Appendix G
Noise Analysis Report

ENVIRONMENTAL NOISE IMPACT ASSESSMENT

McLEANS MOUTAIN WIND FARM
MANITOULIN ISLAND, ONTARIO

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Executive Summary

The purpose of this environmental noise impact assessment, prepared for the Northland Power Inc ("NPI") M1 Wind Project (the "Project"), is to fulfill NPI's requirements under Ontario Regulation 116/01 of the *Environmental Assessment Act* and to provide the basis for the Certificate of Approval – Air ["C of A (Air)"] under Section 9 of the *Environmental Protection Act* ("EPA"). The objective of this assessment is to demonstrate, by means of technical assessment, that the noise impact from the operation of the Project will comply with the Ministry of the Environment's ("MOE") environmental noise guidelines for wind turbines.

Building upon the project specific guidelines, noise impact prediction modelling was undertaken. The noise impact from the Project's wind turbine array and transformers and including neighbouring wind turbines operating at maximum rated power on the nearest points of reception was predicted using an acoustic model, ISO 9613, as required by the MOE.

The analysis shows that the noise impact from the Project does not exceed the most restrictive noise limits that apply for areas with acoustic designation of Class 3 (Rural) as defined by the MOE. Consequently, there is no need for the application of any additional mitigation measures and no further studies are contemplated for environmental noise in relation to the Project.

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GLOSSARY

agl	above ground level
C of A (Air)	Certificate of Approval – Air
Northland	Northland Power Inc.
M1	Northland Power McLean’s Mountain Wind Farm
dB(A)	decibel A-weighted
ENIA	Environmental Noise Impact Assessment
EPA	*Environmental Protection Act*
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kW	kilowatt
kV	kilovolt
LLA	Licence and Option to Lease Agreement
m	metre
m/s	metres per second
MOE	Ontario Ministry of the Environment
MW	Megawatt
PWL	Sound Power Level

1.0 INTRODUCTION

Northland Power Inc. ("NPI") has retained Aercoustics Engineering Limited ("Aercoustics") to prepare an environmental noise impact assessment ("ENIA") of the proposed 77.4 mega Watt ("MW") M1 Manitoulin Island Wind Project ("Project"). The Project is situated near little current, in the Municipality of North-eastern Manitoulin and the Islands, Ontario.

The Government of Ontario has made a commitment to the generation of electricity from renewable sources an important part of Ontario's energy future. Specifically, the Government of Ontario has set the target of having 2,700 MW of renewable electricity in service by 2010. To assist in meeting these targets, NPI will secure a renewable energy supply contract from the Ontario Power Authority (OPA) for the Project.

The purpose of this ENIA is to fulfill NPI's requirements under Ontario Regulation 116/01 of the *Environmental Assessment Act* and to provide the basis for the Certificate of Approval – Air ["C of A (Air)"] under Section 9 of the *Environmental Protection Act* ("EPA"). Consequently, in fulfilling these requirements, the objective of this assessment is to:

1. Predict the noise impacts from the Project at the nearest points of reception and to demonstrate, by means of technical assessment, that the noise impact from the operation of the Project will comply with the Ministry of the Environment's ("MOE") environmental noise guidelines for wind turbines.

The sound level limits and the noise assessment procedures are defined by the MOE in their October 2008 publication: "*Noise Guidelines for Wind Farms, Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities*" ref[17]. For continued reference, the MOE Interpretation (ATTACHMENT A) was prepared to assist proponents of wind turbine installations in determining what information should be submitted when applying for a C of A (Air), under the EPA.

The noise assessment was based on all of the recommended procedures outlined in the MOE's "Noise Guidelines for Wind farms, October 2008" ref [17].

2.0 DISCUSSION OF ACOUSTIC TERMINOLOGY

In order to fully understand the analysis presented in this ENIA, a brief discussion of the technical terms utilized throughout the report is included below.

The noise data presented in this report has been given in terms of sound pressure level. Sound pressure levels are measured in decibels (“dB”). It is common practice to sum sound pressure levels over the entire audible spectrum to give an overall sound pressure level.

The MOE requires that instantaneous sound pressure be processed by a special filter (i.e., A-weighting). As human hearing is less sensitive to low frequency sound, the weighting emphases the frequencies in the range 500 Hertz (“Hz”) to 4000 Hz; while progressively diminishing the relative contributions at high and low frequencies. This corresponds approximately to the hearing response to humans at normal sound levels (e.g., 50 dB). The resulting “A-weighted” sound level is often used as a criterion to indicate a maximum allowable sound level.

The MOE defines a “point of reception” as any point on the premises of a person within 30 m of a dwelling or camping area, where sound or vibration originating from other than those premises is received. The MOE designates points of reception into three classes:

- Class 1 refers to an acoustical environment typical of a major population centre where the background noise is dominated by the urban hum. These areas are highly urbanized and have moderate to high noise levels throughout the day and night.
- Class 2 means an area with an acoustic environment that has low ambient sound levels between 19:00 hours and 07:00 hours; where the evening and night-time levels are defined by natural sounds and infrequent human activity and there are no clearly audible sounds from stationary sources (e.g., industrial, commercial, etc,).
- Class 3 refers to areas that are rural and/or small communities with a population of less than 1,000 with an acoustic environment that is dominated by natural sounds and has little or no road traffic during the night-time period.

3.0 DESCRIPTION OF WIND TURBINE SITE AND SURROUNDS

The Project is located near Little Current, in the town of North Eastern Manitoulin Island, Ontario. The closest communities in the vicinity of the Project is the Town of Little Current. The dominant environmental feature in the vicinity of the Project is the North Channel in Georgian Bay, located north and east of the study area. (Figure 1).

The wind plant will have a nominal rated nameplate capacity of 77.4 MW and will include one transformer at a substation near Green Bush Rd between McLean's Mountain Rd and Columbus Mountain Rd (Figure 2).

Within this agricultural / rural area, the main sources of ambient sound that currently exist include:

1. Vehicular traffic on County and Concession roads.
2. Sounds due to human activity as well as agricultural and rural activities.
3. Sounds due to human domestic activities such as property maintenance and recreation.
4. Natural sounds from wind noise, insects, wildlife, atmospheric effects, etc.

The acoustic classification of the area is generally Class 3 (rural).

3.1 Description of Receptors

Noise receptors have been selected for this analysis based on two criteria: i) their spatial proximity to the Project (i.e., receptors within 1,500 metres of a wind turbine); and ii) level of benefit derived from the Project (e.g., participating or non-participating receptors). A total of 297 receptor dwellings are located within 1,500 metres of a proposed wind turbine and have been included for assessment.

All receptors in the study area were provided to Aercoustics by NPI. Each receptor has been assigned a unique identifier for modelling and reporting purposes. Their locations relative to the wind turbines and transformer station are shown in Figure 2.

For the purposes of this ENIA, points of reception have been modelled at the worst case scenario of either two storey dwelling, or single storey dwelling with one point of reception 4.5m above the centre of the house.

3.2 MOE Environmental Noise Limits

The sound limit requirements for a wind turbine or an array of such units, termed a "wind plant", have been established in accordance with the existing MOE publications (NPC-205/232/233) as well as the wind induced background noise level. The specific definition of sound limits, expressed as a function of wind speed and ambient noise levels, as outlined in the MOE Interpretation, includes the following:

3.2.1 Wind Turbine Installations in Class 1 & 2 Areas (Urban): Wind Speeds Below 8m/s

The lowest sound level limit at a Point of Reception in Class 1 and 2 Areas (Urban), under conditions of average wind speed up to 8 m/s (i.e., 29km/h), expressed in terms of the hourly L_{eq} is 45.0 dB(A) or the minimum hourly background sound level established in accordance with requirements in Publications NPC-205/NPC-233, whichever is higher.

3.2.2 Wind Turbine Installations In Class 3 Areas (Rural): Wind Speeds Below 6m/s

The lowest sound level limit at a Point of Reception in Class 3 Areas (Rural), under conditions of average wind speed up to 6 m/s (i.e., 22km/h), expressed in terms of the hourly L_{eq} is 40.0 dB(A) or the minimum hourly background sound level established in accordance with requirements in Publications NPC-232/NPC-233, whichever is higher.

3.2.3 Wind Turbine Installations In Class 1 & 2 and Class 3 Areas: Wind Speeds Above 8m/s and 6m/s Respectively

The sound level limit at a Point of Reception in Class Areas 1 & 2 (Urban) or in Class 3 Areas (Rural), under conditions of average wind speed above 8 m/s and 6m/s respectively, expressed in terms of the hourly L_{eq}, is the wind induced background sound level, expressed in terms of ninetieth percentile sound level (L_{A90}) plus 7 dB, or the minimum hourly background sound level established in accordance with requirements in Publications NPC-205/NPC-232/NPC-233, whichever is higher. A summary of the above limits is shown in Table 1 for continued reference.

Table 1: MOE Sound Level Limits at Points of Reception for Wind Plants							
Wind Speed (m/s)	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s
Wind Turbine Noise Criterion NPC-232 (dBA) Class 3	40.0 dBA	40.0 dBA	40.0 dBA	43.0 dBA	45.0 dBA	49.0 dBA	51.0 dBA
Wind Turbine Noise Criterion NPC-205 (dBA) Class 1 & 2	45.0 dBA	45.0 dBA	45.0 dBA	45.0 dBA	45.0 dBA	49.0 dBA	51.0 dBA

Notes:
1. The measurement of wind induced background sound level is not required to establish the applicable criterion. The wind induced background sound level reference curve was determined by correlating the ninetieth percentile sound level (L_{A90}) with the average wind speed measured at a particularly quiet site.
2. If the existing minimum hourly background sound level, established in accordance with requirements in Publications NPC-205/NPC-232/NPC-233, is selected as the sound level limit, the measurement of wind speed (for the purpose of determination of wind induced background sound level) is not required. The selected limit applies in the entire range of wind speed under consideration from 4m/s to 11m/s with the exception of wind turbine noise criterion values higher than the existing minimum hourly background sound level.
3. Wind Turbine Noise Criterion at wind speeds expressed as fractional values of m/s should be interpolated from the above table.

The Project sound limits are ultimately a function of several variables:

1. current ambient levels due to sound levels caused by both natural and human activity (e.g., traffic) sounds
2. acoustic classification of the study area (e.g., Class 2 and/or Class 3 as defined by MOE)
3. Wind induced background sound levels.

It should be noted that the ENIA has opted to apply the more conservative Class 3 (Rural) values to all territories within the study area. For the purposes of this environmental noise impact assessment, the Class 3 minimum sound level limit has been applied to the all receptors.

Table 2: Sound Level Limits for Class 3 Areas							
Wind Speed (m/s)	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s
Wind Turbine Sound Level Limit [dB(A)] (Class 3 Area, NPC-232)	40.0 dBA	40.0 dBA	40.0 dBA	43.0 dBA	45.0 dBA	49.0 dBA	51.0 dBA

4.0 DESCRIPTION OF SOURCES

4.1 M1 Transformer Station

NPI plans to build a transformer substation near Green Bush Rd between McLean's Mountain Rd and Columbus Mountain Rd as part of the Project. This substation will contain one transformer unit.

The manufacturer for the transformer has not yet been chosen. A maximum sound power rating of 86.5 dBA was selected for the transformer unit. At or below this sound power level no noise controls are required.

Transformer noise is comprised of casing noise emitted from the operating transformer itself and cooling fan noise. Transformer noise has a pronounced audible tonal quality and appropriate sound level adjustments have been made in the analysis that follows.

The noise contribution from the substation is calculated using the DataKustik CadnaA version 3.7 environmental noise prediction software. The calculations are based on established prediction methods approved by the MOE: ISO 9613-2 standard entitled "Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation". For this analysis, the noise contribution from the substation was added to the noise contributions of the wind turbines to assess the total cumulative effect of the Project.

4.2 Wind Turbine Generators

The Project will utilize Vestas model V90 1.8MW wind turbines. These turbines are designed for medium and high-wind sites and are well suited for energy extraction in the Manitoulin Island area. The Vestas V90 has a nominal rating of 1.8 MW. It is a variable speed, pitch regulated upwind turbine with active yaw control and three blade rotor. A separate hydraulic pitch cylinder for each blade is situated within the nacelle. The generator and associated gearing are housed in a nacelle that is mounted on an 80 m high tower. The nacelle units are equipped with yaw motors to turn the nacelle into the wind.

Additional information on the Vestas V90 turbine is provided in ATTACHMENT B. Turbine coordinates are listed in Table 4.

4.2.1 Potential Sources of Noise

There are several sources that contribute to the sound emitted by a typical wind turbine. As the rotating blades of the turbine extract power from the air-stream, the blades experience lift and drag forces. These forces generate sound, much in the same manner as a rotating propeller or fan – also known as aerodynamic noise. The sound is predominantly tonal, with the fundamental sound established by the blade passage frequency, which is the product of the total number of blades and the rotation rate. For the proposed turbines the blade passage has a maximum frequency of 1 Hz. This is well below the audible frequency range (i.e., 20 Hz to 16,000 Hz).

INFRASOUND

Sounds with frequency contents below 20 Hz are referred to as infrasound. There are many other sources of infrasound such as those generated by winds, waterfalls, and the sound of waves breaking on the beach. Measurements at 200 m from typical units have shown that the infrasound levels are well below the level of perceptibility [1], [2]. As noted above, there are no non-participating Points of Reception within 400 m of a wind turbine and thus the potential effect of infrasound is not anticipated.

AMPLITUDE MODULATION

Perceptible sounds are generated predominantly by mechanical bearings, the electric generator and a characteristic “swoosh” which is essentially higher frequency broadband noise that is amplitude modulated at a low frequency [3]. In contrast to the first-generation wind turbines, some 30 years ago, innovations in blade geometry, materials, and mechanical systems have significantly lowered the sound power levels of present generation wind turbines. A recent study of wind turbine noise amplitude modulation [3] by the University of Salford, UK found that amplitude modulation occurs between 7% and 15% of the time, but the causes of amplitude modulation are still open to debate therefore the causes are not fully understood and that amplitude modulation cannot be fully predicted by current state of the art. The Salford study concludes that further research is recommended to improve understanding of amplitude modulation. The MOE does not impose a penalty applied to wind turbine noise due to amplitude modulation, ref [17].

WIND SHEAR EFFECTS

Vertical Wind shear, sometimes referred to as wind shear or wind gradient, is a vertical difference in wind speed and direction over a relatively short distance in the atmosphere. For acoustic purposes, vertical wind shear is used as a measure of the change in wind speed at various vertical heights above ground level. Wind shear has been accounted for in the M1 noise assessment by adjusting the standard neutral stability wind turbine emission to an emission which accounts for the site specific average summer nighttime wind shear exponent. This approach is consistent with the recommendations of the MOE's Noise Guidelines for Wind Farms [17].

4.2.2 M1 Wind Turbine Noise Emission Rating

The Vestas V90 has a rotor speed of 9 to 14.5 rpm therefore the resultant blade passage frequency is 0.24 Hz. Vestas has provided NPI with noise emission performance for the Vestas V90 wind turbines for wind speeds of 6ms/ to 10m/s. See Table 3 below and Attachment B.

Typical noise emission for 6m/s, 7m/s, 8m/s, 9m/s and 10m/s wind speed, for wind at a 10m reference height was provided by Vestas (see Attachment B). Table 3 presents all the turbine noise emission spectrums that were used in the noise assessment calculations.

Table 3: Vestas V90, Sound Power Spectrums @ wind speeds from 6m/s to 10m/s										
Vestas V90 Electrical Rating: 1.8 MW Hub Height (m): 80m Wind Shear coefficient: 0.435										
	Octave Band Sound Power Level (dB)									
	Manufacturer's Emission Levels					Adjusted Emission Levels				
Wind Speed (m/s)	6	7	8	9	10	6	7	8	9	10
Frequency (Hz)										
63	85.0	86.2	89.9	85.2	85.7	86	-	-	-	-
125	89.4	90.8	90.7	89.8	90.4	90.5	-	-	-	-
250	92.7	93.5	93.2	92.1	92.7	93.8	-	-	-	-
500	95.1	95.9	95.7	94.6	95.1	96.2	-	-	-	-
1000	97.8	98.4	98.5	97.6	98.2	98.9	-	-	-	-
2000	96.2	96.9	97.5	96.8	97.4	97.3	-	-	-	-
4000	94.3	95.3	96.0	98.0	96.4	95.3	-	-	-	-
8000	85.3	88.7	89.3	90.2	91.8	86.4	-	-	-	-
Total dBA	**102.3**	**103.1**	**103.5**	**103.5**	**103.5**	**104.0**	-	-	-	-

The site specific average summer nighttime wind shear exponent was provided by AWS Truewind, wind engineering consultants for Northland Power Inc on this project. Given the wind shear coefficient of 0.435, Vestas was unable to provide spectral data for such high shear values. As such, the maximum sound power of 104 dBA was used for all wind speeds. The spectrum values were provided for reference purposes only.

Table 4: Wind Turbine Locations				
		UTM Coordinates		
Identifier	Equipment Make & Model	X (m)	Y (m)	Remarks
T1	Vestas V90 1.8MW	426031	5089472	M1 Windfarm
T2	Vestas V90 1.8MW	425406	5089290	M1 Windfarm
T3	Vestas V90 1.8MW	420126	5086400	M1 Windfarm
T4	Vestas V90 1.8MW	426896	5088982	M1 Windfarm
T5	Vestas V90 1.8MW	425967	5088867	M1 Windfarm
T6	Vestas V90 1.8MW	425113	5088724	M1 Windfarm
T7	Vestas V90 1.8MW	423700	5088499	M1 Windfarm
T8	Vestas V90 1.8MW	422874	5088445	M1 Windfarm
T9	Vestas V90 1.8MW	426960	5088349	M1 Windfarm
T10	Vestas V90 1.8MW	426243	5088273	M1 Windfarm
T11	Vestas V90 1.8MW	419436	5088245	M1 Windfarm
T12	Vestas V90 1.8MW	424701	5088124	M1 Windfarm
T13	Vestas V90 1.8MW	425578	5087836	M1 Windfarm
T14	Vestas V90 1.8MW	423989	5087892	M1 Windfarm
T15	Vestas V90 1.8MW	426514	5087605	M1 Windfarm
T16	Vestas V90 1.8MW	424453	5087387	M1 Windfarm
T17	Vestas V90 1.8MW	420764	5087030	M1 Windfarm
T18	Vestas V90 1.8MW	422955	5086507	M1 Windfarm
T19	Vestas V90 1.8MW	426002	5086354	M1 Windfarm
T20	Vestas V90 1.8MW	425290	5086246	M1 Windfarm
T21	Vestas V90 1.8MW	421074	5086236	M1 Windfarm
T22	Vestas V90 1.8MW	424656	5085962	M1 Windfarm
T23	Vestas V90 1.8MW	422957	5085855	M1 Windfarm
T24	Vestas V90 1.8MW	425220	5085501	M1 Windfarm
T25	Vestas V90 1.8MW	415527	5085163	M1 Windfarm
T26	Vestas V90 1.8MW	416240	5085139	M1 Windfarm
T27	Vestas V90 1.8MW	417139	5085034	M1 Windfarm
T28	Vestas V90 1.8MW	424761	5085016	M1 Windfarm
T29	Vestas V90 1.8MW	423558	5084877	M1 Windfarm
T30	Vestas V90 1.8MW	424211	5084627	M1 Windfarm
T31	Vestas V90 1.8MW	417060	5084415	M1 Windfarm
T32	Vestas V90 1.8MW	416127	5084476	M1 Windfarm
T33	Vestas V90 1.8MW	415323	5084475	M1 Windfarm
T34	Vestas V90 1.8MW	423477	5084121	M1 Windfarm
T35	Vestas V90 1.8MW	415291	5083842	M1 Windfarm
T36	Vestas V90 1.8MW	416261	5083707	M1 Windfarm
T37	Vestas V90 1.8MW	414740	5083392	M1 Windfarm
T38	Vestas V90 1.8MW	415358	5083208	M1 Windfarm
T39	Vestas V90 1.8MW	417149	5082643	M1 Windfarm
T40	Vestas V90 1.8MW	416485	5082856	M1 Windfarm
T41	Vestas V90 1.8MW	415818	5082495	M1 Windfarm
T42	Vestas V90 1.8MW	417914	5082299	M1 Windfarm
T43	Vestas V90 1.8MW	416627	5082216	M1 Windfarm

4.2.3 Providence Bay Wind Farm

The Providence Bay Wind Farm is an operating 1.6 MW wind farm located near the towns of Providence Bay and Spring Bay, in the Township of Central Manitoulin, Manitoulin Island Ontario. Two Enercon E-48 800 kW wind turbine generators were commissioned and put into operation at Providence Bay on March 25, 2007. The related Providence Bay Expansion Project is in the Advanced-Stage of development.

