Eskdalemuir Consultation: The 2026 Algorithm

Restatement of the Eskdalemuir physics-based algorithm using the approved 2026 List of Approved Turbine Types (LATT)

07/07/2026

Purpose

This document restates the equations used within the Eskdalemuir consultation 2026 algorithm in the same format as the 2014 algorithm. Each equation is referenced to the source document from which it is derived.

Computational reproducibility disclaimer

Different software may give very small numerical differences from floating-point arithmetic, the value used for π, the implementation of logarithms and exponentials, the construction of the frequency grid, interpolation of the frequency-distance weighting function, and the numerical integration convention. The 2014 algorithm report states calculations were made in double precision with a frequency step of 0.001 Hz. Where the same units, constants, coefficient set, weighting function, frequency grid and integration convention are used, independent implementations would be expected to agree to roughly seven or eight significant figures in nanometres. Larger differences should be treated as implementation differences to resolve, not ordinary software noise.

1. Introduction

The 2026 algorithm provides replacement scalable models to the 2014 single algorithm, moving from a worst-case estimate to empirically derived models for approved turbine types, allowing the intentionally conservative 2014 worst case algorithm to be replaced with turbine manufacturer specific models. This document sets out the equations and calculation sequence used to determine the predicted seismic displacement amplitude at the Eskdalemuir Seismic Array (EKA) from wind turbines represented within the List of Approved Turbine Types (LATT). The purpose of the document is to set out the methodology underpinning the seismic impact calculations used within the Eskdalemuir consultation process, using standard numerical tools.

The calculation requires the turbine rotor diameter, hub height, distance to EKA and the spectral coefficient set associated with the selected LATT turbine type. The synthetic source spectrum is parameterised using rotor diameter and hub height, which determine the swept area, blade-pass frequency and wind-speed scaling used throughout the calculation. The spectral coefficients used in the calculation are derived from the Phase 4 measurement programme (Appendix A) and are presented in Table 7.

The methodology first calculates the predicted seismic displacement amplitude at EKA from an individual wind turbine. A procedure is then provided to combine multiple turbines using quadrature summation to calculate the cumulative seismic impact of a wind farm or any collection of wind turbines within the Eskdalemuir Restricted zone.

The turbine rated power is not required for calculation of the seismic displacement amplitude itself. Rated power is only required once the displacement amplitude has been calculated, as the Seismic Impact Limit (SIL) is defined as the predicted displacement amplitude divided by the square root of the turbine rated power.

The methodology presented here follows Annex 12 of this consultation and subsequent refinements developed through the Phase 4 measurement programme (see Appendix A). Annex 13 of this consultation comprised a further series of field measurements undertaken to validate and refine the original algorithm, and the resulting improvements have been incorporated into the calculation procedure presented here. The procedure is presented as a single calculation sequence, in the same format as the 2014 algorithm.

Symbols and Constants

Table 1 List of Variables

Symbol	Description	Units
α	Signal-model scaling factor used in the Freiberger filter normalisation	-
A	Swept rotor area	m²
A_n	rms displacement amplitude at EKA from turbine n	nm
A_{cum}	Cumulative rms displacement amplitude at EKA	nm
$B(f)$	EKA beam coherency function used in FDWF calculation	-
$BM_j(f)$	Bending mode j contribution to synthetic displacement spectrum	m²/Hz
$C(f)$	Frequency-dependent source coupling function	-
D	Rotor diameter	m
f	Frequency	Hz
f_{BP}	Blade-pass frequency	Hz
$F(f)$	Normalised EKA frequency weighting term	-
f_j	Centre frequency of bending mode j	Hz
$F_0(f)$	Unnormalised Freiberger frequency weighting term	-
H	Hub height	m
k_{max}	Highest blade-pass harmonic included in the blade-pass summation	-
N	Number of turbines included in cumulative calculation	-
$N_{eka}(f)$	EKA background noise model	relative power
$P(r,f)$	Frequency-dependent propagation term	-

r	Distance from turbine to EKA	km
$S_{sig}(f)$	FDWF signal model	relative power
$S_{syn,n}(f)$	Synthetic displacement PSD for turbine n	m²/Hz
$S_0(f)$	Unscaled FDWF signal model	relative power
v_{TIP}	Blade tip speed	m/s
v_w	Wind speed at hub height	m/s
$W(r,f)$	Frequency-distance weighting function	-
σ_j	Shape parameter for bending mode j	Hz
σ_{BP}	Blade-pass shape parameter	Hz
Index Definitions		
Symbol	Description	
j	Bending mode index (1–4)	
k	Blade-pass harmonic index	
n	Turbine index	

Table 2 List of Constants

Symbol	Description	Value	Units
a_0	EKA background noise coefficient	0.8678	-
a_1	EKA background noise coefficient	-8.382	-
a_2	EKA background noise coefficient	3.625	-
fc	FDWF signal corner frequency	8.0	Hz
f_{cmax}	Beam coherency corner frequency	6.5	Hz
f_{max}	Upper integration frequency	8.0	Hz
f_{min}	Lower integration frequency	0.5	Hz
f_{norm}	FDWF normalisation frequency	3.28	Hz
N_{ch}	Number of EKA array channels used in beam coherency model	20	

Qc	Attenuation parameter	100	km/s
r_{ref}	Reference distance	1	km
SNR_{max}	Maximum signal-to-noise ratio used in Freiberger filter normalisation	4	-
t^*	Apparent attenuation parameter	0.15	s
v_{ref}	Reference wind speed	12	m/s
z_l	Ground roughness length	0.05	m
z_{ref}	Reference wind speed height	80	m
π	Mathematical constant	3.14159265359…	-
Reference location of EKA			
Easting of EKA crossing point		326500	m
Northing of EKA crossing point		604964	m

Table 3 List of LATT Spectral Coefficients

Symbol	Description
$C_{BM,j}$	Bending mode j amplitude multiplier
C_{BP}	Blade-pass amplitude multiplier
C_{OBN}	Operational broadband noise amplitude multiplier
f_j	Bending mode j centre frequency
p	Blade-pass amplitude exponent
σ_{BP}	Blade-pass shape parameter
σ_j	Bending mode j shape parameter
v_{TIP}	Blade tip speed

Use of LATT turbine types in the Industry Tool

The Industry Tool, currently hosted on the Scottish Renewables website, allows consultees to assess proposed wind farm developments against the MOD-defined List of Approved Turbine Types (LATT), from LATT A to LATT F. Section 4, "Coefficients for 12 m/s Wind Speed Bin", explains how these LATT categories correlate to specific turbine models.

Available turbines and their basis for inclusion in the LATT

The current LATT set available on the industry tool is necessarily limited in number because each turbine type must first be characterised through field measurement of its ground-borne seismic emissions within the Restricted Zone. This is an ongoing process. New turbine models are added only once they have been measured and assessed by the MOD in the restricted zone.

