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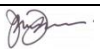
MURRA WARRA WIND FARM

PRELIMINARY ENVIRONMENTAL NOISE ASSESSMENT

Author	Jason Turner (MAAS)	
Reviewer	Chris Turnbull (MAAS)	

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INTRODUCTION

Sonus Pty Ltd has conducted an environmental noise assessment of the proposed Murra Warra Wind Farm, located near Horsham, Victoria.

The assessment has been conducted in accordance with the *New Zealand Standard 6808:2010 Acoustic Wind Farm Noise* as required under Victorian policy and planning guidelines[1]. In conducting the assessment the study was based on the following data:

- the proposed layout of the wind farm as detailed in Appendix A (providing the wind turbine generator (WTG) locations);
- the location and status of existing residences in the vicinity of the proposed wind farm as detailed in Appendix B (the locations of the WTGs relative to the residences is shown in Appendix E);
- Vestas V126 3.3MW or V136 3.45MW platform WTGs with serrated blades and a hub-height of 137m;
- background noise monitoring conducted at 7 representative locations, between 11 August and 26 November 2015.

[1] *Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria (Department of Land, Water and Planning, January 2016) – referenced in this report as "the Policy and Planning Guidelines".*

SITE LOCATION AND PROJECT DESCRIPTION

The Murra Warra Wind Farm is located approximately 25 kilometres due north of Horsham Victoria as shown on the plan below. The wind farm is located in the Wimmera region of Victoria and is wholly within a Farming Zone (FZ). The primary land use in the region is broad acre cropping (wheat, barley, pulses, canola, etc;) with some sheep grazing. The area is sparsely populated with 23 inhabited dwellings within 3km of the development.

The wind farm location has been chosen because of strong winds, good transport links and an onsite connection to the 220kV electricity grid network. The site topography can be regarded as flat for all practical purposes which is uncharacteristic of many other wind farms in Australia.

The project will consist of up to 116 wind turbine generators and associated permanent infrastructure. This will include crane hard standings, access tracks, overhead and underground electrical reticulation and up to four permanent metrological masts. There will be an onsite Terminal Station adjacent to the 220kV grid which will be the point of connection for exporting power generated by the development. A small operations and maintenance building will be located nearby. In addition to this there will be some temporary construction infrastructure which will include works compounds and a temporary quarry. Creation of site entrances and upgrades to minor roads close to the site will also be required.

VICTORIAN STATE PLANNING POLICY

State Planning Policy Framework Section 19.01-1 Renewable Energy

The Section promotes the provision of renewable energy development in a manner that ensures appropriate siting and design considerations are met. Planning must consider as relevant the *Policy and Planning Guidelines for the Development of Wind Energy Facilities in Victoria (Department of Land, Water and Planning, January 2016).*

Particular Provisions Section 52.32-4 Wind Energy Facility Design

The Section states "the noise impact from a proposal (be) prepared in accordance with the *New Zealand Standard NZS6808: 2010, Acoustics Wind Farm Noise*, including an assessment of whether a high amenity noise limit is applicable, as assessed under Section 5.3 of the standard".

The Policy and Planning Guidelines

Section 5.1.2 (a) Noise of the Policy and Planning Guidelines states a wind energy facility should comply with the assessment methodology and noise criteria recommended for the dwellings and other noise sensitive locations in the *New Zealand Standard NZS 6808:2010 Acoustics Wind Farm Noise* (the New Zealand standard) which is described in Section 5.2 of the Standard. The guidelines require post installation noise to be monitored and compliance demonstrated to the satisfaction of the responsible authority. Measurement and compliance assessment methods are set out in the Standard. Relevant to the planning stage the Standard defines how noise from wind farms should be predicted and the results used to assess the likely impact on nearby dwellings.

ASSESSMENT CRITERIA

The New Zealand Standard

Section 5.2 of the New Zealand Standard states:

> *As a guide to the limits of acceptability at a noise sensitive location, at any wind speed wind farm sound levels $L_{A90(10min)}$ should not exceed the background sound level by more than 5 dB, or a level of 40 dB $L_{A90(10min)}$, whichever is the greater.*

High Amenity Areas

The New Zealand Standard contains provisions for residences situated in high amenity areas, deemed applicable when "*a plan promotes a higher degree of protection of amenity related to the sound environment of a particular area*". In high amenity areas, the noise limit becomes the background noise level plus 5 dB(A), or a level of 35 dB(A), whichever is greater.

Dwellings within the vicinity of the proposed wind farm are located within a "Farming Zone" of the Yarriambiack, Horsham and Hindmarsh councils. For the purposes of this assessment, it is assumed that the farming zones do not promote a "higher degree of protection of amenity related to the sound environment".

