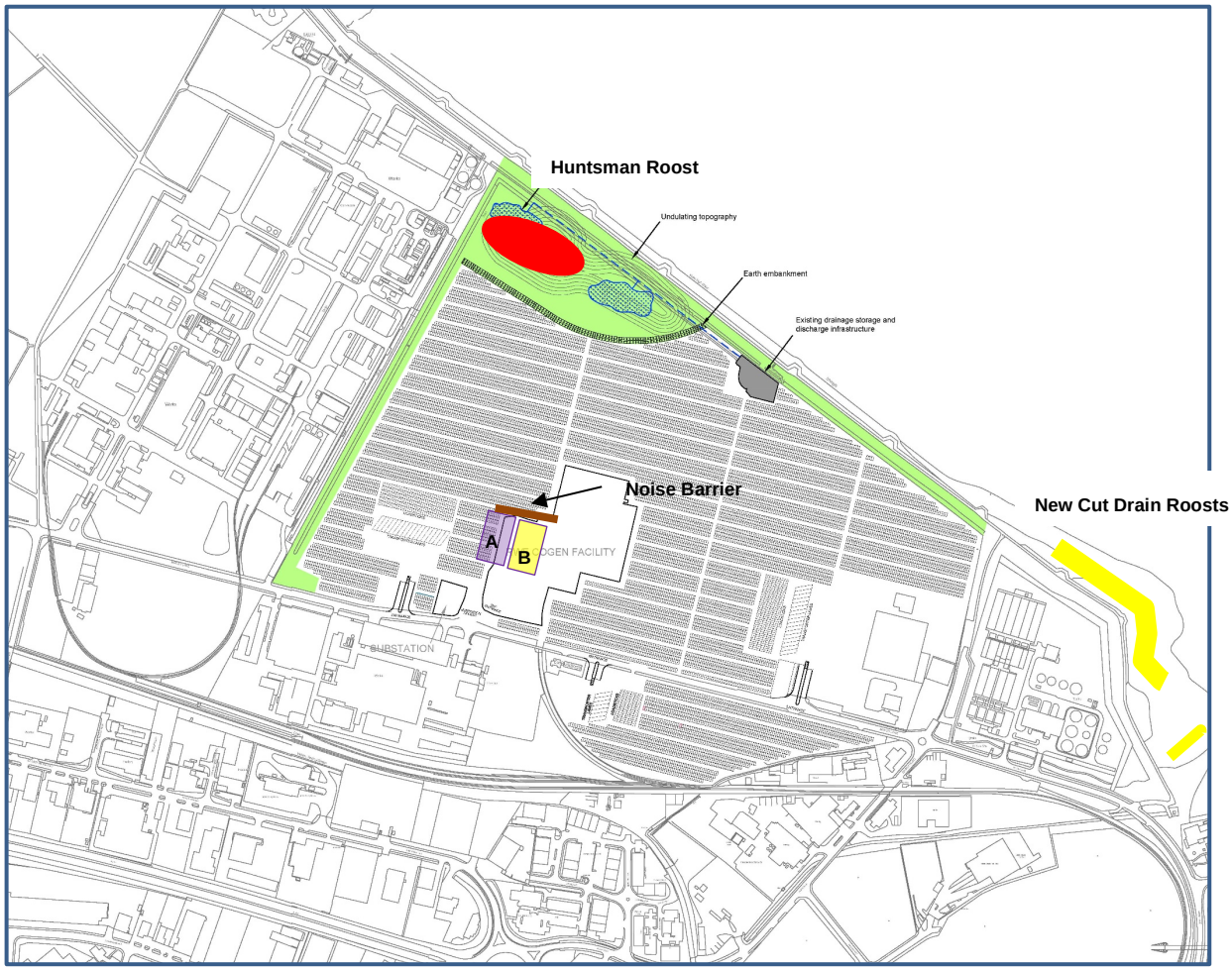

Figure 1: Plan showing Grimsby A (built) and B (to be constructed) sites and land (shaded red and yellow) identified has having some Curlew roosts during passage season.

4. NOISE MITIGATION PROPOSALS

4.1 GENERAL

Noise mitigation relating to construction operations, generally falls into two categories:

- Noise reduction at source, achieved by construction design, to include selection of lower noise equipment and plant and restriction of operating times.
- Noise reduction in the transmission path, commonly achieved through provision of barriers, or bunds, to screen the construction operations from the identified receptor positions.