The Industry Tool currently uses the Spectral Coefficients for the turbine manufacturers listed below. Whilst these coefficients were derived from a specific turbine model for each manufacturer, the underlying methodology is scalable. Therefore, where coefficients for a specific turbine model are not available, the coefficients associated with the same turbine manufacturer can be used to estimate the approximate SGV of that turbine.

- LATT A: Senvion, derived from measurement of a Senvion 3.4M114 at Middlemuir Wind Farm
- LATT B: Vestas, derived from measurement of a V80 at Glenkerie wind farm
- LATT C: Enercon, derived from measurement of an E82 at Craig Wind farm
- LATT D: Nordex, derived from measurement of an N80 at Craig Wind Farm
- LATT E: GE, derived from measurement of a GE 1.6 at Langhope Rig
- LATT F: Siemens, derived from measurement of an SWT2.3 at Clyde Wind Farm

Other turbine spectra available in the Industry Tool and underlying measurement data

The Industry Tool also includes measured spectra for additional turbine models, including the Siemens Gamesa 155, Nordex N163 and Vestas V162. These spectra have not yet been converted into a scalable LATT form as the underlying measurement data was not captured within the Restricted Zone. Therefore, these turbines are List of Candidate Turbine Types (LCTT, formerly known as the Approved Turbine List) turbines, not LATT turbines, as they have not been built out and tested in the array, so have not been used in the SIL calculation. MOD uses LATT turbines only for headroom and SIL calculations, so they are not directly relevant to the published headroom or SIL figures.

Role of spectral coefficients and how they feed into the 2026 algorithm

Each LATT model is represented by a set of spectral coefficients. These coefficients provide a parameterised fit to the measured source spectrum across the frequency band to which the Eskdalemuir Seismic Array is sensitive. They are the direct input to the 2026 algorithm, which scales them for distance and number of turbines to predict each turbine's contribution to displacement at the array.

Table 4: Refence documentation

Seismic vibration produced by wind turbines in the Eskdalemuir region (Release 2.0, Substantial Research Project)	Annex 12
Standardised Measurement of Operational Wind Turbine Seismic Noise	Annex 4
LATT Coefficients	Annex 5
Standardised Measurement of Baseline Seismic Noise	Annex 11
Eskdalemuir Phase 5 — cumulative deployment calculations	Report: Eskdalemuir Seismic Study Work Phase 5 (SGV-205)
Selby And Bowers 2023 (Fawside public inquiry documentation)	https://www.dpea.scotland.gov.uk/Document.aspx?id=921239

2. Reference Basis and Calculation Overview

The methodology presented in this document calculates the predicted seismic displacement amplitude at the Eskdalemuir Seismic Array (EKA) from a wind turbine represented within the List of Approved Turbine Types (LATT). The calculation requires the turbine rotor diameter D, hub height H, distance to EKA r, and the corresponding LATT coefficient set from Table 7.

To ensure consistency between turbine types and measurement datasets, all synthetic spectra are defined on a common reference basis corresponding to a single turbine located at a reference distance r_{ref} of 1 km, operating within the 12 m/s wind-speed bin (11.5–12.5 m/s), with wind speeds referenced to a height of 80 m above ground level.

The calculation procedure presented in Section 3 in this document follows the same sequence used within the Eskdalemuir consultation methodology. The procedure first constructs a synthetic source spectrum for an individual turbine, applies the frequency-distance weighting function to account for propagation and EKA sensitivity, and then calculates the resulting rms displacement amplitude at EKA. Where multiple turbines are considered, individual turbine amplitudes are combined using quadrature summation to determine the cumulative seismic impact.

3. Calculation procedure

The calculation procedure is divided into two stages. The first stage characterises the seismic source by constructing a synthetic displacement power spectral density for the turbine under consideration using its geometry, operating characteristics and the corresponding LATT coefficient set. The second stage estimates the signal detected at EKA by applying the frequency-distance weighting function, which accounts for seismic-wave propagation and the frequency-dependent sensitivity of the array. The resulting displacement amplitudes may then be combined using quadrature summation to determine the cumulative seismic impact.

3.1. Source characterisation

The synthetic displacement spectra used in the LATT methodology are defined on a common reference basis corresponding to a wind speed of 12 m/s at a reference height of 80 m above ground level. Consistent with the physics-based algorithm developed by Xi in 2014 (see Annex 12), the seismic energy produced by a wind turbine is assumed to scale with the swept rotor area and the cube of the wind speed at hub height. The first stage of the calculation therefore, determines the turbine-specific geometric and wind-speed scaling parameters required to construct the synthetic source spectrum at the reference conditions.

Step 1: Calculate the Swept Rotor Area (m^2)

The swept area follows from the rotor diameter:

$$A = \pi \left(\frac{D}{2}\right)^2$$

Doc reference: Source: Annex 12, §8.3.2, (eq. 18).

Step 2: Calculate Wind Speed at Hub Height

The reference spectrum is defined at 12 m/s at 80 m. For a turbine of hub height H, the wind speed at the hub is found from the logarithmic wind profile:

$$v_w = v_{\text{ref}} \frac{\ln\left(\frac{H}{z_l}\right)}{\ln\left(\frac{z_{\text{ref}}}{z_l}\right)}$$

Doc reference: Annex 12, §8.3.1 (eq. 16); consistent with the wind-profile correction in Annex 4 §10.2.2.

Step 3: Calculate the Blade-Pass Frequency

The blade-pass frequency defines the fundamental rotational excitation frequency of the wind turbine and is used to calculate the blade-pass component of the synthetic displacement spectrum. Consistent with the approach adopted in Annex 12, the blade-pass frequency is calculated from the blade tip speed and rotor diameter. The blade tip speed for each LATT turbine type is given in Table 7.

$$f_{\mathrm{BP}} = \frac{3v_{\mathrm{TIP}}}{\pi D}$$

where:

- $f_{\mathbf{BP}}$is the blade-pass frequency (Hz),
- $v_{\mathbf{TIP}}$is the blade tip speed (m/s), and
- $D$is the rotor diameter (m).

The factor of three reflects the assumption of a three-bladed wind turbine and converts the rotor rotational frequency to the blade-pass frequency.

Step 4 - Construct the LATT Synthetic Source Spectrum

The seismic signal from a wind turbine is represented by a synthetic displacement power spectral density (PSD) referenced to the standard conditions defined above. The synthetic spectrum comprises three components representing the principal sources of turbine-generated seismic vibration:

- operational broadband noise (OBN);
- structural bending modes (BM_1–BM_4); and
- blade-pass excitation (BP).