As the Providence Bay is located more than 10km away from boundary of M1 wind farm, the total noise impact assessment on the M1 wind farm points of reception does not include the noise impact from Providence Bay wind farm

5.0 NOISE ASSESSMENT RESULTS

5.1 Transformer Station Impact Assessment

At the time of the noise impact assessment, the transformer manufacturer had not been finalized. As such, the noise model accounted for a point source with a flat noise spectrum with a maximum sound power of 86.5 dBA. This sound power level will represent that maximum sound power that a transformer can have without any noise controls in place. DataKustik CadnaA environmental noise model generated the worst-case results shown in Table 5. These results include sound power levels that account for tonality and contributions of the wind turbines. As indicated in the Table, and applying the conservative application of Class 3 (rural) areas to all Points of Reception, the transformers are not expected to meet the applicable noise guidelines without the application of abatement measures. The receptors identified in Table 5 are the worst-case receptors, closest to the transformer.

Table 5: Total Noise Impact without Transformer Noise Controls, 6m/s wind speed

Receptor	Description	Distance to Transformer (m)	Calculated Sound Level (dBA)	Allowable Level
R282	Residence, (on Green Bush Road)	260	39.1 dBA	40.0 dBA

5.2 Wind Turbine Impact Assessment

The noise impact at 297 receptor dwellings has been predicted using a formula based on ISO 9613-2 Part 2; consistent with the MOE's modelling requirements. The locations and sound power levels of all the wind turbine sources, the transformer station sources and the location of the receptors were integrated into a master data file.

Noise was predicted based on the following noise modelling protocol:

- Temperature = 10C
- Humidity = 70%
- G = 0.70 global ground attenuation factor
- Sound Level Limit = 40.0 dBA @6m/s wind @ 10m agl, i.e. precision to 1/10th of decibel

- Turbine noise emission adjusted to M1 specific conditions of average summer nighttime wind shear exponent =0.435
- Analysis to include only turbines within 5km of a receptor for those receptors whose closest turbine is within 1.5km
- Two storey dwelling = 4.5m receptor height @ center of dwelling
- Single storey dwelling = 4.5m receptor height @ center of dwelling

The highest noise level for each receptor, which represents the worst-case prediction, is outlined below in the assessment summary table.

The programme computes the octave band levels at the receptors from all the sound sources, including the transformers. The resultant A-weighted sound pressure levels are then transferred to the site map that shows both source and receiver locations. The detailed maps showing the locations of the wind turbines, transformer station, and the receptors are found in Figure 2.

Maximum sound levels have been predicted at all 297 dwellings. A Sample detailed calculation is provided in Attachment C. The maximum predicted sound levels at all non-participating receptors are predicted to be within the MOE environmental noise limits for Class 3 (rural) areas.

5.3 Wind Turbine Summary Tables

The sound power emitted by the wind turbines and transformer station, as well as their location with respect to the receptors determines the sound pressure levels induced by the operation of all Project components. The acoustic power of each wind turbine as provided by the manufacturer is shown in ATTACHMENT B.

The total noise impact at each receptor, including all wind turbines and transformer stations, has been summarized in the noise assessment summary table. The noise impact from the simultaneous operation of all wind turbines and transformers is less than or equal to the sound level limit associated with NPC 232 (i.e., 40.0 dBA).

The noise assessment summary table presents the predicted sound levels for all 297 dwellings that are located within 1,500m of a M1 wind turbine.

The closest non-participating receptor dwellings is R019 which is dwelling located 554m from turbine # 37 and R284 which is a located 553m away from turbine #1. All other non-participating receptor dwellings are more than 554m from a proposed M1 wind turbine.

6.0 CONCLUSION

The project site is rural: therefore the MOE's Class 3 (rural) designation applies.

Building upon the project specific sound limit guidelines, noise impact prediction modelling was undertaken. The noise impact on the nearest points of reception was predicted using an acoustic model, ISO 9613, as required by the MOE, based on noise from the Project's wind turbine array, coupled with transformers with transformer tonality penalty.

The noise assessment was based on all of the recommended procedures outlined in the MOE's "Noise Guidelines for Wind farms, October 2008" ref [17]

The analysis shows that the cumulative noise impact from the Project does not exceed the most restrictive noise limits that apply for areas with an acoustic designation of Class 3 (Rural) as defined by the MOE. Consequently, there is no need for the application of any additional mitigation measures and no further studies are contemplated for environmental noise in relation to the Project.

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Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R001	4.5	Residence	425848	5083118	2187	T28	26.9	26.9	26.9	26.9	26.9	40	43	45	49	51	Yes
R002	4.5	Residence	425770	5083073	2189	T28	26.9	26.9	26.9	26.9	26.9	40	43	45	49	51	Yes
R003	4.5	Residence	425207	5083180	1757	T30	28.9	28.9	28.9	28.9	28.9	40	43	45	49	51	Yes
R004	4.5	Residence	424906	5082966	1801	T30	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R005	4.5	Residence	424795	5083040	1691	T30	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R006	4.5	Residence	424422	5082993	1472	T34	30	30	30	30	30	40	43	45	49	51	Yes
R007	4.5	Residence	424307	5083188	1249	T34	31.5	31.5	31.5	31.5	31.5	40	43	45	49	51	Yes
R008	4.5	Residence	423155	5083142	1031	T34	31.7	31.7	31.7	31.7	31.7	40	43	45	49	51	Yes
R009	4.5	Residence	422309	5083084	1562	T34	27.8	27.8	27.8	27.8	27.8	40	43	45	49	51	Yes
R010	4.5	Residence	421365	5083081	2354	T34	23.4	23.4	23.4	23.4	23.4	40	43	45	49	51	Yes
R011	4.5	Residence	414344	5081036	2074	T41	28	28	28	28	28	40	43	45	49	51	Yes
R012	4.5	Residence	414311	5081196	1990	T41	28.4	28.4	28.4	28.4	28.4	40	43	45	49	51	Yes
R013	4.5	Residence	414299	5081242	1969	T41	28.6	28.6	28.6	28.6	28.6	40	43	45	49	51	Yes
R014	4.5	Residence	414412	5081942	1487	T37	31.8	31.8	31.8	31.8	31.8	40	43	45	49	51	Yes
R015	4.5	Residence	414235	5081847	1625	T37	30.5	30.5	30.5	30.5	30.5	40	43	45	49	51	Yes
R016	4.5	Residence	414339	5082499	979	T37	33.9	33.9	33.9	33.9	33.9	40	43	45	49	51	Yes
R017	4.5	Residence	414409	5082880	610	T37	37.3	37.3	37.3	37.3	37.3	40	43	45	49	51	Yes
R018	4.5	Residence	414380	5082933	583	T37	37.7	37.7	37.7	37.7	37.7	40	43	45	49	51	Yes
R019	4.5	Residence	414270	5083098	554	T37	37.8	37.8	37.8	37.8	37.8	40	43	45	49	51	Yes
R020	4.5	Residence	413725	5082956	1105	T37	31.5	31.5	31.5	31.5	31.5	40	43	45	49	51	Yes
R021	4.5	Residence	413701	5082942	1132	T37	31.3	31.3	31.3	31.3	31.3	40	43	45	49	51	Yes
R022	4.5	Residence	413750	5082896	1107	T37	31.3	31.3	31.3	31.3	31.3	40	43	45	49	51	Yes
R023	4.5	Residence	413784	5082742	1156	T37	29.9	29.9	29.9	29.9	29.9	40	43	45	49	51	Yes
R024	4.5	Residence	413775	5082673	1203	T37	29.6	29.6	29.6	29.6	29.6	40	43	45	49	51	Yes
R025	4.5	Residence	413675	5082506	1385	T37	28.3	28.3	28.3	28.3	28.3	40	43	45	49	51	Yes
R026	4.5	Residence	413581	5082369	1546	T37	27.7	27.7	27.7	27.7	27.7	40	43	45	49	51	Yes
R027	4.5	Residence	413606	5082202	1644	T37	26.7	26.7	26.7	26.7	26.7	40	43	45	49	51	Yes
R028	4.5	Residence	413448	5082021	1884	T37	26.6	26.6	26.6	26.6	26.6	40	43	45	49	51	Yes
R029	4.5	Residence	413396	5081968	1958	T37	26.2	26.2	26.2	26.2	26.2	40	43	45	49	51	Yes
R030	4.5	Residence	413345	5081912	2034	T37	26.1	26.1	26.1	26.1	26.1	40	43	45	49	51	Yes
R031	4.5	Residence	413290	5081850	2117	T37	25.8	25.8	25.8	25.8	25.8	40	43	45	49	51	Yes
R032	4.5	Residence	413255	5081810	2170	T37	25.5	25.5	25.5	25.5	25.5	40	43	45	49	51	Yes
R033	4.5	Residence	413185	5081718	2285	T37	24.4	24.4	24.4	24.4	24.4	40	43	45	49	51	Yes
R034	4.5	Residence	413172	5081643	2349	T37	24.1	24.1	24.1	24.1	24.1	40	43	45	49	51	Yes
R035	4.5	Residence	413128	5081605	2407	T37	23.9	23.9	23.9	23.9	23.9	40	43	45	49	51	Yes
R036	4.5	Residence	413108	5081561	2453	T37	23.4	23.4	23.4	23.4	23.4	40	43	45	49	51	Yes
R037	4.5	Residence	413089	5081537	2483	T37	23.3	23.3	23.3	23.3	23.3	40	43	45	49	51	Yes
R038	4.5	Residence	413062	5081495	2533	T37	23.1	23.1	23.1	23.1	23.1	40	43	45	49	51	Yes
R039	4.5	Residence	413030	5081446	2591	T37	22.9	22.9	22.9	22.9	22.9	40	43	45	49	51	Yes
R040	4.5	Residence	413002	5081405	2640	T37	22.1	22.1	22.1	22.1	22.1	40	43	45	49	51	Yes
R041	4.5	Residence	412988	5081382	2666	T37	22	22	22	22	22	40	43	45	49	51	Yes
R042	4.5	Residence	412964	5081349	2707	T37	21.5	21.5	21.5	21.5	21.5	40	43	45	49	51	Yes
R043	4.5	Residence	412949	5081327	2733	T37	21.4	21.4	21.4	21.4	21.4	40	43	45	49	51	Yes
R044	4.5	Residence	412942	5081315	2747	T37	21.4	21.4	21.4	21.4	21.4	40	43	45	49	51	Yes

Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R045	4.5	Residence	413762	5083132	1012	T37	32.1	32.1	32.1	32.1	32.1	40	43	45	49	51	Yes
R046	4.5	Residence	413720	5083178	1042	T37	31.9	31.9	31.9	31.9	31.9	40	43	45	49	51	Yes
R047	4.5	Residence	413696	5083199	1062	T37	31.7	31.7	31.7	31.7	31.7	40	43	45	49	51	Yes
R048	4.5	Residence	413683	5083273	1064	T37	31.9	31.9	31.9	31.9	31.9	40	43	45	49	51	Yes
R049	4.5	Residence	413601	5083352	1140	T37	31.5	31.5	31.5	31.5	31.5	40	43	45	49	51	Yes
R050	4.5	Residence	413574	5083324	1168	T37	31.3	31.3	31.3	31.3	31.3	40	43	45	49	51	Yes
R051	4.5	Residence	413495	5083401	1245	T37	31	31	31	31	31	40	43	45	49	51	Yes
R052	4.5	Residence	413491	5083827	1323	T37	31.2	31.2	31.2	31.2	31.2	40	43	45	49	51	Yes
R053	4.5	Residence	413825	5084524	1456	T37	32.1	32.1	32.1	32.1	32.1	40	43	45	49	51	Yes
R054	4.5	Residence	414213	5084742	1142	T33	33.9	33.9	33.9	33.9	33.9	40	43	45	49	51	Yes
R055	4.5	Residence	414370	5083886	617	T37	38.1	38.1	38.1	38.1	38.1	40	43	45	49	51	Yes
R056	4.5	Residence	414371	5083958	676	T37	37.6	37.6	37.6	37.6	37.6	40	43	45	49	51	Yes
R057	4.5	Residence	414879	5085178	648	T25	37.5	37.5	37.5	37.5	37.5	40	43	45	49	51	Yes
R058	4.5	Residence	414972	5085133	556	T25	38.4	38.4	38.4	38.4	38.4	40	43	45	49	51	Yes
R059	4.5	Residence	414307	5085243	1223	T25	32.9	32.9	32.9	32.9	32.9	40	43	45	49	51	Yes
R060	4.5	Residence	414272	5085861	1436	T25	30.2	30.2	30.2	30.2	30.2	40	43	45	49	51	Yes
R061	4.5	Residence	414215	5085774	1447	T25	30.3	30.3	30.3	30.3	30.3	40	43	45	49	51	Yes
R062	4.5	Residence	414183	5085687	1443	T25	30.6	30.6	30.6	30.6	30.6	40	43	45	49	51	Yes
R063	4.5	Residence	414143	5085669	1474	T25	30.4	30.4	30.4	30.4	30.4	40	43	45	49	51	Yes
R064	4.5	Residence	414087	5085618	1510	T25	30.3	30.3	30.3	30.3	30.3	40	43	45	49	51	Yes
R065	4.5	Residence	414056	5085605	1536	T25	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R066	4.5	Residence	415497	5086237	1074	T25	32	32	32	32	32	40	43	45	49	51	Yes
R067	4.5	Residence	415594	5086574	1413	T25	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R068	4.5	Residence	415432	5086625	1465	T25	29.2	29.2	29.2	29.2	29.2	40	43	45	49	51	Yes
R069	4.5	Residence	415396	5086649	1492	T25	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R070	4.5	Residence	415344	5086540	1389	T25	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R071	4.5	Residence	415301	5086495	1351	T25	29.9	29.9	29.9	29.9	29.9	40	43	45	49	51	Yes
R072	4.5	Residence	415476	5086730	1568	T25	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R073	4.5	Residence	415503	5086756	1593	T25	28.6	28.6	28.6	28.6	28.6	40	43	45	49	51	Yes
R074	4.5	Residence	415549	5086772	1609	T25	28.5	28.5	28.5	28.5	28.5	40	43	45	49	51	Yes
R075	4.5	Residence	415571	5086817	1655	T25	28.3	28.3	28.3	28.3	28.3	40	43	45	49	51	Yes
R076	4.5	Residence	415627	5086826	1666	T25	28.3	28.3	28.3	28.3	28.3	40	43	45	49	51	Yes
R077	4.5	Residence	415617	5086891	1730	T25	27.9	27.9	27.9	27.9	27.9	40	43	45	49	51	Yes
R078	4.5	Residence	415731	5086962	1811	T25	27.4	27.4	27.4	27.4	27.4	40	43	45	49	51	Yes
R079	4.5	Residence	415781	5087030	1884	T25	27	27	27	27	27	40	43	45	49	51	Yes
R080	4.5	Residence	415836	5087086	1948	T25	26.8	26.8	26.8	26.8	26.8	40	43	45	49	51	Yes
R081	4.5	Residence	415995	5087198	2074	T26	26.2	26.2	26.2	26.2	26.2	40	43	45	49	51	Yes
R082	4.5	Residence	415941	5087220	2098	T25	26.1	26.1	26.1	26.1	26.1	40	43	45	49	51	Yes
R083	4.5	Residence	415453	5087273	2111	T25	26.3	26.3	26.3	26.3	26.3	40	43	45	49	51	Yes
R084	4.5	Residence	416012	5087285	2158	T26	25.8	25.8	25.8	25.8	25.8	40	43	45	49	51	Yes
R085	4.5	Residence	416038	5087334	2204	T26	25.6	25.6	25.6	25.6	25.6	40	43	45	49	51	Yes
R086	4.5	Residence	416093	5087356	2222	T26	25.5	25.5	25.5	25.5	25.5	40	43	45	49	51	Yes
R087	4.5	Residence	416094	5087400	2266	T26	25.3	25.3	25.3	25.3	25.3	40	43	45	49	51	Yes
R088	4.5	Residence	416150	5087427	2290	T26	25.2	25.2	25.2	25.2	25.2	40	43	45	49	51	Yes

Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R089	4.5	Residence	416234	5087588	2449	T26	24.5	24.5	24.5	24.5	24.5	40	43	45	49	51	Yes
R092	4.5	Residence	419681	5089119	908	T11	31.1	31.1	31.1	31.1	31.1	40	43	45	49	51	Yes
R093	4.5	Residence	419277	5090192	1953	T11	23.7	23.7	23.7	23.7	23.7	40	43	45	49	51	Yes
R094	4.5	Residence	419206	5090217	1985	T11	23.5	23.5	23.5	23.5	23.5	40	43	45	49	51	Yes
R095	4.5	Residence	418890	5089158	1064	T11	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R096	4.5	Residence	418649	5089115	1173	T11	28	28	28	28	28	40	43	45	49	51	Yes
R097	4.5	Residence	418572	5089260	1333	T11	26.8	26.8	26.8	26.8	26.8	40	43	45	49	51	Yes
R098	4.5	Residence	418439	5089067	1292	T11	27.1	27.1	27.1	27.1	27.1	40	43	45	49	51	Yes
R099	4.5	Residence	418387	5089036	1314	T11	26.9	26.9	26.9	26.9	26.9	40	43	45	49	51	Yes
R100	4.5	Residence	418218	5088922	1394	T11	26.3	26.3	26.3	26.3	26.3	40	43	45	49	51	Yes
R101	4.5	Residence	418170	5088875	1414	T11	26.2	26.2	26.2	26.2	26.2	40	43	45	49	51	Yes
R102	4.5	Residence	418135	5088810	1418	T11	26.2	26.2	26.2	26.2	26.2	40	43	45	49	51	Yes
R103	4.5	Residence	418091	5088876	1486	T11	25.7	25.7	25.7	25.7	25.7	40	43	45	49	51	Yes
R104	4.5	Residence	418054	5088846	1507	T11	25.6	25.6	25.6	25.6	25.6	40	43	45	49	51	Yes
R105	4.5	Residence	418002	5088790	1534	T11	25.4	25.4	25.4	25.4	25.4	40	43	45	49	51	Yes
R106	4.5	Residence	417938	5088736	1576	T11	25.1	25.1	25.1	25.1	25.1	40	43	45	49	51	Yes
R107	4.5	Residence	417895	5088692	1605	T11	25	25	25	25	25	40	43	45	49	51	Yes
R108	4.5	Residence	417814	5088726	1692	T11	24.4	24.4	24.4	24.4	24.4	40	43	45	49	51	Yes
R109	4.5	Residence	417813	5088662	1676	T11	24.5	24.5	24.5	24.5	24.5	40	43	45	49	51	Yes
R110	4.5	Residence	417775	5088658	1712	T11	24.3	24.3	24.3	24.3	24.3	40	43	45	49	51	Yes
R111	4.5	Residence	417685	5088674	1803	T11	23.8	23.8	23.8	23.8	23.8	40	43	45	49	51	Yes
R112	4.5	Residence	417653	5088682	1836	T11	23.6	23.6	23.6	23.6	23.6	40	43	45	49	51	Yes
R113	4.5	Residence	417684	5088577	1783	T11	24	24	24	24	24	40	43	45	49	51	Yes
R114	4.5	Residence	417611	5088617	1863	T11	23.5	23.5	23.5	23.5	23.5	40	43	45	49	51	Yes
R115	4.5	Residence	417792	5088013	1660	T11	24.9	24.9	24.9	24.9	24.9	40	43	45	49	51	Yes
R116	4.5	Residence	417573	5088557	1889	T11	23.4	23.4	23.4	23.4	23.4	40	43	45	49	51	Yes
R117	4.5	Residence	417528	5088537	1930	T11	23.3	23.3	23.3	23.3	23.3	40	43	45	49	51	Yes
R118	4.5	Residence	417399	5088504	2053	T11	23	23	23	23	23	40	43	45	49	51	Yes
R119	4.5	Residence	417294	5088398	2147	T11	22.9	22.9	22.9	22.9	22.9	40	43	45	49	51	Yes
R120	4.5	Residence	417204	5088344	2234	T11	22.7	22.7	22.7	22.7	22.7	40	43	45	49	51	Yes
R121	4.5	Residence	417184	5088328	2254	T11	22.7	22.7	22.7	22.7	22.7	40	43	45	49	51	Yes
R122	4.5	Residence	416992	5088231	2444	T11	22.4	22.4	22.4	22.4	22.4	40	43	45	49	51	Yes
R123	4.5	Residence	417136	5088293	2301	T11	22.6	22.6	22.6	22.6	22.6	40	43	45	49	51	Yes
R124	4.5	Residence	417278	5088168	2159	T11	22.9	22.9	22.9	22.9	22.9	40	43	45	49	51	Yes
R125	4.5	Residence	417267	5088106	2173	T11	23	23	23	23	23	40	43	45	49	51	Yes
R126	4.5	Residence	416826	5088186	2611	T11	22.8	22.8	22.8	22.8	22.8	40	43	45	49	51	Yes
R127	4.5	Residence	416752	5088186	2685	T11	22.8	22.8	22.8	22.8	22.8	40	43	45	49	51	Yes
R128	4.5	Residence	416648	5087998	2799	T11	23.2	23.2	23.2	23.2	23.2	40	43	45	49	51	Yes
R129	4.5	Residence	416489	5087841	2713	T26	23.6	23.6	23.6	23.6	23.6	40	43	45	49	51	Yes
R130	4.5	Residence	416429	5087760	2628	T26	23.9	23.9	23.9	23.9	23.9	40	43	45	49	51	Yes
R131	4.5	Residence	416284	5087570	2431	T26	24.5	24.5	24.5	24.5	24.5	40	43	45	49	51	Yes
R132	4.5	Residence	416332	5087677	2540	T26	24.1	24.1	24.1	24.1	24.1	40	43	45	49	51	Yes

