Norfolk Boreas Offshore Wind Farm

Consultation Report

Appendix 9.9 Norfolk Vanguard Onshore Noise outgoing documents

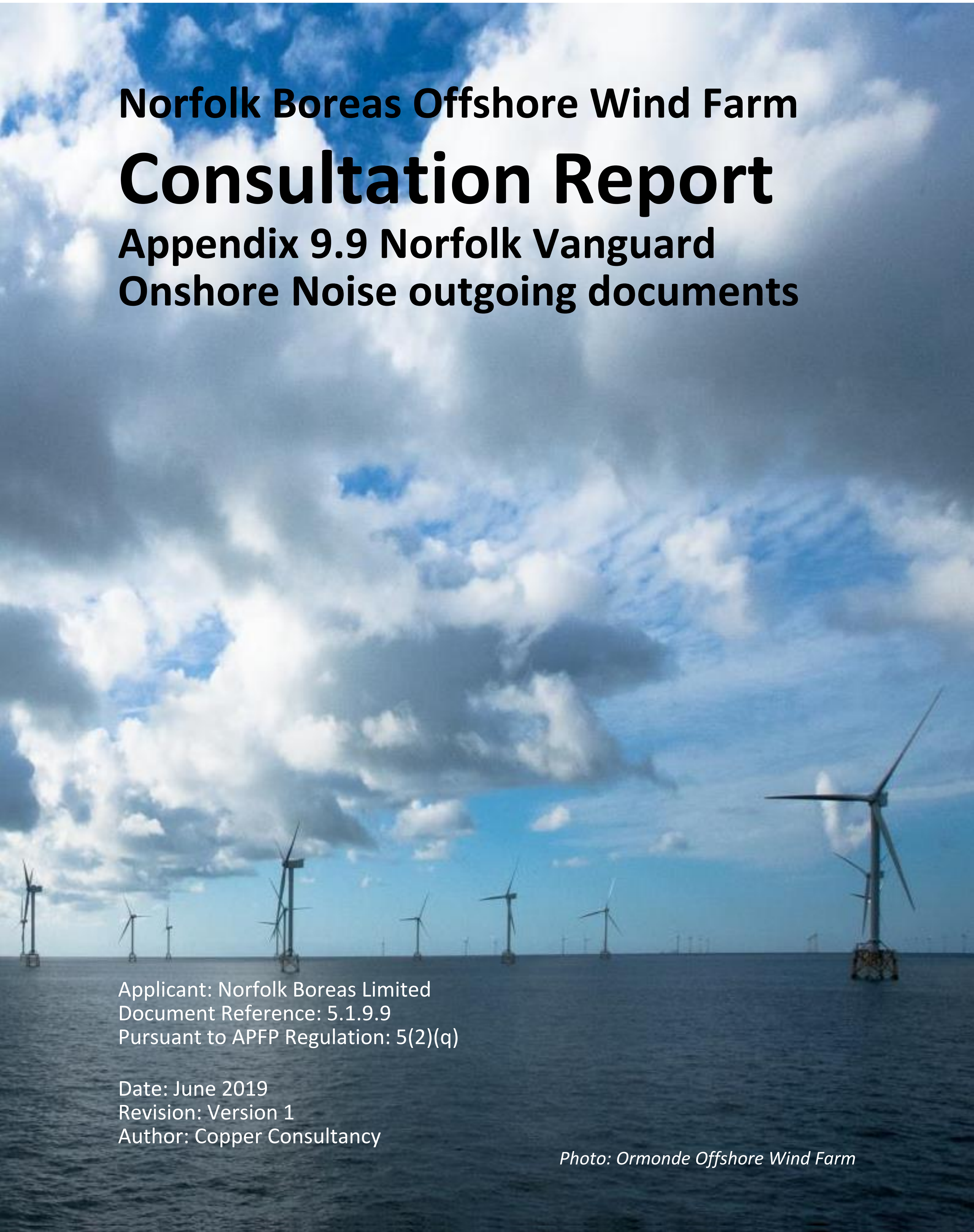

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Photo: Ormonde Offshore Wind Farm

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Norfolk Vanguard Offshore Wind Farm

Environmental Impact Assessment

Onshore Noise and Vibration Method Statement

Document Reference: PB4476-003-026

Author: Royal HaskoningDHV
Date: 13th January 2017
Client: Vattenfall Wind Power Ltd

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Date	Issue No.	Remarks / Reason for Issue	Author	Checked	Approved
06/01/17	00	Draft for Client Review	DC	AB/GK/RH	AD
11/01/17	01	Issue for Vattenfall Review	DC	GK/AB	AD
13/01/17	02	Issue for EPP Topic Group Review	DC	GK/AB	AD/KW

This method statement has been prepared by Royal HaskoningDHV on behalf of Vattenfall Wind Power Limited (VWPL) in order to build upon the information provided within the Norfolk Vanguard Environmental Impact Assessment (EIA) Scoping Report. It has been produced following a full review of the Scoping Opinion provided by the Planning Inspectorate. All content and material within this document is draft for stakeholder consultation purposes, within the Evidence Plan Process.

Table of Contents

1 INTRODUCTION

1. The purpose of this method statement is to build upon the information provided within the Norfolk Vanguard Environmental Impact Assessment (EIA) Scoping Report, in outlining the proposed approach to be taken and considerations to be made in the assessment of noise and vibration effects of the proposed development.

2. This noise and vibration method statement has been produced following a full review of the Scoping Opinion provided by the Planning Inspectorate.

1.1 Assessment Process/Criteria

3. The aims of the noise and vibration impact assessment are summarised as:

- Identifying potentially sensitive existing and future noise receptors within the surrounding area of the onshore infrastructure;
- Characterisation of the existing ambient noise at nearby receptor locations through attended and unattended noise surveys;
- Assessment of potential noise and vibration from the construction of Norfolk Vanguard;
- Assessment of potential noise and vibration generated during the operation of Norfolk Vanguard;
- Assessment of the potential noise effects resultant from changes in traffic on the local road network as a result of the construction of Norfolk Vanguard;
- Provision of proposals for noise mitigation to protect existing noise sensitive receptors in the vicinity of the onshore infrastructure of Norfolk Vanguard during construction phases;
- Identifying and considering mitigation, where appropriate, to protect existing noise sensitive receptors in the vicinity of the onshore infrastructure of Norfolk Vanguard during operational phases; and
- Assessment of the significance of any residual impacts.

1.2 Background

4. A Scoping Report for the Norfolk Vanguard Environmental Impact Assessment (EIA) was submitted to the Planning Inspectorate on the 3rd October 2016. Further background information on the project can be found in the Scoping Report which is available at:

https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-000022-Scoping%20Report.pdf

5. The Scoping Opinion was received on the 11th November 2016 and can be found at:

https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/EN010079/EN010079-000018-Scoping%20Opinion.pdf.

1.3 Norfolk Vanguard Programme

1.3.1 DCO Programme

- Scoping Request submission - 03/10/16 (complete)
- Preliminary Environmental Information submission - Q4 2017
- Environmental Statement and DCO submission - Q2 2018

1.3.2 Evidence Plan Process Programme

6. The Evidence Plan Terms of Reference (Royal HaskoningDHV, 2017)provides an overview of the Evidence Plan Process and expected logistics, below is a summary of anticipated meetings:

- Steering Group meeting -21/03/16 (complete)
- Steering Group meeting - 20/09/16 (complete)
- Post-scoping Expert Topic Group meetings - Q1 2017
  - Discuss method statements and Project Design Statement
- Expert Topic Group and Steering Group meetings as required - 2017
  - To be determined by the relevant groups based on issues raised
- PEIR Expert Topic Group and Steering Group meetings - Q4 2017/ - Q1 2018
  - To discuss the findings of the PEI (before or after submission)
- Pre-submission Expert Topic Group and Steering Group meetings - Q1/Q2 2018
  - To discuss updates to the ES following PEI consultation

1.3.3 Survey Programme

7. The onshore study area (**Figure 1**) for the noise and vibration assessment comprises the area immediately adjacent to all elements of the project and up to a 200m width along the proposed onshore cable corridor.

8. Measurements of the existing ambient noise level will be required to be taken at locations considered representative of nearby Noise Sensitive Receptors (NSRs) that have the potential to be affected by the construction and operation of the project.

9. The survey is intended to commence once the final receptor locations have been agreed with stakeholders and access arrangements (where applicable) organised. The survey is intended to start in the 1st Quarter of 2017.

10. For the Noise and Vibration assessment, key elements of the project are:

- Landfall areas;
- Cable relay station site;
- Cable route;
- Onshore substation: and
- Extension to existing Necton 400kV National Grid substation.

11. The various project elements are detailed on **Figure 1**. Details of provisional identified NSRs are presented in Section 3.2.

2 PROJECT DESCRIPTION

2.1 Site Selection Update

12. Further to the site selection information provided within the Norfolk Vanguard Scoping Report (Royal HaskoningDHV, 2016), additional site selection work has been undertaken to refine the locations of the onshore infrastructure. The Norfolk Vanguard EIA Scoping Report identified search areas for the onshore infrastructure which were identified following constraints mapping to avoid or minimise potential impacts (e.g. noise, visual, landscape, traffic, human health and socio-economic impacts). Further data review has been undertaken to understand the engineering and environmental constraints within the search areas identified. The public drop-in-exhibitions in October 2016 and Scoping Opinion have also contributed to our broader understanding of local constraints and opportunities, feeding into the ongoing site selection and development of the EIA strategy. The project areas shown in Figure 1 are a draft for stakeholder consultation only and are provided in confidence. Equivalent information will be presented during open drop-in-exhibitions in March 2017, providing an opportunity for local people and the wider public to understand the way in which their feedback, as well as the Scoping Opinion and has influenced our design. Given the broad range and complexity of the factors influencing site selection and the scale of the area under discussion, it is our intention that local people and interested parties view the map for the first time, with Vattenfall and suitably qualified experts on hand. This enables a meaningful discussion of the proposed options and enables participants to refer directly to points of reference they may wish to discuss. During the March drop-in exhibitions, participants will also be invited to provide feedback on the latest design.

13. There are currently three landfall options with associated cable relay station search zones as well as an onshore substation search zone in proximity to the existing Necton 400kV National Grid substation (the grid connection point). A 200m wide cable corridor has been identified, within which the cable route will be located (see cable route parameters in Section 2.2.1). Ongoing public and stakeholder consultation as well as initial EIA data collection will be used to inform selection of final locations for the EIA and DCO application, with the aim to further avoid sensitive areas. Impacts that cannot be avoided through site selection will aim to be reduced through sensitive siting, alternative engineering solutions (mitigation by design) and additional mitigation measures where possible. Mitigation options will be developed in consultation with stakeholders.

2.1.1 Landfall Zones

14. The landfall search area was presented in the Scoping Report as Figure 1.3. This has been refined to three landfalls options (Zone 8), Bacton Green, Walcott Gap and Happisburgh South, following studies on the engineering feasibility of horizontal directional drilling (HDD). The two northern landfalls have the advantage that related onshore infrastructure (the cable relay station) could be placed close to the existing Bacton gas terminal in what is already an industrialised area thereby reducing landscape impacts, a preference stated by many at the public drop-in exhibitions. Discussions with the owners and operators of the gas terminal will inform the final landfall location.

15. Both northern options would require offshore cabling through the Cromer Shoal Chalk Beds Marine Conservation Zone (MCZ) and concerns have been expressed by members of the public and a number of statutory authorities about impacts on the MCZ. Information from the offshore cable corridor geophysical and benthic survey from within the Cromer Shoal Chalk Beds MCZ will be reviewed to understand the extent of designated features and therefore the feasibility of installing offshore cables. Data on coastal erosion, including estimates of coastline movement over the life time of the wind farm, and the likelihood of archaeological finds, will be reviewed to understand the feasibility of a landfall south of Happisburgh. This site is outside the MCZ but siting the required onshore infrastructure within a rural location would require careful consideration.

2.1.2 Cable Relay Station Options

16. The cable relay station search area was presented in the Scoping Report as Figure 1.6. Refined search zones (Zone 7) have been defined based on the initial constraints mapping work, the updated landfall site selection and initial consultation. A number of receptors and impacts have been considered during the selection of the scoping search area and the refined search zones, particularly noise and visual impacts, ecology traffic, human health and socio-economic impacts. As with the landfall location, discussions with the owners of the gas terminal will inform the final landfall location.

2.1.3 Onshore Cable Route

17. The onshore cable corridor search area was presented in the Scoping Report (Royal HaskoningDHV, 2016) as Figure 1.5. The route shown on Figure 1 (Zone 4) is considered to be the shortest possible route (thereby minimising disturbance impacts) whilst also aiming to avoiding main residential areas and impacts to landscape and nature conservation designations where possible.

18. Routes in the north of the scoping search area were discounted owing to the presence of existing gas pipelines and the cables from the Dudgeon Offshore Wind

Farm which significantly affected the number of complex crossings that would be required. The proposed route skirts around the main towns of North Walsham, Aylsham, Reepham and Dereham. The route corridor is currently 200m wide thereby allowing for further micro-siting following feedback from the public drop-in-exhibitions planned for March 2017 and information from planned survey work.

2.1.4 Substation Zone

19. The onshore substation search area, comprising five sectors, was presented in the Scoping Report (Royal HaskoningDHV, 2016) as Figure 1.4. Public consultation during the drop-in exhibitions indicated Sector 5 (to the south of the existing Necton 400kV National Grid substation) and Sector 1 (to the east) would be the best options in this location.

20. Sectors 2, 3 and 4 were discounted due to the proximity of the residential areas of Necton, Little Dunham, Great Fransham and Little Fransham.

21. Sector 1 was maintained as an option due to the existing woodland and topography of this area which could provide screening (in addition to project screening mitigation) which may limit visual impacts. Additional access would however be required for this sector.

22. Sector 5 was maintained as an option on the basis of keeping all existing and proposed development together, the lack of housing in this sector and good access from the A47. However concerns were raised regarding the ongoing industrialisation of the area.

23. The refined substation search zone (Zone 3) includes the parts of Sectors 1 and 5, south of the A47 and south of the existing overhead line.

24. A search area for underground cables has also been delineated (the western end of Zone 4) which is required to connect the substation located within Zone 3 to the existing Necton 400kV National Grid substation.

2.1.5 Extension to the Existing Necton 400kV National Grid Extension

25. Since completion of the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016) a decision has been made by the VWPL to include the required extension works to the existing Necton 400kV National Grid substation within the EIA and DCO application for Norfolk Vanguard. The aim of this approach is to enable a more transparent impact assessment and allow the development of more effective mitigation.

26. Appropriate search zones for the extension works have been developed in consultation with National Grid, including:

- Zone 1 - Land adjacent to the existing substation which could accommodate extension to the existing busbars (see Section 2.2.1.5).
- Zone 2 - Land where overhead line realignment works maybe required adjacent to the existing National Grid substation (see Section 2.2.1.5).

27. VWPL will work closely with National Grid to ensure the design of the extension works is appropriate.

2.1.6 Norfolk Boreas

28. Since completion of the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016) a grid connection agreement has been granted by National Grid for Norfolk Boreas at the existing Necton 400kV National Grid substation. Therefore the Norfolk Vanguard EIA will include the option for Norfolk Boreas cable ducts to be installed at the same time as Norfolk Vanguard.

2.2 Indicative Worst Case Scenarios

29. The following sections set out the indicative worst case scenarios for onshore noise and vibration. The PEIR/ES will provide a detailed Project Description describing the final Rochdale envelope for the Norfolk Vanguard DCO application. Each chapter of the PEIR/ES will define the worst case scenario arising from the construction, operation and decommissioning phases of the Norfolk Vanguard project for the relevant receptors and impacts. Additionally, each chapter will consider separately the anticipated cumulative impacts of Norfolk Vanguard with other relevant projects which could have a cumulative impact on the receptors under consideration.

2.2.1 Infrastructure Parameters

30. Two electrical solutions are being considered for Norfolk Vanguard, a High Voltage Alternating Current (HVAC) and a High Voltage Direct Current (HVDC) scheme. The decision as to which option will be used for the project will be agreed post consent and will depend on availability, technical considerations and cost. Both electrical solutions will have implications on the required onshore infrastructure. Typically the HVAC scenario involves a greater area of land take and additional infrastructure, and as such the HVAC scenario is assumed as the worst case in the remainder of this section. Where the worst case assumes the HVDC scenario, this is stated in the text.

31. The following key onshore project parameters are considered:

- Landfall (Horizontal Directional Drilling (HDD) and associated compounds);

- Cable relay station if required (HVAC only) within the cable relay station search zones;
- Cable corridor (with associated construction compounds and mobilisation areas);
- Onshore substation (within the substation search zone); and
- Extension to the existing Necton 400kV National Grid substation, including overhead line modification.

32. There is an option for the cable ducts for Norfolk Boreas, (the sister project to Norfolk Vanguard) to be constructed and installed simultaneously with Norfolk Vanguard within a single cable corridor (see parameters in Section 2.2.1.3). Therefore this scenario will be considered within the Norfolk Vanguard EIA as associated development as part of the DCO application. There is also the scenario that the ducts for Norfolk Boreas cannot be installed at the same time as Norfolk Vanguard and therefore this scenario will be considered within the Cumulative Impact Assessment (CIA), together with the parameters of Norfolk Vanguard (as listed in the bullets points above).

33. All other components of Norfolk Boreas will be considered as part of the Norfolk Vanguard CIA.

34. During the construction phase of Norfolk Vanguard the worst case scenario for noise and vibration is strongly linked to the duration and proximity of proposed activities associated with the landfall, cable relay station, onshore cable route, onshore substation and extension to the existing Necton 400kV National Grid substation.

35. During the operational phase the worst case scenario is strongly linked to the siting of the plant and equipment associated with the cable relay station, onshore substation, and the potential effect of the extension to existing Necton 400kV National Grid substation to identified noise and vibration receptors.

2.2.1.1 Landfall

36. There are three potential landfall locations for Norfolk Vanguard:

- Bacton Green;
- Walcott Gap; and
- Happisburgh South.

37. Initial survey and data collection for the EIA will enable the selection of the landfall location for Norfolk Vanguard. Therefore the approach to baseline characterisation will initially consider all options and will then be refined once a final landfall location is selected. The PEIR and ES will present a single landfall option.

38. The Norfolk Vanguard offshore cables will be jointed to the onshore cables on the landward side of the landfall site. Cable ducts would be installed at the landfall so that the ends of the offshore cables can be pulled through to this joint location. These will be installed using Horizontal Directional Drilling (HDD) which is a trenchless installation technique. The HDD will exit at one of the following two locations:

- On the beach, above the level of mean low water spring (classified as "short HDD").
- At an offshore location, away from the beach (up to 1000m in drill length) (classified as "long HDD").

39. Key parameters:

- A total of 6 ducts and 6 transition pits for the HVAC option or 2 ducts and 2 transition pits for the HVDC option would be required at the landfall for Norfolk Vanguard.
- Noise from each HDD site is generally associated with generators at the location with a noise emission of 77 dB L_{Aeq} at 10m. At 50m distance from an average HDD site the noise level is 70dB(A) and at 100m is typically 60dB(A).
- Drilling and demobilisation will take approximately 30 weeks when considering 12 hour (7am-7pm), 7 day shifts. 24 hour lighting of the temporary footprint will be required through construction.

40. If Norfolk Boreas cable ducts are installed concurrently with the Norfolk Vanguard ducts, the Norfolk Boreas ducts will be installed up to the joint pits on the landward site of the landfall works. No landfall works (e.g. transition pits, HDD works) will be undertaken for Norfolk Boreas and therefore the landfall works for Norfolk Boreas do not form part of the Norfolk Vanguard DCO and will be considered in the CIA (see Section 2.2.5).