Noise reduction at source is most effective, as it benefits all receptor positions, both on and off the construction site. Careful selection of lower noise plant items can significantly reduce the potential for adverse noise impact at sensitive receptors.

Noise reduction by provision of barriers, provides a variable benefit, dependent on the position and height of the barrier and of the construction plant source to be screened. In general, noise barriers are most effective where the barrier is either close to the source or the receptor, as otherwise sound reflecting either around the sides or over the top of the barrier greatly limits the benefit.

BS 5228-1:2009+A1:2014 *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise* provides the relevant guidance on the effectiveness of noise barriers, stating:

As a working approximation, where there is a barrier, or other topographical feature, between the source and receiver position, assume an approximate attenuation of 5dB when the top of the plant is just visible to the receiver over the noise barrier and of 10dB when the noise screen completely hides the sources from the receiver.

In line with this statement from BS 5228-1 the potential performance of noise barriers is often over-estimated by suppliers, for example citing a sound reduction performance as potentially up to 35dB. However, such high performance claims reflect the sound reduction that would typically be achieved from sound passing through the barrier material (so the sound insulation performance of the material), without considering the limiting factor of noise reflecting around the sides and over the top of the barrier.

Accordingly, where the construction activity requires use of large items of heavy plant, the noise reduction benefit of even a high 5m barrier is likely to be limited to around 5dB. Where the main plant noise source is at even greater height, such as the drive motor on a piling rig, a noise barrier could have limited benefit, as it can be impracticable to provide a barrier of sufficient height to provide any effective screening.

4.2 MITIGATION PROPOSALS

Table 3 provides detail of the mitigation proposals relating to the construction activities required for development of the Grimsby B site.

Activity	Plant list	Mitigation proposal
Construction: **Site Foundation Works:** Piling & Concreting	Piling rig; Concrete mixers (2); Tracked Excavator; Dump Truck; Site Generator	• Selection of low noise plant, in particular in relation to using CFA (Auger) piling, instead of impulsive pile driving. • Generator set to be fitted with enclosure. • Items such as dump trucks and concrete mixers to only operate when required i.e. not left idling. • Use of portable acoustic screens, to be placed close to localised plant and operations. • *Where works are completed during the August period of medium sensitivity to the Huntsman's roost and where such works cannot be completed with benefit from portable acoustic screens e.g. due to the height of the plant, consideration will be given to provision of a 5m (h) noise barrier constructed along the sensitive north boundary of the construction site. (see Figure 1).*
Installation of Generator Sets Including installation of gas, pipes, cables and cable ducts.	HGV's (deliveries); Crane; Concrete Breakers, Concrete Core Drill	• Use of HGV's and Crane confined to short periods during delivery and off-load of Containerised Generator sets, such plant to only operate when required i.e. not left idling. • Use of portable acoustic screens, to be placed close to localised concrete breaking and coring operations.
Finishing Works Paving	Paving (concrete) cutter.	• Use of portable acoustic screens, to be placed close to localised concrete cutting operations.

Table 3 Description of proposed mitigation measures

The following points relating to use of acoustic screens, or noise barriers, may be noted:

- In the context of these proposals, a portable acoustic screen, represents a relatively low-height screen (typically 2m) that can be placed close to, or around, a specific item of operating equipment and can moved accordingly. Such screens are particularly effective for reducing noise from local operations conducted close to ground level (see Photo 2).

Photo 2: Portable acoustic screen installed around a specific noisy activity.

- In the context of these proposals a noise barrier represents a larger (and higher) fixed barrier that would typically comprise a temporary fixture constructed along a selected section of construction site boundary, for example in a direction of high sensitivity. A fixed noise barrier along a section of site boundary can provide noise reduction from several items of plant operated across a wider area of the site. However, benefit can still be limited where large plant items, for example, a piling rig, have the main noise source at a height in excess of a barrier of a practical height.

The photos below show typical examples of a noise barrier constructed along a boundary position. Photo 3 shows an option whereby the noise barrier is constructed using individual acoustic mats, or pads, fixed and supported from a metal framework, sometimes scaffolding. Photo 4 shows a noise barrier constructed at an RWE construction site by placement of stacked ISO shipping containers. A stack of 2 containers provides a noise barrier of 5.2m height.