Landowners with Commercial Agreements

The landowners of residences which have commercial agreements with the developer of the wind farm are termed associated landowners in this report.

It is understood that the landowners of one dwelling and three abandoned dwellings have agreed to enter into commercial agreements and these are currently being progressed by the proponent. RES Australia expect that before submission of the planning application commercial agreements will have been concluded with the owners of several dwellings which would enable these dwellings to be discounted from the assessment. H35, H37, H79 and H296 are therefore not included in this preliminary assessment and their status will be confirmed as a part of the final planning documentation. The associated landowners are listed in Appendix B.

It is common for the authorities to accept enhanced criteria for associated landowners. Suitable noise criteria will therefore be agreed upon between the developer and the associated landowner for all dwellings with a commercial agreement which remain occupied. These criteria are likely to be based on the WHO Guidelines[2], which recommend an indoor level of 30 dB(A) to protect against sleep disturbance. The indoor limit of 30 dB(A) equates to an outdoor noise level of 45 dB(A) with windows open or 52 dB(A) with windows closed. For the purposes of this preliminary assessment, all landowners have been considered against the New Zealand Standard noise levels rather than against enhanced criteria developed from the WHO Guidelines.

Substation Noise

To assess substation noise the *Noise from Industry in Regional Victoria* Guidelines[3] (the NIRV) has been referenced. The NIRV specifically excludes the assessment of wind energy facilities, except for noise from substations and transmission infrastructure.

The NIRV provides recommended maximum noise levels based on the planning zone of the noise source and noise receiver. Based on the "Farming Zone" in which the turbines and relevant residences are located, the most onerous (i.e. lowest) criterion is 36 dB(A) L_{Aeq}[4].

[2] "WHO Guidelines for Community Noise" World Health Organisation, 1999
[3] *Noise from Industry in Regional Victoria*, EPA Victoria, October 2011.
[4] This criterion corresponds to the recommended night-time (10pm to 7am) noise level for a noise source which can operate over a 24 hour period.

METHODOLOGY

The assessment methodology incorporates:

- background noise monitoring at dwellings in accordance with the New Zealand Standard;
- predictions of noise levels from the combined operation of the wind turbines at occupied dwellings;
- predictions of noise levels from the operation of the sub-station;
- comparison against the project's assessment criteria.

Background Noise Monitoring

To determine the background noise levels at various wind speeds, background noise monitoring was conducted at seven locations in the vicinity of the proposed wind farm between 12 August 2015 and 26 November 2015.

The monitoring locations, summarised in Table 1, were selected based on preliminary predictions of the wind farm noise. Preference was given to residential locations with the highest predicted noise levels and without commercial agreements, subject to permission being granted by the landowner to place a noise logger. The monitoring at H41 was conducted over two periods to ensure sufficient monitoring data were collected.

Table 1: Monitoring locations and periods.

Monitoring Location ID	Coordinates (UTM WGS84 54H)		Monitoring Period
	Easting	Northing	
H41	613316	5962130	12 August – 8 September 2015 & 10 November – 26 November 2015
H42	617405	5962523	12 August – 23 September 2015
H57	619031	5972440	12 August – 23 September 2015
H65	613196	5968127	24 September – 9 November 2015
H155	610457	5966643	12 August – 23 September 2015
H160	622812	5967041	12 August – 23 September 2015
H161	617959	5966346	24 September - 9 November 2015

The background noise was measured with “Rion NL21” Type 2 sound level meters, which have a noise floor less than 20 dB(A), calibrated at the beginning and end of the measurement period with a Rion NC74 Calibrator. All microphones were fitted with dual high wind speed weather proof windshields, with the microphone approximately 1.5m above ground level.

The noise loggers at existing dwellings were positioned at an equivalent distance from the facade of the dwelling as any significant trees at that location, whilst minimising the influence of fixed noise sources such as local domestic pumps or air conditioning units. The logger at H161 was not able to be placed on the property of the land owner due to access not being granted and therefore an equivalent logging location at the adjacent property was used. A photograph of the logger in relation to the residence is shown in Appendix C with each of the other monitoring locations.

The background noise level was measured in 10 minute intervals at each of the monitoring locations. Although not strictly required for background monitoring, the loggers were placed on the wind farm side of the residences, as would be required for post construction compliance monitoring, to enable a similar logging location for compliance checking.

During the background noise monitoring campaign, RES Australia measured the wind speed with a locally positioned meteorological mast, in 10 minute intervals at various heights. Details of the meteorological mast are provided below in Table 2.