2.2.1.2 Cable Relay Station

41. A Norfolk Vanguard cable relay station is required for an HVAC electrical solution only and would not be included in a HVDC connection solution. Therefore the HVAC option is the worst case scenario for this onshore infrastructure.

42. The cable relay station accommodates the reactive compensation equipment required to compensate the capacitive losses generated by long power cables, and will be located near to the landfall.

43. There are currently seven cable relay station search zones being considered and a final location will be defined following landfall site selection for the EIA and DCO application.

2.2.1.3 Cable Corridor

44. There are several potential scenarios for the cable easement:

- Norfolk Vanguard HVDC: This would require a 35m temporary strip during construction, and a 13m permanent strip (including 8m access) during operation.
- Norfolk Vanguard HVAC: This would require a 50m temporary strip during construction, and a 25m permanent strip (including 8m access) during operation.
- Norfolk Vanguard and Norfolk Boreas HVDC: This would require a 45m temporary strip during construction, and a 20m permanent strip with (including 8m access) during operation.
- Norfolk Vanguard and Norfolk Boreas HVAC: This would require a 100m temporary strip during construction, and a 54m permanent strip (including two separate 8m access tracks and 6m separation between circuits) during operation.

45. The Norfolk Vanguard EIA worst case scenario for the cable route will be where ducts for Norfolk Vanguard and Boreas are installed concurrently using the HVAC scenario, due to the larger land-take required for this option, and associated earthworks and traffic movements.

2.2.1.4 Substation

46. A single onshore substation will be required regardless of whether HVAC or HVDC options are selected and the two options will have similar land take requirements:

- HVAC:
  - Construction area approximately 400m x 400m
  - Substation footprint (within construction area) approximately 250m x 300m
- HVDC:
  - Construction area approximately 400m x 400m
  - Substation footprint (within construction area) approximately 250m x 300m

47. A substation search zone (which has been refined from the substation search area shown in the Norfolk Vanguard EIA Scoping Report (Royal HaskoningDHV, 2016) is located to the south and east of the existing Necton 400kV National Grid substation. Initial survey and data collection for the EIA will enable the selection of the substation location for Norfolk Vanguard. Therefore the approach to baseline characterisation will initially consider the search zone and will then be refined once a

final substation location is selected. The PEIR and ES will present a single substation location.

2.2.1.5 National Grid substation extension

48. An extension to the existing Necton 400kV National Grid substation will be required regardless of whether the HVAC or HVDC electrical solution is selected.

49. The busbar would be extended in an east west direction with seven additional Air Insulation Switchgear (AIS) bays for Norfolk Vanguard.

50. The extension to the existing Necton 400kV National Grid substation for Norfolk Vanguard and Norfolk Boreas combined would require a further busbar extension and five further AIS bays for Norfolk Boreas. This extension to the Necton 400kV National Grid substation will be included in the Norfolk Vanguard DCO and EIA.

51. Re-configuration of overhead lines to change the arrangements of the 400kV circuits in close proximity to the substation would also be required.

52. The National Grid substation extension will be included within the EIA for the Norfolk Vanguard DCO application.

2.2.1.6 Worst case scenario summary

53. The information provided above means that the worst case scenario can be defined as follows:

- Landfall: 6 ducts for the HVAC option for Vanguard Norfolk Vanguard in isolation.
- Cable relay station: HVAC cable relay station required.
- Cable route: Norfolk Vanguard and Norfolk Boreas HVAC.
- Onshore substation:
  - Construction area approximately 400m x 400m
  - Substation footprint (within construction area) approximately 250m x 300m
- Extension to the existing Necton 400kV National Grid substation: Norfolk Vanguard and Norfolk Boreas.

2.2.2 Construction Programme

54. Impacts associated with construction works need to be considered in a temporal and spatial context. The longer the duration of temporary works required to construct the project, the greater the potential for impact on noise and vibration sensitive receptors.

55. Additionally, depending on the scheduling, there may be a potential for overlap of combined work stages operating in proximity to receptors, leading to a cumulative noise impact for Norfolk Vanguard.

56. In a temporal context, the worst case scenario for noise sensitive receptors is therefore the construction of the onshore infrastructure for the Norfolk Vanguard and Norfolk Boreas developments in two separate phases. Concurrent construction may reduce the duration of the cumulative impact of Norfolk Vanguard and Norfolk Boreas. In a spatial context, the worst case scenario for noise sensitive receptors is the overlapping of construction phases leading to a concentration of plant and works at the same receptor location.

57. The HVAC option is based on a three phase development programme which would take a total of seven years (2020-2026), while the HVDC option is based on a two phase development programme which would take a total of six years (2020-2025). Both programmes include two years of enabling works during 2020 and 2021, consisting of road modifications, hedge and tree removal, preconstruction drainage, mobilisation area establishment and major crossing construction.

58. Duct installation for the landfall and onshore cable and primary works for the substation and cable relay station would take place during 2022 and 2023. The installation of the onshore cables would occur in phases in parallel with the commissioning of the phases of the offshore wind farm. In the HVAC programme, the cable and electrical plant installation and commissioning will take place over three years from 2024 to 2026. In the HVDC programme, installation and commissioning will take place over 2 years, from 2024 to 2025.

59. Construction works will not take place continuously in all locations during the proposed construction period. Construction activity along the onshore cable route will move along the route between different sections and activity will be phased, with the trenching and laying of ducts taking place first, followed by the cable installation.

60. The construction period for the cable relay station and substation is expected to be approximately 18 months.

2.2.3 Operation and Maintenance (O&M) Strategy

61. The key potential impact will be the operational noise emissions from the cable relay station and the onshore substation at noise and vibration sensitive receptors.

62. The cable relay station will not be manned during operation, however access will be required periodically for routine maintenance activities, estimated at an average of one visit per week. Peak noise levels will be produced by the oil immersed reactors

with an unmitigated noise level of approximately 95 dB Sound Pressure Level (SPL) at 0.3m across a frequency spectrum up to 800 Hz, peaking at 315 Hz.

63. The onshore substation will not be manned, however access will be required periodically for routine maintenance activities, estimated at an average of one visit per week. Peak operational noise levels will be produced by transformers with an unmitigated noise level of 90 dB SPL at 0.3m with flat profile up to 250 Hz per 1/3 octave band and air core reactors with an unmitigated noise level of approximately 85 dB SPL at 0.3m with a frequency spectrum up to 800 Hz, peaking at 315 Hz. The HVAC substation option requires a greater number of transmission plant items; therefore there is an associated potential for these noise sources to contribute to increased receptor noise levels.

64. Operational noise levels associated with the extension to the existing Necton 400kV National Grid substation are not anticipated to change from existing levels due to the nature of the extension works. This will be assessed further in the EIA.

65. There is no ongoing requirement to maintain the onshore cables following installation. However, periodic access to installed link boxes / test pits may be required for inspection, estimated to be annually. No noise emissions are anticipated to arise from the onshore cables during operation.

2.2.4 Decommissioning

66. No decision has been made regarding the final decommissioning policy for the substation and cable relay station, as it is recognised that industry best practice, rules and legislation change over time. However, the substation and cable relay station equipment will likely be removed and reused or recycled. It is expected that the onshore cables will be removed from ducts and recycled, with the joint pits and ducts left in situ.

67. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan will be provided.

2.2.5 Cumulative Impact Scenarios

68. There is potential for impacts associated with noise and vibration generated during the construction phase site works to lead to a cumulative impact with other proposed developments (already consented and those in the planning system) where the construction phases overlap and where activities will occur in proximity to the same receptors.

69. There is a potential for a cumulative impact associated with construction phase road traffic to occur during the project construction. Further details are contained within the Traffic and Transport Method Statement.

70. Best practice mitigation measures will be implemented on these sites. In addition, where there is a potential for a cumulative impact to increase the predicted impact effect, construction works should be phased where possible to avoid noise-generating works being undertaken concurrently on these sites.

71. Where necessary, a suite of mitigation measures will be recommended to minimise the generation of noise and vibration during the cumulative construction phase scenario, which will be based on achieving, as a minimum, the BS5228 threshold levels.

72. It is anticipated that the proposed developments being constructed in the vicinity of the project would also implement mitigation measures to adequately minimise the generation of noise and vibration during the construction phase. It is therefore considered that the cumulative effect would be minimised.

2.2.5.1 Norfolk Boreas

73. If Norfolk Boreas uses the same landfall as Norfolk Vanguard, a total of 12 ducts would be required at the landfall (under the worst case HVAC electrical solution). The Happisburgh South landfall site is the only landfall option which can accommodate 12 ducts.

74. The following landfall scenarios for Norfolk Vanguard and Norfolk Boreas are currently being considered:

- HVDC - Landfalls for Norfolk Vanguard and Norfolk Boreas at Bacton Green (4 ducts in total)
- HVDC - Landfalls for Norfolk Vanguard and Norfolk Boreas at Walcott Gap (4 ducts in total)
- HVDC - Landfalls for Norfolk Vanguard and Norfolk Boreas at Happisburgh South (4 ducts in total)
- HVAC North - Landfall for Norfolk Vanguard at Bacton Green (6 ducts) with Norfolk Boreas at Walcott Gap (additional 6 ducts); or
- HVAC South - Landfall for Norfolk Vanguard and Norfolk Boreas at Happisburgh South (12 ducts)

75. As discussed in Section 2.2.1, initial data collection for the Norfolk Vanguard EIA will enable selection of the landfall location for Norfolk Vanguard which will also inform the site selection for Norfolk Boreas. Final landfall locations for Norfolk Vanguard

and Norfolk Boreas will be confirmed in the Norfolk Vanguard CIA. The options of HVAC and HVDC will be retained in the Norfolk Vanguard DCO application. Due to the greater number of ducts, an HVAC option will represent the worst case scenario.

76. The Norfolk Boreas cable relay station (only required under the HVAC scenario) will be located within one of the cable relay station search zones shown for Norfolk Vanguard. The Norfolk Vanguard and Norfolk Boreas cable relay stations may be co-located or at separate locations, subject to the landfall site selection. Final cable relay station site locations will be known for the Norfolk Vanguard CIA. The cable relay stations for Norfolk Vanguard and Norfolk Boreas will be constructed separately, although construction periods could overlap. The footprint of the Norfolk Boreas cable relay station will be the same as described for Norfolk Vanguard in Section 2.2.1.

77. The CIA for Norfolk Boreas cable installation includes the following scenarios:

- Ducts for Norfolk Boreas are pre-installed during Norfolk Vanguard construction with cable pull through required during Norfolk Boreas construction;
  - Norfolk Boreas duct installation will be assessed in the project impact assessments for Norfolk Vanguard;
  - The cable pull through for Norfolk Boreas will be considered as part of the Norfolk Vanguard CIA); or
- Norfolk Boreas ducts and cables are installed at a separate time to Norfolk Vanguard.
  - This scenario will also be considered in the CIA, together with the parameters of Norfolk Vanguard alone.

78. The Norfolk Boreas substation will be located in the substation search zone shown for Norfolk Vanguard but will be constructed separately, although Norfolk Vanguard and Norfolk Boreas construction periods could overlap. The footprint of the Norfolk Boreas substation will be the same as those described for Norfolk Vanguard (Section 2.2.1).

79. As discussed in Section 2.2.1, the extension to the existing Necton 400kV National Grid substation for Norfolk Boreas would be done concurrently with Norfolk Vanguard construction under the Norfolk Vanguard DCO and therefore this is considered as part of the Norfolk Vanguard EIA.

2.2.5.2 Other Projects

80. Construction and commissioning of the substation for the Dudgeon Offshore Wind Farm is complete and operation is due to commence in 2017. This will be assessed in the CIA.

81. The cable corridor for the Hornsea Project 3 Offshore Wind Farm makes landfall at Weybourne with grid connection at Norwich Main. Where the Hornsea Project 3 cable corridor crosses the Norfolk Vanguard cable corridor, there will be potential cumulative impacts on noise and vibration during construction and this will be assessed in the CIA.

82. Other developments (such as housing and roads) will be considered in the CIA. CIA screening will be undertaken in consultation with stakeholders.

3 BASELINE ENVIRONMENT

3.1 Desk Based Review

83. A desk-based assessment will be undertaken to identify and evaluate the potential noise and vibration effects on receptors arising from the construction and operation of the project. The legislative context and relevant guidance for noise and vibration impact assessment are provided in Appendix 1.

3.1.1 Data Sources

84. The following information will be used in the baseline review and assessment:

3.1.1.1 Ordnance Survey mapping

85. An Ordnance Survey (OS) Vectormap will be used in the assessment.

3.1.1.2 Aerial Photography

86. Consideration of the project and surrounding environment will be conducted initially using aerial and satellite photography and mapping data in order to determine the nearest noise sensitive receptors for use in the assessment.

3.1.1.3 Topographical data

87. Ordnance Survey topographical data will be used in the assessment and supplemented with Environment Agency Open Data 2.0m resolution LIDAR utilised for the terrain modelling. Open Licence LIDAR data available at: (http://environment.data.gov.uk/ds/survey/#/survey)

3.1.1.4 On-site noise monitoring data.

88. Data obtained during the baseline noise survey (see Section 3.2 below) will be used to inform the noise and vibration assessment.

3.1.1.5 Traffic Data

89. Information regarding the off-site anticipated vehicle movements during the construction phase will be provided by Royal HaskoningDHV in the form of 18 hour AAWT flows with HGV percentages.

3.1.1.6 Construction Data

90. An indicative list of construction equipment will be provided by VWPL for the various phases of activity expected at the cable landfall, cable relay station, cable route, and onshore substation site. Where this information is unavailable an indicative list of

construction equipment will be compiled for the various expected construction phases based on experience of assessing similar schemes.

91. Typical noise emissions used for the noise assessment will be derived from BS5228:2009+A1:2014 Appendix C and Appendix D.

3.1.1.7 DWG/DXF Drawings

92. AutoCAD .dwg files, Scaled, geo-referenced proposed site Masterplan, wider site location plan, and elevation drawings will be used in the noise modelling.

3.1.1.8 Noise Modelling and Propagation Calculations

93. To predict the noise from the various aspects of the proposed development, the assessments will utilise SoundPLAN noise modelling software. The software implements accepted national and international acoustic calculation standards.

94. A three-dimensional model will be created using geo-referenced Ordnance Survey mapping data, topographical data of the local area incorporating buildings, plans and elevations of the project sites.

95. The SoundPLAN model calculates noise levels at a specified receptor 'point'. For the construction phase assessment receptor points are positioned at a height of 1.5m above local ground level at positions considered to be representative of gardens or at a ground floor (GF) of a building. This is due to the premise that construction operations typically occur during daytime hours and so are likely to impact most significantly upon outdoor residential amenity areas.

96. For the construction phase road traffic assessment receptor points will be placed at first floor (4m high) façade positions in accordance with DMRB guidance and at 1.5m height (ground floor). Façade noise levels will incorporate a +2.5dB correction to account for the reflection of sound energy from the receptor building façade, as required by the CRTN calculation method.

97. For the operational phase BS4142 assessments, receptor points will be placed at 1.5m for the daytime period (07:00 to 23:00hrs) and at first floor (4m high) for the night time period (23:00 to 07:00hrs).

3.2 Planned Data Collection

3.2.1 Consultation

98. The study areas for the cable landfall, cable relay station, cable route, onshore substation and the extension to the existing Necton 400kV National Grid substation site are located within the administrative region of the following local authorities:

- North Norfolk District Council (NNDC);
- Broadland District Council (BDC);
- Breckland Council (BC); and
- Norwich District Council (NDC).

99. The proposed extent of the Study Area for the construction phase road traffic noise and vibration assessment is based on details provided by the transport consultants and will likely be governed by the outcome of any consultation. The extent is shown on **Figure 2**. The administrative boundaries of the additional local authorities are labelled with RTN denoting Road Traffic Noise.

- South Norfolk District Council (SNDC) (RTN);
- Great Yarmouth District Council (GYDC) (RTN);
- Waveney District Council (WDC) (RTN);
- King's Lynn and West Norfolk District Council KLWNDC (RTN).

100. Measurements of the existing ambient noise level will be required to be taken at locations considered representative of nearby Noise Sensitive Receptors (NSRs) that have the potential to be affected by the construction and operation of The Project.

101. A baseline survey will be necessary to quantify existing noise levels at sensitive receptor locations close to potential noise generating activities associated with the project, specifically during the construction and operational phases:

- Cable landfall;
- Cable relay station;
- Cable route;
- Onshore substation; and
- Extension to existing Necton 400kV National Grid substation.

3.2.1.1 Potential impacts during construction

102. The potential temporary impacts of construction noise may arise from:

- Activities carried out on the surface along the proposed cable corridor (mainly earth moving and excavation);
- Construction activities at the substation and cable relay station sites including any potential landscaping;
- Horizontal Directional Drilling (HDD) activities;
- Heavy goods vehicles servicing the proposed cable corridors, cable relay station and substation, delivering or removing materials (including spoil and fill) and plant; and
- Vibration will only be considered as an issue where significant piling works are required i.e. foundations for onshore substation.

3.2.1.2 Potential impacts during operation

103. The potential permanent impacts of operational noise from the cable relay station, and onshore substation may arise from:

- The inherent operational noise from the proposed development and its characteristics;
- The proximity of the proposed development to noise sensitive premises (including residential properties) and noise sensitive areas (including PRoW and the Norfolk Broads National Park);
- The proximity of the proposed development to quiet places and other areas that are particularly valued for their acoustic environment or landscape quality; and
- The proximity of the proposed development to designated sites where noise may have an adverse impact on protected species or other wildlife.

104. There are unlikely to be any noise and vibration impacts relating to operational or maintenance vehicular traffic but operational noise impacts may arise from the operation of equipment within the substation and cable relay station (e.g. reactors and transformers). An assessment would be undertaken to determine the likely environmental and health impacts due to operational noise emissions on identified sensitive receptors.

105. Consultation will be undertaken with relevant stakeholders to agree the baseline survey and appropriate methodology of assessment, specifically:

- Local authorities identified in Section 3.2.1
- The Environment Agency.

3.2.2 General Survey Practice

106. In order to characterise the existing environment within the Study Area a baseline noise survey will be undertaken in the vicinity of the project. A proposed survey methodology for the baseline noise assessment to support the Noise and Vibration ES Chapter is outlined below.

107. Baseline survey measurements will be conducted in accordance with current guidance, including BS4142:2014 Method for Rating and Assessing Industrial and Commercial Sound, and BS 7445-2:1991 Description and measurement of environmental noise. Guide to the acquisition of data pertinent to land use.

108. Traceable calibrated Class 1 Sound Level Meters will be used for all measurements during the survey. Measurements will capture the following noise criteria: L_{Aeq}, L_{Amax}, L_{A90}, L_{A10}.

109. For all measurement locations during the noise survey the following general descriptors of noise will be included:

- L_{Aeq} – the equivalent continuous sound pressure level over the measurement period. This parameter was standardised as pertinent for land use within BS 7445-2;
- L_{Amax} – the maximum sound pressure level occurring within the defined measurement period;
- L_{A90} – the sound pressure level exceeded for 90% of the measurement period and is indicative of the background noise level;
- L_{A10} - the sound pressure level exceeded for 10% of the measurement period. The L_{A10} index is used within the Calculation of Road Traffic Noise (CRTN) as an appropriate descriptor of traffic noise.