The synthetic displacement spectrum for turbine $n$is given by:

$$S_{\mathrm{syn},n}(f) = \mathrm{OBN}(f) + \sum_{j=1}^{4} \mathrm{BM}_j\,(f) + \mathrm{BP}(f)$$

The operational broadband noise component is:

$$\mathrm{OBN}(f) = C_{\mathrm{OBN}} A v_w^3 f^{-2}$$

The structural bending mode components are:

$$\mathrm{BM}_j(f) = C_{\mathrm{BM},j} A v_w^3 \exp\left(-\frac{(f - f_j)^2}{2\sigma_j^2}\right)$$

for $j = 1, \ldots, 4$.

The blade-pass component is:

$$\mathrm{BP}(f) = \sum_{k=1}^{k_{\max}} C_{\mathrm{BP}}\, A v_w^3 k^{-p} \exp\left(-\frac{(f - k f_{\mathrm{BP}})^2}{2\sigma_{\mathrm{BP}}^2}\right)$$

where $K$is the highest blade-pass harmonic satisfying:

$$k_{\max} f_{\mathrm{BP}} \leq f_{\max}$$

The operational broadband noise component represents non-discrete vibration sources and decreases with increasing frequency. The bending mode components represent structural resonances of the turbine and are modelled as Gaussian peaks centred on the frequencies f_j. The blade-pass component represents periodic excitation associated with rotor rotation and is modelled as a series of harmonics of the blade-pass frequency calculated in Step 3.

All spectral components scale with swept rotor area *A* and the cube of the wind speed v_w^3, consistent with the energy-scaling assumption adopted in the physics-based algorithm (Annex 12 Section 8.1). The coefficient values required for each LATT turbine type are provided in Table 7.

3.2. Propagation and Impact on EKA

The synthetic source spectrum derived in Section 3.1 represents the seismic signal generated by the turbine at the reference conditions. To estimate the resulting impact at the Eskdalemuir Seismic Array (EKA), the source spectrum must be adjusted to account for attenuation during propagation from the turbine to the array and the frequency-dependent sensitivity of EKA.

These effects are represented by the frequency-distance weighting function, $W(r, f)$, which combines the propagation characteristics of seismic waves with the response of the array. The weighted spectrum is subsequently integrated over the frequency range of interest to determine the predicted displacement amplitude at EKA.

The second stage of the calculation therefore consists of:

- Calculate the frequency-distance weighting function.
- Calculate the displacement amplitude at EKA.

Step 5: Calculate the Frequency-Distance Weighting Function

The frequency-distance weighting function, $W(r, f)$, accounts for the propagation of seismic vibration from the turbine to EKA and the frequency-dependent sensitivity of the array. It is calculated as the product of a normalised EKA frequency weighting term, $F(f)$, and a propagation term, $P(r, f)$. The propagation distance, *r*, is taken as the straight-line horizontal distance between the wind turbine and the centre of the Eskdalemuir Seismic Array, defined as the intersection of the array arms located at Easting 326500 m, Northing 604964 m. The frequency-distance weighting function defines as:

$$W(r,f) = F(f)P(r,f)$$

The EKA frequency weighting term is derived from the Freiberger detection filter:

$$F(f) = \frac{F_0(f)}{F_0(f_{\text{norm}})}$$

where:

$$F_0(f) = \frac{S_{\text{sig}}(f)/N_{\text{EKA}}(f)}{S_{\text{sig}}(f) + N_{\text{EKA}}(f)}$$

The EKA background noise model is:

$$N_{\text{EKA}}(f) = 10^{a_0 + a_1 \log_{10}(f) + a_2 [\log_{10}(f)]^2}$$

The signal model is:

$$S_{\text{sig}}(f) = \alpha C(f)^2 \exp(-2\pi f t^*)\, B(f)$$

with:

$$C(f) = \begin{cases} 1, & f \leq f_c \\ (f/f_c)^{-2}, & f > f_c \end{cases}$$

and:

$$B(f) = \begin{cases} \frac{1}{K} + \frac{K-1}{2K}\left[1 + \cos\left(\frac{\pi f}{f_{\text{cmax}}}\right)\right], & f < f_{\text{cmax}} \\ \frac{1}{K}, & f \geq f_{\text{cmax}} \end{cases}$$

The scaling factor $\alpha$is chosen so that the maximum signal-to-noise ratio is 4:

$$\alpha = \frac{4}{\max\big(S_0(f)/N_{\text{EKA}}(f)\big)}$$

where:

$$S_0(f) = C(f)^2 \exp(-2\pi f t^*)\, B(f)$$

The propagation term is:

$$P(r,f) = \frac{r_{\text{ref}}}{r} \exp\left(-\frac{2\pi f (r - r_{\text{ref}})}{Qc}\right)$$

where Qc is the combined attenuation parameter. This formulation keeps Qc as the published attenuation term, without separately defining Q or wave speed.

Doc reference: Annex 12, §8.3.3 (*eq. 19) / Annex 4, (eqs 2 & 4)*

Step 6: Calculate the Displacement Amplitude at EKA

The synthetic source spectrum from Step 4 is combined with the frequency-distance weighting function from Step 5 and integrated over the frequency range 0.5–8 Hz to determine the predicted root-mean-square (rms) displacement amplitude at EKA.

The displacement amplitude for turbine n is:

$$A_n = \sqrt{\int_{f_{\min}}^{f_{\max}} S_{\text{syn},n}(f)\, W(r,f)\, df}$$

where:

$$f_{\min} = 0.5 \text{ Hz}$$

and:

$$f_{\max} = 8.0 \text{ Hz}$$

The resulting value A_n represents the predicted rms seismic displacement amplitude at EKA due to turbine n.

Doc reference: Annex 12, §8.3.3 (eq. 19)

3.3. Cumulative Impact Assessment

The displacement amplitude calculated in Step 6 represents the contribution from a single turbine. Where multiple turbines are present, the cumulative impact at EKA is calculated using quadrature summation of the individual turbine amplitudes.

Step 7: Calculate the Cumulative Displacement Amplitude

The cumulative rms displacement amplitude is:

$$A_{\text{cum}} = \sqrt{\sum_{n=1}^{N} A_n^2}$$

where:

- A_n is the rms displacement amplitude at EKA from turbine n; and
- N is the number of turbines included in the calculation.

The resulting value A_{cum} represents the cumulative predicted rms displacement amplitude at EKA from all turbines considered.

3.4. Calculation of Cumulative Seismic Vibration at EKA

Table 5 and Table 6 present two scenarios for calculating cumulative SGV: 1) using the worst-case empirical list of approved turbine type (LATT) models for all consented projects (Table 5) and; 2) using known empirical LATT models for those built (Table 6). At this stage, both scenarios are expected to result in a headroom within the headroom range in the consultation. However, cumulative SGV and subsequent available headroom is subject to change as this depends on the project pipeline at the point the regulations come into force, should they be made.