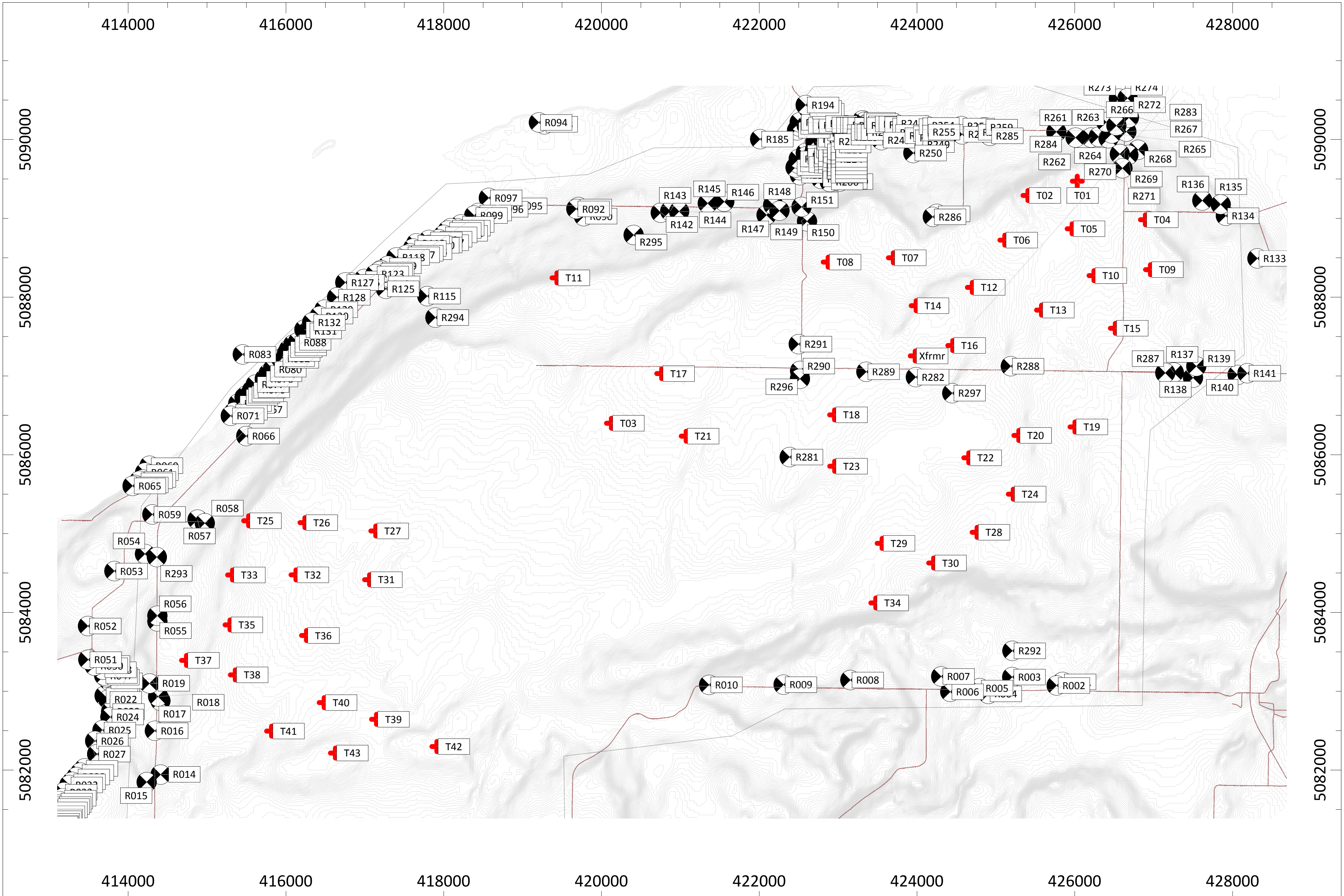
Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R133	4.5	Residence	428315	5088492	1363	T9	31	31	31	31	31	40	43	45	49	51	Yes
R134	4.5	Residence	427915	5089033	1020	T4	33.1	33.1	33.1	33.1	33.1	40	43	45	49	51	Yes
R135	4.5	Residence	427850	5089177	974	T4	33.2	33.2	33.2	33.2	33.2	40	43	45	49	51	Yes
R136	4.5	Residence	427616	5089226	760	T4	35	35	35	35	35	40	43	45	49	51	Yes
R137	4.5	Residence	427256	5087044	930	T15	35	35	35	35	35	40	43	45	49	51	Yes
R138	4.5	Residence	427499	5086978	1168	T15	33.4	33.4	33.4	33.4	33.4	40	43	45	49	51	Yes
R139	4.5	Residence	427540	5087122	1134	T15	33.6	33.6	33.6	33.6	33.6	40	43	45	49	51	Yes
R140	4.5	Residence	428065	5087013	1660	T15	30.6	30.6	30.6	30.6	30.6	40	43	45	49	51	Yes
R141	4.5	Residence	428189	5087035	1769	T15	30.1	30.1	30.1	30.1	30.1	40	43	45	49	51	Yes
R142	4.5	Residence	420751	5089072	1553	T11	27.3	27.3	27.3	27.3	27.3	40	43	45	49	51	Yes
R143	4.5	Residence	420871	5089092	1666	T11	27.1	27.1	27.1	27.1	27.1	40	43	45	49	51	Yes
R144	4.5	Residence	420985	5089087	1763	T11	27.1	27.1	27.1	27.1	27.1	40	43	45	49	51	Yes
R145	4.5	Residence	421348	5089190	1698	T8	27.4	27.4	27.4	27.4	27.4	40	43	45	49	51	Yes
R146	4.5	Residence	421557	5089211	1524	T8	28.4	28.4	28.4	28.4	28.4	40	43	45	49	51	Yes
R147	4.5	Residence	422092	5089042	984	T8	31	31	31	31	31	40	43	45	49	51	Yes
R148	4.5	Residence	422176	5089170	1006	T8	30.7	30.7	30.7	30.7	30.7	40	43	45	49	51	Yes
R149	4.5	Residence	422257	5089097	898	T8	31.8	31.8	31.8	31.8	31.8	40	43	45	49	51	Yes
R150	4.5	Residence	422606	5088962	582	T8	37	37	37	37	37	40	43	45	49	51	Yes
R151	4.5	Residence	422536	5089145	777	T8	29.5	29.5	29.5	29.5	29.5	40	43	45	49	51	Yes
R152	4.5	Residence	422516	5089548	1160	T8	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R153	4.5	Residence	422511	5089612	1222	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R154	4.5	Residence	422460	5089645	1269	T8	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R155	4.5	Residence	422502	5089691	1300	T8	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R156	4.5	Residence	422501	5089754	1361	T8	28.8	28.8	28.8	28.8	28.8	40	43	45	49	51	Yes
R157	4.5	Residence	422590	5089829	1413	T8	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R158	4.5	Residence	422596	5089787	1370	T8	28.9	28.9	28.9	28.9	28.9	40	43	45	49	51	Yes
R159	4.5	Residence	422609	5089684	1267	T8	29.5	29.5	29.5	29.5	29.5	40	43	45	49	51	Yes
R160	4.5	Residence	422680	5089676	1246	T8	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R161	4.5	Residence	422678	5089714	1284	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R162	4.5	Residence	422675	5089755	1325	T8	29.3	29.3	29.3	29.3	29.3	40	43	45	49	51	Yes
R163	4.5	Residence	422680	5089791	1360	T8	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R164	4.5	Residence	422707	5089868	1433	T8	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R165	4.5	Residence	422748	5089886	1446	T8	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R166	4.5	Residence	422800	5089905	1462	T8	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R167	4.5	Residence	422731	5089673	1236	T8	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R168	4.5	Residence	422731	5089718	1281	T8	29.5	29.5	29.5	29.5	29.5	40	43	45	49	51	Yes
R169	4.5	Residence	422731	5089757	1320	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R170	4.5	Residence	422732	5089824	1386	T8	29	29	29	29	29	40	43	45	49	51	Yes
R171	4.5	Residence	422788	5089835	1393	T8	29	29	29	29	29	40	43	45	49	51	Yes
R172	4.5	Residence	422789	5089778	1336	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R173	4.5	Residence	422789	5089728	1286	T8	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R174	4.5	Residence	422791	5089680	1238	T8	29.9	29.9	29.9	29.9	29.9	40	43	45	49	51	Yes
R175	4.5	Residence	422788	5089603	1161	T8	30.2	30.2	30.2	30.2	30.2	40	43	45	49	51	Yes
R176	4.5	Residence	422782	5089544	1103	T8	30.6	30.6	30.6	30.6	30.6	40	43	45	49	51	Yes

Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R177	4.5	Residence	422786	5089501	1060	T8	30.8	30.8	30.8	30.8	30.8	40	43	45	49	51	Yes
R178	4.5	Residence	422837	5089596	1152	T8	30.5	30.5	30.5	30.5	30.5	40	43	45	49	51	Yes
R179	4.5	Residence	423019	5089466	1031	T8	28.9	28.9	28.9	28.9	28.9	40	43	45	49	51	Yes
R180	4.5	Residence	422713	5089969	1532	T8	28.2	28.2	28.2	28.2	28.2	40	43	45	49	51	Yes
R181	4.5	Residence	422729	5090005	1567	T8	29.2	29.2	29.2	29.2	29.2	40	43	45	49	51	Yes
R182	4.5	Residence	422810	5090000	1556	T8	28.6	28.6	28.6	28.6	28.6	40	43	45	49	51	Yes
R183	4.5	Residence	422847	5090085	1640	T8	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R184	4.5	Residence	422929	5090093	1649	T8	29.2	29.2	29.2	29.2	29.2	40	43	45	49	51	Yes
R185	4.5	Residence	422011	5090004	1782	T8	27.2	27.2	27.2	27.2	27.2	40	43	45	49	51	Yes
R186	4.5	Residence	422479	5090116	1717	T8	28	28	28	28	28	40	43	45	49	51	Yes
R187	4.5	Residence	422506	5090166	1760	T8	28.1	28.1	28.1	28.1	28.1	40	43	45	49	51	Yes
R188	4.5	Residence	422513	5090218	1809	T8	27.9	27.9	27.9	27.9	27.9	40	43	45	49	51	Yes
R189	4.5	Residence	422602	5090178	1754	T8	28.2	28.2	28.2	28.2	28.2	40	43	45	49	51	Yes
R190	4.5	Residence	422663	5090181	1749	T8	28.4	28.4	28.4	28.4	28.4	40	43	45	49	51	Yes
R191	4.5	Residence	422739	5090180	1740	T8	28.5	28.5	28.5	28.5	28.5	40	43	45	49	51	Yes
R192	4.5	Residence	422656	5090359	1926	T8	27.6	27.6	27.6	27.6	27.6	40	43	45	49	51	Yes
R193	4.5	Residence	422623	5090394	1965	T8	27.7	27.7	27.7	27.7	27.7	40	43	45	49	51	Yes
R194	4.5	Residence	422589	5090438	2013	T8	27.5	27.5	27.5	27.5	27.5	40	43	45	49	51	Yes
R195	4.5	Residence	422822	5090202	1758	T8	28.6	28.6	28.6	28.6	28.6	40	43	45	49	51	Yes
R196	4.5	Residence	422903	5090183	1738	T8	28.8	28.8	28.8	28.8	28.8	40	43	45	49	51	Yes
R197	4.5	Residence	422960	5090180	1737	T8	28.9	28.9	28.9	28.9	28.9	40	43	45	49	51	Yes
R198	4.5	Residence	423010	5090182	1742	T8	29	29	29	29	29	40	43	45	49	51	Yes
R199	4.5	Residence	423041	5090182	1745	T8	29	29	29	29	29	40	43	45	49	51	Yes
R200	4.5	Residence	423104	5090182	1752	T8	29.2	29.2	29.2	29.2	29.2	40	43	45	49	51	Yes
R201	4.5	Residence	423190	5090177	1754	T7	29.6	29.6	29.6	29.6	29.6	40	43	45	49	51	Yes
R202	4.5	Residence	423098	5090087	1657	T8	29.5	29.5	29.5	29.5	29.5	40	43	45	49	51	Yes
R203	4.5	Residence	423147	5090088	1666	T8	29.6	29.6	29.6	29.6	29.6	40	43	45	49	51	Yes
R204	4.5	Residence	423094	5090033	1603	T8	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R205	4.5	Residence	422948	5089472	1030	T8	28.7	28.7	28.7	28.7	28.7	40	43	45	49	51	Yes
R206	4.5	Residence	422895	5089462	1017	T8	28.6	28.6	28.6	28.6	28.6	40	43	45	49	51	Yes
R207	4.5	Residence	422844	5089599	1154	T8	30.5	30.5	30.5	30.5	30.5	40	43	45	49	51	Yes
R208	4.5	Residence	422845	5089639	1194	T8	30.2	30.2	30.2	30.2	30.2	40	43	45	49	51	Yes
R209	4.5	Residence	422845	5089691	1246	T8	29.9	29.9	29.9	29.9	29.9	40	43	45	49	51	Yes
R210	4.5	Residence	422846	5089739	1294	T8	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R211	4.5	Residence	422844	5089791	1346	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R212	4.5	Residence	422845	5089844	1399	T8	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R213	4.5	Residence	422892	5089867	1422	T8	29.1	29.1	29.1	29.1	29.1	40	43	45	49	51	Yes
R214	4.5	Residence	422889	5089810	1365	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R215	4.5	Residence	422890	5089736	1291	T8	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R216	4.5	Residence	422890	5089639	1194	T8	30.3	30.3	30.3	30.3	30.3	40	43	45	49	51	Yes
R217	4.5	Residence	422890	5089639	1194	T8	30.3	30.3	30.3	30.3	30.3	40	43	45	49	51	Yes
R218	4.5	Residence	422890	5089590	1145	T8	30.6	30.6	30.6	30.6	30.6	40	43	45	49	51	Yes
R219	4.5	Residence	422889	5089547	1102	T8	30.7	30.7	30.7	30.7	30.7	40	43	45	49	51	Yes
R220	4.5	Residence	422948	5089552	1109	T8	30.8	30.8	30.8	30.8	30.8	40	43	45	49	51	Yes

Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R221	4.5	Residence	422946	5089602	1159	T8	30.6	30.6	30.6	30.6	30.6	40	43	45	49	51	Yes
R222	4.5	Residence	422948	5089653	1210	T8	30.3	30.3	30.3	30.3	30.3	40	43	45	49	51	Yes
R223	4.5	Residence	422948	5089704	1261	T8	30.1	30.1	30.1	30.1	30.1	40	43	45	49	51	Yes
R224	4.5	Residence	422948	5089749	1306	T8	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R225	4.5	Residence	422948	5089815	1372	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R226	4.5	Residence	422951	5089869	1426	T8	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R227	4.5	Residence	422995	5089931	1491	T8	29.3	29.3	29.3	29.3	29.3	40	43	45	49	51	Yes
R228	4.5	Residence	422932	5089974	1530	T8	29	29	29	29	29	40	43	45	49	51	Yes
R229	4.5	Residence	423145	5090030	1608	T8	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R230	4.5	Residence	423146	5090090	1667	T8	29.5	29.5	29.5	29.5	29.5	40	43	45	49	51	Yes
R231	4.5	Residence	423191	5090099	1679	T7	29.6	29.6	29.6	29.6	29.6	40	43	45	49	51	Yes
R232	4.5	Residence	423219	5090091	1663	T7	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R233	4.5	Residence	423271	5090090	1648	T7	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R234	4.5	Residence	423351	5090090	1629	T7	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R235	4.5	Residence	423309	5090243	1787	T7	29.7	29.7	29.7	29.7	29.7	40	43	45	49	51	Yes
R236	4.5	Residence	423340	5090227	1765	T7	29.8	29.8	29.8	29.8	29.8	40	43	45	49	51	Yes
R237	4.5	Residence	423365	5090198	1732	T7	30	30	30	30	30	40	43	45	49	51	Yes
R238	4.5	Residence	423343	5090178	1717	T7	29.9	29.9	29.9	29.9	29.9	40	43	45	49	51	Yes
R239	4.5	Residence	423451	5090198	1717	T7	30.1	30.1	30.1	30.1	30.1	40	43	45	49	51	Yes
R240	4.5	Residence	423498	5090196	1709	T7	30	30	30	30	30	40	43	45	49	51	Yes
R241	4.5	Residence	423572	5090189	1695	T7	30.2	30.2	30.2	30.2	30.2	40	43	45	49	51	Yes
R242	4.5	Residence	423672	5090170	1671	T7	30.5	30.5	30.5	30.5	30.5	40	43	45	49	51	Yes
R243	4.5	Residence	423723	5090202	1703	T7	30.4	30.4	30.4	30.4	30.4	40	43	45	49	51	Yes
R244	4.5	Residence	423707	5090089	1590	T7	30.9	30.9	30.9	30.9	30.9	40	43	45	49	51	Yes
R245	4.5	Residence	423552	5089992	1500	T7	31.1	31.1	31.1	31.1	31.1	40	43	45	49	51	Yes
R246	4.5	Residence	423828	5090048	1554	T7	31.3	31.3	31.3	31.3	31.3	40	43	45	49	51	Yes
R247	4.5	Residence	423935	5090074	1592	T7	31.4	31.4	31.4	31.4	31.4	40	43	45	49	51	Yes
R248	4.5	Residence	423960	5090021	1544	T7	31.7	31.7	31.7	31.7	31.7	40	43	45	49	51	Yes
R249	4.5	Residence	424053	5089936	1480	T7	32.4	32.4	32.4	32.4	32.4	40	43	45	49	51	Yes
R250	4.5	Residence	423953	5089829	1354	T7	32.7	32.7	32.7	32.7	32.7	40	43	45	49	51	Yes
R251	4.5	Residence	424006	5090163	1650	T2	31.2	31.2	31.2	31.2	31.2	40	43	45	49	51	Yes
R252	4.5	Residence	424053	5090175	1617	T2	31.2	31.2	31.2	31.2	31.2	40	43	45	49	51	Yes
R253	4.5	Residence	424051	5090082	1569	T2	31.7	31.7	31.7	31.7	31.7	40	43	45	49	51	Yes
R254	4.5	Residence	424114	5090178	1568	T2	31.3	31.3	31.3	31.3	31.3	40	43	45	49	51	Yes
R255	4.5	Residence	424124	5090094	1513	T2	31.7	31.7	31.7	31.7	31.7	40	43	45	49	51	Yes
R256	4.5	Residence	424562	5090170	1219	T2	32.5	32.5	32.5	32.5	32.5	40	43	45	49	51	Yes
R257	4.5	Residence	424572	5090066	1139	T2	33.2	33.2	33.2	33.2	33.2	40	43	45	49	51	Yes
R259	4.5	Residence	424854	5090155	1026	T2	33.7	33.7	33.7	33.7	33.7	40	43	45	49	51	Yes
R260	4.5	Residence	424251	5089057	784	T7	37.1	37.1	37.1	37.1	37.1	40	43	45	49	51	Yes
R262	4.5	Residence	426208	5090025	581	T1	37	37	37	37	37	40	43	45	49	51	Yes
R263	4.5	Residence	426302	5090035	625	T1	36.4	36.4	36.4	36.4	36.4	40	43	45	49	51	Yes
R264	4.5	Residence	426427	5090016	673	T1	35.9	35.9	35.9	35.9	35.9	40	43	45	49	51	Yes

Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R265	4.5	Residence	426470	5090076	747	T1	35.1	35.1	35.1	35.1	35.1	40	43	45	49	51	Yes
R266	4.5	Residence	426400	5090220	834	T1	34.1	34.1	34.1	34.1	34.1	40	43	45	49	51	Yes
R267	4.5	Residence	426654	5090101	885	T1	33.9	33.9	33.9	33.9	33.9	40	43	45	49	51	Yes
R268	4.5	Residence	426803	5089870	869	T1	34.7	34.7	34.7	34.7	34.7	40	43	45	49	51	Yes
R269	4.5	Residence	426680	5089805	729	T1	35.9	35.9	35.9	35.9	35.9	40	43	45	49	51	Yes
R270	4.5	Residence	426571	5089815	640	T1	35.7	35.7	35.7	35.7	35.7	40	43	45	49	51	Yes
R271	4.5	Residence	426605	5089636	597	T1	36.7	36.7	36.7	36.7	36.7	40	43	45	49	51	Yes
R272	4.5	Residence	426686	5090278	1039	T1	32.5	32.5	32.5	32.5	32.5	40	43	45	49	51	Yes
R273	4.5	Residence	426560	5090519	1173	T1	32	32	32	32	32	40	43	45	49	51	Yes
R274	4.5	Residence	426669	5090525	1231	T1	31.6	31.6	31.6	31.6	31.6	40	43	45	49	51	Yes
R275	4.5	Residence	426494	5090859	1462	T1	30.1	30.1	30.1	30.1	30.1	40	43	45	49	51	Yes
R276	4.5	Residence	427119	5091071	1934	T1	27.9	27.9	27.9	27.9	27.9	40	43	45	49	51	Yes
R277	4.5	Residence	427330	5091149	2121	T1	27.2	27.2	27.2	27.2	27.2	40	43	45	49	51	Yes
R278	4.5	Residence	427400	5091255	2248	T1	26.6	26.6	26.6	26.6	26.6	40	43	45	49	51	Yes
R279	4.5	Residence	427452	5091277	2297	T1	26.5	26.5	26.5	26.5	26.5	40	43	45	49	51	Yes
R280	4.5	Residence	427503	5091292	2341	T1	26.3	26.3	26.3	26.3	26.3	40	43	45	49	51	Yes
R281	4.5	Residence	422386	5085971	583	T23	38.5	38.5	38.5	38.5	38.5	40	43	45	49	51	Yes
R282	4.5	Residence	423985	5086985	617	T16	39.8	39.8	39.8	39.8	39.8	40	43	45	49	51	Yes
R283	4.5	Residence	426527	5090176	862	T1	33.8	33.8	33.8	33.8	33.8	40	43	45	49	51	Yes
R284	4.5	Residence	426010	5090024	553	T1	37.5	37.5	37.5	37.5	37.5	40	43	45	49	51	Yes
R285	4.5	Residence	424926	5090047	896	T2	34.6	34.6	34.6	34.6	34.6	40	43	45	49	51	Yes
R286	4.5	Residence	424200	5089019	721	T7	37	37	37	37	37	40	43	45	49	51	Yes
R287	4.5	Residence	427148	5087039	850	T15	35.5	35.5	35.5	35.5	35.5	40	43	45	49	51	Yes
R288	4.5	Residence	425189	5087124	781	T16	39.4	39.4	39.4	39.4	39.4	40	43	45	49	51	Yes
R289	4.5	Residence	423357	5087054	679	T18	38.2	38.2	38.2	38.2	38.2	40	43	45	49	51	Yes
R290	4.5	Residence	422517	5087064	709	T18	36.7	36.7	36.7	36.7	36.7	40	43	45	49	51	Yes
R291	4.5	Residence	422500	5087404	1006	T18	35.5	35.5	35.5	35.5	35.5	40	43	45	49	51	Yes
R292	4.5	Residence	425210	5083512	1497	T30	30.2	30.2	30.2	30.2	30.2	40	43	45	49	51	Yes
R293	4.5	Residence	414364	5084702	985	T33	34.9	34.9	34.9	34.9	34.9	40	43	45	49	51	Yes
R294	4.5	Residence	417895	5087741	1621	T11	25.2	25.2	25.2	25.2	25.2	40	43	45	49	51	Yes
R295	4.5	Residence	420407	5088789	1113	T11	29.4	29.4	29.4	29.4	29.4	40	43	45	49	51	Yes
R296	4.5	Residence	422517	5086964	633	T18	37.3	37.3	37.3	37.3	37.3	40	43	45	49	51	Yes
R297	4.5	Residence	424447	5086782	605	T16	39.4	39.4	39.4	39.4	39.4	40	43	45	49	51	Yes

Point of Reception ID	Receptor Height [m]	Receptor Description			Distance to nearest Turbine [m]	Turbine ID	Calculated Sound Pressure Level [dBA] at Selected Windspeed [m/s]					Sound Level Limit [dBA] at Selected Windspeed [m/s]					Compiance with Limit [Yes/No]
			Easting	Northing			<=6	7	8	9	10	<=6	7	8	9	10	
R090	4.5	Residence	419777	5089027	853	T11	31.9	31.9	31.9	31.9	31.9	40	43	45	49	51	Yes
R091	4.5	Residence	419708	5089143	938	T11	30.8	30.8	30.8	30.8	30.8	40	43	45	49	51	Yes
R258	4.5	Residence	424757	5090092	1032	T2	33.7	33.7	33.7	33.7	33.7	40	43	45	49	51	Yes
R261	4.5	Residence	425766	5090096	678	T1	36.4	36.4	36.4	36.4	36.4	40	43	45	49	51	Yes



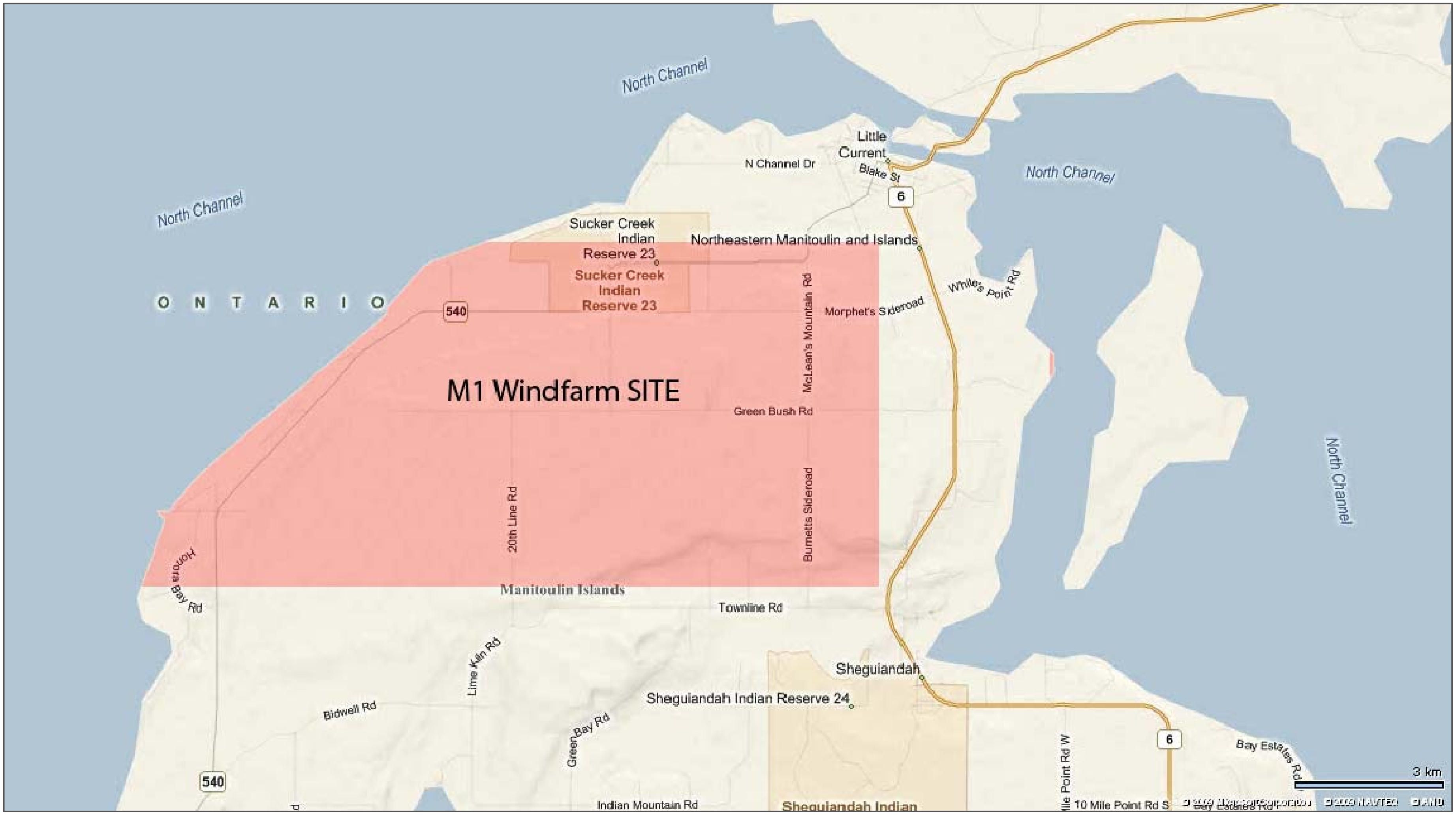
AERCOUSTICS
ENGINEERING LIMITED

50 Ronson Drive Suite 165 Toronto, Canada M9W 1B3

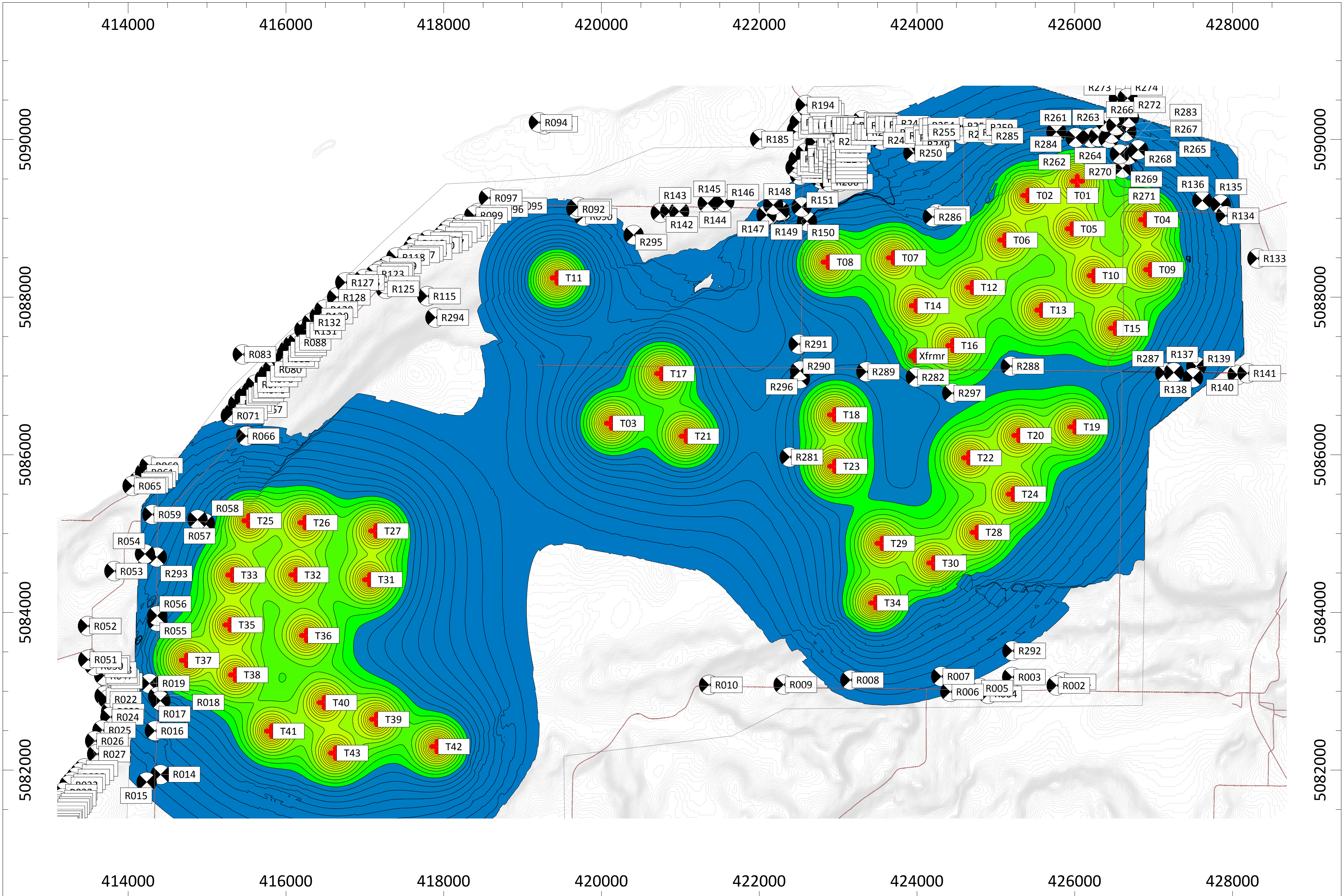
M1 Manitoulin Island Wind Farm
Turbine and Transformer Layout
VESTAS V90 WTGs

Drawn:	Eng:	Drawing:
PA	WR	Noise Contour

Date:	Scale:	Fig
July 22, 2009	NTS	2



AERCOUSTICS ENGINEERING LIMITED	50 Ronson Drive Suite 165 Toronto Canada M9W 1B3 (416)249-3361	M1 MANITOULIN ISLAND WIND FARM SITE AREA	Drawn PA	Eng. WR	Drawing Key Plan
			The scope of the work outlined in this document is limited to the acoustic noise & vibration control aspects of the design. Contractor to verify all dimensions.		Scale NTS
					Figure 1



AERCOUSTICS ENGINEERING LIMITED	M1 Manitoulin Island Wind Farm VESTAS V90 WTGs Windspeed: 6m/s m=0.435	Drawn: PA	Eng: WR	Drawing: Noise Contour
50 Ronson Drive Suite 165 Toronto, Canada M9W 1B3		Date: July 22, 2009	Scale: NTS	Fig 3

ATTACHMENT A

REPRINT OF MOE PUBLICATION, OCTOBER 2008

NOISE GUIDELINES FOR WIND FARMS INTERPRETATION FOR APPLYING MOE NPC PUBLICATIONS TO WIND POWER GENERATION FACILITIES

Noise Guidelines for Wind Farms

Interpretation for Applying MOE NPC Publications to
Wind Power Generation Facilities

Ministry of the Environment

October 2008

PIBS 4709e

NOISE GUIDELINES FOR WIND FARMS

Interpretation for Applying MOE NPC Publications to Wind Power Generation Facilities
October 2008

This document establishes the sound level limits for land-based wind power generating facilities and describes the information required for noise assessments and submissions under the Environmental Assessment Act and the Environmental Protection Act. It replaces the document "Interpretation for Applying MOE NPC Technical Publications to Wind Turbine Generators," Version 1.0, July 6, 2004.

Table of Contents

TABLES

FIGURE

1. SCOPE

Noise impacts of proposed land-based wind power generation facilities, i.e. Wind Farms, are considered in the course of assessing an application for a Certificate of Approval (Air/Noise), in accordance with section 9 of the *Environmental Protection Act*. Wind Farms two megawatts or more are subject to review under the Environmental Screening Process, in accordance with Ontario Regulation 116/01 under the *Environmental Assessment Act*, and noise impacts are also considered during review under the screening process. The purpose of this document is to describe the applicable sound level limits and to specify the information proponents are to submit to the Ministry of the Environment when seeking approval for a proposed land-based Wind Farm. This document has been developed to provide consistency in the submissions and to streamline the review and approval process. Accordingly, the guidance contained herein is intended to provide uniformity in planning of Wind Farms in Ontario.

Proponents of Wind Farms are to prepare and submit to the Ministry of the Environment (MOE) a Noise Assessment Report that includes details of the wind turbine design and operation, location of the wind turbine(s) within the specific site and surrounding area, as well as summary of compliance with the applicable sound level limits. If applicable, the Noise Assessment Report must also include similar details of the Transformer Substation used for transforming the power from the wind turbine units. This document defines a template for the Noise Assessment Report to be submitted to the MOE.

This document also provides guidance on the assessment of the combined noise impact produced by the proposed Wind Farm in combination with the noise impact of approved Wind Farms or Wind Farms that are in the process of being planned.

2. REFERENCES

Reference is made to the following publications:

[1] NPC-104, “Sound Level Adjustments,” Ontario Ministry of the Environment

[2] NPC-205, “Sound Level Limits for Stationary Sources in Class 1 & 2 Areas (Urban),” Ontario Ministry of the Environment

[3] NPC-206, “Sound Levels due to Road Traffic,” Ontario Ministry of the Environment

[4] NPC-232, “Sound Level Limits for Stationary Sources in Class 3 Areas (Rural),” Ontario Ministry of the Environment

[5] CAN/CSA-C61400-11-07, “Wind Turbine Generator Systems - Part 11: Acoustic Noise Measurement Techniques”

[6] ISO 9613-2, “Acoustics-Attenuation of sound during propagation outdoors - Part 2: General method of calculation”

[7] ANSI/IEEE C57.12.90, “Distribution, Power, and Regulating Transformers”

3. DEFINITIONS

For the purpose of this document, the following definitions apply:

“Environmental Screening Process” is a prescribed planning process for electricity projects set out in Part B of the Guide to Environmental Assessment Requirements for Electricity Projects. As set out in Ontario Regulation 116/01 under the *Environmental Assessment Act*, certain electricity projects are subject to review under the Environmental Screening Process.

"Noise Assessment Report" means a report for wind power electricity generation projects, prepared in accordance with the guidance described in this document.

"Participating Receptor" means a property that is associated with the Wind Farm by means of a legal agreement with the property owner for the installation and operation of wind turbines or related equipment located on that property.

"Switching Station" means a collection point for the outputs of the wind turbine generators. Switching Stations are not significant noise sources.

"Transformer Substation" means a central facility comprised of power transformer(s) and associated equipment such as cooling fans for transforming the electrical outputs from the wind turbine generators to a higher voltage for input to the grid transmission system. Transformer Substations are significant noise sources.

"Wind Farm" means an electrical generating facility comprised of an array of wind turbine generators and a common electrical connection point such as a Transformer Substation or a Switching Station.

The following definitions are also included in the current Publications NPC-205 and NPC-232, References [2] and [4]:

"Class 1 Area" means an area with an acoustical environment typical of a major population centre, where the background noise is dominated by the urban hum.

"Class 2 Area" means an area with an acoustical environment that has qualities representative of both Class 1 and Class 3 Areas, and in which a low ambient sound level, normally occurring only between 23:00 and 07:00 hours in Class 1 Areas, will typically be realized as early as 19:00 hours.

Other characteristics which may indicate the presence of a Class 2 Area include:

i. absence of urban hum between 19:00 and 23:00 hours;
ii. evening background sound level defined by natural environment and infrequent human activity; and
iii. no clearly audible sound from stationary sources other than from those under consideration.

"Class 3 Area" means a rural area with an acoustical environment that is dominated by natural sounds having little or no road traffic, such as the following:

i. a small community with less than 1000 population;
ii. agricultural area;
iii. a rural recreational area such as a cottage or a resort area; or
iv. a wilderness area.

The following definition is also included in the current Publication NPC-232, Reference [4]:

"Point of Reception" means any point on the premises of a person within 30 m of a dwelling or a camping area, where sound or vibration originating from other than those premises is received.

For the purpose of approval of new sources, including verifying compliance with section 9 of the *Environmental Protection Act*, the Point of Reception may be located on any of the following existing or zoned for future use premises: permanent or seasonal residences, hotels/motels, nursing/retirement homes, rental residences, hospitals, camp grounds, and noise sensitive buildings such as schools and places of worship.

For equipment/facilities proposed on premises such as nursing/retirement homes, rental residences, hospitals, and schools, the Point of Reception may be located on the same premises.

4. DESCRIPTION OF WIND FARM NOISE

A Wind Farm is a collection of wind turbines, located in the same area, used for the production of electric power. As the individual wind turbines are separated by several hundred metres from each other, a large wind farm covers an area of tens of square kilometres. Larger Wind Farms may include a Transformer Substation that collects and increases the voltage produced by the turbines to the higher voltage for the grid transmission system.

A typical wind turbine consists of a tall tower with a hub (nacelle or housing) containing the drive-train and generator mounted on top of the tower. Three rotating blades (typically) are connected to a horizontal hub. In general, the significant noise sources associated with the operation of a Wind Farm are the wind turbines and the Transformer Substation. Noise from wind turbines consists of the aerodynamic noise caused by blades passing through the air, and mechanical noise created by the operation of mechanical elements of the drive-train. Close to the turbine, the noise typically exhibits a swishing sound as the blades rotate; and the whirr of the drive-train and generator. However, as distance from the turbine increases, these effects are reduced. The wind turbine noise perceived at receptors is typically broadband in nature. Any tonal character associated with the wind turbine noise is generally associated with maintenance issues.