110. The equivalent continuous sound pressure level (L_{Aeq}) is the conventional descriptor of environmental noise and is defined below:

$$L_{eq,T} = 10 \times \log\left[\frac{1}{T}\int \frac{\rho^2(t)\partial t}{\rho_0^2}\right] dB$$

111. Noise measurements are normally taken with an A-weighting (denoted by a subscript 'A') to approximate the frequency response of the human ear. An Appendix will provide further descriptions of these terms.

112. Record of the meteorological conditions during the survey will be made and measurements will not be taken during periods of rain or when average wind speeds exceed 5m/s.

3.2.3 Proposed Data Acquisition Approach

113. Different noise survey methodologies will be used for the cable relay station, onshore substation and extension to National Grid 400KV Necton substation, than those for the onshore cable corridor. The onshore cable corridor comprises only temporary construction works whereas the cable relay station and both substations will be continuously operational.

114. Fixed baseline measurement locations are subject to access being agreed with landowners and tenants, therefore some variation may be required. For this reason identification of exact measurement locations of NSRs will be agreed with appropriate stakeholders. Indicative locations of NSRs are detailed in the relevant survey sections below..

115. Please note that noise monitoring is weather dependent and therefore measurement durations and timescales may be revised if suitable weather conditions are not available. Data obtained during the survey period will be screened to ensure its validity in accordance with BS 7445-2:1991.

3.2.3.1 Landfall areas

116. Three landfall search zones are being considered at this stage:

- Bacton Green;
- Walcott Gap; and
- Happisburgh South.

117. Installation compounds and transition joint pits will be sited within these zones. The offshore cables will be installed under existing sea defences and jointed to the onshore cables at the transition pits on the landward side of the landfall site. To enable this installation, Horizontal Directional Drilling (HDD) is proposed. The typical works for HDD installation per duct include instatement of a temporary construction compound to accommodate the drilling rig, ducting and associated materials and welfare facilities.

118. Measurements are proposed at a number of receptor locations presented in Table 3.1 for each landfall area and to be agreed during consultation.

Table 3.1 – Baseline and Assessment Receptors – Landfall areas

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
LFR1B	Residential, Medium	633837	334398	NR12 0JB
LFR2B	Residential, Medium	634200	334152	NR12 0EP
LFR3B	Residential, Medium	633874	334266	NR12 0JH
LFR1W	Residential, Medium	635493	333202	NR12 0LS
LFR2W	Residential, Medium	635692	333023	NR12 0LU
LFR3W	Residential, Medium	635260	332743	NR12 0LU
LFR1H	Residential, Medium	638537	330874	NR12 0PR
LFR2H	Residential, Medium	638416	330635	NR12 0PY
LFR3H	Residential, Medium	638506	329813	NR12 0AJ
LFR4H	Residential, Medium	639337	330246	NR12 0QL

Note: LF denotes Landfall, R1 denotes a unique Receptor identifier; B,W,H denotes first initial of preferred landfall zone.

119. Short-term attended measurements will be taken at various times throughout the daytime (up to 1 hour) and night time (up to 30 minutes) reference periods.

3.2.3.2 Cable Relay Station

120. The cable relay station search zones are located on the North Norfolk Coast within 5km of Bacton Green and Eccles-on-Sea, a predominantly rural area with small villages and isolated residential properties which are likely to experience low ambient noise levels presently. The main noise sources in this area are likely to be local roads, the Bacton gas terminal operation, and the industrial area to the north at Paston. The northern tip of the Norfolk Broads National Park has been excluded from the search zone. There are 7 potential sites being considered, detailed on **Figure 1** as Zone 7.

121. Measurements are proposed to be conducted at a number of receptor locations in the vicinity of the cable relay station site, to be finalised and determined during consultation. For each potential site (A to G), receptors were identified and detailed in Table 3.2.

Table 3.2 – Baseline and Assessment Receptors – Cable Relay Station areas

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
CRR1A	Residential, Medium	633664	334344	NR12 0JA
CRR2A	Residential, Medium	633179	333947	NR12 0JN
CRR1B	Residential, Medium	633316	333590	NR12 0JP
CRR2B	Residential, Medium	632660	332935	NR28 9TW
CRR3B	Residential, Medium	632341	333155	NR28 9TN
CRR1C	Residential, Medium	631930	332621	NR28 9TJ
CRR2C	Residential, Medium	631259	332059	NR28
CRR3C	Residential, Medium	631692	331266	NR28 9UE
CRR1D	Residential, Medium	633916	332875	NR12 0LG
CRR2D	Residential, Medium	634054	332066	NR28 9TP
CRR3D	Residential, Medium	634908	332348	NR28 9TX
CRR1E	Residential, Medium	635949	331285	NR12 0PB
CRR2E	Residential, Medium	636275	330859	NR12 0NU
CRR3E	Residential, Medium	635628	330631	NR12 0PA
CRR4E	Residential, Medium	634739	330870	NR28 9NU

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
CRR1F	Residential, Medium	636233	330633	NR12 0NX
CRR2F	Residential, Medium	636378	330155	NR12 0RG
CRR3F	Residential, Medium	637451	330256	NR12 0RA
CRR1G	Residential, Medium	635919	330534	NR12 0PA
CRR2G	Residential, Medium	636313	330189	NR12 0RG
CRR3G	Residential, Medium	635265	330525	NR28 9NX
CRR4G	Residential, Medium	635380	329807	NR12 9HZ

Note: CR denotes Cable Relay, R1 denotes a unique Receptor identifier; A to G denotes each zone.

122. Where land-access and security constraints allow, continuous logging equipment will be installed for up to 1-week and will measure 5-minute records of the noise level. If logging equipment cannot be left unmanned, multiple short-term attended measurements will be taken at various times throughout the daytime and night time reference periods.

123. The approach will include the use of sound level meters with full octave band analysis capability to enable assessment of the variations in the background sound level at the unattended noise sensitive receptor locations and includes for the use of a weather station as recommended in the BS4142:2014 measurement procedure.

3.2.3.3 Cable Route

124. The substation interconnecting cable route will connect the wind farm substation to the existing Necton 400kV National Grid substation. This cable route will be dependent on the final onshore substation location, within the substation search zone.

125. The cable route which runs from the cable relay station search zones on the coast to the substation search zone is predominantly rural in nature.

126. The largest settlements within the area are at North Walsham, Aylsham and Dereham, the Robertson Barracks at Swanton Morley and smaller villages and isolated residential properties throughout the area. The main noise sources within the area are likely to be:

- The A47 and the A1067 roads in the west of the area;
- The A140 and the A149 roads in the east of the area;

- The Norwich to Holt railway line in the east of the area;
- The railway line at Dereham;
- Industrial areas at North Walsham, Aylsham and Dereham; and
- The Robertson Barracks and Swanton Morley Airfield.

127. To enable construction, primary mobilisation areas will be required to store equipment and provide welfare facilities. These mobilisation areas will be located adjacent to the onshore cable route, accessible from the local highways network suitable for the delivery of cable drums and other heavy and oversized equipment. Each mobilisation area will serve an installation gang and will be evenly distributed along the route length where possible.

128. Secondary mobilisation areas are required to serve construction crews working remotely from the primary mobilisation areas to allow close proximity to storage and welfare facilities during installation. These additional mobilisation areas provide flexibility to the construction programme and allow the impacts on the public transport network to be minimised through diversified access locations.

129. Due to the large geographical area covered by the onshore cable route (60km), the required corridor width (up to 200m), and the temporary nature of the construction works, measurements will not be taken at all locations representing specific sensitive receptors along the route. Locations representative of 'areas' along the cable route will be selected.

130. Details of the exact proposed construction scheduling are not currently available. Sensitive receptors that are close to or within the cable corridors, in proximity to mobilisation areas will be selected initially and are to be the subject of discussion and agreement with stakeholders. These locations are likely to be indicative and an initial site visit may highlight site specific factors that require a change in some monitoring locations.

131. Measurements are proposed to be conducted at a number of receptor locations along the cable route. The final locations will be determined during consultation. Table 3.3 details the proposed initial receptor locations along the cable route.

Table 3.3 – Baseline and Assessment Receptors – Cable Route

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
CRR1	Residential, Medium	629198	331553	NR28 0RB
CRR2	Residential, Medium	628589	331706	NR28 0RE
CRR3	Residential, Medium	626854	331810	NR28 0NE

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
CRR4	Residential, Medium	624030	330724	NR11 7EP
CRR5	Residential, Medium	622827	330294	NR11 7EB
CRR6	Residential, Medium	621546	330310	NR11 7ED
CRR7	Residential, Medium	621542	329521	NR11 7DY
CRR8	Residential, Medium	621064	328818	NR11 6LS
CRR9	Residential, Medium	620121	328664	NR11 6LR
CRR10	Residential, Medium	617483	327683	NR11 6NN
CRR11	Residential, Medium	616336	326789	NR11 6UL
CRR12	Residential, Medium	614711	325473	NR10 4HT
CRR13	Residential, Medium	613563	324840	NR10 4HZ
CRR14	Residential, Medium	612394	324575	NR10 4EP
CRR15	Residential, Medium	610616	323759	NR10 4FJ
CRR16	Residential, Medium	610373	324059	NR10 4RZ
CRR17	Residential, Medium	607770	323244	NR10 4RS
CRR18	Residential, Medium	606953	322777	NR10 4RJ
CRR19	Residential, Medium	607207	321427	NR10 4RQ
CRR20	Residential, Medium	606512	319757	NR9 5QU
CRR21	Residential, Medium	604276	318184	NR20 4QF
CRR22	Residential, Medium	604088	317164	NR20 3EP
CRR23	Residential, Medium	601847	315633	NR20 4NT
CRR24	Residential, Medium	602288	316063	NR20 4NX
CRR25	Residential, Medium	601167	315515	NR20 4PT
CRR26	Residential, Medium	599455	315130	NR19 2DQ
CRR27	Residential, Medium	598878	314731	NR19 2SU
CRR28	Residential, Medium	596691	315085	NR19 2QD
CRR29	Residential, Medium	595122	313967	NR19 2PA
CRR30	Residential, Medium	594861	312828	NR19 2QN

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
CRR31	Residential, Medium	594423	312613	NR19 2QN
CRR32	Residential, Medium	594847	312215	NR19 2PF
CRR33	Residential, Medium	593102	311688	NR19 2LU

Note: CC denotes cable corridor, R1 denotes a unique Receptor identifier.

132. It is anticipated that cable route construction works will generally be conducted over a daytime period only; though under some circumstances construction may occur over a 24-hour period. The onshore cable corridor route survey will therefore comprise daytime and night time measurements. Primary and Secondary mobilisation areas may require the operation of generators and plant associated with security.

133. A single 30-minute measurement will be made at each identified and agreed site during the daytime and one 15-minute period at night, in order to capture the range of existing noise levels within the study area and to allow for the flexibility of construction phasing requirements.

3.2.3.4 Onshore Substation Site

134. The substation search zone is located around the village of Necton to the west of the larger town of Dereham. Noise in this area is likely to be dominated by road traffic on the A47. The area is generally rural in nature with the village of Necton containing the largest concentration of residential properties. Smaller villages and isolated residential properties are also located within the search zone.

135. The location for the project substation will be within the vicinity of the existing Necton 400kV National Grid substation, within the substation search zone. The exact location within the site boundary is still to be determined.

136. Measurements are proposed to be conducted at a number of receptor locations determined during consultation. An indication of the nearest receptors to the proposed substation footprint is detailed in Table 3.4. Note: SS denotes substation, R1 denotes a unique Receptor identifier.

Table 3.4 – Baseline and Assessment Receptors – Project Substation

Receptor Identifier	Receptor Classification and Sensitivity	X	Y	Nearest Postcode
SSR1	Residential, Medium	588485	309896	PE37 8HY
SSR2	Residential, Medium	589785	309566	PE37 8JB
SSR3	Residential, Medium	592051	310041	IP25 7QR
SSR4	Residential, Medium	590969	311001	NR19 2JX
SSR5	Residential, Medium	588814	311122	PE37 8DL
SSR6	Residential, Medium	591734	311640	NR19 2JY
SSR7	Residential, Medium	589747	311318	NR19 2RQ
SSR8	Residential, Medium	589971	311705	NR19 2JW
SSR9	Residential, Medium	591059	311817	NR19 2JU
SSR10	Residential, Medium	590756	309364	IP25 7QZ
SSR11	Residential, Medium	588474	310818	PE37 8DL

137. Where land-access and security constraints allow, continuous logging equipment will be installed for up to 1-week and will measure 5-minute records of the noise level. If logging equipment cannot be left unmanned, multiple short-term attended measurements will be taken at various times throughout the daytime and night time reference periods.

138. Our approach includes for the use of sound level meters with full octave band analysis capability to enable assessment of the variations in the background sound level at the unattended noise sensitive receptor locations, and includes for the use of a weather station as recommended in the BS4142:2014 measurement procedure.

3.2.4 Construction related vibration

139. Ground-borne vibration can result from construction works and may lead to perceptible levels of vibration within nearby properties, which can at higher levels cause annoyance to residents. In extreme cases, cosmetic or structural building damage can occur, however vibration levels have to be very high and such cases are rare.

140. High vibration levels generally arise from 'heavy' construction works such as piling, deep excavation, or dynamic ground compaction. Construction of the onshore cable route and landfall may generate vibration impacts. The use of piling during the construction of the Onshore substation, and cable relay station has not been discounted; however to reduce potential impacts, it is recommended to increase the separation distance between the construction works and receptors or give preference to methods which generate lower levels of vibration.

141. It is not proposed at this stage to carry out a baseline vibration assessment.

4 IMPACT ASSESSMENT METHODOLOGY

4.1 Overall Approach

142. This section sets out the overall approach to the assessment and highlights the main potential impacts on noise and vibration sensitive receptors during the construction and operational phases of the project.

4.2 Defining Impact Significance

4.2.1 Sensitivity

143. The closest human receptors to the proposed development are to be determined during consultation with relevant stakeholders. Indicative NSRs are detailed in Table 3.1 to Table 3.4 in the previous section.

144. The aims of the NPPF and the NPSE require that a SOAEL should be "avoided" and that where a noise level which falls between SOAEL and LOAEL, then according to the explanatory notes in the statement:

"…reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life whilst also taking into consideration the guiding principles of sustainable development. This does not mean that such effects cannot occur."

145. Further guidance can be found in the PPG notes which summarise the noise exposure hierarchy based on the likely average response, as summarised in Table 4.1.

Table 4.1 – PPG Noise Exposure Hierarchy

Perception	Examples of Outcomes	Increasing Effect Level	Action
Not noticeable	No Effect	No Observed Effect	No specific measures required
Noticeable and not intrusive	Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required
		Lowest Observed Adverse Effect Level	

Perception	Examples of Outcomes	Increasing Effect Level	Action
Noticeable and intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
		Significant Observed Adverse Effect Level	
Noticeable and disruptive	The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Noticeable and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Unacceptable Adverse Effect	Prevent

146. Sensitive receptors, in the context of noise and vibration are typically residential premises but can also include schools, places of worship and noise sensitive commercial premises. Table 4.2 presents the definitions used relating to the sensitivity of the receptor.

Table 4.2 Definitions of the different sensitivity levels for a noise and vibration receptor

Sensitivity	Definition	Examples
High	Receptor has very limited tolerance of effect	Noise Receptors have been categorised as high sensitivity where noise may be detrimental to vulnerable receptors . Such receptors include Hospitals (e.g. operating theatres or high dependency units), care homes at night Vibration Receptors have been categorised as high sensitivity where the receptors are listed buildings or Scheduled Ancient Monuments.
Medium	Receptor has limited tolerance of effect	Noise Receptors have been categorised as medium sensitivity where noise may cause disturbance and a level of protection is required but a level of tolerance is expected. Such subgroups include Residential accommodation, private gardens, hospital wards, care homes, schools, universities, research facilities, national parks, during the day; and temporary holiday accommodation at all times Vibration Receptors have been categorised as medium sensitivity where the structural integrity of the structure is limited but the receptor is not a listed building or Scheduled Ancient Monument.
Low	Receptor has some tolerance of effect.	Noise Receptors have been categorised as low sensitivity where noise may cause short duration effects in a recreational setting although particular high noise levels may cause a moderate effect. Such subgroups include Offices, shops, outdoor amenity areas, long distance footpaths, doctors surgeries, sports facilities and places of worship. Vibration Receptors have been categorised as low sensitivity where the structural integrity of the structure is expected to be high. The level of vibration required to cause damage is very high and such levels are not expected to be reached during the Proposed Development.
Negligible	Receptor generally tolerant of effect.	Noise Receptors have been categorised as negligible sensitivity where noise is not expected to be detrimental Such subgroups include Warehouses, light industry, car parks, agricultural land Vibration Receptors have been categorised as negligible sensitivity where vibration is not expected to be detrimental.

147. For each identified receptor details will be provided in a figure and tabulated to allow for ease of comparison for the different assessments. Table 4.3 provides an example.

Table 4.3 – Receptor Identification, Sensitivity and Classification

Receptor Identifier	Receptor Classification	Receptor Sensitivity	X	Y	Description
R1	Residential	Medium	XXXXXX	XXXXXX	

4.2.2 Magnitude

148. Receptor magnitude has been defined with consideration to the PPG guidance, spatial extent, duration, frequency and severity of the effect. Impact magnitude is defined in Table 4.4.

Table 4.4 Criteria for appraisal of magnitude of effect for a noise and vibration receptor

Magnitude	Definition	Example
High/Major	Fundamental, permanent / irreversible changes, over the whole receptor, and / or fundamental alteration to key characteristics or features of the particular receptors character or distinctiveness. PPG - Unacceptable Adverse Effect (UAE)	Construction noise levels predicted to exceed BS5228 trigger levels by >5dBA and for a duration triggering noise insulation requirements or temporary re-housing. A 5dB or more change in LA10, 18 hour traffic noise. Vibration exceeding 10mm/s PPV at Human receptor the highest threshold values at frequencies likely to be encountered. PPV Transient level >50mm/s at all frequencies, likely to cause building damage for Industrial and Commercial buildings. PPV Transient level >15mm/s at 4Hz to 200mm/s at 15Hz and >20mm/s at 15Hz increasing to 50mm/s at 40Hz and above likely to cause building damage for Light unreinforced buildings. Rating level for Operational Noise Measured LA90 ± ≥10dB.
Medium/Moderate	Considerable, permanent / irreversible changes, over the majority of the receptor, and / or discernible alteration to key characteristics or features of the particular receptors character or distinctiveness. PPG - Significant Observed Adverse Effect (SOAEL)	Construction noise levels predicted to exceed BS5228-1 threshold values for a period of one month or more, but not for a level and duration to trigger noise insulation or temporary rehousing requirements. An exceedance of between 3 to 4.9dBA of BS5228 threshold level. A 3dB - 4.9dB change in LA10, 18 hour traffic noise. Vibration effects measurable between 1.0 and 10.0mm/s PPV at Human receptor. Rating level for Operational Noise Measured LA90 ± ≥5 to <10dB.
Low/Minor	Discernible, temporary (throughout project duration) change, over a minority of the receptor, and / or limited but discernible alteration to key characteristics or features of the particular receptors character or distinctiveness.	Noise levels may cause some minor temporary disturbance, but noise levels do not exceed BS5228-1 threshold values for a period of one month or more or for a level and duration to trigger noise insulation or temporary re-housing requirements. An exceedance of between 1 to 2.9dBA of BS5228 threshold level.