Some wind farm planning applications utilise the 2014 algorithm because they have budget allocation assigned that was already secured by legal agreements or by the approach detailed in paragraph 7a of Appendix A of MOD's safeguarding strategy regarding replacement development. This has been incorporated into the headroom range detailed in our consultation and the tables below.

The average distance of individual turbines from EKA, have been approved by MOD and are detailed in the table below. The average distance to EKA is provided as a summary descriptor. The SGV calculation is based on individual turbine locations, which are generally available through the relevant planning portal records. Use of the average distance should allow an approximate reproduction of the calculation, but an exact reproduction requires the individual turbine coordinates and the applicable turbine assumption for each project.

The tables below represent the most recent information but could be subject to change depending on attrition within the pipeline. We reserve the right to update the list as necessary.

Table 5 Scenario 1: worst case empirical turbines

Wind Farm	Number of Turbines	Capacity (MW)	Average Distanc e to EKA (km)	Average Hub Height (m)	Average Rotor Diameter (m)	Amplitude of Wind Farm (nm)	Cumulative Amplitude of Wind Farms (nm)
Bowbeat	24	31.2	42.30	45.0	62.0	0.003781	0.003781
Minsca	17	42.5	24.84	80.0	82.3	0.027591	0.027849
Dalswinton	15	30	35.87	80.0	82.0	0.008415	0.029092
Craig (Carlesghill)	5	13.2	19.66	59.8	80.4	0.024700	0.038163
Halkburn OR Long Park WF	19	38	42.84	59.0	82.0	0.004647	0.038445
Harestanes	71	213	27.28	77.5	86.6	0.046040	0.059981
Clyde	152	456	29.99	78.3	93.0	0.058002	0.083438
Ewe Hill	22	50.6	19.02	67.9	93.0	0.067744	0.107476
Carcant	3	9.9	49.19	58.5	82.4	0.001056	0.107481
Langhope Rig	10	15	21.35	80.0	82.5	0.031343	0.111958
Andershaw A	11	36.3	46.62	81.5	117.0	0.003984	0.112029
Middle Hill OR Glenkerie A	11	22	29.24	68.2	80.0	0.013076	0.112789
Aikrigg Cottage	1	0.006	49.63	9.0	5.5	0.000022	0.112789
Kingstown Industrial Estate	1	0.015	47.43	15.0	5.6	0.000031	0.112789
Lammerlaw Farm	1	0.011	44.27	18.3	13.0	0.000102	0.112790
Brunstock Close	1	0.006	48.53	15.2	4.1	0.000021	0.112790
Minnygap	10	20	25.27	75.0	99.8	0.024475	0.115414
Craig Ext (Carlesgill Ext)	1	3.2	19.03	59.0	82.0	0.012114	0.116048
Langshaw Farm	1	0.05	43.82	30.0	19.0	0.000176	0.116049
Land East of Braidwood	1	0.006	34.54	15.0	5.6	0.000104	0.116049
Westmill Farm	1	0.011	44.37	18.3	13.0	0.000101	0.116049
Rennieston Edge	1	0.06	41.06	10.3	5.5	0.000050	0.116049
Scotston Bank Farm	3	0.045	40.96	15.0	9.6	0.000168	0.116049
Windyknowe	1	0.006	43.54	15.0	5.6	0.000044	0.116049
Land NW of Ferniehaugh Farm	2	0.06	48.04	15.0	9.6	0.000072	0.116049
Land NW of Threepwood House	1	0.015	45.25	20.6	12.8	0.000095	0.116049
Lauder B	2	0.12	49.76	30.0	14.0	0.000107	0.116049
Meadowside Cottage	1	0.02	44.20	20.6	12.8	0.000104	0.116049
Mosshouses Farm	1	0.015	43.91	15.1	9.6	0.000074	0.116049
Land SW of Larkhill	1	0.015	47.90	20.6	12.8	0.000074	0.116049
Muirlea Farm	1	0.02	43.23	20.5	13.0	0.000115	0.116049
Hillfield	1	0.005	47.67	15.0	5.5	0.000030	0.116049
Cargo Farm Cottage	2	0.04	47.00	20.6	12.8	0.000114	0.116049
Land NW of the Batts	1	0.015	47.54	15.5	11.1	0.000062	0.116049
Kirkpatrick Hill	1	0.011	39.45	18.3	13.0	0.000160	0.116049
Burnhouse	1	0.015	43.00	15.0	8.5	0.000071	0.116049
The Beeches	1	0.02	46.05	20.6	13.1	0.000090	0.116049
Symington Mains Farm	1	0.02	46.23	20.5	13.0	0.000088	0.116049
Newton of Wiston	1	0.015	42.62	15.1	8.5	0.000074	0.116049
Midhill	1	0.015	43.60	20.6	12.8	0.000110	0.116049
Whinney Rig	1	0.1	36.11	36.5	19.2	0.000386	0.116050
Newtonhead	1	0.06	49.60	37.0	23.6	0.000137	0.116050
Gaups Hill Farm	1	0.01	49.67	18.8	7.3	0.000035	0.116050
South Melbourne Farm	1	0.006	43.09	15.2	5.6	0.000047	0.116050
Walston Braehead Farm	3	0.18	45.46	20.5	13.1	0.000164	0.116050
Easton Farm	1	0.02	47.68	20.5	13.0	0.000077	0.116050
Lochmailing	1	0.015	40.75	15.6	10.8	0.000113	0.116050