Photo 3: Noise barrier construction from individual mats, attached to support frame.

Photo 4: Noise barrier construction from ISO shipping containers

Table 4 provides both qualitative and quantitative detail regarding the benefits of the mitigation proposals. Where sound level data is quoted, this has been referenced from BS 5228-1, Appendix C.

Activity	Mitigation proposal	Mitigation benefits	
		Quantitative	Qualitative
Construction: **Site Foundation Works:** Piling & Concreting	• Use of CFA (Auger) piling, instead of impulsive pile driving.	CFA piling: $L_{Aeq,T}$ 77dB @ 10m. Percussive piling: $L_{Aeq,T}$ 92dB @ 10m 15dB noise reduction.	Auger piling also eliminates production of impulsive noise associated with startle effect.
	• Dump trucks, excavator and concrete mixer to only operate when required i.e. not left idling.	Typical sound level of each plant item: $L_{Aeq,T}$ 75dB @ 10m	Noise emission is largely associated with engine noise, which has a steady rather than impulsive character.
	• Generator set to be fitted with enclosure.	$L_{Aeq,T}$ 65dB @ 10m	Low noise equipment item
	• Use of portable noise screens, to be placed close to localised operations.	Typical 10dB noise reduction, for operations at low height (below top of screen)	Portable screens efficient for reducing localised operations conducted close to ground level.
	• Noise barrier of 5m height to be constructed along north boundary of construction site (see circumstances noted in Table 3)	Typical 10dB noise reduction, for plant and operations located below the height of the barrier	Site boundary noise barrier effective for reducing noise across a wider area of the construction site and for larger plant items.
Installation Works Including installation of gas, pipes, cables and cable ducts.	• Use of HGV's and Crane confined to short periods during delivery and off-load of Containerised Gen. Sets. Plant to only operate when required i.e. not left idling.	Typical sound level of each plant item: $L_{Aeq,T}$ 70dB @ 10m	Noise emission is largely associated with engine noise, which has a steady rather than impulsive character.
	• Use of portable noise screens, to be placed close to localised concrete breaking and coring operations.	$L_{Aeq,T}$ 85dB @ 10m. No screen. $L_{Aeq,T}$ 75dB @ 10m With screen 10dB noise reduction	Portable screens efficient for reducing localised operations conducted close to ground level.
Finishing Works Paving	• Use of portable noise screens, to be placed close to localised concrete cutting operations.	$L_{Aeq,T}$ 85dB @ 10m. No screen. $L_{Aeq,T}$ 75dB @ 10m With screen 10dB noise reduction	Portable screens efficient for reducing localised operations conducted close to ground level.

Table 4: Benefits of mitigation proposals, relating to periods of medium and high ecological sensitivity.

5. CONCLUDING SUMMARY

The technical report provides detail of the noise mitigation proposals for minimising potential impact on ecological receptors using the currently cleared and vacant land, to the west, north and east of the Grimsby B site.

In line with the practical considerations outlined in the document, the combination of selecting low noise plant, for the main ground preparation works, together with use of portable noise screens, for the installation and finishing works, provides the following key noise mitigation benefits:

- Noise from piling operations reduced by 15dB, with, importantly, impulsive noise character eliminated.
- Noise from mobile plant would be of lower noise level ($L_{Aeq,T}$ 75dB @ 10m), so similar in level and character (engine noise) to that produced by the consented operation of the A-site gas generator sets.
- Noise from localised works, such as concrete breaking and cutting operations, would be reduced by at least 10dB by use of portable noise screens, resulting in noise emission of $L_{Aeq,T}$ 75dB, so at a similar level to the other mitigated noise sources.

Where works are completed during the August period of medium sensitivity to the Huntsman's roost and where such works cannot be completed with benefit from portable acoustic screens e.g. due to the height of the plant, consideration will be given to provision of a 5m high noise barrier constructed along the sensitive north boundary of the construction site. (see Figure 1).

APPENDIX B

Equipment sound power listing for the Huntsman Tioxide CHP Plant.