Magnitude	Definition	Example
	PPG – Observed Adverse Effect (OAE)	A 1dB - 2.9dB change in LA10, 18 hour traffic noise. Vibration effects measurable and between 0.3 to <1.0mm/s PPV at Human receptor, below threshold of minimum cosmetic damage at all frequencies. Rating level for Operational Noise Measured LA90 ± up to 5dB
Negligible	Discernible, temporary (for part of the project duration) change, or barely discernible change for any length of time, over a small area of the receptor, and/or slight alteration to key characteristics or features of the particular receptors character or distinctiveness. PPG – Lowest Observed Adverse Effect (LOAEL)	Construction noise levels between 0.1 to 0.9dBA above BS5228-1threshold levels at a receptor façade. A 0.1dB - 0.9dB change in LA10, 18 hour traffic noise. Vibration effects measurable and between 0.14 to 0.3mm/s PPV at Human receptor, at all frequencies. Rating level for Operational Noise = Measured LA90.
No Impact	Not discernible, temporary change, or change for any length of time, over a small area of the receptor, and/no alteration to key characteristics or features of the particular receptors character or distinctiveness. PPG – No Observed Effect (NOEL)	Construction noise levels below BS5228-1 threshold levels at a receptor façade. Vibration effects minimal and below threshold of effect for a Human receptor (≤0.14mm/s PPV). Rating level for Operational Noise < Measured LA90. A ≤0.0dB change in LA10, 18 hour traffic noise.

4.2.3 Significance

149. The impact significance matrix presented in Table 4.4 will be used to determine the potential impact significance based on receptor sensitivity and magnitude of effect.

Table 4.1 Impact Significance Matrix

		Magnitude				
		High/ Major	Medium/ Moderate	Low/ Minor	Negligible/ Very Low	No change/ No Impact
Sensitivity	High	*Major*	*Major*	*Moderate*	*Minor*	*No change*
	Medium	*Major*	*Moderate*	*Minor*	*Minor*	*No change*
	Low	*Moderate*	*Minor*	*Minor*	*Negligible*	*No change*
	Negligible	*Minor*	*Negligible*	*Negligible*	*Negligible*	*No change*

150. For example, in terms of PPG guidance, an unacceptable adverse effect (UAEL) is considered to align with a Major/High Impact in Table 4.4 for a medium sensitivity receptor.

151. Assessment of impact significance is qualitative and reliant on professional experience, interpretation and judgement. The matrix should therefore be viewed as a framework to aid understanding of how a judgement has been reached, rather than as a prescriptive, formulaic tool.

152. Effects that result in Major or Moderate impacts are usually considered to be 'significant' in EIA terms. Significant impacts are those which are likely to influence the outcome of the planning application. Adverse significant impacts may require mitigation that is difficult or expensive to achieve whereas beneficial significant impacts contribute to the case in favour of the Proposed Development.

Table 4.2 Impact Significance Definitions

Impact Significance	Definition
Major	Very large or large change in receptor condition, both adverse or beneficial, which are likely to be important considerations at a regional or district level because they contribute to achieving national, regional or local objectives, or, could result in exceedance of statutory objectives and / or breaches of legislation.
Moderate	Intermediate change in receptor condition, which are likely to be important considerations at a local level.
Minor	Small change in receptor condition, which may be raised as local issues but are unlikely to be important in the decision making process.
Negligible	No discernible change in receptor condition.
No change	No impact, therefore no change in receptor condition.

153. Separate assessment guidance, criteria and thresholds exist for construction and operational phases. Specific criteria for each assessment are provided in this section.

5 ASSESSMENT METHODOLOGY

5.1 Potential Impacts

5.1.1 Construction Phase

5.1.1.1 Impact: Change in Noise Level at Human Receptors

154. There is the potential for activities associated with the construction of the project to temporarily increase the noise levels experienced at identified receptors throughout the study area. Specifically during the construction of the following phases:

- Landfall area,
- Cable relay substation,
- Cable route,
- Project substation, and
- Extension to the existing Necton 400kV substation.

5.1.1.2 Approach to assessment

155. The same methodology for each construction phase/activity detailed above will be used throughout the assessment and is presented in this section.

156. BS5228:2009+A1:2014 describes several methods for assessing noise impacts during construction projects. The approach to be used in this assessment is the 'ABC' method. BS5228 details the "ABC method" which specifies a construction noise limit based on the existing ambient noise level and for different periods of the day. The predicted construction noise levels were assessed against noise limits derived from advice within Annex E of BS 5228. Table 5.1, reproduced from BS 5228:2009+A1:2014 Table E.1, presents the criteria for selection of a noise limit for a specific receptor location.

Table 5.1 – Construction Noise Threshold Levels Based on the ABC Method (BS5228)

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A[A)]	Category B[B)]	Category C[C)]
Night time (23.00 to 07.00)	45	50	55
Evening and weekends [D)]	55	60	65
Daytime (07.00 – 19.00) and Saturdays (07.00 - 13.00)	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)			

Assessment category and threshold value period (L_{Aeq})	Threshold value, in decibels (dB)		
	Category A[A)]	Category B[B)]	Category C[C)]
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) 19.00–23.00 weekdays, 13.00–23.00 Saturdays and 07.00–23.00 Sundays.			

157. The ‘ABC method’ described in BS 5228 establishes that there is no impact below the three thresholds presented above.

158. BS5228 states:

“If the site noise level exceeds the appropriate category value, then a potential significant effect is indicated. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect.”

159. The model will incorporate noise sources located in the proposed scheme area, nearby residential dwellings and other buildings, intervening ground cover and topographical information.

160. Noise levels for the construction phase will be calculated using the methods and guidance in BS 5228. An appropriate threshold value (using the guidance in Table 5.1) will be assigned to each identified receptor or group of receptors (based on a measured level from the measurement survey).

161. BS5228 provides methods for predicting receptor noise levels from construction works based on the number and type of construction plant and activities operating on site, with corrections to account for:

- the ‘on-time’ of the plant, as a percentage of the assessment period;
- distance from source to receptor;
- acoustic screening by barriers, buildings or topography; and
- ground type.

162. To predict the noise from the various construction phases of the project, the assessment will utilise SoundPLAN noise modelling software.

163. SoundPLAN calculates noise levels at a specified receptor ‘point’. For the construction phase assessment receptor points will be positioned at a height of 1.5m above local ground level at positions considered to be representative of gardens or at a ground floor (GF) of a building.

164. Details of plant to be used in the construction phase will be provided by Vanguard; for example, noise from each HDD site is generally associated with generators at the location with a noise emission of 77 dB L_{Aeq} at 10m. At 50m distance from an average HDD site the noise level is 70dB(A) and at 100m is typically 60dB(A).

165. Drilling and demobilisation will take approximately 30 weeks when considering 12 hour (7am-7pm), 7 day shifts. 24 hour lighting of the temporary footprint will be required through construction.

166. Where this information is not available, an indicative list of construction equipment will be developed for the construction programme and detailed in a tabulated format similar to Table 5.2. Construction plant for each assumed phase and typical emissions (source noise levels) for each piece of plant or equipment operating will be used as the basis for the calculation. Where specific plant information is not provided, noise emission data will be derived from Annex C and Annex D of BS 5228-1:2009+A1:2014.

Table 5.2 – Example Construction Noise Plant Summary Table

Activity	Plant	Number	Noise Level dB L_{Aeq} @ 10m	On time
Landfall works	Excavator	2	75	75
	Dump truck	1	77	75
	Mobile Crane	1	78	75
	HDD drill rig	1	94	75
	Water pump	1	64	75
Haul road construction	Excavator	2	75	75
	Dump Truck	2	77	75
	Aggregate Wagon	10 (per hour)[*]	81	15 (km/h)[**]
Cable installation	Excavator	2	75	75
	Dump Truck	2	77	75
	Tractor towing trailer	1	79	75
Operational access construction	Excavator	2	75	75
	Dump Truck	2	77	75
	Aggregate Wagon	10 (per hour)	81	15 (km/h)

Activity	Plant	Number	Noise Level dB L_{Aeq} @ 10m	On time
Substation construction	Excavator	2	75	75
	Backhoe Loader	2	67	75
	Dozer	2	80	75
	Dump truck	2	77	75
	Mobile Crane	2	78	75
	Cement mixer truck (discharging)	1	75	50
	Truck mounted concrete pump + boom arm	1	78	50
	Piling	1	93***	25
	Generator	2	76	100

* An assumed number of hourly movements, expected to exceed actual number during construction.
** For mobile plant using a well-defined route, a speed (in km/h) is required, rather than a percentage on-time.
*** Activity equivalent continuous sound pressure level L_{Aeq} at 10m (one cycle).

167. Predicted construction noise will be assessed using the impact magnitude presented in Table 5.3 for the daytime period.

Table 5.3 – Daytime Construction Noise Significance Criteria

Construction Noise Level (dB)			Impact Magnitude
A 65dB Threshold	B 70dB Threshold	C 75dB Threshold	
≤ 65	≤70	≤ 75	No Impact
≥65.1 to ≤65.9	≥70.1 to ≤70.9	≥75.1 to ≤75.9	Negligible Adverse
≥66.0 to ≤67.9	≥71.0 to ≤72.9	≥76.0 to ≤77.9	Minor Adverse
≥68.0 to ≤69.9	≥73.0 to ≤74.9	≥78.0 to ≤79.9	Moderate Adverse
≥70	≥75	≥80	Major Adverse

168. Construction noise will be assessed using the impact magnitude presented in Table 5.4 for the Evening and Weekend period.

Table 5.4 – Evening and Weekends Construction Noise Significance Criteria

Construction Noise Level (dB)			Impact Magnitude
A 65dB Threshold	B 70dB Threshold	C 75dB Threshold	
≤ 55	≤60	≤ 65	No Impact
≥55.1 to ≤55.9	≥60.1 to ≤60.9	≥65.1 to ≤65.9	Negligible Adverse
≥56.0 to ≤57.9	≥61.0 to ≤62.9	≥66.0 to ≤67.9	Minor Adverse
≥58.0 to ≤59.9	≥63.0 to ≤64.9	≥68.0 to ≤69.9	Moderate Adverse
≥60	≥65	≥70	Major Adverse

169. Construction noise will be assessed using the impact magnitude presented in Table 5.5 for the Night time period.

Table 5.5 – Night time Construction Noise Significance Criteria

Construction Noise Level (dB)			Impact Magnitude
A 65dB Threshold	B 70dB Threshold	C 75dB Threshold	
≤ 45	≤50	≤ 55	No Impact
≥45.1 to ≤45.9	≥50.1 to ≤50.9	≥55.1 to ≤55.9	Negligible Adverse
≥46.0 to ≤47.9	≥51.0 to ≤52.9	≥56.0 to ≤57.9	Minor Adverse
≥48.0 to ≤49.9	≥53.0 to ≤54.9	≥58.0 to ≤59.9	Moderate Adverse
≥50	≥55	≥60	Major Adverse

5.1.1.3 Impact: Construction Phase Road Traffic Emissions Assessment

170. Details of the road network study area for the Construction phase traffic assessment will be provided by the traffic consultants as AAWT 18hr flows, % HGVs and Speed data.

5.1.1.4 Approach to assessment

171. Following the methodology contained in HD 213/11 Revision 1 within Design Manual for Roads and Bridges, Volume 11, Section 3, Part 7 ‘Noise and Vibration’, 2011, an initial screening assessment will be undertaken to assess whether there would be any significant changes in traffic volumes and composition on surrounding local roads as a result of the proposed scheme.

172. The DMRB methodology explains that the objective of an assessment is to gain an understanding of the noise climate both with and without the project, referred to as the Do-Something and Do-Minimum scenarios respectively.

173. In order to determine impacts, scenarios need to be assessed for a baseline year and also a future year. For an assessment of temporary construction noise and impacts, the baseline year is taken as that immediately prior to the start of works. The future assessment year would be a year during the period of construction works.

174. Initial screening using the criteria specified in the DMRB guidance document seeks to identify existing roads or possible new routes where traffic flow changes (volume or composition (i.e. HGVs/Light vehicles)) exceeding plus 25% or minus 20%, are expected. It is stated that traffic flow variations below this level would give rise to a maximum change in the noise level of less than 1 dB(A).

175. Where road links are predicted to experience an increase less than 25% or a decrease less than 20%, then the guidance indicates that no further assessment needs to be conducted. Where road links are predicted to experience an increase of greater than 25% or a decrease of 20%, a noise level calculation will be undertaken following the procedure outlined in Calculation of Road Traffic Noise (CRTN).

176. Construction phase road links within the Study Area will be presented in a table similar to the example in Table 5.6.

Table 5.6 – Construction Traffic Noise for Assessed Links Example

Link ID and Description	Baseline flows 18hr AAWT		Baseline construction Traffic Development 18hr AAWT		% Change	% Change	Speed (km/h)
	Total Vehicles	% HGVs	Total Vehicles	% HGVs	Total Vehicles	% HGVs	
Road X	10,000	10	13,000	12	30	56	48

177. A comparison will be made between the Baseline year and the Baseline year with construction traffic for the predicted noise levels from the CRTN calculation. Any associated changes in noise level due to a corresponding change in volume and composition which exceed the DMRB criteria outlined above (for example detailed in Table 5.6) will be assessed using the construction phase noise impact magnitude criteria detailed in Table 5.7 which was reproduced from Table 3.1 of DMRB.

178. The sensitivity of the identified receptor will be combined with the predicted impact magnitude to determine the impact significance.

Table 5.7 – Traffic Noise Impact Magnitude Criteria (Short Term)

Increase in Traffic Noise Level (dB $L_{A10,18h}$)	Impact Magnitude
0.0	No change
0.1 – 0.9	Negligible Adverse
1.0 – 2.9	Minor Adverse
3.0 – 4.9	Moderate Adverse
≥ 5.0	Major Adverse

5.1.2 Impact: Construction Vibration

179. Ground-borne vibration can result from construction works and may lead to perceptible levels of vibration at nearby receptors, which at higher levels can cause annoyance to residents. In extreme cases, cosmetic or structural building damage can occur, however vibration levels have to be very high for this effect to be manifested and such cases are rare.

180. High vibration levels generally arise from 'heavy' construction works such as piling, deep excavation, or dynamic ground compaction. The use of piling during the construction of the project may be required.

181. Section 3.29 of DMRB considers the effect of ground-borne vibration. DMRB states:

"People often express concern that vibrations they feel will cause structural damage to their dwelling. However, it has been shown that vibrations that can be felt indoors and which often cause occupants anxiety are an order of magnitude smaller than would be needed to activate pre-existing strains and cause cracks to propagate. "

182. DMRB provides context of perceived impacts:

"PPVs in the structure of buildings close to heavily trafficked roads rarely exceed 2 mm/s and typically are below 1 mm/s. Normal use of a building such as closing doors, walking on suspended wooden floors and operating domestic appliances can generate similar levels of vibration to those from road traffic."

5.1.2.1 Approach to assessment

183. Annex E of BS5228-2:2009+A1:2014 contains empirical formulae derived by Hiller and Crabb (2000) from field measurements relating to resultant peak particle velocity (PPV) with a number of other parameters for vibratory compaction, dynamic

compaction, percussive and vibratory piling, the vibration of stone columns and tunnel boring operations. These prediction equations are based on the energy approach. Use of these empirical formulae enables resultant PPV to be predicted and for some activities (vibratory compaction, vibratory piling and vibrated stone columns) they can provide an indicator of the probability of these levels of PPV being exceeded.

184. The empirical equations for predicting construction-related vibration provide estimates in terms of PPV and, therefore, the consequences of predicted levels in terms of human perception and disturbance can be established through direct comparison with the BS 5228-2:2009+A1:2014 guidance vibration levels.

185. Ground-borne vibration assessments may be drawn from the empirical methods detailed in BS 5228-2:2009+A1:2014, in the Transport and Road Research Laboratory Research Report (TRRL) 246: Traffic induced vibrations in buildings and within the Transport Research Laboratory (TRL) Report 429 (2000): Ground-borne vibration caused by mechanical construction works.

186. These calculation methods rely on detailed information, including the type and number of plant being used, their location and the length of time they are in operation. Given the mobile nature of much of the plant that has the potential to impart sufficient energy into the ground, and the varying ground conditions in the immediate vicinity of the construction works, it is considered that an accurate representation of vibration conditions using these predictive methods is not possible.

187. Consequently, a series of calculations, following the methodologies referred to above is usually carried out based on typical construction activities that have the potential to impart sufficient energy into the ground, applying reasonable worst-case assumptions, in order to determine set-back distances at which critical vibration levels may occur.

188. Humans are very sensitive to vibration, which can result in concern being expressed at energy levels well below the threshold of damage. Guidance on the human response to vibration in buildings is found in BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings, Part 1, Vibration sources other than blasting.

189. BS 6472 describes how to determine the vibration dose value (VDV) from frequency-weighted vibration measurements. The VDV is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. Consideration is given to the time of day and use made of occupied space in buildings, whether residential, office or workshop.

190. BS 6472 states that in homes, adverse comment about building vibrations is likely when the vibration levels to which occupants are exposed are only slightly above thresholds of perception.

191. BS 6472 contains a methodology for assessing the human response to vibration in terms of either the VDV, or in terms of the acceleration or the peak velocity of the vibration, which is also referred to as PPV. The VDV is determined over a 16-hour daytime period or 8-hour night-time period.

192. The response of a building to ground-borne vibration is affected by the type of foundation, ground conditions, the building construction and the condition of the building. For construction vibration, the vibration level and effects detailed in Table 4.12 will be adopted, based on guidance from BS5228. Limits for transient vibration, above which cosmetic damage could occur, are given numerically in terms of PPV.

Table 4.12 – Transient Vibration Guide Values for Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4Hz to 15Hz	15Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50mms^{-1} at 4Hz and above	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15mms^{-1} at 4Hz increasing to 20mms^{-1} at 15Hz	20mms^{-1} at 15Hz increasing to 50mms^{-1} at 40Hz and above

193. Table 4.13 lists the minimum set-back distances at which vibration levels of reportable significance for other typical construction activities that may occur on a construction site. Where applicable in the relevant calculation methods, a 66.6% certainty factor was included in order to provide a conservative approach.

Table 4.13 – Predicted Distances at which Vibration Levels may Occur

Activity	Set-back Distance at which Vibration Level (PPV) occurs			
	0.3 mm/s	1.0 mm/s	10 mm/s	15 mm/s
Vibratory Compaction (Start-up)	166m	65m	9m	6m
Vibratory Compaction (Steady State)	102m	44m	8m	6m
Percussive Piling+	48m	19m	3m	2m
HGV Movement on uneven Haul Route	277m	60m	3m	2m
Vibratory Compaction (Start-up)	166m	65m	9m	6m

194. For construction vibration from sources other than blasting, the vibration level and effects presented in Table 4.14 have been adopted based on Table B-1 of BS 5228-2. These levels and effects are based on human perception of vibration in residential environments.

Table 4.14 – Impact Magnitude Construction Vibration

Vibration Limit PPV (mm/s)	Interpreted Significance to Humans	Impact Magnitude
≤0.14	Vibration unlikely to be perceptible	No Impact
0.14 to 0.3	Vibration might just be perceptible in the most sensitive situations for most vibration frequencies associated with construction	Negligible Adverse
0.3 to 1.0	Vibration might just be perceptible in residential environments	Minor Adverse
1.0 to ≤10.0	It is likely that vibration at this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents	Moderate Adverse
≥10	Vibration is likely to be intolerable for any more than a brief exposure to this level	Major Adverse

5.1.3 Impact: Construction Phase - Ecological Receptors

195. Paragraph 3.162 of the Scoping Opinion (Reference: EN010079, November 2016) states:

"The Secretary of State welcomes consideration of noise impacts on nature conservation areas. Consideration should also be given to ecological receptors (e.g. protected species) and appropriate crossreference made to the Onshore Ecology chapter."