Wind Farm	Number of Turbines	Capacity (MW)	Average Distanc e to EKA (km)	Average Hub Height (m)	Average Rotor Diameter (m)	Amplitude of Wind Farm (nm)	Cumulative Amplitude of Wind Farms (nm)
Pumro Fell	1	0.0015	27.62	12.2	1.7	0.000061	0.116050
Rivox	1	0.015	23.37	15.1	8.6	0.000513	0.116052
Land at Arthurshiels	1	0.02	44.80	20.6	13.1	0.000101	0.116052
Hyndshawland	1	0.02	43.70	20.6	13.1	0.000112	0.116052
East Millrig	1	0.015	41.62	20.6	13.1	0.000135	0.116052
Braco Farm	2	0.06	49.03	15.5	11.1	0.000077	0.116052
Mallshill	1	0.005	37.61	10.0	5.5	0.000069	0.116052
Brockhouse	1	0.011	47.91	18.3	13.0	0.000073	0.116052
Broom Hills	1	0.01	40.23	15.0	7.0	0.000076	0.116052
Land SW of Copland Farm	1	0.011	41.59	18.0	13.0	0.000130	0.116052
Birkenside Farmhouse	1	0.05	48.47	26.6	19.2	0.000113	0.116052
Libberton Mains Farm	1	0.02	47.12	20.6	13.1	0.000082	0.116052
SW of Bankhouse Farm	1	0.012	45.97	18.9	7.2	0.000049	0.116052
Lammerlaw Farm 2	2	0.044	44.50	18.3	13.0	0.000141	0.116052
Green Croft	1	2	49.86	24.6	19.2	0.000098	0.116052
Cormiston Farm	1	0.02	41.11	18.3	13.0	0.000137	0.116052
Hartsop	1	0.015	40.89	15.4	11.1	0.000114	0.116052
Parkhouse Farm	2	0.04	44.07	22.0	10.4	0.000123	0.116052
Shankfield Head	2	0.04	39.89	20.0	7.0	0.000119	0.116052
Cambwell	1	0.011	39.85	18.4	13.0	0.000154	0.116052
South of Hyndfordwells Farm	3	0.18	45.34	20.6	13.1	0.000166	0.116053
Rose Cottage	1	0.006	44.82	15.0	5.5	0.000039	0.116053
Hillend Farm	1	0.011	39.67	18.3	13.0	0.000157	0.116053
Land N of Midtown Farm	1	0.05	47.86	24.6	19.2	0.000117	0.116053
Clyde Extension	54	162	29.90	87.2	103.4	0.038661	0.122323
W of Hyndfordwells Farm	1	0.02	45.69	15.0	10.4	0.000068	0.122323
Blackdyke Farm Riding Centre	1	0.01	44.37	20.0	7.0	0.000056	0.122323
Cottage Farmhouse	1	0.011	49.29	18.3	13.0	0.000065	0.122323
Lampits Farm 2	1	0.25	49.98	49.5	30.0	0.000187	0.122323
Land NW of West Morriston Fm	1	0.25	49.98	49.5	30.0	0.000187	0.122323
Land E of Mossbank Langshaw	1	0.011	42.98	18.3	13.0	0.000115	0.122323
Middle Muir WF	15	51	45.57	85.5	114.0	0.004998	0.122425
Glenkerie Ext	6	15	29.67	60.0	80.0	0.008996	0.122756
Lion Hill WF	4	9.2	29.27	80.0	93.0	0.009548	0.123126
Townfoot	1	0.01	43.87	18.3	13.0	0.000106	0.123126
Windy Edge	9	22.5	22.67	75.0	90.0	0.027652	0.126193
Rose Cottage 2	1	0.006	44.87	15.0	5.5	0.000039	0.126193
East of Newton of Covington	2	0.04	44.56	22.0	10.4	0.000118	0.126193
Bailey Town Farm	1	0.01	37.86	15.0	13.2	0.000179	0.126193
Kilravoch	1	0.0012	39.32	12.0	2.0	0.000022	0.126193
Crookedstane Farm	4	9.2	31.51	80.0	93.0	0.007618	0.126423
South Melbourne Farm 2	1	0.011	42.85	18.4	13.0	0.000116	0.126423
Cloich[1]	18	54	42.54	70.0	90.0	0.006490	0.126590
Solwaybank	15	30	25.65	76.5	100.0	0.028993	0.129867

[1] Calculated using 2014 algorithm

Wind Farm	Number of Turbines	Capacity (MW)	Average Distanc e to EKA (km)	Average Hub Height (m)	Average Rotor Diameter (m)	Amplitude of Wind Farm (nm)	Cumulative Amplitude of Wind Farms (nm)
SW of Kettleshill Farmhouse	1	0.012	48.24	15.4	7.3	0.000038	0.129867
Trough Head Farm	2	0.02	36.46	15.0	13.2	0.000290	0.129868
Twentyshilling Hill	9	27	48.03	81.5	117.0	0.003187	0.129907
72 Carlisle Road	2	0.17	44.80	36.6	23.5	0.000298	0.129907
East of Whitslaid Farm	2	0.05	49.75	18.0	14.0	0.000094	0.129907
Solway BeckBurn WF	9	31.05	36.87	73.8	105.0	0.007600	0.130129
SW of Clackmae Farmhouse	1	0.1	44.96	22.6	23.6	0.000186	0.130129
Whins Farm	1	0.09	32.86	22.6	23.6	0.000593	0.130131
South Slipperfield Farmhouse	1	0.05	48.39	16.5	21.0	0.000111	0.130131
Jockstown Farm	1	0.1	34.09	22.0	24.4	0.000540	0.130132
Deanfoot Farmhouse	1	0.05	49.21	18.1	21.0	0.000106	0.130132
West of M6	1	0.5	44.03	40.0	54.0	0.000553	0.130133
Hallburn Farm	6	18	39.81	76.5	100.0	0.004500	0.130211
Burnswark Garage	1	0.5	30.77	24.9	23.5	0.000746	0.130213
Whitelaw Brae WF	14	50.4	23.85	80.0	107.0	0.037169	0.135414
Priestgill Littlegill Farm[2]	7	22.4	36.91	119.3	150.0	0.014344	0.136172
Pines Burn SW of Lurgiescleuch[3]	11	36.3	27.75	77.7	127.2	0.034631	0.140506
Loganhead[4]	8	25.6	18.58	75.0	120.0	0.080088	0.161728
Crossdykes[5]	10	48	16.65	110.0	133.0	0.100350	0.190331
Hopsrig[6]	12	42	16.13	90.0	100.0	0.111134	0.220402
Little Hartfell Castlemilk[7]	9	49.896	16.48	93.5	133.0	0.131787	0.256797

[2] Calculated using 2014 algorithm
[3] Calculated using 2014 algorithm
[4] Calculated using 2014 algorithm
[5] Recalculated using 10 rather than 15 turbines; it is understood that the planning consent which has been implemented at Crossdykes is for ten turbines of 176.5m, and that any conflicting consents have expired. Calculated using 2026 algorithm.
[6] Calculated using 2014 algorithm
[7] Calculated using 2014 algorithm