EQUIPMENT SOUND POWER LEVELS

Project: Huntsman Tioxide CHP Scheme : Based on 12MW Cyclone Power Plant

Client: National Power

Model Reference: ***Run 1: Prediction to Position 1, Woad Lane, Great Coats***

Model Run Date: 22/05/00

Plant Name	Ref	No.	Dist.	Height	Octave Band Centre Frequency (Hz)									
		Off	(m)	(m)	31	63	125	250	500	1k	2k	4k	8k	dB(A)
GT Generator Enclosure Panels	85dB(A) enclosure	1	1100	5	108	104	100	100	102	102	95	95	92	105
Gas Turbine : Enclosure Panels	85dB(A) enclosure	1	1100	5	112	105	108	102	105	104	97	97	94	107
Gas Turbine : Filter / Air intake opening	with intake silencer	1	1100	10	102	104	100	90	85	85	90	90	85	96
GT Air Inlet Duct / Bend Walls	with intake silencer	1	1100	10	103	102	98	93	88	80	85	85	81	92
GT Enclosure - ventilation air inlet	Silenced Ventilation	1	1100	2	107	104	96	90	85	85	85	86	83	93
GT Enclosure ventilation outlet	Silenced Ventilation	1	1100	5	107	104	96	90	85	85	85	86	83	93
GT Exhaust / Silencer Duct	Lagged Duct	1	1100	3	110	108	103	98	94	93	96	95	87	101
HRSG entry ducts	Lagged Duct	1	1100	5	108	106	101	96	92	90	93	93	85	99
HRSG walls, inc. top and bottom surfaces	Lagged Walls	1	1100	15	120	118	105	95	90	85	80	75	65	96
HRSG Stack Aperture including stack wall	see table A1	1	1100	35	130	124	108	90	95	94	83	77	86	101
ST Building	see table A2	1	1100	8	91	93	91	87	88	84	84	76	68	90
ST Building ventilation system		1	1100	8	100	98	98	90	80	75	75	75	75	87
Transformer units		2	1100	3	90	93	93	85	87	75	72	68	65	86
Air Cooled Condenser		1	1100	5	105	110	105	100	98	95	93	85	80	101
Steam Pipes	Lagged pipes and valves	1	1100	3	80	80	80	90	92	92	92	95	88	100
PRDS station		1	1100	1	97	95	90	88	88	88	92	94	88	98
Gas Compressor		1	1100	5	100	99	98	96	92	90	89	87	77	96
Deaerator		1	1100	5	100	98	96	92	93	95	95	96	93	102
Package Boilers		1	1100	7	115	110	102	95	93	92	94	95	93	101
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Overall Sound Power Level		20			**131**	**126**	**115**	**108**	**108**	**108**	**105**	**105**	**101**	**113**

APPENDIX C

Guidance on assessment of noise impact on existing bird populations

Guidance on assessment of noise impact on existing bird populations

In order to assess the impact of anthropogenic noise on bird populations it is necessary to follow the guidance outlined by both the EU Habitat's Directive and the UK regulations document "Conservation of Habitats and Species Regulations".

The EU 'Habitats' Directive (92/43/EEC) Article 6 (2)[i] states that:

"Member States shall take appropriate steps to avoid, in the special areas of conservation[iiiii], the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated, in so far as such disturbance could be significant in relation to the objectives of this Directive."

With regard to noise disturbance specifically, it can be interpreted that the introduction of noise which has a significant impact on existing ecology should be avoided or mitigated against. The Conservation of Habitats and Species Regulations (2010)[iv] goes a little further in outlining what constitutes disturbance:

"disturbance of animals includes in particular any disturbance which is likely

- to impair their ability
- to survive, to breed or reproduce, or to rear or nurture their young, or
- in the case of animals of a hibernating or migratory species, to hibernate or migrate; or
- to affect significantly the local distribution or abundance of the species to which they belong."

Additionally the "Guidance document on the strict protection of animal species of Community interest under the 'Habitats' Directive 92/43/EEC"[v] states that

"Disturbance (e.g. by noise, source of light) does not necessarily directly affect the physical integrity of a species but can nevertheless have an indirect negative effect on the species (e.g. by forcing them to use lots of energy to flee...)"

In accordance with the Habitats Regulations, which are underpinned by the 'precautionary principle', a detailed and informed account of species specific reactions to noise disturbance should be performed if, on the basis of initial assessment, there can be shown to exist a likelihood of significant impact. Assessment of a site should therefore take place in two stages:

1. A general assessment – which will predict noise levels at any relevant areas of conservation (as outlined in government listings) and conclude whether a second stage report is necessary (based on precautionary minimal limits of impact significance).
2. A detailed assessment which will take into account the species specific responses using measured and archive data to define both the sensitivity and magnitude of any impact, and offer suggestions for limitation and mitigation where necessary.