5.1.3.1 Approach to assessment

196. Ecological receptors within the Study Area will be included in the assessment of construction noise where appropriate and through consultation with Onshore Ecology stakeholders in order to provide a conservative assessment.

Water bird receptors

197. Wright *et al.* (2010) investigated the effects upon water birds from impulsive noise and have identified a range of L_{Aeq} values which caused a behavioural response (based on a measured L_{Aeq}). These can be generally outlined as:

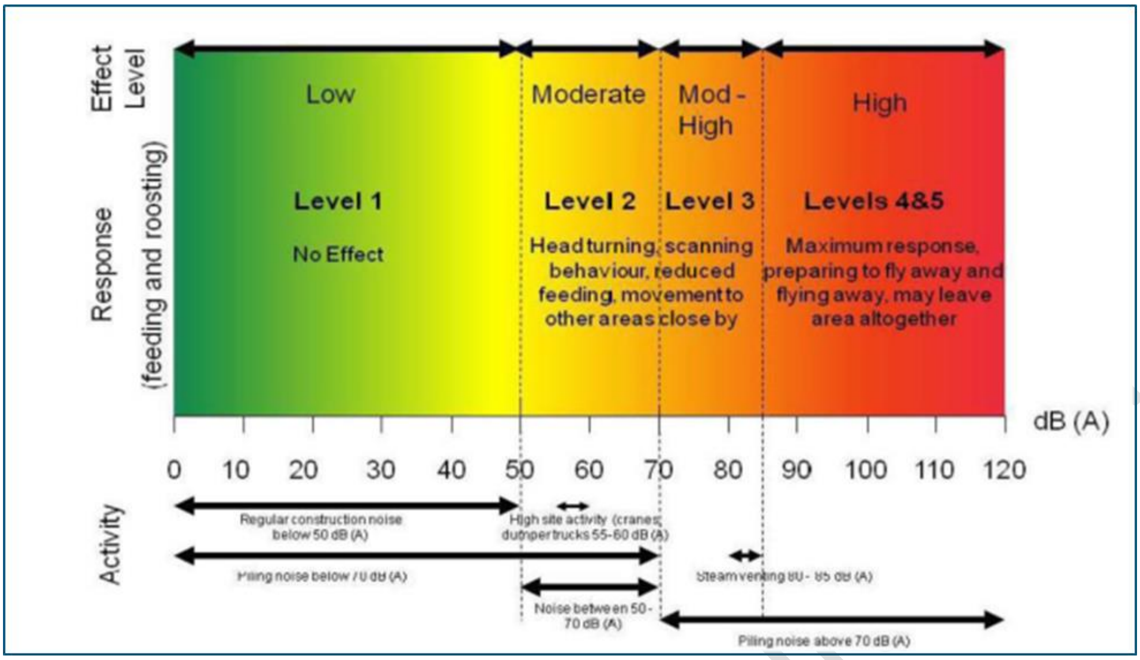
- no observable behavioural response: 54.9 to 71.5dBA (with a high proportion of extreme outliers);
- non-flight behavioural response: 62.4 to 79.1dBA;
- flight with return: 62.4 to 73.9dBA; and,
- flight with all birds abandoning the site: 67.9 to 81.1dBA.

198. BS5228:2009+A1:2014 states examples of impulsive noise from construction plant can include driven piling, rattling type noise from vibratory rollers, machine reversing alarms.

199. The above information highlights that below 55dBA, effects would not be significant, but when noise levels increase, particularly approaching 70dBA, there is a range of bird responses, which have the potential to experience significant effects. Further information on noise levels affecting waterbirds is provided by Cutts et al. (2008). This provides a useful figure of waterbird response to construction disturbance, reproduced below within Figure 5.1. Cutts et al. (2008) comment that:

"….ambient construction noise levels should be restricted to below 70dBA, birds will habituate to regular noise below this level. Where possible sudden irregular noise above 50dBA should be avoided as this causes maximum disturbance to birds".

Figure 5.1: Waterbird Response to Construction Disturbance



Source: Cutts, N; Phelps, A; Burdon, D. (2008) Construction and Waterfowl: Defining Sensitivity, Response, Impacts and Guidance. Report to Humber INCA. Institute of Estuarine and Coastal Studies, University of Hull.

200. Based on these studies, in order to present a conservative approach, a noise level of <50dBA for general construction noise is considered to be a suitable threshold to indicate a level of effect where disturbance due to noise would not cause a behavioural response.

201. However an alternative approach would be to obtain baseline noise measurements at identified locations where there is concern for potential ecological receptor noise impacts. This approach is based on establishing the existing noise levels that ecological receptors i.e. waterfowl, are currently subjected to. This pre-construction noise level may already be in excess of the 50dBA threshold stated in the research.

202. Noise modelling will be undertaken using SoundPLAN software. A report will be provided containing the results of the quantitative construction noise modelling at areas of ecological interest, along with noise contour isopleths of the study area for interpretation by a qualified Ecologist.

203. A comparison will be made of the predicted noise levels with measured levels and published guidance on waterfowl disturbance during construction operations and an assessment made of whether there will likely be any significant impacts on the habitat as a consequence of predicted site noise levels.

5.1.4 Potential Impacts during O&M

204. The assessment will consider the impacts of the proposed onshore elements of the project on noise and vibration, including impacts on ecological and other sensitive receptors from operational activities.

205. The potential permanent impacts of operational noise from the substation and cable relay station may arise from:

- The inherent operational noise from the proposed development, and its characteristics;
- The proximity of the proposed development to noise sensitive premises (including residential properties) and noise sensitive areas (including PRoW and the Norfolk Broads National Park);
- The proximity of the proposed development to quiet places and other areas that are particularly valued for their acoustic environment or landscape quality; and
- The proximity of the proposed development to designated sites where noise may have an adverse impact on protected species or other wildlife.

206. There are unlikely to be any noise and vibration impacts relating to operational or maintenance vehicular traffic but operational noise impacts may arise from the operation of equipment within the substation and cable relay station (e.g. reactors and transformers). An assessment will be undertaken to determine the likely environmental and health impacts due to operational noise emissions on identified sensitive receptors.

207. There are considered to be no significant sources of vibration associated with the operational scheme and operational vibration impacts have therefore been scoped out of further assessment.

5.1.5 Impact: Fixed and Mobile Plant – Cable Relay Station and Onshore Substation

208. Where there are noise sources such as fixed plant associated with industrial operations, the most appropriate assessment guidance is BS 4142:2014. The guidance describes a method of determining the level of noise of an industrial noise source and the existing background noise level.

5.1.5.1 Approach to assessment

209. BS 4142:2014 describes methods for rating and assessing sound of an industrial and/or commercial nature. The methods use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident, and combines procedures for assessing the impact in relation to:

- sound from industrial and manufacturing processes;

- sound from fixed installations which comprise mechanical and electrical plant and equipment;
- sound from the loading and unloading of goods and materials at industrial and/or commercial premises; and
- sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from forklift trucks, or that from train or ship movements on or around an industrial and/or commercial site.

210. This standard is applicable to the determination of the following levels at outdoor locations:

"a) rating levels for sources of sound of an industrial and/or commercial nature; and

b) ambient, background and residual sound levels, for the purposes of:

1) investigating complaints;

2) assessing sound from proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature; and

3) assessing sound at proposed new dwellings or premises used for residential purposes."

211. The standard incorporates a requirement for the assessment of uncertainty in environmental noise measurements and introduces the concepts of "significant adverse impact" rather than likelihood of complaints.

212. The standard applies to industrial/commercial and background noise levels outside residential buildings and for assessing whether existing and new industrial/commercial noise sources are likely to give rise to significant adverse impacts on the occupants living in the vicinity.

213. Assessment is undertaken by subtracting the measured background noise level from the rating level; the greater this difference, the greater the magnitude of the impact.

214. BS 4142 refers to the following:

"A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context.

A difference of around + 5dB is likely to be an indication of an adverse impact, depending on the context.

The lower the rating level relative to the measured background sound level the less likely it is that the specific sound source will have an adverse impact or a 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, depending on the context".

215. When assessing the noise from a source, which is classified as the Rated Noise Level, it is necessary to have regard to the acoustic features that may be present in the noise. Section 9.1 of BS 4142 states:

"Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, add a character correction to the specific sound level to obtain the rating level."

216. The methods for assessing whether an acoustic feature is present are:

- Subjective method;
- Objective method for tonality; and
- Reference method.

217. For the subjective method a rating penalty for tones of 2 – 6dB can be added; a penalty of +2dB for a tone which is just perceptible at the noise receptor, +4dB where it is clearly perceptible and +6dB where it is highly perceptible.

218. For impulsive noise a correction of up to 9dB can be applied; a penalty of +3dB for impulsivity which is just perceptible at the noise receptor, +6dB where it is clearly perceptible and +9dB where it is highly perceptible.

219. For other sound features, where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of +3dB can be applied.

220. Where tonal and impulsive characteristics are present in the specific sound within the same reference period then both corrections can be taken into account. If one feature is dominant, then it would be appropriate to apply a single correction. Where both features are likely to affect perception and response, the corrections can be added in a linear manner.

221. When the specific sound has identifiable on/off conditions and the intermittency is readily distinctive against the residual acoustic environment, a penalty of +3dB can be applied.

222. The perception of audibility at the monitoring location determines the value of the penalty to be applied. For the objective and reference methods sections 9.3.2 and 9.3.3 and Annexes C and D of BS4142:2014 should be referred to.

223. The determination of the specific sound level free from sounds influencing the ambient sound at the assessment location is obtained by measurement or a combination of measurement and calculation. This is to be measured in terms of the $L_{Aeq,T}$, where 'T' is a reference period of:

- 1 hour during daytime hours (07:00 hrs to 23:00 hrs); and
- 15 minutes during night-time hours (23:00 to 07:00 hrs).

224. The assessment of noise from proposed fixed and mobile plant associated with the operational elements of the project (cable relay station, onshore substation and extension to the Necton 400kv National Grid substation) will be considered at the nearest receptors and any penalty corrections will be based on the justification detailed in the operational assessment section.

225. To predict the noise from the operational aspects of the project, SoundPLAN noise modelling software will be utilised. The model will incorporate proposed buildings based on elevation drawings, proposed fixed and mobile plant and additional associated noise sources located at the site. The model will also include nearby residential dwellings and other buildings in the proposed scheme area, intervening ground cover and topographical information.

226. Noise levels for the operational phase will be predicted at the nearest NSR locations identified in the baseline survey and through the consultation process. The calculation algorithm described in International Standard (ISO) 9613 was used in the operational noise propagation modelling exercise.

227. An indicative list of plant and equipment noise levels will be provided by Vattenfall and compiled based on details of the operational activities at the Proposed Development. Where details are not known or available, target noise levels will be recommended based on the measured background/ambient noise level and in accordance with relevant policy.

228. The following assumptions for operational activities will be included in the noise model:

- Operational activities would take place 24 hours a day, 7 days a week;

- All noise sources to be modelled as moving line, area and point sources, as appropriate;
- Residential properties to be modelled as two-storey buildings at a height of 8.5m;
- All ground assumed to have an absorption factor of 0 (acoustically hard and reflective), i.e. concrete/tarmac;
- Roads assumed to be acoustically hard and reflective, i.e. concrete/tarmac and a +5dB adjustment included in the SoundPLAN noise model using the 'create ground effects from roads surfaces' function; and
- Acoustic propagation effects calculated using the ISO9613-2 method.

229. The magnitude of effect will be based on a quantitative assessment of noise impact using BS 4142:2014 for an industrial development are summarised in Table 4.15.

Table 4.15 – Operational Noise Impact Magnitude Criteria for Industrial/Commercial Sound Sources

BS4142 Assessment	
Rating level dB $L_{Ar,Tr}$	Magnitude of Effect
< Measured L_{A90}	No Impact
= Measured L_{A90}	Low Adverse
L_{A90} + up to 5 dB	Low to Minor Adverse
Measured L_{A90} + >5 dB to <10dB	Minor to Moderate Adverse
Measured L_{A90} + ≥10 dB	Significant (Major) Adverse

5.1.6 Assessment of Internal Habitable Rooms and External Noise Levels

230. An assessment of the predicted external daytime and night time noise levels calculated at the identified NSRs from proposed operational activities originating at the site will be undertaken.

231. The World Health Organisation provides the following guidelines on community noise levels with regard to their effects on annoyance, speech intelligibility and sleep disturbance, detailed in Table 4.16.

Table 4.16 – WHO Internal Noise Level Guidelines

Specific Environment	Critical Health Effect(s)	L_{Aeq} (dB)	Time Base (hrs)	L_{Amax} (dB)
Dwelling, indoor	Speech intelligibility and moderate annoyance, daytime and evening	35	16	-

Specific Environment	Critical Health Effect(s)	L_{Aeq} (dB)	Time Base (hrs)	L_{Amax} (dB)
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60

232. BS 8233:2014 refers to attenuation from an open window as typically -10dBA to -15dBA. Therefore, to achieve recommended internal noise levels for dwellings according to the standard, the level outside a room used for daytime resting would need to be within the range L_{Aeq} 45dB to 50dB and for a dining space the noise level outside the window would need to be in the range of L_{Aeq} 50dB to 55dB.

233. For the night-time period an external noise level would need to be within the range of 40dB and 45dB to achieve the acoustic design standard within the bedroom.

234. WHO recommended external daytime noise levels are detailed in Table 4.17.

Table 10.12 – WHO Guidelines for Community Noise - External

Specific Environment	Typical Situation	$L_{Aeq,T}$ (dB)	Time Base (hrs)
External Amenity Areas	Majority of people avoid serious annoyance, daytime evening	55	16
	Majority of people avoid moderate annoyance, daytime evening	50	16

5.1.6.1 Impact: Operational vibration from the Onshore Substation Site

235. Transformers and other wound power equipment vibrate at twice the power frequency i.e. 100Hz and associated harmonic frequencies e.g. 200Hz, 300Hz. However the effects are negligible and are countered by the use of industry standard mitigation techniques such as the use of vibration isolation pads to prevent transmission of ground borne vibration. Embedded mitigation in the form of anti-vibration mounts will be used at the operational substations, which is likely to result in a negligible source of ground borne vibration. Therefore this can be scoped out of the EIA requirements for the operational phase of the project.

5.1.7 Impact: Operational Phase – Low Frequency Noise (LFN)

236. Operational transformer and shunt reactor noise is typically constant, with a 'low frequency hum' occurring at harmonics of the supply frequency; usually 100Hz and

200Hz components are dominant. Transformers generally run continuously except for occasional maintenance and fault outages.

5.1.7.1 Approach to assessment

237. EN-1 states that any distinctive tonal and low frequency characteristics of the noise are identified. The Low Frequency Noise element will be considered as part of the operational assessment in accordance with BS4142:2014.

238. To predict the potential low frequency noise impact from the operational aspects of the project, SoundPLAN noise modelling software will be utilised. Data for proposed plant associated with the operational substation will be incorporated into the model. The model will predict external noise levels. These external noise levels can be used to determine the perceptibility of tones within the NSRs; however this will require an assumption of the likely sound reduction index provided by the building elements of the dwelling houses. BS4142:2014 provides guidance for the subjective assessment method of a tonal sound for a given external sound source. The approach considers the subjective prominence of the character of the specific sound at the noise sensitive location and whether this characteristic will attract attention.

239. The assessment states that *"for sound ranging from not tonal to prominently tonal the Joint Nordic Method gives a correction of between 0 dB and +6 dB for tonality. Subjectively, this can be converted to a penalty of 2 dB for a tone which is just perceptible at the noise receptor, 4 dB where it is clearly perceptible and 6 dB where it is highly perceptible."*

5.1.8 Potential impacts during decommissioning

240. No decision has been made regarding the final decommissioning policy for the substation and cable relay station, as it is recognised that industry best practice, rules and legislation change over time. However, the substation and cable relay station equipment will likely be removed and reused or recycled. It is expected the onshore cables will be removed from ducts and recycled, with the transition pits and ducts left in situ.

241. The detail and scope of the decommissioning works will be determined by the relevant legislation and guidance at the time of decommissioning and agreed with the regulator. A decommissioning plan would be provided.

242. It is anticipated that the decommissioning impacts will be similar in nature to those of construction, but will be more limited in geographical extent and timescale.

5.1.9 Potential cumulative impacts

243. Onshore cumulative impacts will be considered as part of the EIA process. Any other project with the potential to result in impacts that may act cumulatively with Norfolk Vanguard will be identified during consultation as part of the EPP and following a review of available information (see Section 2.2.5). These projects will then be included in the CIA and therefore are scoped into the assessment.

244. The assessment would consider the potential for significant cumulative impacts to arise as a result of the construction, operation and decommissioning of Norfolk Vanguard in the context of other developments that are existing, consented or at application stage.

245. There is potential for impacts associated with noise and vibration generated during the construction phase site works to lead to a cumulative impact with other proposed developments (already consented and those in the planning system) where the construction phases overlap and where activities will occur in proximity to the same receptors.

246. The potential cumulative impact at NSRs could arise through concurrent construction phases associated with Norfolk Vanguard and Norfolk Boreas, through concurrent construction of the cable route, the substations and, depending on the option chosen for connection to the grid, at cable relay stations. However the extent of the cumulative impact is dependent on the eventual scheduling along the corridor and on the substation/cable relay station locations.

247. There is a potential for a cumulative impact associated with construction phase road traffic to occur during the project construction in conjunction with other proposed schemes. Further details are contained within the Traffic and Transport Method Statement.

248. An assessment of potential operational phase noise impacts (including Low Frequency Noise (LFN)) associated with the location of additional power generating plant will need to be undertaken and consider the following schemes in combination:

- Existing Necton 400kV National Grid substation,
- Extension to the National Grid substation,
- Dudgeon substation,
- Norfolk Vanguard onshore substation,
- Norfolk Boreas onshore substation.

6 REFERENCES

BSI (2003); British Standards Institution BS 7445-1:2003 - Description and measurement of environmental noise. Guide to quantities and procedures. BSI, London.

BSI (2003); British Standards Institution BS EN 61672-1:2003 Electroacoustics. Sound level meters. Specifications. BSI, London.

BSI, (2008); British Standards Institution BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Part 1: Vibration sources other than blasting, BSI, London.

BSI, (2014), British Standards Institution BS4142:2014 Methods for rating and assessing industrial and commercial sound, BSI, London.

BSI, (2014); British Standards Institution [BS] 5228-1:2009+A1:2014 "Code of practice for noise and vibration control on construction and open sites – Part 1: Noise".

BSI, (2014); British Standards Institution [BS] 5228-2: 2009+A1:2014 "Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration".

BSI, (2014); British Standards Institution BS8233: Sound Insulation and Noise Reduction for Buildings. BSI, London.

Department of Energy & Climate Change (2011); National Policy Statement for Renewable Energy Infrastructure (EN-3), The Stationery Office, London.

Department of Energy & Climate Change (2011); National Policy Statement for Electricity Networks Infrastructure (EN-5), The Stationery Office, London.

Department of Energy & Climate Change (2011); Overarching National Policy Statement for Energy (EN-1), The Stationery Office, London.

Department of Transport, Welsh Office (1988); Calculation of Road Traffic Noise HMSO, London.

Environmental Protection Act 1990. HMSO, London.

Highways Agency (2011); Design Manual for Roads and Bridges, Volume 11, Section 3, Part 7: Noise and Vibration. The Highways Agency.

Hiller. DM and Crabb GI, (2000). Ground borne vibrations caused by mechanised construction works. Highways Agency, Transport Research Laboratory, TRL report 429.

International Organization for Standardization, (1996). ISO9613-2:1996 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation. ISO, Switzerland.