The Transformer Substation noise is produced by the vibration of the transformer core and associated components, and by the operation of other equipment such as cooling fans. The noise produced by a Transformer Substation generally exhibits a pronounced hum, associated with the fundamental electrical frequency and its harmonics. Consequently, the Transformer Substation noise perceived at receptors is typically tonal.

The noise produced by wind turbines, as well as the background noise, typically increases with wind speed. The noise produced by a Transformer Substation is unaffected by the wind speed.

5. SOUND LEVEL LIMITS FOR WIND FARMS

5.1 Limits for Wind Turbine Generators

The sound level limits for wind turbines are set relative to the existing MOE Noise Guidelines in Publications NPC-205 and NPC-232, References [2] and [4], as well as to a reference wind induced background sound level. Consistent with these guidelines, the sound level limits, expressed in terms of the hourly, “A-weighted,” equivalent sound level (L_{eq}), apply at Points of Reception.

a) <u>Receptors in Class 1 & 2 Areas (Urban)</u>

The sound level limits at a Point of Reception in Class 1 & 2 Areas (Urban) are given by the applicable values in Table 1 and Figure 1, or by the sound level limits, established in accordance with requirements in Publication NPC-205.

b) Receptors in Class 3 Areas (Rural)

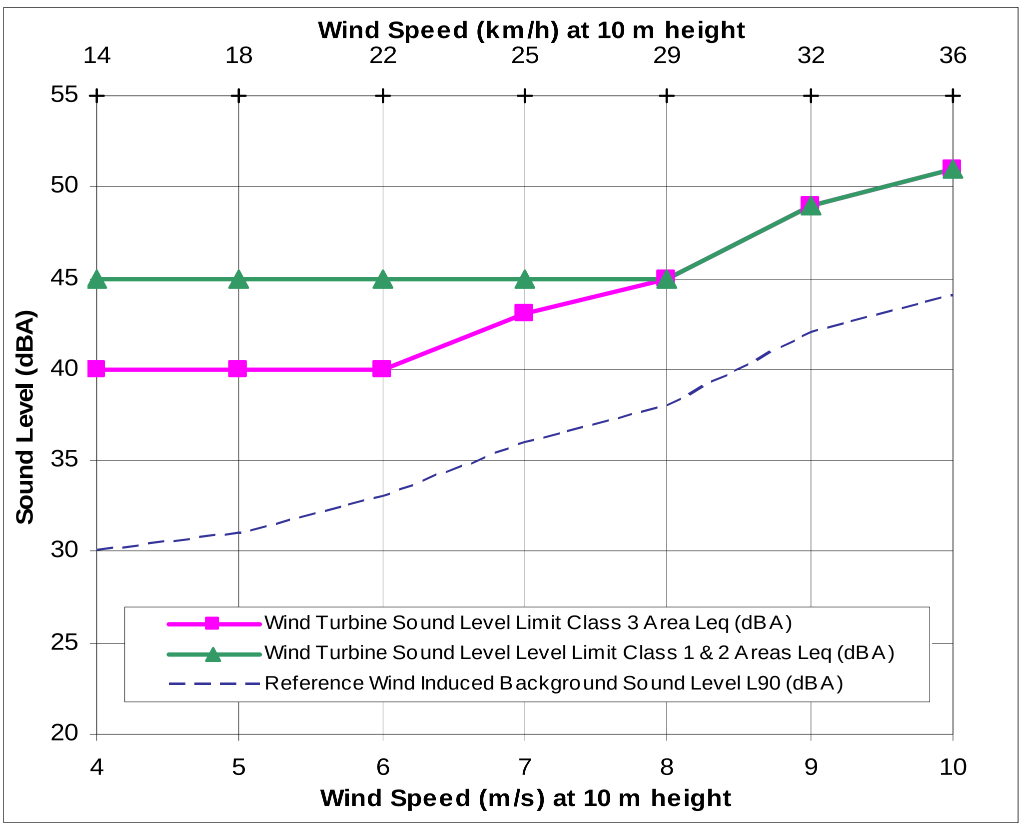
The sound level limits at a Point of Reception in Class 3 Areas (Rural) are given by the applicable values in Table 1 and Figure 1, or by the sound level limits, established in accordance with requirements in Publication NPC-232.

The wind turbine sound level limits are given at integer values of the wind speed and are shown as the solid lines in Figure 1. The dashed line in Figure 1 does not represent a limit and is included only for information purposes[1]. These sound level limits range from the lowest value of 40 dBA for Class 3 Areas and wind speeds at or below 4 m/s to the maximum value of 51 dBA for wind speeds at or above 10 m/s.

Table 1 Summary of Sound Level Limits for Wind Turbines

Wind Speed (m/s) at 10 m height	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Wind Turbine Sound Level Limits Class 3 Area, dBA	40.0	40.0	40.0	43.0	45.0	49.0	51.0
Wind Turbine Sound Level Limits Class 1 & 2 Areas, dBA	45.0	45.0	45.0	45.0	45.0	49.0	51.0

Figure 1 Summary of Sound Level Limits for Wind Turbines



[1] The measurement of wind induced background sound level is not required to establish the applicable limit. The wind induced background sound level reference curve, dashed line in Figure 1, was determined by correlating the A-weighted ninetieth percentile sound level (L_{90}) with the average wind speed measured at a particularly quiet site. The applicable L_{eq} sound level limits at higher wind speeds are given by adding 7 dB to the wind induced background L_{90} sound level reference values, using the principles for establishing sound level limits described in Publication NPC-232, Reference [4].

5.2 Limits for Wind Turbine Generators and Transformer Substations

In cases where the noise impact at a Point of Reception is composed of combined contributions due to the Transformer Substation as well as the wind turbine generators, the applicable limits are those shown in Table 1 and Figure 1, as described in Section 5.1.

The combined noise impact must comply with the limits at all the wind speeds from 0 m/s to 10 m/s. It should be noted that the acoustic emissions from a Transformer Substation are independent and unrelated to the wind speed, unlike the acoustic emissions from wind turbine generators which are wind speed dependent.

In determining the combined impact, a 5 dB adjustment must be added to the Transformer Substation noise in accordance with Publication NPC-104, Reference [1].

5.3 Limits for Transformer Substations

In unique cases where the noise impact assessment at a Point of Reception is limited to the operation of the Transformer Substation, as in a case described in Section 6.4.1, the sound level limit at a Point of Reception is given in the Publication NPC-205, Reference [2] or Publication NPC-232, Reference [4], whichever is applicable. The limit is independent of wind induced noise.

In order to account for the tonal characteristics of Transformer Substation noise, a 5 dB adjustment must be added to the acoustic emissions in accordance with Publication NPC-104, Reference [1].

6. NOISE ASSESSMENT REPORT

A Noise Assessment Report must be prepared for all proposed Wind Farms. The requirements for a detailed noise impact assessment depend on the proximity of the Wind Farm to receptors and are described in Section 6.4. The report must be submitted in a hard copy as well as in an electronic format.

The Noise Assessment Report must demonstrate compliance with the applicable sound level limits and the supporting information must be organized in a clear and concise manner. The report must be prepared by a qualified acoustical consultant and the cover document must be signed by the proponent for the project.

The Noise Assessment Report should be performed early in the planning of the project, as part of the Environmental Screening Process. The expectation of the MOE is that the submitted Noise Assessment Report be complete and accurate. Results of the Noise Assessment Report should be included in the Screening Report or Environmental Review Report prepared under the Environmental Screening Process. Any revisions to the Noise Assessment Report following the completion of the Environmental Screening Process should be very limited and clearly identified. In cases where complete information about the Wind Farm (e.g., information relating the transformer equipment) was not available at the environmental screening stage, such information must be provided to the MOE with the application for the Certificate of Approval under section 9 of the *Environmental Protection Act* for the Wind Farm.

As a minimum, the report must include the following sections in the given sequence:

6.1 Project Layout

The overall plan of the Wind Farm must be described in detail for the purpose of supporting the noise impact assessment calculations and for demonstrating compliance with the sound level limits. General project layout description must be supported with clear maps of the site and surrounding area, complete with scale, northing, and legend information. A suitable minimum drawing scale for the overall plan of the project is 1 cm : 500 m.

The following details must be included:

a) Geographic location of the project study area;
b) Locations of wind turbines;
c) Location of Transformer Substation or Switching Station;
d) Locations of all receptors including buildings, dwellings, campsites, places of worship, and institutions, up to 2000 m from any wind turbine location; and
e) Property boundaries of lands associated with the project and location of dwellings therein.

The following additional information must be included, if applicable:

f) Municipal zoning and land-use plans;
g) Topographical features including roadways, terrain elevations, and ground cover; and
h) Available information regarding the location and scope of other approved[2] Wind Farms, and Wind Farms in the process of being planned[3], located within 5 km of any wind turbine generators of the proposed Wind Farm.

6.2 Noise Sources

For the purposes of this document, noise sources mean land-based wind turbine generators and Transformer Substations.

6.2.1 Description

The Noise Assessment Report must include the description of the wind turbine generators, including: manufacturer's make and model, maximum electrical output rating, hub height above grade, range of rotational speeds, and mode of operation.

The Noise Assessment Report must also include the description of the Transformer Substation, including all available information at the time of submission on the manufacturer's make and model designations, maximum electrical output rating, primary and secondary voltages, method of cooling, physical dimensions, drawing showing elevation and plan views of the unit, and any noise abatement measures.

Manufacturer's specifications should be included in an Appendix.

6.2.2 Wind Turbines

The acoustic emissions of the wind turbine must be specified by the manufacturer for the full range of rated operation and wind speeds. As a minimum, the information must include the sound power levels, frequency spectra in octave bands (63 to 8000 Hz), and tonality at integer

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[2] For the purposes of this document, a Wind Farm is considered to be "approved" if a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has been issued.

[3] For the purposes of this document, a Wind Farm is considered to be "in the process of being planned" if a Notice of Commencement has been issued for the project in accordance with the Environmental Screening Process prescribed under Ontario Regulation 116/01 under the *Environmental Assessment Act*, but for which a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has not yet been issued.

wind speeds from 6 to 10 m/s. The acoustic emission information must be determined and reported in accordance with the international standard CAN/CSA-C61400-11-07, Reference [5].

6.2.3 Adjustment to Wind Turbine Generator Acoustic Emissions for Wind Speed Profile

The wind speed profile on site of the Wind Farm may have an effect on the manufacturer's wind turbine acoustic emission data and, consequently, on the sound levels predicted at a Point of Reception. Therefore, the wind turbine generator acoustic emission levels must be consistent with the wind speed profile of the project area.

To address this issue, the assessment must use manufacturer's acoustic emission data adjusted for the average summer night time wind speed profile, representative of the site.

The adjusted acoustic emissions data must be used in the noise impact assessment at each receptor. The manufacturer's acoustic emissions data and the adjusted acoustic emission data used in the noise impact assessment must be tabulated in Table 3.

6.2.4 Transformer Substation

The acoustic emissions of each transformer unit must be specified by the manufacturer and conform to the standard ANSI/IEEE C57.12.90, Reference [7]. In cases where the specific information is not available in the early stages of planning the proposed Wind Farm, as described in the introduction to Section 6, proponents must submit a maximum rated value of the transformer acoustic emissions.

The requirements do not apply to the small transformer units attached to each wind turbine. These small transformers are insignificant noise sources and, therefore, their contributions do not require assessment.

The acoustic emissions data must be used in the noise impact assessment at each receptor.

6.2.5 Noise Sources and Locations

All wind turbine units and Transformer Substations must be assigned a unique source identification and must be listed along with their Universal Transverse Mercator (UTM) coordinates in a table in the report. The table should be provided in electronic form along with the report. A sample table format is shown in Table 4.

The source identifications should remain consistent throughout the submission and review process. Any changes to source identifications in revised versions of the Noise Assessment Report should be explicitly stated.

6.3 Receptors

For the purposes of this document, receptors mean Points of Reception and Participating Receptors, including vacant lots described in Section 6.3.3.

The definitions of a Point of Reception and a Participating Receptor are given in Section 3. The distance requirements for detailed noise assessments at receptors are described in Section 6.4.1. To provide clarity and consistency in the detailed noise assessments, the following describes the specific receptor locations for assessment purposes:

6.3.1 Wind Farm Does Not Include Transformer Substation

a) Single Storey Dwelling

- 4.5 m above grade at the centre of the dwelling; or
- 1.5 m above grade and 30 m horizontally from the façade of the dwelling in the direction of each wind turbine location. If the 30 m radius spans beyond the property line of the dwelling then the receptor location is at the property line.

Either of the two locations is acceptable for assessment[4].

b) Two Storey Dwelling (or Raised Bungalow)

- 4.5 m above grade at the centre of the dwelling.

c) Three Storey or Higher Dwelling

- at the centre of the highest storey of the dwelling.

6.3.2 Wind Farm Includes Transformer Substation

a) Dwellings up to Two Storey High

- 4.5 m above grade at the centre of the dwelling; or
- 1.5 m above grade and 30 m horizontally from the façade of the dwelling in the direction of each wind turbine location. If the 30 m radius spans beyond the property line of the dwelling then the receptor location is at the property line.

The location that results in the higher noise impact must be selected[5].

b) Three Storey or Higher Dwelling

- at the centre of the highest storey of the dwelling; or
- 1.5 m above grade and 30 m horizontally from the façade of the dwelling in the direction of each wind turbine location. If the 30 m radius spans beyond the property line of the dwelling then the receptor location is at the property line.

The location that results in the higher noise impact must be selected[6].

6.3.3 Vacant Lots

Receptors include vacant lots that have been zoned by the local municipality to permit residential or similar noise-sensitive uses, as described in the definition of a Point of Reception in Section 3.

The receptor location, if unknown at the time of the proposal, shall be based on a 1 hectare (10,000 m²) building envelope within the vacant lot property that would reasonably be expected to

[4] Assessment at the centre of the dwelling is simpler. The sound level at 4.5 m above grade at the centre of the dwelling is generally higher.

[5] Assessment at the centre of the dwelling is simpler. The sound level at 4.5 m above grade at the centre of the dwelling is generally higher except where transformer substation noise is a factor.

[6] Assessment at the centre of the dwelling is simpler. The sound level at the highest storey at the centre of the dwelling is generally higher except where transformer substation noise is a factor.

contain the use, and that conforms with the municipal zoning by-laws in effect. The specific receptor location for assessment purposes should be assumed to be 4.5 m above grade and:

- consistent with the typical building pattern in the area, or
- at the centre of the 1 hectare building envelope.

6.3.4 Area Classification of Receptors

Based on the rural nature of the areas surrounding most wind power projects, the Class 3 Area sound level limits shown in Table 1 and Figure 1 apply to all receptors, regardless of their proximity to a roadway, unless it can be shown clearly that less restrictive sound level limits are justified.

Less restrictive sound level limits for receptors within their designated area classification must be justified by analysis of hourly-traffic volumes data or by hourly acoustic monitoring results consistent with Publication NPC-206, Reference [3]. The use of general estimates, such as the Annual Average Daily Traffic data (AADT), is an insufficient method for determining the minimum hourly sound level of the background.

6.3.5 Receptors and Locations

All receptors must be assigned a unique receptor identification and must be tabulated along with their precise coordinates in the report. The table should be provided in electronic form along with the report. A sample table format is shown in Table 5 and Table 6.

The receptor identifications should remain consistent throughout the review process. Any changes to receptor identifications in revised versions of the Noise Assessment Report must be explicitly stated.

6.4 Detailed Noise Impact Assessment

Assessment of the sound levels produced by a Wind Farm, i.e. detailed noise impact assessment, must be made at each Point of Reception and Participating Receptor, within the distance requirements described in Section 6.4.1. In the event that all Points of Reception and Participating Receptors are outside the distance requirements described in Section 6.4.1, a detailed noise impact assessment is not required and the provisions contained in Sections 6.4.2 through to 6.4.10 are not applicable. Note that all proposals for Wind Farm projects must address the requirements described in Sections 6.1, 6.2 and 6.3, and Table 4, Table 5 and Table 6, even if a detailed noise assessment is not required.

The noise assessment must represent the maximum rated output of the Wind Farm, and reflect the principle of “predictable worst case” noise impact, Publications NPC-205 and NPC-232, References [2] and [4].

6.4.1 Distance Requirement

a) Wind Farm Does Not Include Transformer Substation

- A detailed noise impact assessment of the Wind Farm is required if one or more Points of Reception or Participating Receptors are located within 1500 m of a wind turbine generator.

b) Wind Farm Includes Transformer Substation

- A detailed noise impact assessment of the Wind Farm including a Transformer Substation is required if one or more Points of Reception or Participating Receptors are located within 1500 m of a wind turbine generator.
- A detailed noise impact assessment limited to the Transformer Substation is required if no Points of Reception or Participating Receptors are located within 1500 m of a wind turbine generator but a Point of Reception or a Participating Receptor is located within 1000 m of a Transformer Substation.

6.4.2 Whole Wind Farm Assessment

In the event that a detailed noise impact assessment is required, the assessment must not be limited to a 1500 m radius from a receptor, but must consider the impact of the whole Wind Farm subject to the limitations relating to very large distances described in Section 6.4.9.

6.4.3 Transformer Substation Assessment

In general, Transformer Substation noise impact must be assessed in combination with the noise impact from the wind turbine generators. In the unique case where the noise impact is caused only by the Transformer Substation, as described in Section 6.4.1 b), the detailed noise impact assessment is only required to consider the sound levels from the Transformer Substation.

6.4.4 Impact of Adjacent Approved Wind Farms

If a Point of Reception or a Participating Receptor is or can be affected by adjacent, approved[7] Wind Farms, the detailed noise impact assessment must address the combined impact of the proposed and the adjacent Wind Farms. The distance requirements described in Sections 6.4.1 and 6.4.9 apply.

Note that in accordance with Section 6.4.2, where a detailed noise impact assessment is required, it must consider all the wind turbine generators and Transformer Substations in the proposed as well as in the adjacent approved Wind Farms, subject to the limitations relating to very large distances described in Section 6.4.9.

6.4.5 Impact of Adjacent Wind Farms in the Process of Being Planned

If a Point of Reception or a Participating Receptor is or can be affected by adjacent Wind Farms in the process of being planned[8], the detailed noise impact assessment must address, subject to available information[9], the combined impact of the proposed and the adjacent Wind Farms. The distance requirements described in Sections 6.4.1 and 6.4.9 apply.

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[7] For the purposes of this document, a Wind Farm is considered to be "approved" if a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has been issued.

[8] For the purposes of this document, a Wind Farm is considered to be "in the process of being planned" if a Notice of Commencement has been issued for the project in accordance with the Environmental Screening Process prescribed under Ontario Regulation 116/01 under the *Environmental Assessment Act*, but for which a Certificate of Approval (Noise) under section 9 of the *Environmental Protection Act* has not yet been issued.

[9] The combined impact would be expected to be assessed if, for example, the information on turbine locations and models at an adjacent proposed Wind Farm is publicly available (e.g., through a Screening Report or Environmental Review Report under the Environmental Screening Process).

Note that in accordance with Section 6.4.2, where a detailed noise impact assessment is required, it must consider all the wind turbine generators and Transformer Substations in the proposed Wind Farm as well as in the adjacent Wind Farm in the process of being planned, subject to the limitations relating to very large distances described in Section 6.4.9.

6.4.6 Assessment of Participating Receptors

A receptor is a Participating Receptor and not considered as a Point of Reception if the property of the receptor is associated with the Wind Farm, see definition in Section 3. The sound level limits stated in Section 5 do not apply to Participating Receptors.

Despite this exemption, it is prudent to design Wind Farms so as to minimize the noise impact on all receptors, including Participating Receptors.

In some cases, a detailed noise assessment may be required of a receptor that was considered a Participating Receptor for an adjacent approved Wind Farm, or is being considered as a Participating Receptor for an adjacent Wind Farm in the process of being planned. Unless the property owner has also entered into an agreement with the proponent of the proposed Wind Farm, the receptor shall be considered a Point of Reception for the purposes of the detailed noise impact assessment for the proposed Wind Farm.

6.4.7 Prediction Method

Predictions of the total sound level at a Point of Reception or a Participating Receptor must be carried out according to the method described in the standard ISO 9613-2, Reference [6]. The calculations are subject to the specific parameters indicated in Section 6.4.10.

6.4.8 Adjustment for Special Quality of Sound

Should the manufacturer's data indicate that the wind turbine acoustic emissions are tonal, the acoustic emissions must be adjusted by 5 dB for tonality, in accordance with Publication NPC-104, Reference [1]. Otherwise, the prediction should assume that the wind turbine noise requires no adjustments for special quality of sound described in Publication NPC-104, Reference [1].