Defining a threshold of significance for a general assessment

Research has focused primarily on two forms of disturbance which are, in general, caused by different types of noise. Instantaneous disturbance is characterised by "immediate and observable changes in behaviour, specifically: inducing flight from the site, hearing loss and increases in stress" (Barber 2010)[vi], and is generally classified by researchers observing the reaction of birds to purposefully generated impulsive noise sources. Long term impairment disturbance is most clearly defined by indirect deleterious effects due to continuous noise, commonly due to masking of communication and predatory detection mechanisms.

In order to best characterize a base level for a likelihood of significant impact it will be necessary to take both continuous and impulsive noise into account and apply appropriate thresholds for each type based on the available research consensus.

Instantaneous disturbance

In relation to Barber's characterisation of disturbance, Dooling and Popper (2007)[vii] provide evidence which indicates that hearing damage or permanent threshold shift are not a significant concern except in situations where noise levels are extremely high (higher than those which would cause damage in humans) as birds have less sensitive hearing mechanisms which have the ability to heal. In any case, extremely high impulsive noise at a sensitive reception point would lead to immediate recommendation for a detailed species specific survey. The effect of noise on stress levels of birds has not been sufficiently studied (due to the inherent difficulties in measuring stress levels in birds) to provide any useful insight.

Behavioural changes have been more widely studied. Goodman and Cameron (2010)[viii] observed the behavioural responses of several species of birds to the noise of an air horn at various distances and found a good correlation between noise level and behavioural response (although they do acknowledge that it was impossible to completely eliminate the effect of the visual impact of the researchers). They identify 4 categories of behavioural response ranging from no behavioural change to flight with abandonment of the site, acknowledging that flight with abandonment does not necessarily have to be induced for the noise impact to be significant as the increased energy expenditure will be detrimental to the breeding efficacy (as outlined further below). From these observations they generalize across the species studied to conclude that a response was more likely than not at noise above 65dB L_{Aeq} and flight with abandonment is the most likely response above 75dB L_{Aeq}. In terms of a threshold for significant impact they suggest 70dB L_{Aeq} might be appropriate.

There have been several studies (e.g. Dooling and Popper 2007, Forman 2002, Peris and Pescador 2004) into the disturbance due to road noise which provide helpful information on noise which is categorized as continuous rather than impulsive. Each has found variation in population density and breeding levels with increasing traffic volumes or proximity to the source, but Peris and Pescador particularly noted a significant species variation whereby some species appeared to breed more efficiently under noisier circumstances. Dooling and Popper suggest this may constitute population filtering by species sensitivity which should be considered in the decision regarding significance (Francis (2011) studied this in more detail - see below).

Cutts et al. (2009)[ix] also express approximate thresholds for significance, specifically 70dB(A) for continuous and 50dB(A) for impulsive noise based on a wide ranging review of existing literature. This is more stringent than the results obtained by Goodman and Cameron (2010) suggesting that these figures account for more sensitive species reactions – which concurs with the Habitats Directive 'precautionary principle' outlined above. These levels are widely used as basic threshold levels for the significance of noise impact at a site.

Unfortunately, Cutts et al. do not specify an accurate metric of noise measurement for these levels, so considering that the impulsive character of the noise in question a level of 50dB L_{Amax} is suggested. Research[x] shows that although less sensitive, the shape of most birds' audibility curves are similar to those of humans so whilst an A-weighted curve might not be specifically designed for use with avian audibility curves it may be the most relevant of the available weighting systems.

Long term disturbance

Beale (2007)[xi] states that "disturbance from anthropogenic activity can reduce breeding success even in the absence of behavioural effects" and highlights that dangers of "the use of simple behavioural indices as a direct measure of disturbance impact". In terms of long term deleterious effects, the key consideration is interference with the ability of bird populations to listen and communicate (which if significant will "reverberate through many facets of their lives" (Patricelli and Blickley (2006)[xii]).

Dooling and Popper (2007) show that continuous noise can severely limit the distance at which birds are able to detect one another for communication purposes. They indicate that if this maximum communication distance is reduced below the limits of the bird's territory, consequences can be serious.