Royal HaskoningDHV (2016). Norfolk Vanguard Offshore Wind Farm Environmental Impact Assessment Scoping Report

Royal HaskoningDHV (2017) Norfolk Vanguard Offshore Wind Farm: Evidence Plan Terms of Reference. Document Reference PB4476.001.004. Unpublished – Live Document

Transport Research Laboratory (2000); Hiller D.M and Crabb G.I Groundborne vibration caused by mechanised construction works. TRL Report 429. Wokingham:TRL,2000.

Vattenfall (2016) Norfolk Vanguard Offshore Wind Farm: Project Design Statement. Document reference NV-TPM-DD-0011-Project Design Statement. December 2016.

Watts, GR (1990). Traffic induced vibrations in building. Department for Transport, Transport and Road Research Laboratory Research Report (TRRL), Research Report 246.

World Health Organisation (WHO) (1999); Berglund et al. - Guidelines for Community Noise. Geneva.

World Health Organization (2009). Night Noise Guidelines for Europe; available at URL:

http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf

APPENDIX 1 – LEGISLATIVE CONTEXT AND RELEVANT GUIDANCE

Legislative Context

249. The following Planning Policy, Legislation and Guidance will be used to inform the assessment.

250. A series of National Policy Statements (NPS) set out national policy for energy infrastructure. Overarching National Policy Statement for Energy (EN-1), in combination with the relevant technology-specific NPSs, has effect on the decisions by the Infrastructure Planning Commission (IPC) on applications for energy developments that fall within the scope of the NPSs.

251. National Policy Statements EN-1, EN-3 and EN-5 provide the primary basis on which the IPC is required to make its decisions. Specific assessment requirements for noise and vibration, as detailed within each relevant NPS are detailed below.

252. EN-1 sets out national policy for energy infrastructure.

In relation to the 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".

253. The NPS also states that:

"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.

254. Further assessment guidance for specific features of those renewables technology and electricity networks is found in NPS EN-3 and NPS EN-5. 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.

6.1.1.1 Environmental Protection Act 1990

255. Section 79 of the Act defines statutory nuisance with regard to noise and determines that local planning authorities have a duty to detect such nuisances in their area.

256. The Act also defines the concept of "Best Practicable Means" (BPM):

" 'practicable' means reasonably practicable having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications;

the means to be employed include the design, installation, maintenance and manner and periods of operation of plant and machinery, and the design, construction and maintenance of buildings and structures;

the test is to apply only so far as compatible with any duty imposed by law; and

the test is to apply only so far as compatible with safety and safe working conditions, and with the exigencies of any emergency or unforeseeable circumstances."

Section 80 of the Act provides local planning authorities with powers to serve an abatement notice requiring the abatement of a nuisance or requiring works to be executed to prevent their occurrence.

6.1.1.2 The Control of Pollution Act 1974

257. Section 60 of the Act provides powers to Local Authority Officers to serve an abatement notice in respect of noise nuisance from construction works.

258. Section 61 provides a method by which a contractor can apply for 'prior consent' for construction activities before commencement of works. The 'prior consent' is agreed between the Local Authority and the contractor and may contain a range of agreed working conditions, noise limits and control measures designed to minimise or prevent the occurrence of noise nuisance from construction activities. Application for a 'prior consent' is a commonly used control measure in respect of potential noise impacts from major construction works.

6.1.1.3 National Planning Policy

National Planning Policy Framework 2012

259. The National Planning Policy Framework (NPPF) was introduced in March 2012 replacing the former Planning Policy Guidance 24: Planning and Noise. Paragraph 123 of the National Planning Policy Framework states that planning policies and decisions should aim to:

"avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;

mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;

recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and

identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason."

The NPPF also refers to the Noise Policy Statement for England (NPSE) (Defra, 2010).

Noise Policy Statement for England (NPSE) 2010

260. The NPSE document was published by Defra in 2010 and paragraph 1.7 states three policy aims:

"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

avoid significant adverse impacts on health and quality of life;

mitigate and minimise adverse impacts on health and quality of life; and

where possible, contribute to the improvement of health and quality of life."

The first two points require that significant adverse impact should not occur and that, where a noise level falls between a level which represents the lowest observable adverse effect and a level which represents a significant observed adverse effect:

"…all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life whilst also taking into consideration the guiding principles of sustainable development. This does not mean that such effects cannot occur." (Paragraph 2.24, NPSE, March 2010).

Section 2.20 of the NPSE introduces key phrases including "Significant adverse" and "adverse" and two established concepts from toxicology that are being applied to noise impacts:

"NOEL – No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

LOAEL – Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected".

Paragraph 2.21 of the NPSE extends the concepts described above and leads to a significant observed adverse effect level – SOAEL, which is defined as the level above which significant effects on health and quality of life occur.

The NPSE states:

"it is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations". (Paragraph 2.22, NPSE, March 2010).

Furthermore, paragraph 2.22 of the NPSE acknowledges that:

"further research is required to increase understanding of what may constitute a significant adverse effect on health and quality of life from noise".

However, not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available.

National Planning Practice Guidance for Noise (NPPG) 2014

261. The National Planning Practice Guidance for Noise (NPPG Noise, December 2014), issued under the NPPF, states that noise needs to be considered when new developments may create additional noise and when new developments would be sensitive to the prevailing acoustic environment. When preparing local or neighbourhood plans, or taking decisions about new development, there may also be opportunities to consider improvements to the acoustic environment.

Guidance

262. The following guidance will be referenced and used for the purpose of informing the noise and vibration assessment:

British Standard (BS) 7445: Parts 1 and 2 - Description and Measurement of Environmental Noise

263. This Standard provides details of the instrumentation and measurement techniques to be used when assessing environmental noise and defines the basic noise quantity as the continuous A-weighted sound pressure level (LAeq). Part 2 of BS 7445 replicates ISO standard 1996-2.

BS8233:2014 – Guidance on Sound Insulation and Noise Reduction for Buildings

264. Provides a methodology to calculate the noise levels entering a building through facades and façade elements and provides details of appropriate measures for sound insulation between dwellings. It includes recommended internal noise levels which are provided for a variety of situations, which are based on WHO recommendations.

British Standard (BS) 4142:2014 – Method for Rating and Assessing Industrial and Commercial Sound

265. BS 4142 describes methods for rating and assessing sound of an industrial and/or commercial nature. The methods use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

British Standard (BS) 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Part 1: Noise

266. This document provides recommendations for basic methods of noise and vibration control relating to construction and open sites where work activities/operations generate significant noise and/or vibration levels. The legislative background to noise and vibration control is described and recommendations are given regarding procedures for the establishment of effective liaison between developers, site operators and local authorities. This British Standard provides guidance on methods of predicting and measuring noise and assessing its impact on those exposed to it.

British Standard (BS) 5228-2:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 2: Vibration

267. Part 2 of this Standard gives recommendations for basic methods of vibration control relating to construction and open sites where work activities/operations generate significant vibration levels. The Standard includes tables of vibration levels

measured during piling operations throughout the UK. It provides guidance concerning methods of mitigating vibration from construction, particularly with regard to percussive piling.

BS 6472-1:2008 - Guide to Evaluation of Human Exposure to Vibration in Buildings

268. This standard provides general guidance on human exposure to building vibration in the range of 1Hz to 80Hz and includes curves of equal annoyance for humans. It also outlines the measurement methodology to be employed. It introduces the concept of Vibration Dose Value (VDV) and estimated Vibration Dose Value (eVDV) for the basis of assessment of the severity of impulsive and intermittent vibration levels, such as those caused by a series of trains passing a given location.

Calculation of Road Traffic Noise (CRTN) 1988

269. The Calculation of Road Traffic Noise (CRTN) document provides a method for assessing noise from road traffic in the UK and a method of calculating noise levels from the Annual Average Weekday Traffic (AAWT) flows and from measured noise levels. Since published in 1988 this document has been the nationally accepted standard in predicting noise levels from road traffic. The calculation methods provided include correction factors to take account of variables affecting the creation and propagation of road traffic noise, accounting for the percentage of heavy goods vehicles, different road surfacing, inclination, screening by barriers and relative height of source and receiver.

Design Manual for Roads and Bridges (DMRB) 2011

270. Volume 11, Part 3, Section 7 provides guidance on the environmental assessment of noise impacts from road schemes. DMRB contains advice and information relating to transport-related noise and vibration, which has relevance with regard to the construction and operational traffic impacts affecting sensitive receptors adjacent to road networks. It also provides guideline significance criteria for assessing traffic related noise impacts.

World Health Organisation (WHO) (1999) Guidelines for Community Noise

271. These guidelines present health-based noise limits intended to protect the population from exposure to excess noise. They present guideline limit values at which the likelihood of particular effects, such as sleep disturbance or annoyance, may increase. The guideline values are 50 or 55dB LAeq during the day, related to annoyance, and 45dB LAeq or 60dB LAmax at night, related to sleep disturbance.

272. The guidance states:

"The effects of noise in dwellings, typically, are sleep disturbance, annoyance and speech interference. For bedrooms the critical effect is sleep disturbance. Indoor guideline values for bedrooms are 30dB LAeq for continuous noise and 45dB LAmax for single sound events. Lower noise levels may be disturbing depending upon the nature of the noise source."

273. The WHO guidance also highlights that:

"Night-time, outside sound levels about 1 metre from facades of living spaces should not exceed 45dB LAeq, so that people may sleep with bedroom windows open. This value was obtained by assuming that the noise reduction from outside to inside with the window open is 15dB. To enable casual conversation indoors during daytime, the sound level of interfering noise should not exceed 35dB LAeq. To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55dB LAeq on balconies, terraces and in outdoor living areas. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50dB LAeq. Where it is practical and feasible, the lower outdoor sound level should be considered the maximum desirable sound level for new development."

World Health Organisation (2009) Night Noise Guidelines for Europe

274. In 2009, the WHO published the Night Noise Guidelines for Europe, which it describes as an extension to the WHO Guidelines for Community Noise (1999).

275. It concludes that:

"Considering the scientific evidence on the thresholds of night noise exposure indicated by Lnight outside as defined in the Environmental Noise Directive (2002148/EC), an Lnight outside of 40dB should be the target of the night noise guideline (NNG) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly. Lnight outside value of 55dB is recommended as an interim target for those countries where the NNG cannot be achieved in the short term for various reasons, and where policy-makers choose to adopt a stepwise approach."

International Standard ISO 9613-2

276. ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a noise source.

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Classification:	Open		
Enclosures:	3		

Norfolk Vanguard: Environmental Impact Assessment – Baseline Noise Survey

We have been appointed as the Acoustic Consultants for the Norfolk Vanguard Environmental Impact Assessment (EIA), to be carried out on behalf of Vattenfall Wind Power Limited (VWPL).

A Scoping Report was submitted to stakeholders[1], and it is recommended this is read in conjunction with this letter to illustrate the proposed project and search areas.

Scoping Report and Scoping Opinion can be found on the website here.

We are contacting you regarding our proposed approach to the baseline noise survey.

For the Noise and Vibration assessment, key elements of the project are:

- Landfall search zones;
- Cable relay station search zones;
- Onshore cable corridor;
- Onshore project substation search zone; and
- Extension to existing Necton 400kV National Grid Substation.

In order to characterise the existing environment within the search zones a baseline noise survey will be undertaken. We are planning to undertake a baseline noise survey to commence between April and June 2017 (date to be confirmed) to establish the noise climate at existing identified sensitive receptors.

Following a desk-based review to identify and evaluate the potential noise and vibration effects on noise sensitive receptors (NSRs) arising from the construction and operation of the proposed project, we are

[1] Royal HaskoningDHV (2016), Environmental Impact Assessment Scoping Report Document Reference: PB4476-102-001, October 2016.

proposing to undertake baseline surveys at the monitoring locations referred to in the following drawings which have been provided to you :

- PB4476_03_NoiseReceptor_Substation
- PB4476_03_NoiseReceptor_LandfallCableRelayStation
- PB4476_03_NoiseReceptor_CableCorridor (parts 1 – 3)

Baseline Survey Methodology

A proposed survey methodology for the baseline noise assessment to support the Noise and Vibration EIA is outlined below.

Baseline survey measurements will be conducted in accordance with current guidance, including 'BS4142:2014 Method for Rating and Assessing Industrial and Commercial Sound', and 'BS 7445-2:1991 Description and measurement of environmental noise: guide to the acquisition of data pertinent to land use'.

Traceable calibrated Class 1 Sound Level Meters will be used for all measurements during the survey. Measurements will capture the following noise criteria: L_{Aeq}, L_{Amax}, L_{A90}, L_{A10}.

The same noise survey methodologies will be used for the cable relay station search zone, onshore substation search zone and extension to National Grid 400KV Necton substation search zone. A different approach will be used for the onshore cable corridor search zone. The onshore cable corridor comprises only temporary construction works and no permanent above ground infrastructure, whereas the cable relay station and both substations will be continuously operational.

Fixed baseline measurement locations are subject to access being agreed with landowners and tenants, therefore some variation may be required. For this reason identification of exact measurement locations of NSRs will be agreed with appropriate stakeholders. Indicative locations of NSRs are detailed in the relevant survey sections below.

A record of the meteorological conditions during the survey will be made and measurements will not be taken during periods of rainfall or when average wind speeds exceed 5m/s.

For all measurement locations and durations, qualitative observations will be taken throughout the survey.

Landfall study area survey locations:

Indicated on drawing PB4476_03_NoiseReceptor_LandfallCableRelayStation. Note: LF denotes Landfall, R1 denotes a unique Receptor identifier; B,W,H denotes first initial of preferred landfall zone.

Short-term attended measurements will be taken at various times throughout the daytime (up to 1 hour) and night time (up to 30 minutes) reference periods.

Cable relay station search areas survey locations:

The cable relay station search zones are located on the North Norfolk Coast within 5km of Bacton Green and Eccles-on-Sea. This area is predominantly rural with small villages and isolated residential properties which are likely to currently experience low ambient noise levels. The main noise sources in this area are likely to be local roads, the Bacton gas terminal operation, and the industrial area to the north at Paston. The northern tip of the Norfolk Broads National Park has been excluded from the search zone. There are 7 potential sites being considered for the cable relay station, though not all options will be taken forward.

Measurements are proposed to be conducted at a number of receptor locations in the vicinity of the cable relay station zones, to be finalised and determined during consultation. For each potential site (A to G), receptors were identified as detailed on drawing PB4476_03_NoiseReceptor_LandfallCableRelayStation. Note: CR denotes Cable Relay, R1 denotes a unique Receptor identifier; A to G denotes each zone.

Where land access and security allows, continuous logging equipment will be installed for up to 1 week and will measure 5 minute records of the noise level. If logging equipment cannot be left unmanned, multiple short-term attended measurements will be taken at various times throughout the daytime and night-time reference periods.

The approach will include for the use of sound level meters with full octave band analysis capability to enable assessment of the variations in the background sound level at the unattended noise sensitive receptor locations and includes for the use of a weather station as recommended in the BS4142:2014 measurement procedure.

Cable corridor survey locations:

The cable corridor runs from the landfall and cable relay station search zones on the coast to the substation search zone at Necton and crosses land that is predominantly rural in nature. Due to the large geographical area covered by the onshore cable route (60km), the required cable corridor width (at this stage up to 200m), and the temporary nature of the construction works, measurements will not be taken at all locations representing specific sensitive receptors along the route. Locations representative of 'areas' along the cable route will be selected.

The largest settlements within the area are at North Walsham, Aylsham, Dereham, the Robertson Barracks at Swanton Morley and smaller villages and isolated residential properties throughout the area.

The main noise sources within the area are likely to be:

- The A47 and the A1067 roads in the west of the area;
- The A140 and the A149 roads in the east of the area;
- The Norwich to Holt railway line in the east of the area;
- The railway line at Dereham;
- Industrial areas at North Walsham, Aylsham and Dereham; and
- The Robertson Barracks and Swanton Morley Airfield.

Measurements are proposed to be conducted at a number of receptor locations along the cable route. Provisional receptors are detailed on attached drawing PB4476_03_NoiseReceptor_CableCorridor (3 parts) – Revision 1. Note: CR denotes cable corridor, R1 denotes a unique Receptor identifier.

A single 30 minute measurement will be made at each identified and agreed site during the daytime and one 15 minute period at night, in order to capture the range of existing noise levels within the study area and to allow for the flexibility of construction phasing requirements.

Onshore project substation search area survey locations:

The onshore project substation search zone is located around the village of Necton to the west of the larger town of Dereham. Noise in this area is likely to be dominated by road traffic on the A47.

Measurements are proposed to be conducted at a number of receptor locations determined during consultation and shown on drawing PB4476_03_NoiseReceptor_Substation. Note: SS denotes substation, R1 denotes a unique Receptor identifier.

Where land access and security allows, continuous logging equipment will be installed for up to 1 week and will measure 5 minute records of the noise level. If logging equipment cannot be left unmanned, multiple short-term attended measurements will be taken at various times throughout the daytime and night-time reference periods.

Our approach includes for the use of sound level meters with full octave band analysis capability to enable assessment of the variations in the background sound level at the unattended noise sensitive receptor locations, and includes for the use of a weather station as recommended in the BS4142:2014 measurement procedure.

Summary:

Please can you confirm that the outlined approach is acceptable in terms of measurement locations and proposed durations for each stage of the project.

We would particularly welcome input in identifying receptors which may have been omitted during our desktop review, and conversely if there are any receptors which you feel are unnecessary or duplicated i.e. Cable Relay Station Options E, F and G are in close proximity and a reduced number of measurement positions would still provide representative data for the area.

At this stage it would be useful for us to discuss the scheme in further detail, and would welcome the opportunity to schedule in a convenient appointment with you.

If you require any further information, please do not hesitate to contact me. We look forward to your response.

Submitted by
For and on behalf of HaskoningDHV UK Ltd

[redacted]

Dean Curtis
Acoustic Consultant
Environment Advisory Group

Royal HaskoningDHV
Enhancing Society Together

Note / Memo

HaskoningDHV UK Ltd.
Industry & Buildings

To:	Norfolk Vanguard Ltd
From:	Mark Smith
Date:	08/03/2018
Copy:	
Our reference:	PB4476.003.051
Classification:	Confidential

Subject: Norfolk Vanguard: Onshore project substation operational noise modelling

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1.0 Background and Context

Since the publication of the Norfolk Vanguard Preliminary Environmental Information Report (PEIR) in October 2017, Vattenfall have updated the project design for Norfolk Vanguard Offshore Wind Farm (OWF) (the project) based on consultation responses, community feedback and as a result of progressing discussions with technology providers. The PEIR previously included an assessment of the likely worst case for the high voltage alternating current (HVAC) and high voltage direct current (HVDC) transmission options for Norfolk Vanguard using the available information at that time. The subsequent PEIR noise chapter assumed the HVAC option as a worst case in terms of noise emissions for the onshore project substation. The cumulative noise impacts associated with Norfolk Boreas (Development Consent Order (DCO) application due to be submitted Q2 2019), the sister project to Norfolk Vanguard were also included as part of the preliminary assessments. In February 2018, a refined design was announced by Vattenfall which committed the project to progressing only the HVDC option as part of the DCO application. By making this commitment to the HVDC option, the requirement for an onshore Cable Relay Substation (CRS) has been removed from the project.

This technical note therefore represents the updated results of noise modelling based on the revised project design (HVDC) and performance specification received from the supply chain technology suppliers. This note sets out the modelling approach applied along with the assumptions which underpin it. It is intended to inform discussion and consultation with the key regulators, stakeholders and will be included as part of the noise assessment in the Environmental Statement (ES) and DCO application.