Table 6 Scenario 2: known case empirical turbines

Wind Farm	Number of Turbines	Capacity (MW)	Average Distance to EKA (km)	Average Hub Height (m)	Average Rotor Diameter (m)	Amplitude of Wind Farm (nm)	Cumulative Amplitude of Wind Farms (nm)
Bowbeat	24	31.2	42.30	45.0	62.0	0.003122	0.003122
Minsca	17	42.5	24.84	80.0	82.3	0.022668	0.022882
Dalswinton	15	30	35.87	80.0	82.0	0.005049	0.023432
Craig (Carlesghill)	5	13.2	19.66	59.8	80.4	0.021358	0.031705
Halkburn OR Long Park WF	19	38	42.84	59.0	82.0	0.002825	0.031831
Harestanes	71	213	27.28	77.5	86.6	0.046040	0.055972
Clyde	152	456	29.99	78.3	93.0	0.047426	0.073363
Ewe Hill	22	50.6	19.02	67.9	93.0	0.056921	0.092855
Carcant	3	9.9	49.19	58.5	82.4	0.000881	0.092859
Langhope Rig	10	15	21.35	80.0	82.5	0.031343	0.098006
Andershaw A	11	36.3	46.62	81.5	117.0	0.003854	0.098082
Middle Hill OR Glenkerie A	11	22	29.24	68.2	80.0	0.011923	0.098804
Aikrigg Cottage	1	0.006	49.63	9.0	5.5	0.000022	0.098804
Kingstown Industrial Estate	1	0.015	47.43	15.0	5.6	0.000031	0.098804
Lammerlaw Farm	1	0.011	44.27	18.3	13.0	0.000102	0.098804
Brunstock Close	1	0.006	48.53	15.2	4.1	0.000021	0.098804
Minnygap	10	20	25.27	75.0	99.8	0.020216	0.100851
Craig Ext (Carlesgill Ext)	1	3.2	19.03	59.0	82.0	0.010674	0.101414
Langshaw Farm	1	0.05	43.82	30.0	19.0	0.000176	0.101415
Land East of Braidwood	1	0.006	34.54	15.0	5.6	0.000104	0.101415
Westmill Farm	1	0.011	44.37	18.3	13.0	0.000101	0.101415
Rennieston Edge	1	0.06	41.06	10.3	5.5	0.000050	0.101415
Scotston Bank Farm	3	0.045	40.96	15.0	9.6	0.000168	0.101415
Windyknowe	1	0.006	43.54	15.0	5.6	0.000044	0.101415
Land NW of Ferniehaugh Farm	2	0.06	48.04	15.0	9.6	0.000072	0.101415
Land NW of Threepwood House	1	0.015	45.25	20.6	12.8	0.000095	0.101415
Lauder B	2	0.12	49.76	30.0	14.0	0.000107	0.101415
Meadowside Cottage	1	0.02	44.20	20.6	12.8	0.000104	0.101415
Mosshouses Farm	1	0.015	43.91	15.1	9.6	0.000074	0.101415
Land SW of Larkhill	1	0.015	47.90	20.6	12.8	0.000074	0.101415
Muirlea Farm	1	0.02	43.23	20.5	13.0	0.000115	0.101415
Hillfield	1	0.005	47.67	15.0	5.5	0.000030	0.101415
Cargo Farm Cottage	2	0.04	47.00	20.6	12.8	0.000114	0.101415
Land NW of the Batts	1	0.015	47.54	15.5	11.1	0.000062	0.101415
Kirkpatrick Hill	1	0.011	39.45	18.3	13.0	0.000160	0.101415
Burnhouse	1	0.015	43.00	15.0	8.5	0.000071	0.101415
The Beeches	1	0.02	46.05	20.6	13.1	0.000090	0.101415
Symington Mains Farm	1	0.02	46.23	20.5	13.0	0.000088	0.101415
Newton of Wiston	1	0.015	42.62	15.1	8.5	0.000074	0.101415
Midhill	1	0.015	43.60	20.6	12.8	0.000110	0.101415
Whinney Rig	1	0.1	36.11	36.5	19.2	0.000386	0.101416
Newtonhead	1	0.06	49.60	37.0	23.6	0.000137	0.101416
Gaups Hill Farm	1	0.01	49.67	18.8	7.3	0.000035	0.101416
South Melbourne Farm	1	0.006	43.09	15.2	5.6	0.000047	0.101416
Walston Braehead Farm	3	0.18	45.46	20.5	13.1	0.000164	0.101416
Easton Farm	1	0.02	47.68	20.5	13.0	0.000077	0.101416
Lochmailing	1	0.015	40.75	15.6	10.8	0.000113	0.101417
Pumro Fell	1	0.0015	27.62	12.2	1.7	0.000061	0.101417

Wind Farm	Number of Turbines	Capacity (MW)	Average Distance to EKA (km)	Average Hub Height (m)	Average Rotor Diameter (m)	Amplitude of Wind Farm (nm)	Cumulative Amplitude of Wind Farms (nm)
Rivox	1	0.015	23.37	15.1	8.6	0.000513	0.101418
Land at Arthurshiels	1	0.02	44.80	20.6	13.1	0.000101	0.101418
Hyndshawland	1	0.02	43.70	20.6	13.1	0.000112	0.101418
East Millrig	1	0.015	41.62	20.6	13.1	0.000135	0.101418
Braco Farm	2	0.06	49.03	15.5	11.1	0.000077	0.101418
Mallshill	1	0.005	37.61	10.0	5.5	0.000069	0.101418
Brockhouse	1	0.011	47.91	18.3	13.0	0.000073	0.101418
Broom Hills	1	0.01	40.23	15.0	7.0	0.000076	0.101418
Land SW of Copland Farm	1	0.011	41.59	18.0	13.0	0.000130	0.101418
Birkenside Farmhouse	1	0.05	48.47	26.6	19.2	0.000113	0.101418
Libberton Mains Farm	1	0.02	47.12	20.6	13.1	0.000082	0.101418
SW of Bankhouse Farm	1	0.012	45.97	18.9	7.2	0.000049	0.101418
Lammerlaw Farm 2	2	0.044	44.50	18.3	13.0	0.000141	0.101418
Green Croft	1	2	49.86	24.6	19.2	0.000098	0.101419
Cormiston Farm	1	0.02	41.11	18.3	13.0	0.000137	0.101419
Hartsop	1	0.015	40.89	15.4	11.1	0.000114	0.101419
Parkhouse Farm	2	0.04	44.07	22.0	10.4	0.000123	0.101419
Shankfield Head	2	0.04	39.89	20.0	7.0	0.000119	0.101419
Cambwell	1	0.011	39.85	18.4	13.0	0.000154	0.101419
South of Hyndfordwells Farm	3	0.18	45.34	20.6	13.1	0.000166	0.101419
Rose Cottage	1	0.006	44.82	15.0	5.5	0.000039	0.101419
Hillend Farm	1	0.011	39.67	18.3	13.0	0.000157	0.101419
Land N of Midtown Farm	1	0.05	47.86	24.6	19.2	0.000117	0.101419
Clyde Extension	54	162	29.90	87.2	103.4	0.031712	0.106262
W of Hyndfordwells Farm	1	0.02	45.69	15.0	10.4	0.000068	0.106262
Blackdyke Farm Riding Centre	1	0.01	44.37	20.0	7.0	0.000056	0.106262
Cottage Farmhouse	1	0.011	49.29	18.3	13.0	0.000065	0.106262
Lampits Farm 2	1	0.25	49.98	49.5	30.0	0.000187	0.106262
Land NW of West Morriston Fm	1	0.25	49.98	49.5	30.0	0.000187	0.106262
Land E of Mossbank Langshaw	1	0.011	42.98	18.3	13.0	0.000115	0.106262
Middle Muir WF	15	51	45.57	85.5	114.0	0.002992	0.106304
Glenkerie Ext	6	15	29.67	60.0	80.0	0.005464	0.106444
Lion Hill WF	4	9.2	29.27	80.0	93.0	0.008717	0.106801
Townfoot	1	0.01	43.87	18.3	13.0	0.000106	0.106801
Windy Edge	9	22.5	22.67	75.0	90.0	0.027652	0.110322
Rose Cottage 2	1	0.006	44.87	15.0	5.5	0.000039	0.110322
East of Newton of Covington	2	0.04	44.56	22.0	10.4	0.000118	0.110323
Bailey Town Farm	1	0.01	37.86	15.0	13.2	0.000179	0.110323
Kilravoch	1	0.0012	39.32	12.0	2.0	0.000022	0.110323
Crookedstane Farm	4	9.2	31.51	80.0	93.0	0.006928	0.110540
South Melbourne Farm 2	1	0.011	42.85	18.4	13.0	0.000116	0.110540
Cloich[8]	18	54	42.54	70.0	90.0	0.006490	0.110730
Solwaybank	15	30	25.65	76.5	100.0	0.026908	0.113953
SW of Kettleshill Farmhouse	1	0.012	48.24	15.4	7.3	0.000038	0.113953
Trough Head Farm	2	0.02	36.46	15.0	13.2	0.000290	0.113953