However, this measure is only useful if the frequency characteristics of the intervening noise are known. As Dooling (1982) points out, the critical frequency region for birds varies with species but generally lies in the region 1-6 kHz. As with human hearing, masking from background noise occurs primarily in the critical band, so it is essential to know how much energy occurs in this region in order to quantify whether significant masking (and consequently disturbance) will occur.

Francis (2011)[xiii] studied the reactions of several species to compressor noise with respect to vocalization frequency in well controlled conditions and concluded that their "finding that signal frequency explained variation in responses to noise for two data sets provides evidence for a causal relationship between sensitivity to noise and vocal frequency." They state that their study supports the assertion that "noise may exclude species with low-frequency vocalizations from noisy environments", although they warn that this only offers an explanation for negative responses to noise (some smaller species still apparently react positively to noise).

Species with higher frequency vocalizations (or those with the ability to adapt to noisy environments by altering the level and/or frequency of their vocalizations) can still be negatively affected by means increased energy expenditure, reduction in repertoire and reduced propagation at higher frequencies. Therefore it cannot be assumed that an increase in frequency leads to a net increase in the area over which the vocalization can be detected (Patricelli and Blickley (2006), Brumm and Slabbekoorn (2005), Francis (2011)).

Cutts et al. suggested a limit for continuous noise of 70dB(A), but considering that the nature of most anthropogenic noise is low frequency biased it is suggested that a more useful approach would be to assess noise levels only in the critical region. This could be achieved by measuring or predicting noise levels in terms of octave band frequencies and considering data in terms of various descriptors such as L_{50}, L_{eq}, L_{90} and L_{10}.

Other considerations

- protected species should be considered much more sensitive to disturbance as any deleterious effect is effectively amplified in significance the smaller the total population in existence.
- avoidance behaviour such as flight from the site with return which might fall below the perceived level of significance according to Goodman and Cameron's observations of direct disturbance, but might still be indirectly significant in terms of increased the energy costs of avoidance which could affect survival, breeding and nurturing.
- the opposite risk of avoidance behaviour – i.e. that habituation to invasive noise might reduce the ability of the birds to detect and react to dangerous predators – affecting survival (Cutts et al. 2008).
- there has been no conclusive agreement on whether relative or specific level is key to categorising disturbance, but it is certainly the case that continuous noise below background levels cannot be considered to have a masking effect (Dooling and Popper 2007).

Measurement and observation

When making initial measurements and predictions it is important to make some key observances regarding the conditions and location of the noise source and bird habitat. In their review of existing literature, Cutts et al. (2008) suggest a series of key observances in how birds react to all forms of disturbance (noise being one example), including:

- impacts of disturbance will be increased in hard weather conditions
- in oystercatchers, more than 1.5 disturbances per hour in good feeding conditions (and 0.5 in poor conditions) can result in reduced fitness.
- roosting birds are sensitive to disturbance around high tide (particularly where alternative roosting areas are limited).

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[i] *http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31992L0043:EN:HTML*
[ii] *http://jncc.defra.gov.uk/page-1515*
[iii] *http://www.natureonthemap.naturalengland.org.uk/map.aspx?map=sssi*
[iv] *http://www.legislation.gov.uk/uksi/2010/490/contents/made*
[v] *http://circa.europa.eu/Public/irc/env/species_protection/library?l=/commission_guidance/final-completepdf/_EN_1.0_&a=d*
[vi] *warnercnr.colostate.edu/~sereed/publications/Barberetal2011.pdf*
[vii] *http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf*
[viii] *http://www.wwt.org.uk/userfiles/files/12Wrightetalpp150-167.pdf*
[ix] *http://infrastructure.independent.gov.uk/wp-content/ipc/uploads/projects/EN010001/2.%20Post-Submission/Application %20Documents/Environmental%20Statement/4.20%20-%20Annex%208%20-%20References/REFERENCED%20REPORTS/ HPC-NNBPEA-XX-000-RET-000089.pdf*
[x] *http://www.nrel.gov/wind/pdfs/30844.pdf*
[xi] *http://www.comparativepsychology.org/ijcp-vol20-2-3-2007/03.Beale_PDF.pdf*
[xii] *http://www.eve.ucdavis.edu/gpatricelli/Assets/Patricelli_and_Blickley_Auk_2006.pdf*
[xiii] *http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0027052*

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