It is important to note that the existing Necton National Grid Substation will be extended to accommodate the Norfolk Vanguard onshore project substation connection, and this will be included as part of the DCO application. Any extension required to the existing Necton National Grid substation to accommodate the Norfolk Boreas project will be subject to a separate DCO application. The equipment required to extend the existing Necton National Grid substation for operation does not include components which would contribute any significant noise contributions in the area. This was discussed as part of previous Expert Topic Group meetings and agreed with Breckland Council[1]. The extension to the existing Necton National Grid Substation is therefore not included as part of the noise modelling presented within this technical note.

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[1] Norfolk Vanguard Expert Topic Group Meeting (20th July 2017)

2.0 Methodology

Assessment Criteria

Noise from fixed plant is typically assessed in the context of BS 4142:2014, which involves a comparison of the rating level and the measured background (L_{A90}) noise level at potential receptor locations.

BS 4142[2] prescribes the accepted methods for rating and assessing sound of an industrial and/or commercial nature. BS 4142 is the standard assessment methodology expected and required by regulators and statutory consultees for the assessment of the impact noise emissions arising from infrastructure such as that for the Norfolk Vanguard project on nearby sensitive receptors. The BS 4142 methodology uses outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident and combines procedures for assessing the impact in relation to the development of new industrial and/or commercial sources affecting existing receptors.

The standard applies to industrial/commercial and background noise levels outside residential buildings and for assessing whether existing and new industrial/commercial sound sources are likely to give rise to significant adverse impacts on the occupants living in the vicinity.

The assessment is undertaken by subtracting the existing measured background noise level from the derived rating level; the greater this difference, the greater the magnitude of the impact.

BS 4142 refers to the following;

> *"A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.*
>
> *A difference of around + 5 dB is likely to be an indication of an adverse impact, depending on the context.*
>
> *The lower the rating level relative to the measured background sound level the less likely it is that the specific sound source will have an adverse impact or a 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, depending on the context".*

Taking the above guidance into account the impact magnitude criteria presented in **Table 1** have been applied to this assessment.

[2] British Standards Institute (2014) BS 4142:2014 Methods for rating and assessing industrial and commercial sound. BSI, London.

Table 1 Operational noise impact magnitude criteria for industrial/commercial sound sources

Rating Level dB $L_{Ar,Tr}$	Impact Criteria
≤ Measured LA90	No impact
= Measured LA90 dB to +2.9 dB	Negligible
Measured LA90 + 3 dB to 4.9 dB	Minor
Measured LA90 + 5 dB to 9.9 dB	Moderate
≥ Measured LA90 + 10 dB	Major

Additionally, onshore substation installations are required to not exceed 32dB linear (hereinafter referred to as dB(Z)) at any identified sensitive residential receptor locations.

This technical note also considers cumulative noise impacts from the operational substation for Dudgeon OWF substation (Dudgeon) and Norfolk Boreas onshore project substation in combination with Norfolk Vanguard. Results of compliance monitoring suggest that Dudgeon is operating well below the existing background noise levels. Additionally, background noise values for the Norfolk Vanguard assessment and cumulative assessment were derived from noise monitoring conducted whilst Dudgeon was not operating at full capacity. The resulting L_{A90} values used in the assessment therefore provide a conservative baseline to inform the design of the onshore project substation and ensures the amenity of nearby residents.

Modelling Details

The onshore project substations (Norfolk Vanguard and Norfolk Boreas) were modelled using SoundPLAN noise modelling software. This package directly implements the calculation methods outlined in ISO 9613-2[3] and other nationally and internationally recognised acoustic standards which have been used to derive noise levels to inform the BS4142 assessment.

The following scenarios were assessed:

- Scenario 1 – Norfolk Vanguard substation in isolation; and
- Scenario 2 **–** Norfolk Vanguard and Norfolk Boreas substations co-located.

The onshore project substations were modelled as HVDC installations with no mitigation applied, aside from the embedded mitigation provided by the converter hall construction, with all other noise sources exposed. These presents a worst-case scenario considered for assessments. The main noise sources have been identified within **Table 2**.

For reference a glossary of acoustic terms is presented in **Appendix A**.

[3] International Standard (1996) ISO 9613-2:1996 Acoustics – Attenuation of sound during propagations outdoors – Part 2: General method of calculation. ISO, Switzerland.

Table 2 Operational Noise Sources (Per Substation)

Name	No.	Source Type	LwA dB(A)	Relative Height	Frequency (Hz) [dB(A)]								
					31.5	63	125	250	500	1000	2000	4000	8000
Harmonic Filter Reactors	6	Point	85.6	5.0m	22	47	83	48	80	78	21	17	17
Harmonic Filter Capacitors	12	Point	80.6	9.5m	21	44	78	45	75	73	20	16	16
Autotransformers	8(6no. active at any one given time)	Box	97.8	9.5m	68	75	59	86	88	88	82	81	96
Cooling fans	4	Area	85.7	4.5m	66	66	68	78	80	80	78	74	64
Air Handling Unit	4	Point	75.7	3.0m	56	56	58	68	70	70	68	64	54
Converter Hall	2	Box	80.0	19.0m	-	-	80	-	56	-	-	-	-

All sound power levels were calculated using source measurements as provided by the suppliers of suitable substation equipment obtained by Norfolk Vanguard Ltd. Sound source data used represents noise emissions from substation components without additional sound mitigation measures applied. All sources were modelled using 100% output at all times to present a conservative assessment.

The attenuation afforded by the converter hall construction is detail in **Table 3** below.

Table 3 Converter Hall Construction Transmission Loss

Name	Lw" dB(A)[4]	Rw	C	Ctr	Frequency (Hz) [dB(A)]					
					125	250	500	1000	2000	4000
Converter Hall Construction	47	47	-1	-6	30	35	45	55	60	51

Operational maintenance activities will require the use of an additional generator which has been included with a 50% output to account for the its limited usage required only during maintenance activities, detailed in **Table 4** below.

Table 4 Operational Maintenance (Generator Required)

Name	No.	Source Type	LwA dB(A)	On time Correction	Relative Height	Frequency (Hz) [dB(A)]							
						63	125	250	500	1000	2000	4000	8000
Generator	1	Point	85	50%	1.5m	84	78	61	58	57	52	49	41

[4] Lw" signifies the calculated sound power level at each façade based upon the internal noise detailed in Table 1 taking into consideration the attenuation detailed below and a CD correction of -3dB to account for the internal dimensions and reflective surfaces.

For the purpose of assessing the implications of the new onshore project substations within the existing environment, the receptors detailed in **Table 5** and **Appendix B Figures 1 and 2** were identified. These receptors were discussed and agreed with Breckland Council as part of previous Expert Topic Group meetings through the Method Statement, and the agreed receptors were presented within the PEIR. A digital ground model was created using OS data with a 50x50m resolution to model the effects of the topography**.**

Table 5 Receptor Locations

NSR	Description	Grid reference	
		X	Y
SSR1	Residential	588486	309896
SSR2	Residential	589787	309564
SSR3	Residential	592046	310041
SSR4	Residential	590955	311011
SSR5	Residential	588826	311107
SSR6	Residential	591717	311554
SSR7	Residential	589770	311296
SSR8	Residential	589914	311696
SSR9	Residential	591060	311805
SSR10	Residential	590741	309382
SSR11	Residential	588478	310811

3.0 Results of Assessment Modelling

Table 6 & **Table 7Error! Reference source not found.** detail the results of the unmitigated noise modelling for Scenarios 1 & 2 respectively.

Table 6 Unmitigated Noise Level Assessment - Scenario 1

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
SSR1	GF (Ground Floor)	21.7	25.2	37.7	33.8	No Impact
	FF (First Floor)	23.0	25.2	37.7	33.8	No Impact
SSR2	GF	26.8	30.9	32.2	28.4	No Impact
	FF	29.9	31.9	32.2	28.4	Negligible
SSR3	GF	20.3	24.3	32.2	28.4	No Impact
	FF	22.0	24.7	32.2	28.4	No Impact
SSR4	GF	26.2	29.5	31.0	22.9	Minor
	FF	27.2	29.7	31.0	22.9	Minor
SSR5	GF	24.3	26.9	50.5	29.9	No Impact
	FF	26.7	27.5	50.5	29.9	No Impact
SSR6	GF	17.8	23.4	36.0	28.6	No Impact
	FF	19.1	23.4	36.0	28.6	No Impact
SSR7	GF	27.8	30.8	46.3	39.4	No Impact
	FF	28.5	30.8	46.3	39.4	No Impact
SSR8	GF	23.8	27.6	58.4	36.8	No Impact
	FF	24.9	27.5	58.4	36.8	No Impact
SSR9	GF	19.8	24.8	36.5	32.2	No Impact
	FF	20.8	24.8	36.5	32.2	No Impact
SSR10	GF	25.1	28.6	34.0	21.8	Minor

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
	FF	25.9	28.6	34.0	21.8	Minor
SSR11	GF	24.2	26.5	56.5	31.3	No Impact
	FF	26.3	27.2	56.5	31.3	No Impact
(green)		32dBZ 100Hz Requirement Met				
(red)		32dBZ 100Hz Requirement Exceeded				

Table 7 Unmitigated Noise Level Assessment - Scenario 2

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
SSR1	GF (Ground Floor)	23.9	27.7	37.7	33.8	No Impact
	FF (First Floor)	25.2	27.6	37.7	33.8	No Impact
SSR2	GF	31.2	35.8	32.2	28.4	Negligible
	FF	33.1	34.3	32.2	28.4	Minor
SSR3	GF	24.1	28.2	32.2	28.4	No Impact
	FF	25.6	28.5	32.2	28.4	No Impact
SSR4	GF	29.4	33.5	31.0	22.9	Moderate
	FF	30.5	33.7	31.0	22.9	Moderate
SSR5	GF	26.0	29.1	50.5	29.9	No Impact
	FF	28.0	29.7	50.5	29.9	No Impact
SSR6	GF	21.3	26.8	36.0	28.6	No Impact
	FF	22.4	26.8	36.0	28.6	No Impact
SSR7	GF	29.8	32.9	46.3	39.4	No Impact

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
	FF	30.5	33.0	46.3	39.4	No Impact
SSR8	GF	26.4	30.0	58.4	36.8	No Impact
	FF	27.4	30.0	58.4	36.8	No Impact
SSR9	GF	22.9	28.0	36.5	32.2	No Impact
	FF	23.9	28.0	36.5	32.2	No Impact
SSR10	GF	29.6	32.7	34.0	21.8	Moderate
	FF	30.5	32.8	34.0	21.8	Moderate
SSR11	GF	26.4	29.0	56.5	31.3	No Impact
	FF	28.3	29.6	56.5	31.3	No Impact
		32dBZ 100Hz Requirement Met				
		32dBZ 100Hz Requirement Exceeded				

It is apparent from the data presented within **Table 6** that using the updated component data provided by the substation supply chain, Norfolk Vanguard substation in isolation (scenario 1), without the application of additional noise mitigation measures will fall within the 32dBZ(100hz) limit and result in at most a **Minor Impact** at identified receptor locations in accordance with BS4142:2014 derived Impact Magnitudes. **Table 7** represents scenario 2 with two onshore project substations, Norfolk Vanguard and Norfolk Boreas substations both operating at the same time. It is apparent that in several cases a **Moderate Impact** on nearby properties may be experienced (under the conservative assumptions with onshore project substations operating at maximum load and unmitigated conditions modelled). **Section 4** of this paper considers the effect of readily available mitigation measures which could be applied to the onshore project substations in order to prevent any adverse noise impacts on residential amenity. This is not to commit the onshore project substations design to the mitigation as specified within this note, however it does provide evidence on the effectiveness of a possible mitigation option. As a result Norfolk Vanguard Ltd are committing to embedding mitigation into the design (at detailed design stage) or including additional mitigation as required during the procurement process.

4.0 Mitigation

Table 7 demonstrates that without additional mitigation there is potential for a **Moderate Impact** associated with the concurrent operation of both Norfolk Vanguard and Norfolk Boreas onshore project substations. In order to present a conservative assessment this assumes both onshore project substations are operating under maximum load.

The magnitude of impacts has been assessed in accordance with BS 4142:2014 derived thresholds. The results of the modelling will be used to assist in the detailed design of the projects post consent. Commitments relating to operational noise will be included as part of the DCO requirements and managed through the Environmental Management Plan. Suitable mitigation measures will deliver the required noise reduction to ensure the final design of both projects operating together meet the low noise emission requirements.

At this stage the assessment provides indicative information on the level of mitigation which would be required within the final design of the onshore project substations at detailed design stage.

Investigative noise modelling has identified the autotransformers and harmonic filter reactors as being the dominant noise sources in terms of both broadband [dB(A)] and 100Hz [dB(Z)] noise contributions at nearby sensitive receptors. **Table 8** details the performance of suitable solutions which have been included for the purposes of the investigative noise modelling as an example of mitigation which would result in compliance with the low noise requirements in the area. These solutions have been taken from Sonobex literature, and reproduced in **Appendix C**. Sonobex are an example of one of many available suppliers who are able to provide such solutions. The mitigation performance modelled here is based on a conservative application of the onshore project substation noise mitigation techniques and technologies which are readily available today.

Table 8 Operational Noise Mitigation

	Transmission Loss (dB)			
	Harmonic Filter Reactor Mitigation		Autotransformer Mitigation	
Frequency (Hz)	1/3 Octave Band	1/1 Octave Band	1/3 Octave Band	1/1 Octave Band
50	14.8	-	-	-
63	7.1	20.0	-	-
80	18.1	-	-	-
100	29.5	-	23.3	-
125	33.9	35.6	29.3	37.5
160	24.4	-	36.6	-

	Transmission Loss (dB)			
	Harmonic Filter Reactor Mitigation		Autotransformer Mitigation	
200	33.7	-	38.5	-
250	37.3	40.0	43.2	48.2
315	33.7	-	45.8	-
400	37.8	-	48.4	-
500	37.6	41.7	51.7	56.7
630	35	-	54.0	-
800	36.1	-	55.1	-
1000	41.5	44.4	57.4	62.6
1250	39.7	-	59.8	-
1600	42.4	-	63.1	-
2000	42.2	47.8	66.7	72.9
2500	44.1	-	71.0	-
3150	45	-	73.2	-
4000	44.1	48.7	73.5	77.5
5000	42.3	-	71.1	-
Sum	R_w $(C;C_{tr})$ = 40 (-1; -3) dB		R_w $(C;C_{tr})$ = 52 (-3; -10) dB	

Table 9 & **Table 10** detail the results of the mitigated modelling exercise.

Table 9 Mitigated Noise Level Assessment – Scenario 1

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
SSR1	GF (Ground Floor)	11.1	22.8	37.7	33.8	No Impact

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
	FF (First Floor)	11.9	22.9	37.7	33.8	No Impact
SSR2	GF	16.0	28.0	32.2	28.4	No Impact
	FF	18.2	28.9	32.2	28.4	No Impact
SSR3	GF	9.7	22.0	32.2	28.4	No Impact
	FF	10.8	22.3	32.2	28.4	No Impact
SSR4	GF	15.7	27.5	31.0	22.9	No Impact
	FF	16.4	27.6	31.0	22.9	No Impact
SSR5	GF	12.7	24.5	50.5	29.9	No Impact
	FF	14.5	25.0	50.5	29.9	No Impact
SSR6	GF	8.5	21.1	36.0	28.6	No Impact
	FF	9.0	21.2	36.0	28.6	No Impact
SSR7	GF	17.3	29.1	46.3	39.4	No Impact
	FF	17.7	29.1	46.3	39.4	No Impact
SSR8	GF	13.3	25.6	58.4	36.8	No Impact
	FF	13.9	25.5	58.4	36.8	No Impact
SSR9	GF	10.0	22.6	36.5	32.2	No Impact
	FF	10.6	22.6	36.5	32.2	No Impact
SSR10	GF	14.5	26.1	34.0	21.8	No Impact
	FF	15.0	26.1	34.0	21.8	No Impact
SSR11	GF	12.9	24.2	56.5	31.3	No Impact
	FF	14.5	24.8	56.5	31.3	No Impact

(green)	32dBZ 100Hz Requirement Met
(red)	32dBZ 100Hz Requirement Exceeded

Table 10 Mitigated Noise Level Assessment – Scenario 2

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
SSR1	GF (Ground Floor)	13.5	25.5	37.7	33.8	No Impact
	FF (First Floor)	14.2	25.3	37.7	33.8	No Impact
SSR2	GF	19.5	31.1	32.2	28.4	No Impact
	FF	21.0	31.6	32.2	28.4	No Impact
SSR3	GF	13.7	25.9	32.2	28.4	No Impact
	FF	14.5	26.0	32.2	28.4	No Impact
SSR4	GF	19.3	31.3	31.0	22.9	No Impact
	FF	20.0	31.4	31.0	22.9	No Impact
SSR5	GF	14.8	26.8	50.5	29.9	No Impact
	FF	16.3	27.3	50.5	29.9	No Impact
SSR6	GF	11.9	24.6	36.0	28.6	No Impact
	FF	12.4	24.6	36.0	28.6	No Impact
SSR7	GF	19.3	31.2	46.3	39.4	No Impact
	FF	19.7	31.3	46.3	39.4	No Impact
SSR8	GF	15.7	28.0	58.4	36.8	No Impact
	FF	16.3	28.0	58.4	36.8	No Impact
SSR9	GF	13.1	25.7	36.5	32.2	No Impact
	FF	13.6	25.8	36.5	32.2	No Impact
SSR10	GF	18.9	30.2	34.0	21.8	No Impact
	FF	19.6	30.3	34.0	21.8	No Impact
SSR11	GF	15.3	26.9	56.5	31.3	No Impact

NSR	Floor	Substation Noise Level Contribution at Receptor		Background Noise Level at Receptor L_{A90} [dB(A)]		BS4142 derived Impact Magnitude
		Broadband [dB(A)]	100Hz [dB(Z)]	Daytime	Night Time	
	FF	16.8	27.4	56.5	31.3	No Impact
		32dBZ 100Hz Requirement Met				
		32dBZ 100Hz Requirement Exceeded				

5.0 Discussion and Conclusions

Operational noise modelling was carried out for the Norfolk Vanguard and Norfolk Boreas offshore wind farm installations. It is concluded that, with provision for noise mitigation, colocation of both Norfolk Vanguard and Norfolk Boreas HVDC substations in the locations shown in the appended figures would result in **No Impact** at sensitive receptors in the vicinity of the site and meet the 32dBZ (linear) 100Hz noise limits.

The exact type of mitigation measures, whether it be enclosures, barriers, bunds, selection of quitter kit through procurement or mitigation by design and layout, will be specified after consent as part of the development of the front end engineering design (FEED) and the detailed design of the project. Commitments relating to operational noise will be included as part of the DCO requirements and managed through the Environmental Management Plan. The mitigation type and performance modelled within this document is based on a conservative application of the onshore project substation noise mitigation techniques and technologies which are readily available today. As a result, Vattenfall consider the mitigated noise assessment to be robust for use within the ES and DCO application determination.

Furthermore, it is concluded that cumulative noise impacts arising from the existing, operational Dudgeon OWF substation and Norfolk Vanguard and Norfolk Boreas onshore project substations will not result in any significant adverse impacts.