No special adjustments are necessary to address the variation in wind turbine sound level (swishing sound) due to the blade rotation, see Section 4. This temporal characteristic is not dissimilar to other sounds to which no adjustments are applied. It should be noted that the adjustments for special quality of sound described in Publication NPC-104, Reference [1], were not designed to apply to sounds exhibiting such temporal characteristic.

The calculations of the transformer noise must be consistent with the provisions of Section 6.2.4. Furthermore, since transformer acoustic emissions are tonal, an adjustment of 5 dB must be added to the specified acoustic emissions in accordance with Publication NPC-104, Reference [1].

6.4.9 Sound Level Contributions from Distant Wind Turbine Generators

The standard on which the noise impact prediction method is based, namely standard ISO 9613-2, Reference [6], is designed for source/receiver distances up to about 1000 m. Although the use of the standard may be extended to larger distances, other factors affecting sound level contributions from the distant sources may need to be considered. In practice, sound level contributions from sources such as wind turbines located at very large distances from receptors are affected by additional attenuation effects.

To address the above in a prediction method, contributions from sources located at very large distances from receptors, larger than approximately 5 km, do not need to be included in the calculation.

6.4.10 Specific Parameters

The assessment must use the following parameters that have been designed to provide clarity and consistency as well as reflect the principle of the "predictable worst case" noise impact.

a) All calculations must be performed in terms of octave band sound levels (63 to 8000 Hz) and for each integer wind speed from 6 to 10 m/s.

b) The attenuation due to atmospheric absorption must be based on the atmospheric attenuation coefficients for 10ºC temperature and 70% relative humidity, specifically:

Table 2 Atmospheric Absorption Coefficients

Centre Octave Band Frequency (Hz)	63	125	250	500	1000	2000	4000	8000
Atmospheric Absorption Coefficient (dB/km)	0.1	0.4	1.0	1.9	3.7	9.7	32.8	117.0

c) The term for Ground Attenuation must be calculated using the "General" method in the standard ISO 9613-2, Reference [6]. For Class 2 and 3 Areas, the assessment must use ground factor values not exceeding the following:

$G_s = 1.0$
$G_m = 0.8$
$G_r = 0.5$

Where G_s is ground factor for the source region,
G_m is ground factor for the middle region, and
G_r is ground factor for the receiver region.

Alternatively, a global value ground factor not exceeding 0.7 may be used.

Ground factor values for assessments in Class 1 Areas are not specified in this document. The choice of the ground factor values for assessments in Class 1 Areas is site-specific.

6.5 Results and Compliance

6.5.1 Presentation of Results

Results of the noise impact assessment calculations must be presented in accordance with the Noise Impact Assessment Summary Tables, Table 7 and Table 8. In addition, the results should be plotted on drawings of the site plan, showing property boundaries, noise sources and receptor locations with their identifications. A suitable scale for these drawings is 1 cm : 250 m.

A separate drawing must be presented for each of the following wind speeds: 6, 8 and 10 m/s. The sound level scale should be the same on all drawings. If practical, each drawing should show the sound level contours for the 40 dBA level as well as the contour for the applicable sound level limit. The drawings should be included as an Appendix.

6.5.2 Assessment of Compliance

Compliance must be based on the comparison of the combined sound levels from all sources, described in Section 6, at each Point of Reception with the sound level limits stated in Section 5. All calculations and the determination of compliance with the sound level limits must be presented to a precision of one decimal place.

6.6 Summary Tables

6.6.1 Wind Turbine Acoustic Emissions Summary Table

The wind turbine acoustic emissions data used in the calculations must be presented as shown in Table 3. Separate tables should be used if the project involves different models of equipment.

Table 3 Wind Turbine Acoustic Emissions Summary

Make and Model:
Electrical Rating:
Hub Height (m):
Wind shear coefficient, as per Section 6.2.3[10]:

	Octave Band Sound Power Level (dB)									
	Manufacturer's Emission Levels					**Adjusted Emission Levels**				
Wind Speed[11] (m/s)	**6**	**7**	**8**	**9**	**10**	**6**	**7**	**8**	**9**	**10**
Frequency[12] (Hz)										
63										
125										
250										
500										
1000										
2000										
4000										
8000										
A-weighted										

[10] Adjustment based on the differences in wind shear factors reflecting manufacturer's data and on-site data.
[11] At 10 m reference height.
[12] Centre Octave Band Frequency.

6.6.2 Locations of Wind Turbine Generators, Transformer Substations and Receptors

Location coordinates of all wind turbine generators, Transformer Substations, Points of Reception and Participating Receptors must be given in accordance with Table 4, Table 5 and Table 6.

Table 4 Wind Turbine Locations

Project Name:				
Identifier	**Equipment Make & Model**	**UTM Coordinates**		**Remarks**
		X	**Y**	

Changes in ID or location in revised submissions must be clearly identified under the "Remarks" column.

Table 5 Point of Reception Locations

Project Name:			
Point of Reception ID	**Description**	**UTM Coordinates**	
		X	**Y**

Table 6 Participating Receptor Locations

Project Name:			
Receptor ID	**Description**	**UTM Coordinates**	
		X	**Y**

6.6.3 Noise Impact Assessment Summary Tables

Table 7 Combined Noise Impact Summary – Points of Reception

Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)					Sound Level Limit (dBA)				
					6	7	8	9	10	6	7	8	9	10

Values in the table that exceed the applicable limit should be **Underlined and Bolded**.

Table 8 Combined Noise Impact Summary – Participating Receptors

Participating Receptor ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)				
					6	7	8	9	10

Table 9 Wind Turbine Noise Impact Summary – Points of Reception

Point of Reception ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)					Sound Level Limit (dBA)				
					6	7	8	9	10	6	7	8	9	10

Values in the table that exceed the applicable limit should be **Underlined and Bolded**.

Table 10 Wind Turbine Noise Impact Summary – Participating Receptors

Participating Receptor ID	Description	Height (m)	Distance to Nearest Turbine (m)	Nearest Turbine ID	Calculated Sound Level at Selected Wind Speeds (dBA)				
					6	7	8	9	10

6.7 Appendices

All information necessary to support the conclusions of the report, but not specifically described as required in Section 6, should be referenced and attached as Appendices to the report. Supporting information includes but is not limited to specifications, drawings, letters/agreements, photos, measurements and miscellaneous technical information.

In addition, sample calculation should be included in the Appendices. The sample calculation must include at least one detailed calculation for a source to receiver "pair," preferably addressing the closest wind turbine unit. The sample calculation must represent all other "pairs." If applicable, a sample calculation for the Transformer Substation is also required.

In cases where a Transformer Substation is part of the Wind Farm, Table 11 and Table 12 must be included in the Appendices:

Table 11 Transformer Substation Noise Impact Summary – Points of Reception

Point of Reception ID	Description	Distance to Transformer Substation (m)	Calculated Sound Level (dBA)	Sound Level Limit (dBA)

Values in the table that exceed the applicable limit should be **Underlined and Bolded**.

Table 12 Transformer Substation Noise Impact Summary – Participating Receptors

Point of Reception ID	Description	Distance to Transformer Substation (m)	Calculated Sound Level (dBA)

ATTACHMENT B

VESTAS V90 TURBINE DATA

JULY, 2009

Class I
Document no.: 0000-6153 V00
2008-03-06

General Specification

V90 – 1.8 MW VCUS

Vestas®
No.1 in Modern Energy

Vestas Wind Systems A/S · Alsvej 21 · 8900 Randers · Denmark · www.vestas.com

Table of Contents

Buyer acknowledges that these general specifications are for Buyer's informational purposes only and do not create or constitute a warranty, guarantee, promise, commitment, or other representation by supplier, all of which are disclaimed by supplier except to the extent expressly provided by supplier in writing elsewhere.

See section 11 'General Reservations, Notes and Disclaimers', p. 34 for general reservations, notes, and disclaimers applicable to these general specifications.

1 General Description

The Vestas V90-1.8 MW wind turbine is a pitch regulated upwind turbine with active yaw and a three-blade rotor. The Vestas V90-1.8 MW turbine has a rotor diameter of 90 m with a generator rated at 1.8 MW. The turbine utilizes a microprocessor pitch control system called OptiTip® and the Variable Speed concepts (VCUS: Vestas Converter Unity System). With these features the wind turbine is able to operate the rotor at variable speed (RPM), helping to maintain the output at or near rated power.

2 Mechanical Design

2.1 Rotor

The V90-1.8 MW is equipped with a 90 meter rotor consisting of three blades and the hub. Based on the prevailing wind conditions, the blades are continuously positioned to help optimise the pitch angle.

Rotor	
Diameter	90 m
Swept Area	6362 m^2
Rotational Speed Static, Rotor	14.5 rpm
Speed, Dynamic Operation Range	9.0 – 14.5 rpm
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Blade Coning	2°
Number of Blades	3
Aerodynamic Brakes	Full feathering

Table 2-1: Rotor data

2.2 Blades

The 44 m Prepreg (PP) blades are made of carbon and glass fibre and consist of two airfoil shells bonded to a supporting beam.

PP Blades	
Type Description	Airfoil shells bonded to supporting beam
Blade Length	44 m
Material	Fibreglass reinforced epoxy and carbon fibres
Blade Connection	Steel roots inserted
Air Foils	RISØ P + FFA –WA
Chord:	
Blade root	3.512 m
Blade tip	0.391 m
Twist (blade root/blade tip)	17.5°
Weight	6,700 kg

Table 2-2: PP blades data

2.3 Blade Bearing

The blade bearings are double row 4-point contact ball bearings.

Blade Bearing	
Type	2 row 4-point contact ball bearing
Lubrication	Grease lubrication, manually re-greased

Table 2-3: Blade bearing data

2.4 Pitch System

The energy input from the wind to the turbine is adjusted by pitching the blades according to the control strategy. The pitch system also works as the primary brake system by pitching the blades out of the wind. This causes the rotor to idle.

Double row 4-point contact ball bearings are used to connect the blades to the hub. The pitch system relies on hydraulics and uses a cylinder to pitch each blade. Hydraulic power is supplied to the cylinder from the hydraulic power unit in the nacelle through the main gearbox and the main shaft via a rotating transfer.

Hydraulic accumulators inside the rotor hub ensure sufficient power to stop the turbine in case of grid failure.

Pitch System	
Type	Hydraulic
Cylinder	Ø125/80 – 760
Number	1 pcs./ blade
Range	-5º to 90º

Table 2-4: Pitch system data

Hydraulic System	
Pump capacity:	44 l/min
Working pressure:	180 - 200 bar
Oil quantity:	160 l
Motor:	18.5 kW

Table 2-5: Hydraulic system data

2.5 Hub

The hub supports the 3 blades and transfers the reaction forces to the main bearing. The hub structure also supports blade bearings and pitch cylinder.

Hub	
Type	Cast ball shell hub
Material	Cast iron EN GJS 400-18U-LT / EN1560
Weight	8,400 kg.

Table 2-6: Hub Data

2.6 Main Shaft

Type:	Forged, trumpet shaft
Material:	42 CrMo4 QT / EN 10083

2.7 Bearing Housing

Type:	Cast foot housing with lowered centre
Material:	EN-GJS-400-18U-LT

2.8 Main Bearings

Type:	Spherical roller bearings
Lubrication	Grease lubrication, manually re-greased

2.9 Machine Foundation

Type:	Cast EN-GJS-400-18U-LT

2.10 Gearbox

The main gearbox transmits torque and revolutions from the rotor to the generator.

The main gearbox consists of a planetary stage combined with a two-stage parallel gearbox, torque arms and vibration dampers.

Torque is transmitted from the high-speed shaft to the generator via a flexible composite coupling, located behind the disc brake. The disc brake is mounted directly on the high-speed shaft.

Gearbox	
Type:	1 planetary stage / 2 helical stages
Ratio:	60 Hz: 1:92.6 nominal
Cooling:	Oil pump with oil cooler
Oil heater:	2 kW
Max gear oil temp:	80°c
Oil cleanliness:	-/15/12 ISO 4406

Table 2-7: Gearbox data

2.11 Generator Bearings

The bearings are greased and grease is supplied continuously from an automatic lubrication unit when the nacelle temperature is above -10°C. The yearly grease flow is approximately 2,400 cm^3/year.

2.12 High Speed Shaft Coupling

The flexible coupling transmits the torque from the gearbox high speed output shaft to the generator input shaft. The flexible coupling is designed to minimize misalignments between gearbox and generator. The coupling consists of two composite discs and an intermediate tube with two aluminium flanges and a glass fibre tube. The coupling is fitted to 3-armed hubs on the brake disc and the generator hub.

High Speed Shaft Coupling	
Type Description	VK 420

Table 2-8: High speed shaft coupling data

2.13 Yaw System

The yaw system is designed to keep the turbine upwind when the operating mode is RUN or PAUSE. The nacelle is mounted on the yaw plate, which is bolted to the turbine tower. The yaw bearing system is a plain bearing system with built-in friction. Asynchronous yaw motors with brakes enable the nacelle to rotate on top of the tower.

The VMP controller receives information of the wind direction from the wind sensor. Automatic yawing is deactivated when the mean wind speed is below 3 m/s.

Yaw System	
Type	Plain bearing system with built in friction
Material	Forged yaw ring heat-treated. Plain bearings PETP
Yawing Speed	< 0.5˚/sec.

Table 2-9: Yaw system data

Yaw Gear	
Type	Non-locking combined worm gear and planetary gearbox Electrical motor brake
Motor	1.5 kW, 6 pole, asynchronous
Number of yaw gears	6
Ratio Total (4 planetary stages)	1,120 : 1
Rotational Speed at Full Load	Approx. 1 rpm at output shaft

Table 2-10: Yaw gear data

2.14 Crane

The nacelle houses the service crane. The crane is a single system chain hoist.

Crane	
Lifting Capacity	Max. 800 kg

Table 2-11: Crane data

2.15 Tower Structure (Onshore)

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. Magnets provide load support in a horizontal direction and internals, such as platforms, ladders, etc., are supported vertically (i.e. in the gravitational direction) by a mechanical connection.

The hub heights listed include a distance from the foundation section to the ground level of approximately 0.6 m depending on the thickness of the bottom flange and a distance from the tower top flange to the centre of the hub of 1.95 m.

Tower Structure	
Type Description	Conical tubular
Hub Heights	80 m/105 m
Material	S355 (A709/A572-50)
Weight	80 m IEC 2A 160 metric tons* 105 m IEC 2A 245 metric tons**

Table 2-12: Tower structure (Onshore) data

NOTE */** Typical values. Dependant on wind class, and can vary with site / project conditions.

2.16 Nacelle Base-Frame and Cover

The nacelle cover is made of fibreglass. Hatches are positioned in the floor for lowering or hoisting equipment to the nacelle and evacuation of personnel.

The roof section is equipped with wind sensors and skylights which can be opened from inside the nacelle to access the roof and from outside to access the nacelle. The nacelle cover is mounted on the girder structure. Access from the tower to the nacelle is through the yaw system.

The nacelle bedplate is in two parts and consists of a cast iron front part and a girder structure rear part. The front of the nacelle bedplate is the foundation for the drive train, which transmits forces from the rotor to the tower, through the yaw system. The bottom surface is machined and connected to the yaw bearing and the yaw-gears are bolted to the front nacelle bedplate.

The nacelle bedplate carries the crane beams through vertical beams positioned along the site of the nacelle. Lower beams of the girder structure are connected at the rear end.

The rear part of the bedplate serves as foundation for controller panels, cooling system and transformer.

Type Description	Material
Nacelle Cover	GRP
Base Frame Front	SG cast iron
Base Frame Rear	Welded Grid Structure

Table 2-13: Nacelle base-frame and cover data

2.17 Cooling

The cooling systems for the main components in the turbine shown below are all placed inside the nacelle and therefore conditioned by nacelle air. The transformer is conditioned by ambient air as it is placed in the air intake. The mass flow of air through the nacelle is mainly driven by the generator external fan and the gear oil cooler fans which lead the heated air out of the nacelle.

Component	Cooler type	Internal heating at low temperature
Nacelle	Forced air	No (yes LT/off shore)
Hub/nose cone	Natural air	No (yes LT/off shore)
Gear	Forced oil/air	Yes
Generator	Forced air/air	Yes
Slip rings	Forced air/air	Yes
Transformer	Forced air	No (heat source)
VCS	Forced water/air	No (heat source)
VRUS	Forced water/air	No (heat source)
VMP section	Forced air/air	Yes
Hydraulics	Forced air	Yes

All other heat generating systems are also equipped with fans and or coolers but are considered as minor contributors to nacelle thermodynamics.

2.18 Generator Cooling

The generator cooling system consists of an air to air cooler mounted on the top of the generator and two internal fans and one external fan. All the fans can run at high or low speed (1800/3600 rpm.).

Generator Cooling	
Air Inlet Temp. – External:	35°
Nominal Air Flow – Internal:	2.2 m^3/s
Nominal Air Flow – External:	1.95 m^3/s
Cooling Capacity	75 kW

Table 2-14: Cooling, generator data

2.19 Converter Cooling

The converter cooling system consists of a water pump that circulates the cooling water through the converter modules and a water cooler with a two-speed fan.

Converter Cooling	
Nominal Water Flow	Approx. 45 l/min (50% glycol)
Water Inlet Pressure	Max 2.0 bar
Water Inlet Temperature	Max. 56 ºC
Cooling Capacity	10 kW

Table 2-15: Cooling, converter data

2.19.1 Gearbox- and Hydraulic Cooling

The gearbox cooling system consists of two oil circuits and two oil coolers. The first circuit is equipped with a mechanically driven oil pump and oil cooler with built-in thermo bypass valve and the second circuit is equipped with an electrically driven oil pump and oil cooler.

Gearbox Cooling	
Gear Oil Cooler 1 (Mechanically driven oil pump)	
Nominal Oil Flow	72 l/min
Oil Inlet Pressure	80 °C
Air Inlet Temperature	45 °C
Nominal Air Flow	1.5 m^3/s
Cooling Capacity	32 kW
Gear Oil Cooler 2 (Electrically driven oil pump)	
Nominal Oil Flow	105 l/min
Oil Inlet Temp.	80 °C
Air Inlet Temp.	45 °C
Nominal Air Flow	3.2 m^3/s
Cooling Capacity	60 kW

Table 2-16: Cooling, gearbox data

The combined lubrication/cooling system is driven by a mechanical pump, mounted on the gear. This pumps oil, whenever gear is rotating. The cooling pump circuit is electric, and only activated when the mechanical circuit cannot meet the cooling demand.

Hydraulic Cooling	
Nominal Water Flow	Approx. 50 l/min (50% glycol)
Water Inlet Pressure	Max 2.0 bar
Water Inlet Temperature	Max. 53 ºC
Cooling Capacity	12 kW

Table 2-17: Cooling, hydraulic data

2.19.2 Transformer Cooling

The transformer is equipped with forced air cooling. The ventilator consists of six fans, located below the transformer leading the cooling air to locations beneath and between the HV and LV windings of the transformer.

Transformer Cooling	
Nominal Air Flow	1470 m^3/h
Air Inlet Temperature	Max. 30°C

Table 2-18: Cooling, transformer data

2.19.3 Nacelle Cooling

Heated air generated by mechanical and electrical equipment is removed from the nacelle by the 3 oil cooler fans and the generator cooling fan. The airflow enters the nacelle through louver dampers in the weather shield underneath the nacelle. The fans can run at low or high speed depending on the temperature in the nacelle, gear and generator.

Nacelle Cooling	
Nominal Airflow	7.3 m^3/s
Air Inlet Temperature	Max. 40°C

Table 2-19: Cooling, nacelle data

3 Electrical Design

3.1 Generator (VCUS – 60 Hz)

The generator is a 3-phase asynchronous generator with wound rotor, which is connected to the Vestas Converter Unity System (VCUS) via a slip ring system. The generator is an air-to-air cooled generator with an internal and external cooling circuit. The external circuit uses air from the nacelle and exhausts it out through the rear end of the nacelle.

The generator has six poles. The generator is wound with form windings in both rotor and stator. The stator is connected in star at low power and delta at high power. The rotor is connected in star and is insulated from the shaft. A slip ring unit is mounted to the rotor for the purpose of the VCUS control.

Generator	
Type Description	Asynchronous with wound rotor, slip rings and VCUS
Rated Power (PN)	1.86 MW
Rated Apparent Power	1.86 MVA (Cosφ = 1.00)
Frequency	60 Hz
Voltage, Generator	690 Vac
Voltage, Converter	480 Vac
Number of Poles	6
Winding Type (Stator/Rotor)	Form/Form
Winding Connection, Stator	Star/Delta
Rated Efficiency (generator only)	> 96.5 %
Power Factor (cos)	1.0
Over Speed Limit acc. to IEC (2 min.)	2,900 rpm
Vibration Level	≤ 1.8 mm/s
Weight	Approx. 8,100 kg
Generator Bearing - Temperature	2 Pt100 sensors
Generator Stator Windings - Temperature	3 Pt100 sensors placed at hot spots and 3 as back-up

Table 3-1: Generator data

3.2 HV Cables

HV cable runs from the transformer in the nacelle down the tower to the switchgear (switchgear not included). The cable is a 4-conductor rubber insulated halogen free cable.