[8] Calculated using 2014 algorithm

Wind Farm	Number of Turbines	Capacity (MW)	Average Distance to EKA (km)	Average Hub Height (m)	Average Rotor Diameter (m)	Amplitude of Wind Farm (nm)	Cumulative Amplitude of Wind Farms (nm)
Twentyshilling Hill	9	27	48.03	81.5	117.0	0.003114	0.113996
72 Carlisle Road	2	0.17	44.80	36.6	23.5	0.000298	0.113996
East of Whitslaid Farm	2	0.05	49.75	18.0	14.0	0.000094	0.113996
Solway BeckBurn WF	9	31.05	36.87	73.8	105.0	0.006972	0.114209
SW of Clackmae Farmhouse	1	0.1	44.96	22.6	23.6	0.000186	0.114209
Whins Farm	1	0.09	32.86	22.6	23.6	0.000593	0.114211
South Slipperfield Farmhouse	1	0.05	48.39	16.5	21.0	0.000111	0.114211
Jockstown Farm	1	0.1	34.09	22.0	24.4	0.000540	0.114212
Deanfoot Farmhouse	1	0.05	49.21	18.1	21.0	0.000106	0.114212
West of M6	1	0.5	44.03	40.0	54.0	0.000553	0.114214
Hallburn Farm	6	18	39.81	76.5	100.0	0.004500	0.114302
Burnswark Garage	1	0.5	30.77	24.9	23.5	0.000746	0.114305
Whitelaw Brae WF	14	50.4	23.85	80.0	107.0	0.037169	0.120196
Priestgill Littlegill Farm[9]	7	22.4	36.91	119.3	150.0	0.014344	0.121049
Pines Burn SW of Lurgiescleuch[10]	11	36.3	27.75	77.7	127.2	0.034631	0.125905
Loganhead[11]	8	25.6	18.58	75.0	120.0	0.080088	0.149219
Crossdykes[12]	10	48	16.65	110.0	133.0	0.088689	0.173585
Hopsrig[13]	12	42	16.13	90.0	100.0	0.111134	0.206113
Little Hartfell Castlemilk[14]	9	49.896	16.48	93.5	133.0	0.131787	0.244644

[9] Calculated using 2014 algorithm
[10] Calculated using 2014 algorithm
[11] Calculated using 2014 algorithm
[12] Recalculated using 10 rather than 15 turbines; it is understood that the planning consent which has been implemented at Crossdykes is for ten turbines of 176.5m, and that any conflicting consents have expired. Calculated using 2026 algorithm.
[13] Calculated using 2014 algorithm
[14] Calculated using 2014 algorithm

4. Coefficients for 12 m/s Wind Speed Bin

The following table presents the fitted spectral coefficients for each turbine type at the 12 m/s wind speed bin (). These coefficients define the amplitude, frequency, and shape parameters for each spectral component in the synthetic displacement spectrum, covering blade-pass frequency, four structural bending modes, and operational broadband noise. All values have been reviewed and agreed with the Ministry of Defence and are to be used directly in the MOD and Industry Tool for cumulative seismic impact assessments. A summary of the derivation of the coefficients is presented in Appendix B.

Table 7 Spectral coefficients for synthetic displacement spectra at 12 m/s wind speed bin (11.5–12.5 m/s) for turbines in the LATT-STM.

STM-A-Senvion a coefficient are used to scale Senvion turbines. STM-B-Vestas coefficient are used to scale Senvion turbines. STM-C-Enercon coefficient are used to scale Enercon turbines. STM-D-Nordex coefficient are used to scale Nordex turbines. STM-E-GE coefficient are used to scale GE turbines. STM-F-Siemens coefficient are used to scale Siemens turbines.

	STM-A-Senvion	STM-B-Vestas	STM-C-Enercon	STM-D-Nordex	STM-E-GE	STM-F-Siemens
Blade pass amplitude multiplier	1.10500E-25	9.33870E-25	2.45010E-26	2.62440E-25	9.89200E-25	4.16510E-25
Blade pass amplitude exponent	3.8500	4.0500	1.3500	3.2175	3.0360	3.6000
Blade pass shape parameter	0.0100	0.0220	0.0440	0.0319	0.0100	0.0400
Bending mode 1 amplitude multiplier	6.71310E-27	1.10960E-26	7.50960E-28	1.25140E-26	4.23730E-25	2.18000E-26
Frequency of bending mode 1	2.390	2.240	2.960	2.140	2.680	2.810
Bending mode 1 shape parameter	0.0820	0.0660	0.0090	0.0210	0.0100	0.0500
Bending mode 2 amplitude multiplier	3.86520E-27	4.65310E-27	7.65660E-27	5.39010E-27	9.86870E-28	1.06550E-26
Frequency of bending mode 2	3.990	4.200	4.600	4.200	4.110	3.250
Bending mode 2 shape parameter	0.0410	0.1850	0.0690	0.0700	0.0320	0.0400
Bending mode 3 amplitude multiplier	3.31510E-27	3.93720E-27	1.48310E-27	3.52650E-27	1.67270E-27	7.20380E-29
Frequency of bending mode 3	4.800	5.900	5.660	6.300	5.400	5.300
Bending mode 3 shape parameter	0.0930	0.2160	0.1200	0.1045	0.1360	0.0640
Bending mode 4 amplitude multiplier	8.53820E-27	1.07170E-29	2.27720E-27	1.04600E-27	7.89480E-27	7.50130E-28
Frequency of bending mode 4	5.800	7.100	6.890	8.000	6.700	6.200
Bending mode 4 shape parameter	0.0570	0.5000	0.0510	0.3380	0.1120	0.0980
Operational broadband noise multipliers	1.90820E-26	3.88870E-26	3.40070E-26	3.40070E-26	1.96920E-26	2.08660E-26
Tip Speed (m/s)	71.7712	69.8	60.5	69.9	77.49	77.49

5. Document references

Each quantity and equation used in the procedure, with the document reference where it is defined. All annexes and reports can be found on the Scottish Renewables Eskdalemuir Seismic Array webpage.