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Appendix A
Acoustic Terminology

Term	Description
C C_{tr}	The spectrum adaptation terms C and Ctr are used to take into account different source spectra as indicated in the standard. C : A-weighted Pink Noise spectrum. C_{tr} : A-weighted urban traffic noise spectrum. C and C_{tr} corrections can also be added to R_w.
Decibel (dB)	A unit of noise level derived from the logarithm of the ratio between the value of a quantity and a reference value. It is used to describe the level of many different quantities. For sound pressure level the reference quantity is 20 µPa, the threshold of normal hearing is 0dB, and 140dB is the threshold of pain. A change of 1dB is only perceptible under controlled conditions. Under normal conditions a change in noise level of 3dB(A) is the smallest perceptible change.
dB(A)	Decibels measured on a sound level meter incorporating a frequency weighting (A weighting) which differentiates between sounds of different frequency (pitch) in a similar way to the human ear. Measurements in dB(A) broadly agree with people's assessment of loudness. A change of 3 dB(A) is the minimum perceptible under normal conditions, and a change of 10 dB(A) corresponds roughly to halving or doubling the loudness of a sound. The background noise level in a living room may be about 30 dB(A); normal conversation about 60 dB(A) at 1 metre; heavy road traffic about 80 dB(A) at 10 metres; the level near a pneumatic drill about 100 dB(A).
$L_{Aeq,T}$	The equivalent continuous sound level – the sound level of a notionally steady sound having the same energy as a fluctuating sound over a specified measurement period (T). $L_{aeq,\ T}$ is used to describe many types of noise and can be measured directly with an integrating sound level meter.
$L_{A10,T}$	The A weighted noise level exceeded for 10% of the specified measurement period (T). L_{A10} is the index generally adopted to assess traffic noise.
$L_{A90,\ T}$	The A weighted noise level exceeded for 90% of the specified measurement period (T). In BS 4142: 2014 it is used to define the 'background' noise level.
L_{Amax}	The maximum A-weighted sound pressure level recorded during a measurement.
L_{Amin}	The minimum A-weighted sound pressure level recorded during a measurement.
L_{wA}	Sound power level (SWL) or acoustic power level is a logarithmic measure of the power of a sound relative to a reference value. Sound power level, denoted L_W and measured in dB. The A denotes the weighting applied.
R_w	The weighted sound reduction index, R_w, is a single figure description of

sound reduction index which is defined in BS EN ISO 717-1: 1997. The R_w is calculated from measurements in an acoustic laboratory to BS EN ISO 140-3:1997 and ratings to BS EN ISO 717-1:1997. Sound insulation ratings derived from site (which are invariably lower than the laboratory figures) are referred to as the R'_w ratings (apparent weighted sound reduction index) and measured to BS EN ISO 140-4:1998

Appendix B
Figures

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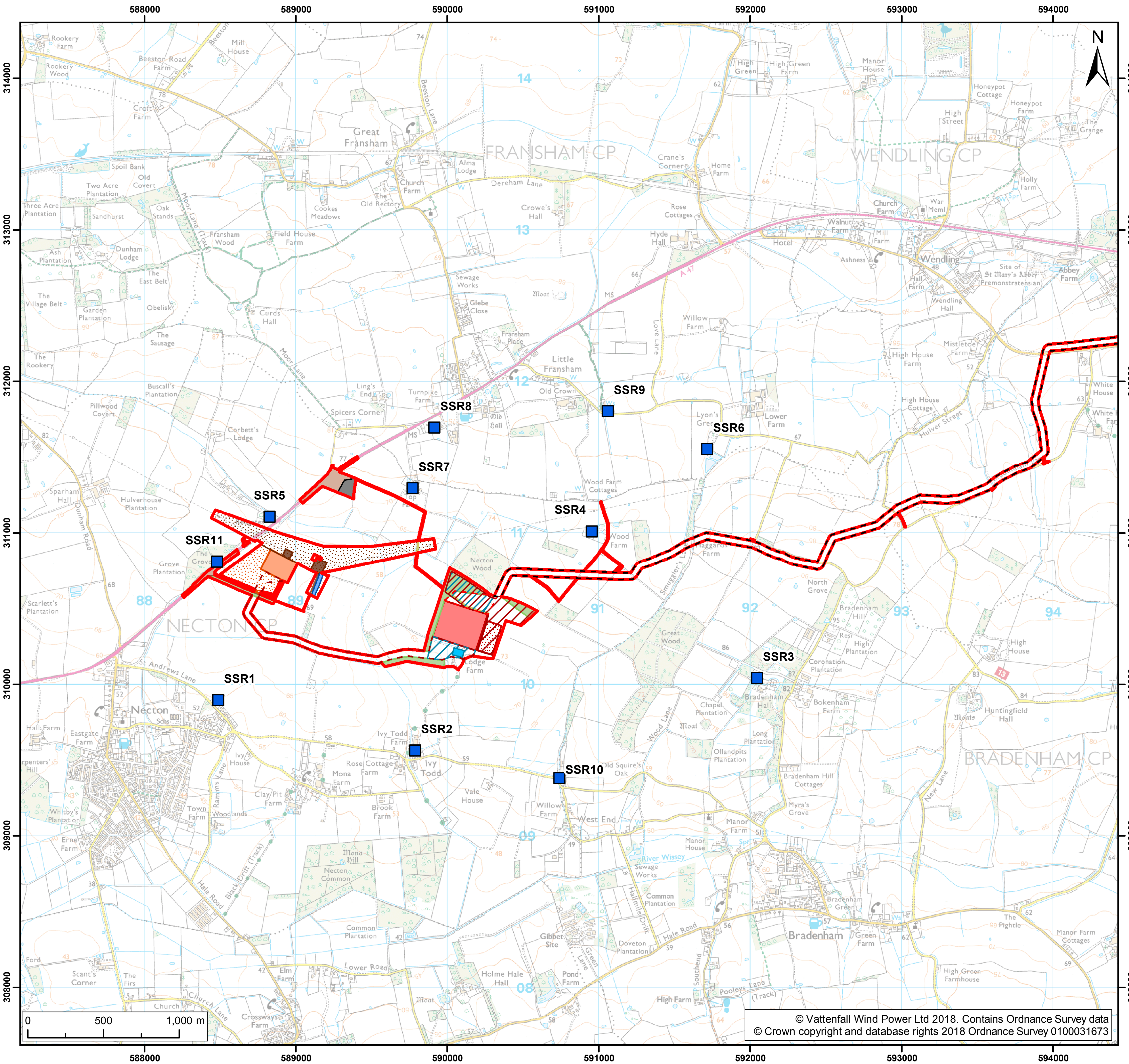

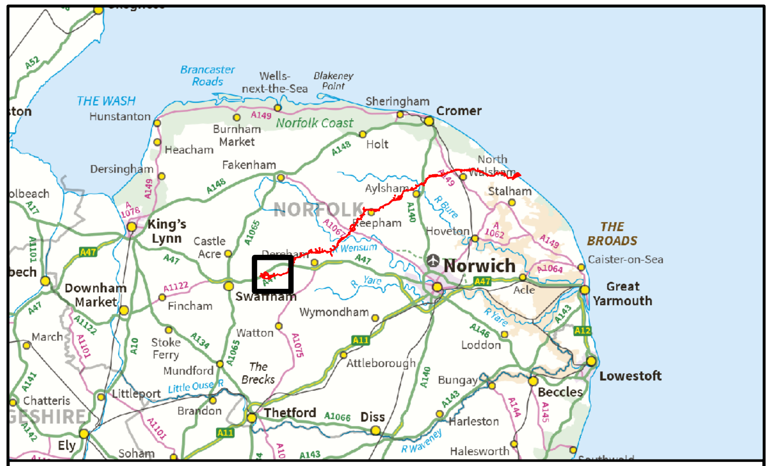

Legend:

- Noise receptor location
- Norfolk Vanguard red line boundary

Norfolk Vanguard onshore project infrastructure

- Onshore cable corridor
- Cable route entry to substation
- 400kv cable corridor
- Indicative mobilisation area footprint
- Indicative onshore project substation temporary construction compound footprint
- Onshore project substation temporary construction compound search area
- Indicative attenuation pond location
- Attenuation pond search area
- Mitigation area
- National Grid attenuation pond location
- National Grid temporary works
- Overhead line temporary works
- Side accesses - permanent access
- Side accesses - construction
- Side accesses - operation
- National Grid new / replacement OHL tower
- National Grid substation extension
- Onshore project substation

Project:	Report:
Norfolk Vanguard	Operational Substation Noise Modelling

Title:

Operational Substation Noise Modelling

Figure:	A1	Drawing No:	PB4476-003-MS-100		
Revision:	**Date:**	**Drawn:**	**Checked:**	**Size:**	**Scale:**
01	07/03/2018	GC	MS	A3	1:25,000

Co-ordinate system: British National Grid **EPSG:** 27700

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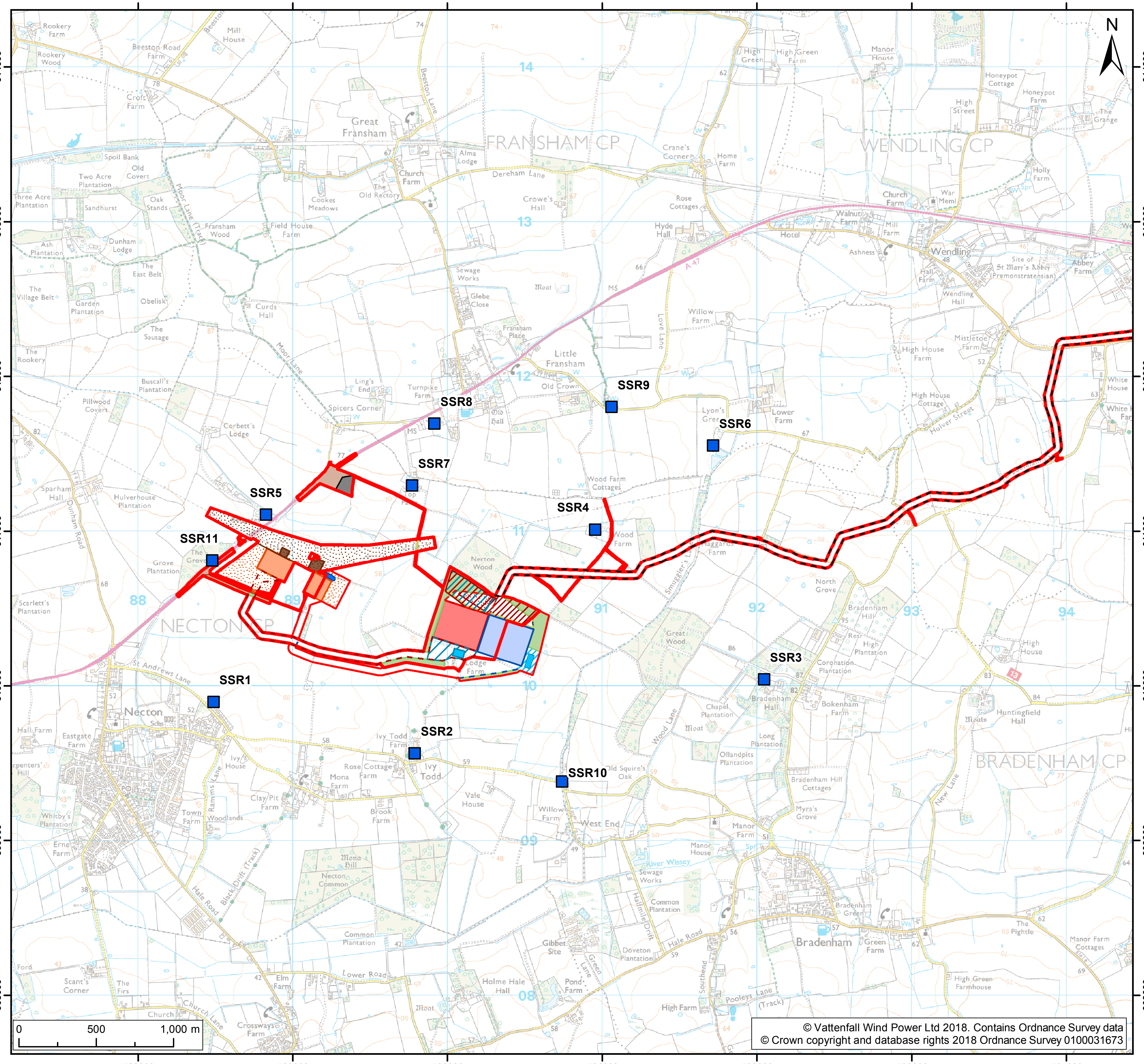

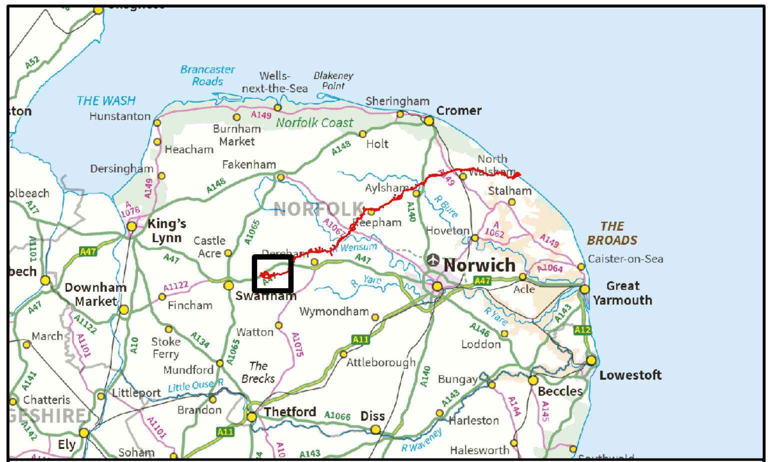

Legend:

- Noise receptor location
- Norfolk Vanguard red line boundary

Norfolk Vanguard onshore project infrastructure

- Onshore cable corridor
- Cable route entry to substation
- 400kv cable corridor
- Indicative mobilisation area footprint
- Indicative onshore project substation temporary construction compound footprint
- Onshore project substation temporary construction compound search area
- Indicative attenuation pond location
- Attenuation pond search area
- Mitigation area
- National Grid attenuation pond location
- National Grid temporary works
- Overhead line temporary works
- Side accesses - permanent access
- Side accesses - construction
- Side accesses - operation
- National Grid new / replacement OHL tower
- National Grid substation extension
- Onshore project substation

Norfolk Boreas Additional Onshore Project Infrastructure (Scenario 1)

- 400kV cable corridor
- Cable route entry to substation

Norfolk Boreas Onshore Project Infrastructure (Scenario 1 & 2)

- Onshore cable corridor
- Onshore project substation
- National Grid substation extension
- Norfolk Boreas red line boundary

Project:	Report:
Norfolk Vanguard	Operational Substation Noise Modelling

Title:

Operational Substation Noise Modelling

Figure: A1 | Drawing No: PB4476-003-MS-101

Revision:	Date:	Drawn:	Checked:	Size:	Scale:
01	07/03/2018	GC	MS	A3	1:25,000

Co-ordinate system: British National Grid **EPSG:** 27700

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Appendix C
Technical Data

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Test specimen mounted by: Client
Product identification: 0.8perf,2x50 140rw,2x15pb,50 140rw,2x15pb,vb&prof

Measurement procedure: ISO 140-3:1995 Test procedure: ISO 717-1:1996

Mass per unit: 113 kg/m² Size: 8.64 m²

Temperature [°C]: 20.5 Humidity [%]: 49.4

Test room identification: Small Rev Room / Large Rev Room
Source room Volume: 136 m³
Receiving room Volume: 220 m³
Date of test: 17/09/08 FREQUENCIES 50, 63 & 80 Hz ARE NOT UKAS ACCREDITED

Weighted Sound reduction $R_w(C,C_{tr})$ = 52 (-3;-10) dB

Sum of unfavourable deviations: 29.2 dB
Max. unfavourable deviation: 9.7 dB at 100 Hz

$C_{50-3150}$: --- $C_{50-5000}$: --- $C_{100-5000}$: -2 dB
$C_{tr50-3150}$: --- $C_{tr50-5000}$: --- $C_{tr100-5000}$: -10 dB

Frequency [Hz]	R [dB]	L1 [dB]	L2 [dB]	T [s]	Corr. [dB]	u.Dev. [dB]	
100	23.3	100.4	76.0	3.19	-1.1	9.7	
125	29.3	101.2	70.8	3.19	-1.1	6.7	
160	36.6	101.5	63.4	2.88	-1.5	2.4	
200	38.5	102.2	62.8	3.33	-0.9	3.5	
250	43.2	100.0	57.0	4.27	0.2	1.8	
315	45.8	99.8	54.3	4.36	0.3	2.2	
400	48.4	98.8	50.5	4.22	0.1	2.6	
500	51.7	98.5	47.2	4.43	0.4	0.3	
630	54.0	98.9	45.4	4.59	0.5	-.-	
800	55.1	99.5	45.0	4.72	0.6	-.-	
1000	57.4	100.0	43.2	4.71	0.6	-.-	
1250	59.8	100.6	41.2	4.42	0.4	-.-	
1600	63.1	101.6	38.6	4.17	0.1	-.-	
2000	66.7	100.2	33.3	3.90	-0.2	-.-	
2500	71.0	101.7	30.1	3.55	-0.6	-.-	
3150	73.2	102.5	28.1	3.06	-1.2	-.-	
4000	73.5	105.4	30.0	2.61	-1.9	-.-	
5000	71.1	107.7	33.6	2.06	-3.0	-.-	

University of Salford School of Computing Science & Engineering

No. of test report: AC08/132/08 Salford, 17.09.2008

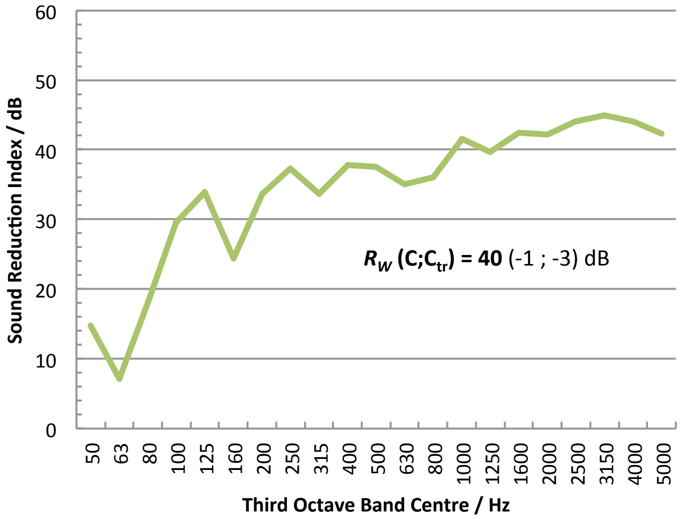
SonoTEC® – Slimline

Acoustic Panel Data Sheet

Unique Performance

Sonobex have pioneered the development of a unique acoustic panel technology using their understanding of metamaterials. The panel consists of coupled resonator elements that attenuate airborne noise. There is no need for acoustic infill.

Unlike traditional resonators the bandwidth is broad making it suitable for practical applications and sufficiently robust to deal with changes in environmental conditions.



Absorption

Absorption coefficient at in the 100Hz third octave band is 0.65; Measured in accordance with BS EN ISO 354:2003

Transmission Loss (TL)

Third Octave Band (HZ)	Transmission Loss (dB)
50	14.8
63	7.1
80	18.1
100	29.5
125	33.9
160	24.4
200	33.7
250	37.3
315	33.7
400	37.8
500	37.6
630	35.0
800	36.1
1000	41.5
1250	39.7
1600	42.4
2000	42.2
2500	44.1
3150	45.0
4000	44.1
5000	42.3
Rw	40

Sound Transmission Loss, independently tested in the UKAS laboratory at the Building Research Establishment, in accordance with BS EN ISO 10140-2:2010.

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