HV Cables	
Type	NTSCGEHXOEU
Cross Section	3x70/70 mm^2
Rated Voltage	12/20 kV and 20/35 kV depending on the transformer voltage.

Table 3-2: HV cables data

3.3 Transformer

The transformer is located in a separate locked room in the nacelle with surge arresters mounted on the high voltage side of the transformer. The transformer is a two winding, three-phase dry-type transformer, which is self-extinguishing. The windings are delta-connected on the high voltage side unless otherwise specified.

The low voltage windings have a voltage of 690 V and a tapping at 480 V and are star-connected. The 690 V and 480 V systems in the nacelle are a TN-system, which means the star point is connected to earth.

Transformer	
Type Description	Dry-type cast resin
Primary Voltage	10-33 kV
Rated Apparent Power	2,100 kVA
Secondary Voltage 1	690 V
Rated Power 1 at 1000 V	1,900 kVA
Secondary Voltage 2	480 V
Rated Power 2 at 400 V	200 kVA
Vector Group	Dyn5 (option YNyn0)
Frequency	60 Hz
HV-tappings	± 2 x 2.5 % offload
Inrush Current	6-10 x $\hat{I}_n$ depending on type.
Short-circuit Impedance	7.8 % ±10% @ 690V, 1,900 kVA, 120°C
Insulation Class	F
Climate Class	C2
Environmental Class	E2
Fire behaviour Class	F1

Table 3-3: Transformer data

3.4 Converter

The converter controls the energy conversion in the generator. The VCUS converter feeds power from the grid into the generator rotor at sub sync speed and feeds power from the generator rotor to the grid at super sync speed.

Converter	
Rated Slip	12%
Rated RPM	1,344 RPM
Rated Rotor Power (slip=12%, 400V)	185 kW
Rated Grid Current (slip = 12%)	210 A
Rated Rotor Current	101 A
Rated Rotor Current (cos φ= 1.0, slip = 12%)	576 A

Table 3-4: Converter data

3.5 AUX System

The AUX System is supplied from the 690/480 V outlet from the HV transformer. All motors, pumps, fans and heaters are supplied from this system.

All 110 V power sockets are supplied from a 690/110 V transformer.

Power Sockets	
Single Phase	110 V (20 A)
Three Phase	690 V (16 A)

Table 3-5: AUX system data

3.6 Wind Sensors

The turbine is equipped with 2 ultrasonic wind sensors with built in heaters.

Wind Sensors	
Type	FT702LT
Principle	Acoustic Resonance
Built in Heat	99 W

Table 3-6: Wind sensor data

3.7 VMP (Vestas Multi Processor) Controller

The turbine is controlled and monitored by the VMP5000 control system.

VMP5000 is a multiprocessor control system comprised of 4 main processors (Ground, Nacelle, Hub and Converter) interconnected by an optical-based 2.5 Mbit ArcNet network.

I/O modules are connected to CAN interface modules by a serial digital bus, CTBus.

The VMP5000 controller serves the following main functions:

- Monitoring and supervision of overall operation
- Synchronizing of the generator to the grid during connection sequence in order to limit the inrush current
- Operating the wind turbine during various fault situations
- Automatic yawing of the nacelle
- OptiTip® - blade pitch control
- Noise emission control
- Monitoring of ambient conditions
- Monitoring of the grid
- Monitoring of the smoke detection system

VMP5000 is built from the following main modules:

Module	Function	Network
CT3601	Main processor. Control and monitoring (ground, nacelle and hub)	ArcNet, CAN
CT318	Main processor. Converter control and monitoring	ArcNet
CT3218	Counter/encoder module. RPM and Azimuth measurement	CTBus
CT3134 Digital in CT3153 Digital out	24 VDC digital input/output. 4 channels configurable for either input or output.	CTBus
CT3215	2 Ch. RS 422/485 port. Serial interface for e.g. wind sensors.	CTBus
CT3220 Pigiback C	2 Ch. Analogue input 0.24 mA (Configurable).	CTBus
CT3220 Pigiback F	3 Ch. PT100 interface module. 4 wire pt100 measurement technology	CTBus
CT218	Operator Panel. RS422 interface	-----

Table 3-7: VMP controller data

3.8 Uninterruptible Power Supply (UPS)

The UPS is equipped with AC/DC DC/AC converter (double conversions), which receives power from battery cells in the same cabinet as the UPS. During grid outage, the UPS will supply the specified component with 230V AC.

The back-up time for the UPS system is proportional to the power consumption. Actual back-up time may vary.

UPS		
Battery Type	Valve-Regulated Lead Acid (VRLA)	
Rated Battery Voltage	2 x 8 x 12 V (192 V)	
Converter Type	Double conversion online	
Rated Output Voltage	230 V AC	
Rated Output Voltage	230 V AC	
Converter Input	230 V +/-20%	
Back-up Time*	Controller system	30 seconds
	Safety Systems	35 minutes
Re-charging Time	Typical	Approx. 2.5 hours

Table 3-8: UPS data

NOTE * For alternative back-up times, please consult Vestas!

4 Turbine Protection Systems

4.1 Braking Concept

The main brake on the turbine is aerodynamic. Braking the turbine is done by feathering the three blades. Each blade can be feathered individually to slow the turbine in an emergency stop.

In addition there is a mechanical disc brake on the high speed shaft of the gearbox. The mechanical brake is only used as a parking brake, and when activating the emergency stop push buttons.

4.2 Short Circuit Protections

Breakers	**Generator / Q8** **ABB S7H 1600** **690 V**	**Controller / Q15** **ABB S3X** **690 V**	**VCS-VCUS / Q7** **ABB S5H 400** **480 V**
Breaking Capacity I_{cu}, I_{cs}	25, 20 KA	75, 75 KA	40, 40 KA
Making Capacity I_{cm} **(415V Data)**	143 KA	440 KA	143 KA
Thermo Release I_{th}	1600 A	100 A	400 A
Magnetic Release I_m	9.6 KA	1.0 KA	1600 A

Table 4-1: Short circuit protection data

4.3 Overspeed Protection

The generator RPM and the main shaft RPM are registered by inductive sensors and calculated by the wind turbine controller in order to protect against over-speed and rotating errors.

The turbine is also equipped with a VOG (Vestas Overspeed Guard), which is an independent computer module measuring the rotor RPM, and in case of an overspeed situation the VOG activates full feathering of the three blades independently of the turbine controller in the turbine.

Overspeed Protection	
VOG Sensors Type	Inductive
Trip Levels	19.36 (Rotor RPM)/2,110 (Generator RPM)

Table 4-2: Overspeed protection data

4.4 Lightning System

The Lightning System (LS) consists of three main parts.

- Lightning receptors
- Down conducting system
- Earthing System

Lightning Protection Design Parameters			**Protection Level I**
Current Peak Value	i_{max}	[kA]	200
Total Charge	Q_{total}	[C]	300
Specific Energy	W/R	[MJ/Ω]	10
Average Steepness	di/dt	[kA/μs]	200

Table 4-3: Lightning design parameters

NOTE Lightning system is designed according to IEC (see 7.7). Lightning strikes are considered force majeure, i.e. damage caused by lightning strikes is not warranted by Vestas.

4.5 Earthing (also known as grounding)

A separate set of documents describe the earthing system in detail, depending on the type of foundation the turbine has been installed on.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements, as well as project requirements, may require additional measures.

4.6 Corrosion Protection

Classification of corrosion categories for atmospheric corrosion is according to ISO 9223:1992

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5	C3 and C4 Climate strategy: Heating the air inside the nacelle compared to the outside air temperature lowers the relative humidity and helps ensure a controlled corrosion level.
Hub	C5	C3
Tower	C5-I	C3

Table 4-4: Corrosion protection data for nacelle, hub and tower

5 Safety

The safety specifications in Section 5 provide limited general information about the safety features of the turbine and are not a substitute for Buyer and its agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, (c) conducting all appropriate safety training and education and (d) reading and understanding all safety-related manuals and instructions. See section 5.14 Manuals and Warnings, p. 22 for additional guidance.

5.1 Access

Access to the turbine from the outside is through the bottom of the tower. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or lift (optional). Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is equipped with a lock. Unauthorized access to electrical switch boards and power panels in the turbine is prohibited according to IEC 60204-1 2006.

5.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch or from the roof of the nacelle.

The hatch in the roof can be opened from both the inside and outside.

Escape from the tower lift is by ladder.

5.3 Rooms/Working Areas

The tower and nacelle are equipped with connection points for electrical tools for service and maintenance of the turbine.

5.4 Floors, Platforms, Standing and Working Places

There is one floor per tower section.

There are places to stand at various locations along the ladder.

The floors have anti-slip surfaces.

Foot supports are placed in the turbine for maintenance and service purposes.

5.5 Climbing Facilities

A ladder with a fall arrest system (rigid rail or wire system) is mounted through the tower.

Rest platforms are provided at intervals of 9 metres along the tower ladder between platforms.

There are anchorage points in the tower, nacelle, hub and on the roof for attaching a fall arrest harness.

Over the crane hatch there is an anchorage point for the emergency descent equipment.

Anchorage points are coloured yellow and are calculated and tested to 22.2 kN

5.6 Moving Parts, Guards and Blocking Devices

Moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

It is possible to block the pitch of the cylinder with mechanical tools in the hub.

5.7 Lighting

The turbine is equipped with light in the tower, nacelle, transformer room and in the hub.

There is emergency light in case of loss of electrical power.

5.8 Noise

When the turbine is out of operation for maintenance, the sound level in the nacelle is below 80 dB(A). In operation mode ear protection is required.

5.9 Emergency Stop

There are emergency stops in the nacelle, hub and in the bottom of the tower.

5.10 Power Disconnection

The turbine is designed to allow for disconnection from all its power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and in the bottom of the tower.

5.11 Fire Protection/First Aid

A 5 kg CO_2 fire extinguisher must be located in the nacelle at the left yaw gear. The location of the fire extinguisher, and how to use it, must be confirmed before operating the turbine.

A first aid kit must be placed by the wall at the back end of the nacelle. The location of the first aid kit, and how to use it, must be confirmed before operating the turbine.

Above the generator there is a fire blanket which can be used to put out small fires.

5.12 Warning Signs

Additional warning signs inside or on the turbine must be reviewed before operating or servicing of the turbine.

5.13 Offshore Installation

In addition to the safety equipment mentioned above, offshore turbines are provided with a fire extinguisher and first aid box at the bottom of the tower, and a survival kit on the second platform in the tower.

5.14 Manuals and Warnings

Vestas OH&S manual and manuals for operation, maintenance and service of the turbine provide additional safety rules and information for operating, servicing or maintaining the turbine.

6 Environment

6.1 Chemicals

Chemicals used in the turbine are evaluated according to Vestas Wind Systems A/S Environmental system certified according to ISO 14001:2004.

- Anti-freeze liquid to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

7 Approvals, Certificates and Design Codes

7.1 Type Approvals

The turbine is type certified according to the certification standards listed below:

Standard	Conditions	Hub Height
IEC SoC	IEC Class 2A	80 m
	IEC Class 2A	105 m

Table 7-1: Type approvals data

7.2 Design Codes – Structural Design

The structural design has been developed and tested with regard to, but not limited to, the following main standards.

Design Codes - Structural Design	
Nacelle and Hub	IEC 61400-1:2005 EN 50308
Tower	IEC 61400-1:2005 Eurocode 3

Table 7-2: Structural design codes

7.3 Design Codes - Mechanical Equipment

The mechanical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – Mechanical Equipment	
Gear	Designed in accordance to rules in ISO 81400-4
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) IEC WT 01 IEC DEFU R25 ISO 2813 DS/EN ISO 12944-2

Table 7-3: Mechanical equipment design codes

7.4 Design Codes - Electrical Equipment

The electrical equipment has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – Electrical Equipment	
High Voltage ac circuit breakers	IEC 60056
High Voltage testing techniques	IEC 60060
Power Capacitors	IEC 60831
Insulating bushings for ac voltage above 1kV	IEC 60137
Insulation co-ordination	BS EN 60071
AC Disconnectors and earth switches	BS EN 60129
Current Transformers	IEC 60185
Voltage Transformers	IEC 60186
High Voltage switches	IEC 60265
Disconnectors and Fuses	IEC 60269
Flame Retardant Standard for MV Cables	IEC 60332
Transformer	IEC 60076-11
Generator	IEC 60034
Specification for sulphur hexafluoride for electrical equipment	IEC 60376
Rotating electrical machines	IEC 34
Dimensions and output ratings for rotating electrical machines	IEC 72 & IEC 72A
Classification of insulation, materials for electrical machinery	IEC 85
Safety of machinery – Electrical equipment of machines	IEC 60204-1

Table 7-4: Electrical equipment design codes

7.5 Design Codes - I/O Network System

The distributed I/O network system has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes – I/O Network System	
Salt Mist Test	IEC 60068-2-52
Damp Head, Cyclic	IEC 60068-2-30
Vibration Sinus	IEC 60068-2-6
Cold	IEC 60068-2-1
Enclosure	IEC 60529
Damp Head, Steady State	IEC 60068-2-56
Vibration Random	IEC 60068-2-64
Dry Heat	IEC 60068-2-2
Temperature Shock	IEC 60068-2-14
Free Fall	IEC 60068-2-32

Table 7-5: I/O Network system design codes

7.6 Design Codes - Lightning Protection

The LPS is designed according to Lightning Protection Level (LPL) I:

Design Codes – Lightning Protection	
Designed according to	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006
Non Harmonized Standard and Technically Normative Documents	IEC/TR 61400-24:2002

Table 7-6: Lightning protection design codes

7.7 Design Codes – Earthing

The Vestas Earthing System design is based on and complies with the following international standards and guidelines:

- IEC 62305-1 Ed. 1.0: Protection against lightning – Part 1: General principles.
- IEC 62305-3 Ed. 1.0: Protection against lightning – Part 3: Physical damage to structures and life hazard.
- IEC 62305-4 Ed. 1.0: Protection against lightning – Part 4: Electrical and electronic systems within structures.

- IEC/TR 61400-24. First edition. 2002-07. Wind turbine generator systems - Part 24: Lightning protection.
- IEC 60364-5-54. Second edition 2002-06. Electrical installations of buildings - Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors.
- IEC 61936-1. First edition. 2002-10. Power installations exceeding 1kV a.c.- Part 1: Common rules.

8 Colour and Surface Treatment

8.1 Nacelle Colour and Surface Treatment

Surface Treatment of Vestas Nacelles	
Standard Nacelle Colours	RAL 7035 (light grey) RAL 9010 (pure white)
Gloss	According to ISO 2813

Table 8-1: Surface treatment, nacelle

8.2 Tower Colour and Surface Treatment

Surface Treatment of Vestas Tower Section		
	External:	**Internal:**
Tower Colour Variants	RAL 7035 (light grey) RAL 9010 (pure white) – only Onshore	RAL 9001 (cream white)
Gloss	50-75% UV resistant	Maximum 50%

Table 8-2: Surface treatment, tower

8.3 Blades Colour

There is a range of available blade colours depending on country specific requirements.

Blades Colour	
Blade Colour Variants	RAL 7035 (Light Grey), RAL 9010 (White), RAL 7038 (Agate Grey)
Tip-End Colour Variants	RAL 2009 (Traffic Orange), RAL 3000 (Flame Red), RAL 3020 (Traffic Red)
Gloss	< 20%

Table 8-3: Colours, blades

9 Operational Envelope and Performance Guidelines

Actual climatic and site conditions have many variables and must be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

NOTE As evaluation of climate and site conditions is complex, it is needed to consult Vestas for every project.

9.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters		
Wind Climate	**IEC 2A**	**IEC 3A**
Ambient Temperature Interval (Normal Temperature Turbine)	-30° to +50 °C	
Extreme Wind Speed (10 min. average)	42.5 m/s	37.5 m/s
Survival Wind Speed (3 sec. gust)	59.5 m/s	52.5 m/s

Table 9-1: Extreme design parameters

Average Design Parameters		
Wind Climate	**IEC 2A**	**IEC 3A**
Wind Speed	8.5 m/s	7.5 m/s
A-factor	9.59 m/s	8.46 m/s
Form Factor, c	2.0	2.0
Turbulence Intensity acc. to IEC 61400-1, including Wind Farm Turbulence (@15 m/s – 90% quantile)	18%	
Wind Shear	0.20	
Inflow Angle (vertical)	8°	

Table 9-2: Average design parameters

9.1.1 Complex Terrain

Classification of complex terrain acc. to IEC 61400-1:2005 Chapter 11.2.

For sites classified as complex appropriate measures are to be included in site assessment.

9.1.2 Altitude

The turbine is designed for use at altitudes up to 1000 m above sea level as standard.

Above 1000 m special considerations must be taken regarding e.g. HV installations and cooling performance. Consult Vestas for further information.

9.1.3 Wind Farm Layout

Turbine spacing to be evaluated site-specifically. Spacing in any case not below three rotor diameters (3D).

DISCLAIMER

As evaluation of climate and site conditions is complex, consult Vestas for every project. If conditions exceed the above parameters Vestas must be consulted!

9.2 Operational Envelope – Temperature and Wind

Values refer to hub height and as determined by the sensors and control system of the turbine.

Operational Envelope – Temperature and Wind	
Ambient Temperature Interval (Normal Temperature Turbine)	-20° to +40° C
Cut-in (10 min. average)	3.5 m/s
Cut-out (100 sec. exponential average)	25 m/s
Re-cut in (100 sec. exponential average)	20 m/s

Table 9-3: Operational envelope - temperature and wind

9.3 Operational Envelope - Grid Connection *

Values refer to hub height and as determined by the sensors and control system of the turbine.

Operational Envelope - Grid Connection		
Nominal Phase Voltage	$U_{P,\ nom}$	400 V
Nominal Frequency	f_{nom}	60 Hz

Table 9-4: Operational envelope - grid connection

The Generator and the converter will be disconnected if:

	U_P	U_N
Voltage above 110 % of nominal for 60 sec.	440 V	759 V
Voltage above 113.5 % of nominal for 0.2 sec.	454 V	783 V
Voltage above 120 % of nominal for 0.08 sec.	480 V	828 V
Voltage below 90 % of nominal for 60 sec.	360 V	621 V
Voltage below 85 % of nominal for 0.4 sec.	340 V	586 V
Voltage below 75 % of nominal for 0.08 sec.	300 V	517 V
Frequency is above [Hz] for 0.2 sec.	62 Hz	
Frequency is below [Hz] for 0.2 sec.	57 Hz	

Table 9-5: Generator and converter disconnecting values

NOTE * Over the lifetime of the turbine, grid dropouts are to be limited to no more than once a month on average as calculated over one year.

9.4 Performance – Own Consumption

The consumption of electrical power by the wind turbine is defined as consumption when the wind turbine is not producing energy (generator is not connected to the grid). This is defined in the control system as Production Generator (zero).

The following components have the largest influence on the power consumption of the wind turbine:

Own Consumption	
Hydraulic Motor	18.6 kW
Yaw Motors 6 x 1.75 kW	10.5 kW
Oil Heating 3 x 0.76 kW	2.3 kW
Air Heaters 3 x 3.4 kW	10.2 kW
Oil Pump for Gearbox Lubrication	3.5 kW
HV Transformer located in the nacelle has a no-load loss of	Max. 3.9 kW

Table 9-6: Own consumption data

9.5 Operational Envelope - Conditions for Power Curve, Noise Levels, C_p & C_t Values (at Hub Height)

See Appendix 1 for C_p & C_t values, Appendix 2 for power curve and Appendix 3 for noise level.