Quantity / equation	Doc reference
Wind speed at hub height (log law)	Annex 12 §8.3.1 eq. 16 / Annex 4 §10.2.2
Swept area $A = \pi D^2/4$	Annex 12 §8.3.2 eq. 18 (standard geometry)
Blade-pass frequency f_{BP}	Annex 12§8.3.2 eq. 17
Reference spectrum structure (OBN/BM/BP)	Annex 12§8.2.1 eqs 12–15
Spectral coefficients	Annex 12 Table 22 (Parameters and values used to construct the reference worst-case turbine spectrum) / Annex 5 (Table 2 Spectral coefficients for synthetic displacement spectra at 12 m/s wind speed bin (11.5–12.5 m/s) for turbines in the LATT-STM)
Amplitude-scaling law $(A \cdot v_w^3)$	Annex 12 §7 (conservation of energy)
FDWF / propagation & band integration	Annex 12 §8.3.3 eq. 19 / Annex 4 eqs 2 & 4
Acceleration → displacement PSD	Annex 4 §15.3.4
Quadrature aggregation	Annex 12 §8.4.1
Eskdalemuir geology / velocities	Annex 4 Table 14 / Annex 12 §2.2

6. Appendix A – Summary of Phase 4 Measurement Programme

Appendix A provides the technical background to the development of the 2026 algorithm. It summarises the progression from the original 2014 physics-based algorithm published in Annex 12 through the subsequent Phase 4 measurement programme and the refinements that followed. The appendix explains the technical basis for those refinements and provides the rationale for their incorporation into the algorithm presented in this document. It is intended to provide context and traceability for the methodology, while the main body of this document remains the normative specification of the calculation procedure.

The Phase 4 measurement programme was undertaken to refine the existing physics-based algorithm (i.e. The 2014 Algorithm) using an expanded dataset of measured seismic ground vibration from operational wind farms within the Eskdalemuir Restricted zone. The full report can be found at Annex 13. Seven representative[15] wind farms were selected to provide coverage of the principal wind turbine manufacturers and models operating within the restricted zone, namely Craig Hill (Nordex N80 and Enercon E82), Glenkerie (Vestas V80), Harestanes (Gamesa G8x), Langhope Rig (GE 1.6), Minnygap (Nordex N100), Solwaybank (Vestas V100) and Ewe Hill (Siemens SWT2.3). These measurements complemented earlier surveys undertaken at Clyde (Siemens SWT2.3) and Middle Muir (Senvion 3.4M114). Collectively, these campaigns captured all known megawatt-class turbine manufacturers operating within the restricted zone.

At each wind farm, broadband seismometers were deployed to measure seismic ground vibration from operational turbines. The measured spectra were post-processed and normalised to represent the seismic source of a single turbine located at a reference distance of 1 km, operating in the 12 m/s wind-speed bin referenced to a height of 80 m above ground level. This common reference basis allows direct comparison between different turbine types and provides the source spectra used by the predictive algorithm.

The normalised spectra were subsequently fitted using synthetic displacement spectra representing the principal turbine manufacturers. Building on the original 2014 methodology, the fitting procedure was revised by weighting the measured spectra using the frequency-distance weighting function (FDWF) appropriate for a turbine located 10 km from the Eskdalemuir Seismic Array. The revised fitting also expanded the structural resonance

[15] the seven wind farms were selected in advance, following a documented audit of turbines in the relevant 50 km area around the Array, to cover the principal manufacturers, models and turbine sizes relevant to the assessment.

model from a single representative bending mode to four structural bending modes, allowing a more representative description of the measured spectra from modern wind turbines. The fitted spectra comprise operational broadband noise, four structural bending modes and blade-pass excitation, with the amplitude, centre frequency and shape parameter of each spectral component determined from measured displacement spectra for each turbine type. A summary of the fitting methodology is provided in Appendix B in this document. The resulting manufacturer-specific spectral coefficients form the basis of the List of Approved Turbine Types (LATT) and are used directly in the calculation procedure presented in this document.

7. Appendix B – Derivation of the LATT Spectral Coefficients

This appendix describes the derivation of the LATT spectral coefficients used by the 2026 algorithm. It summarises the methodology used to derive the coefficients from measured seismic data while retaining compatibility with the underlying physics-based prediction framework. The resulting coefficients are incorporated directly into the calculation procedure described in Section 3.

The LATT spectral coefficients were derived by fitting synthetic displacement spectra to measured seismic displacement power spectral density (PSD) data obtained from representative wind turbine types operating within the Eskdalemuir Restricted zone. The fitting was undertaken using the normalised spectra described in Appendix A, which represent the seismic source of a single turbine at a reference distance of 1 km operating within the 12 m/s wind speed bin (11.5–12.5 m/s), with wind speeds referenced to a height of 80 m above ground level.

The synthetic spectrum comprises three physical components: operational broadband noise (OBN), blade-pass excitation (BP) and four structural bending modes (BM_1–BM_4). Each discrete spectral component is represented by a Gaussian function defined by an amplitude multiplier, centre frequency and shape parameter, while the operational broadband noise component is represented by an inverse-square frequency relationship. The parameters describing each spectral component were estimated by fitting the synthetic spectrum to the measured displacement PSD using a least-squares optimisation over the frequency range of interest.

The fitting procedure retained the underlying physics-based scaling relationships developed in the 2014 methodology, while extending the structural resonance model from one to four bending modes and incorporating frequency-distance weighting representative of a turbine located 10 km from the Eskdalemuir Seismic Array during the fitting process. This produced manufacturer-specific spectral coefficients that more accurately represent the measured seismic characteristics of modern wind turbines while remaining compatible with the scalable prediction methodology.

The resulting spectral coefficients are presented in Table 7 and are used directly within the calculation procedure described in Section 3 and listed in Table 7.