Conditions for Power Curve, Noise Levels, C_p & C_t Values (at Hub Height)	
Wind Shear	0.10 - 0.16 (10 min. average)
Turbulence Intensity	8 - 12% (10 min. average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ± 2 °
Grid Frequency	60 ± 0.5 Hz

Table 9-7: Conditions for power curve, noise levels, C_p & C_t values

10 Drawings

10.1 Structural Design - Illustration of Outer Dimensions

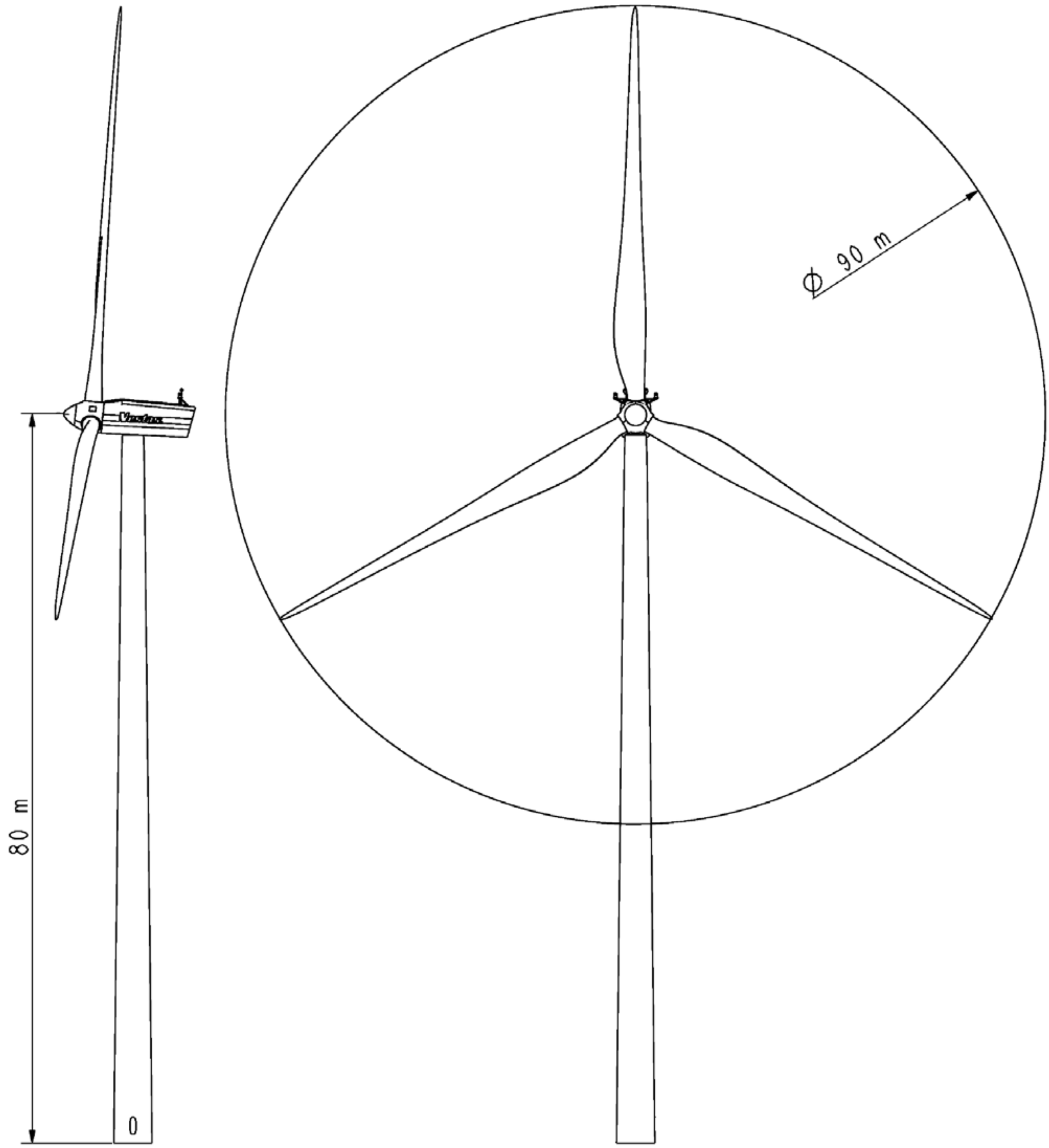

Figure 10-1: Illustration of outer dimensions – structure (Drawing no. 956042)

10.2 Structural Design - Side View Drawing

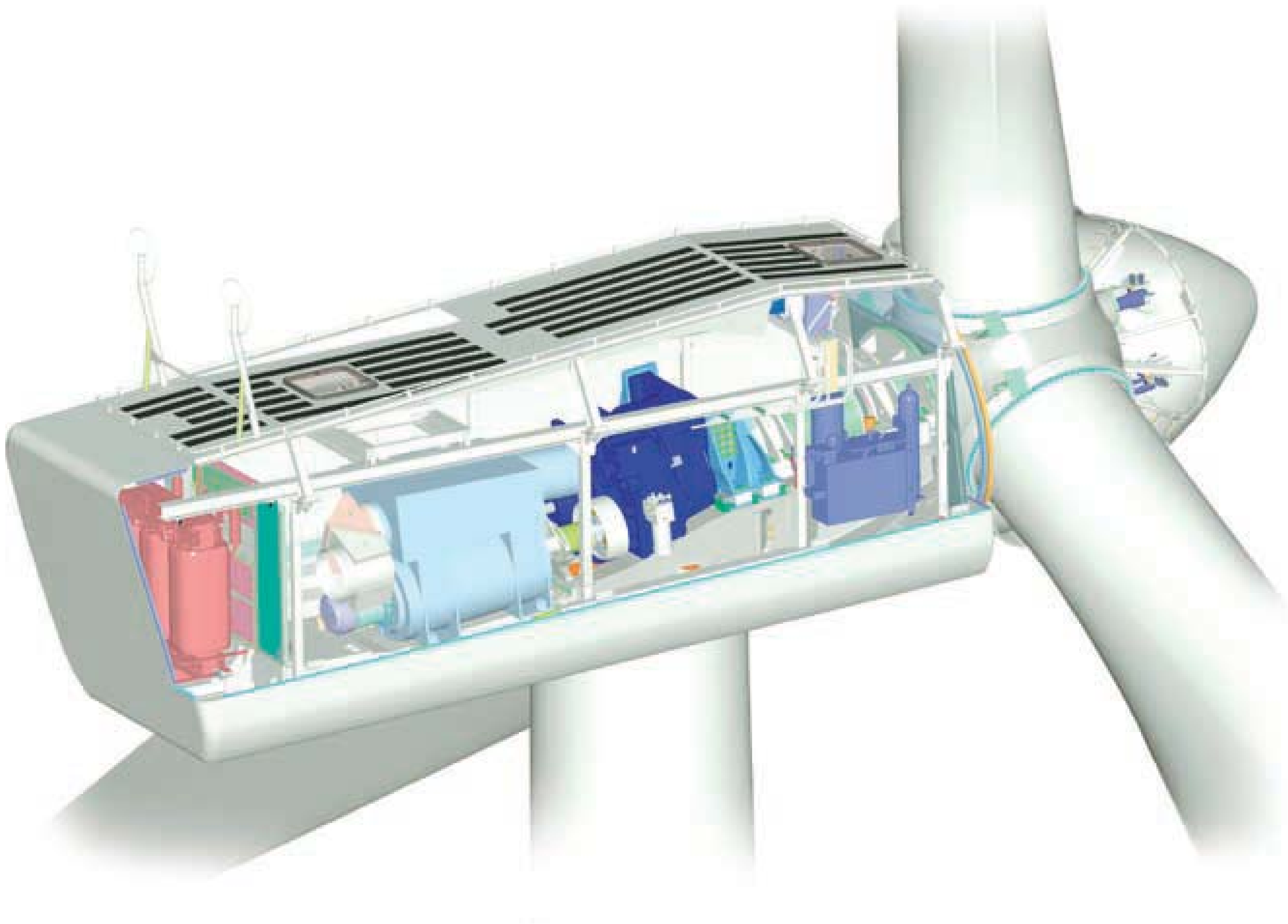

Figure 10-2: Side view drawing

10.3 Electrical Design – Main Wiring 60 Hz

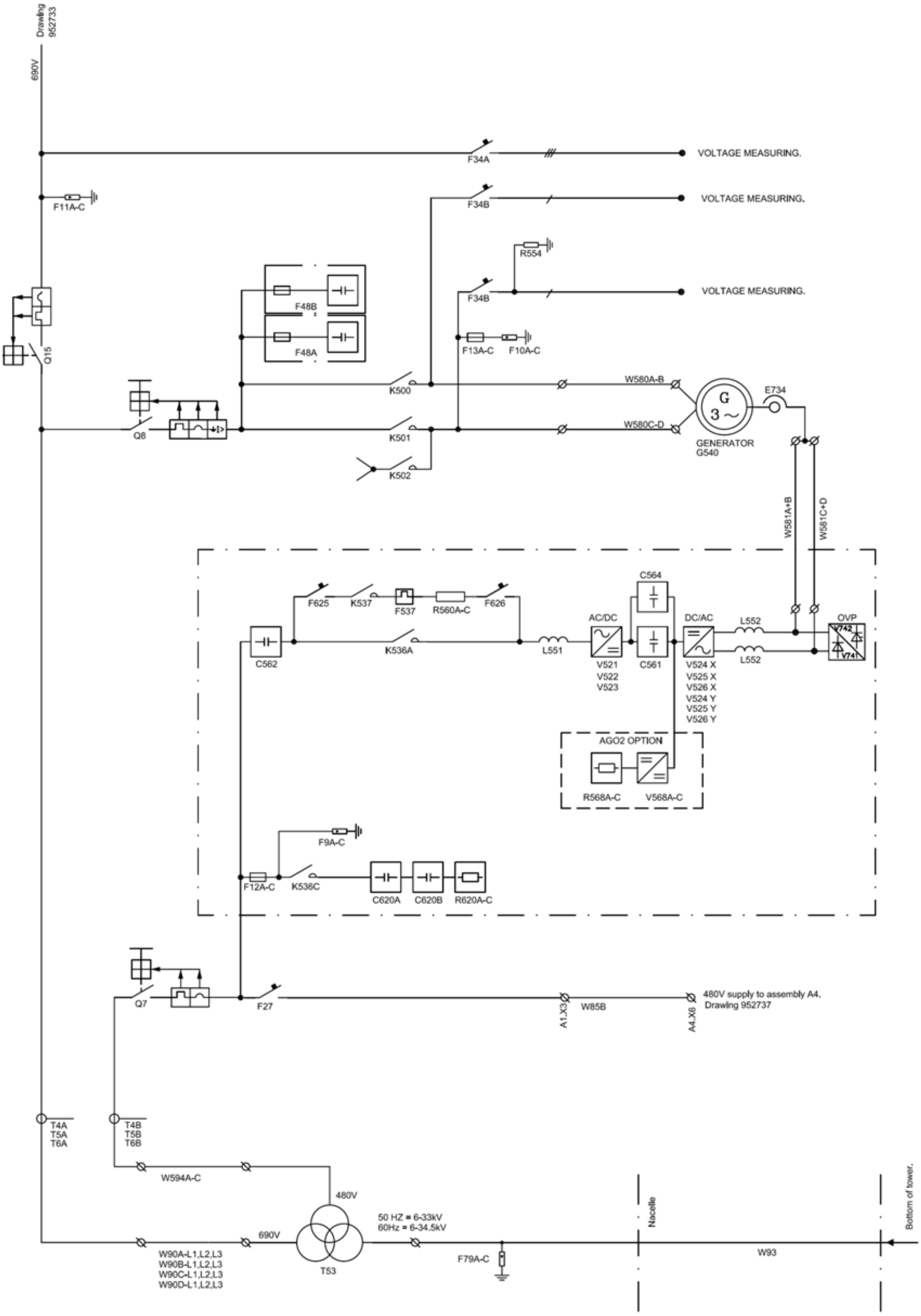

Figure 10-3: Main wiring 60 Hz

11 General Reservations, Notes and Disclaimers

- These general specifications apply to the current version of the V90 wind turbine. Updated versions of the V90 wind turbine, which may be manufactured in the future, may have general specifications that differ from these general specifications. In the event that Vestas supplies an updated version of the V90 wind turbine, Vestas will provide updated general specifications applicable to the updated version.
- Periodic operational disturbances and generator power de-rating may be caused by combination of high winds, low voltage or high temperature.
- Vestas recommends that the electrical grid be as close to nominal as possible with little variation in frequency.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- The estimated power curve for the different estimated noise levels (sound power levels) is for wind speeds at 10 minute average value at hub height and perpendicular to the rotor plane.
- All listed start/stop parameters (e. g. wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements, and codes of standards.
- Lightning strikes are considered force majeure, i.e. damage caused by lightning strikes is not warranted by Vestas.
- For the avoidance of doubt, this document ‘General Specifications’ is not, and does not contain, any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

12 Appendices

12.1 Performance – C_p & C_t Values

Performance – C_p & C_t Values – Air Density 1.225 kg/m^3		
Wind Speed	**Cp (Mode 0)**	**Ct (Mode 0)**
m/s	[-]	[-]
3	0.4246	0.8470
4	0.4836	0.7962
5	0.4841	0.8007
6	0.4841	0.8008
7	0.4841	0.8009
8	0.4839	0.7805
9	0.4696	0.6990
10	0.4343	0.6047
11	0.3775	0.4915
12	0.2907	0.3556
13	0.2287	0.2725
14	0.1831	0.2153
15	0.1489	0.1740
16	0.1227	0.1432
17	0.1023	0.1196
18	0.0861	0.1012
19	0.0732	0.0866
20	0.0628	0.0748
21	0.0542	0.0652
22	0.0472	0.0572
23	0.0413	0.0506
24	0.0363	0.0450
25	0.0322	0.0403

Table 12-1: C_p & C_t values

12.2 Performance - Estimated Power Curves

At 1000V / 400V, low voltage side of the high voltage transformer.

Wind speed at hub height, 10 min average.

12.2.1 Power Curve, Mode 0

Wind speed [m/s]	1.225	0.97	1	1.03	1.06	1.09	1.12	1.15	1.18	1.21	1.24	1.27
3	18	12	12	13	13	14	15	16	16	17	18	19
4	88	63	66	69	72	75	78	81	84	87	90	93
5	202	153	159	165	171	176	182	188	194	199	205	211
6	363	280	289	299	309	319	328	338	348	358	367	377
7	589	459	474	490	505	520	536	551	566	582	597	612
8	888	695	718	741	764	786	809	831	854	877	899	922
9	1226	965	995	1026	1057	1088	1119	1149	1180	1211	1241	1271
10	1548	1235	1273	1311	1349	1387	1426	1461	1496	1531	1564	1594
11	1758	1492	1531	1569	1607	1645	1684	1705	1726	1747	1764	1775
12	1808	1700	1719	1737	1755	1773	1791	1796	1801	1805	1809	1811
13	1815	1789	1793	1798	1803	1807	1812	1813	1814	1815	1815	1815
14	1815	1812	1813	1813	1814	1814	1815	1815	1815	1815	1815	1815
15	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
16	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
17	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
18	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
19	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
20	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
21	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
22	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
23	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
24	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815
25	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815	1815

Figure 12-1: Power curve, mode 0

12.3 Noise Levels

12.3.1 Noise Curve V90 – 1.8 MW, 60 Hz, Mode 0

Sound Power Level at Hub Height: Noise mode 0		
Conditions for Sound Power Level:	**Measurement standard IEC 61400-11 ed. 2 2002** **Wind shear: 0.16** **Max. turbulence at 10 meter height: 16%** **Inflow angle (vertical): 0 ± 2°** **Air density: 1.225 kg/m³**	
Hub Height	80 m	105 m
L_{wA} @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	94.6 5.6	95.5 5.8
L_{wA} @ 5 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	99.4 7.0	100.3 7.3
L_{wA} @ 6 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	102.3 8.4	102.6 8.7
L_{wA} @ 7 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.1 9.8	103.3 10.2
L_{wA} @ 8 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.5 11.2	103.5 11.7
L_{wA} @ 9 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.5 12.6	103.5 13.1
L_{wA} @ 10 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.5 14.0	103.5 14.6
L_{wA} @ 11 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.5 15.3	103.5 16.0
L_{wA} @ 12 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.5 16.7	103.5 17.5
L_{wA} @ 13 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	103.5 18.1	103.5 18.9

Figure 12-2: Noise curve, mode 0

ATTACHMENT C

SOUND PRESSURE LEVELS PREDICTED BY AERCOUSTICS SOUND PROPAGATION MODEL

JULY, 2009

ISO Protocol Sample Calculations: R282

Receiver:	R282	Total (dBA)
ID:	R282	40
X:	423985	
Y:	5086985	
Z:	316.18	
Ground:	311.68	

ID	T16	T14	Xfrmr	T18	T22	T12	T20	T23	T07	T13	T08
X	424453	423989	423978	422955	424656	424701	425290	422957	423700	425578	422874
Y	5087387	5087892	5087255	5086507	5085962	5088124	5086246	5085855	5088499	5087836	5088445
Z	395.57	395.52	319.78	391.95	380	392.26	373.75	384.8	373	366.47	381.55
Ground	315.57	315.52	316.78	311.95	300	312.26	293.75	304.8	293	286.47	301.55
ReflOrd	0	0	0	0	0	0	0	0	0	0	0
LxT	103.4	103.4	91.5	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4
LxN	103.4	103.4	91.5	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4
L/A	1	1	1	1	1	1	1	1	1	1	1
Dist.	622.04	910.47	270.11	1138.04	1225.09	1347.5	1500.82	1529.18	1541.64	1806.76	1835.81
hm	42.13	37.96	3.92	43.08	44.21	37.07	42.91	43.94	35.97	37.35	34.47
Freq	0	0	0	0	0	0	0	0	0	0	0
Adiv	66.88	70.19	59.63	72.12	72.76	73.59	74.53	74.69	74.76	76.14	76.28
K0b	0	0	0	0	0	0	0	0	0	0	0
Agr	-0.68	-0.64	-1.31	-0.61	-0.6	-0.59	-0.57	-0.57	-0.57	-0.55	-0.54
Abar	0	0	0	0	0	0	0	0	0	0	0
z	0	0	0	0	0	0	0	0	0	0	0
Aatm	2.41	3.24	1.57	3.82	4.02	4.31	4.64	4.7	4.73	5.27	5.32
Afol	0	0	0	0	0	0	0	0	0	0	0
Ahous	0	0	0	0	0	0	0	0	0	0	0
Cmet	0	0	0	0	0	0	0	0	0	0	0
CmetN	0	0	0	0	0	0	0	0	0	0	0
Dc	0	0	0	0	0	0	0	0	0	0	0
RL	0	0	0	0	0	0	0	0	0	0	0
LtotT	34.81	30.64	31.64	28.1	27.24	26.12	24.83	24.6	24.5	22.56	22.36
LtotN	34.81	30.64	31.64	28.1	27.24	26.12	24.83	24.6	24.5	22.56	22.36

T24	T06	T19	T28	T29	T30	T10	T15	T02	T05	T34	T21
425220	425113	426002	424761	423558	424211	426243	426514	425406	425967	423477	421074
5085501	5088724	5086354	5085016	5084877	5084627	5088273	5087605	5089290	5088867	5084121	5086236
368.74	370.24	350.11	363.67	372.32	366.5	363.64	355.27	370.88	370	370.62	391.62
288.74	290.24	270.11	283.67	292.32	286.5	283.64	275.27	290.88	290	290.62	311.62
0	0	0	0	0	0	0	0	0	0	0	0
103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4
103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4	103.4
1	1	1	1	1	1	1	1	1	1	1	1
1931.38	2073.51	2113.67	2116.93	2151.54	2369.34	2599.95	2604.18	2708.37	2733.71	2909.21	3006.76
42.2	32.92	40.33	41.69	43.22	41.42	41.44	43.72	38.2	39.67	45.08	42
0	0	0	0	0	0	0	0	0	0	0	0
76.72	77.33	77.5	77.51	77.66	78.49	79.3	79.31	79.65	79.74	80.28	80.56
0	0	0	0	0	0	0	0	0	0	0	0
-0.53	-0.52	-0.52	-0.52	-0.52	-0.5	-0.51	-0.52	-0.55	-0.56	-0.62	-0.65
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
5.51	5.77	5.84	5.85	5.91	6.29	6.67	6.68	6.85	6.89	7.15	7.3
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
21.73	20.84	20.6	20.58	20.37	19.14	17.96	17.95	17.48	17.37	16.62	16.22
21.73	20.84	20.6	20.58	20.37	19.14	17.96	17.95	17.48	17.37	16.62	16.22

T01	T17	T09	T04	T03	T11
426031	420764	426960	426896	420126.08	419436
5089472	5087030	5088349	5088982	5086400.14	5088245
372	400.49	359.21	359.86	392	357.36
292	320.49	279.21	279.86	312	277.36
0	0	0	0	0	0
103.4	103.4	103.4	103.4	103.4	103.4
103.4	103.4	103.4	103.4	103.4	103.4
1	1	1	1	1	1
3220.93	3222.42	3273.07	3530.42	3903.72	4720.46
41.89	41.91	44.42	41.2	40.02	28.15
0	0	0	0	0	0
81.16	81.16	81.3	81.96	82.83	84.48
0	0	0	0	0	0
-0.72	-0.72	-0.73	-0.81	-0.9	-1.09
0	0	0	0	0	0
0	0	0	0	0	-0.02
7.61	7.61	7.68	8.03	8.51	9.45
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
15.37	15.37	15.18	14.24	12.98	10.58
15.37	15.37	15.18	14.24	12.98	10.58