Table 2: Meteorological Mast Details

Measurement Heights (m)	Position	
	Easting	Northing
72, 95, 100	618734	5965803

During the background noise measurement periods, rainfall and wind speed at the microphone height (approximately 1.5m above ground level) were also measured at Residence H161 using a HOBO Micro Station Logger H21-002. The collected rainfall and wind speed data were used to determine when weather on the microphone may have adversely affected the background noise measurement. This potentially affected data and any points clearly influenced by local activity (as can be caused by vehicles, people or birds in close proximity to the microphone) were removed from the data set before further analysis. The removed data included periods where rainfall was measured and/or where the measured wind speed exceeded 5 m/s at the microphone for more than 90% of the measurement period.

Predictions

Noise from the wind farm has been predicted based on the use of either Vestas V126 3.3MW or V136 3.45MW platform WTGs with "serrated blades". The proposed wind farm consists of 116 turbines with the coordinates of each given in Appendix A.

The predictions of turbine noise have been based on sound power level data determined and provided by Vestas in accordance with IEC 61400-11[5] as required by the New Zealand Standard. The data is summarised in "*V126-3.3MW-Mk2A-50/60 Hz Third Octaves according to General Specification"*, dated 11 November 2014 and "*V136-mk3 -3.45 MW Third octave noise emission"*, dated 23 November 2015.

The wind speed range for the assessment corresponds to between the approximate "cut-in" wind speed and the "rated power" wind speed when considered at the proposed hub height of 137m, which is a larger (more comprehensive) range than the minimum range recommended by the New Zealand Standard.

The sound power level and spectrum corresponding to each hub height integer wind speed used in this assessment are provided in Tables 3 and 4.

[5] IEC 61400 Part 11: 2006 Acoustic noise measurement techniques

Table 3: Vestas V126 3.3MW (Serrated Blades) Sound Power Levels (dB(A))

Hub Height Wind Speed [m/s]	Frequency (Hz)																								Overall (dB(A))
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	6.3k	8k	
4	44.5	55	57.1	59.3	61.7	69.2	74.5	68.7	73.9	76.7	77.5	78.2	77.3	81.8	77.9	77.6	77.9	77.1	78.2	77	75.9	73.9	73.2	66.5	62.2	55.5	**89.5**
5	44.9	55	57.4	60	62.8	70	75.4	70.4	75.2	77.8	78.7	79.4	78.4	82.5	79.1	78.8	79	77.8	78.9	77.5	76.7	74.5	73.4	66.8	61.4	53.9	**90.4**
6	53.9	59.2	60.1	65	69.7	79.3	76.8	78.9	80.3	81.4	82.1	82.5	81.9	82.9	84.6	84.5	84.4	83.7	81.8	81.4	80	76.9	74.8	67.8	60.8	57.3	**94.3**
7	54.1	58.7	63.2	68.5	72.1	75.3	82.2	80.5	81.4	84	84.4	84.9	84.5	86.1	87.6	87.8	88.1	86.5	84.9	84.1	82.5	79.4	76.5	70.1	62.8	58.6	**97.1**
8	61.9	63.8	68.7	73.4	77.8	79.4	83.1	85.1	85	86.9	88.1	88.6	88.5	89.9	92	92.3	92.4	91.4	88.8	88.4	86.2	83	80.1	73.5	67.1	63	**101.2**
9	65.2	67.1	71.3	76.3	79.9	82.2	84.8	89.2	87.6	89.4	90.6	91.2	91.3	92.6	95	95.6	95.7	94.7	91.9	91.4	89.1	85.9	83	76.5	70	65.6	**104.2**
10	68.5	66.8	70.8	76.2	79.7	81.9	84.5	90.1	87.7	89.4	90.8	91.6	91.8	93.2	95.7	96.4	96.5	95.7	92.8	92	89.6	86.4	83.5	77	70.9	66.5	**104.9**
11	70.5	71	75	80.1	83.3	85.3	87.5	91.2	89.1	90.1	91.1	91.8	91.9	93.3	95.8	96.4	96.8	96.2	93.4	92.5	90.1	87	85.1	78.8	74.1	71.2	**105.3**
12	70.9	71	75	80	83.1	85.2	87.3	90.9	88.9	89.8	91	91.9	92.2	93.6	96.1	96.7	97.1	96.6	93.7	92.9	90.3	87.1	85.7	78.7	74.1	71.9	**105.5**

Table 4: Vestas V136 3.45MW (Serrated Blades) Sound Power Levels (dB(A))

Hub Height Wind Speed [m/s]	Frequency (Hz)																								Overall (dB(A))
	25	31.5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	6.3k	8k	
4	63.5	66.3	69.3	74.2	75.9	79.6	82.6	75.1	82.0	85.5	84.7	84.9	85.0	84.7	85.0	83.2	82.5	83.8	81.1	81.5	81.3	78.9	79.2	71.8	66.2	61.6	**95.6**
5	61.1	62.8	66.3	71.6	73.8	77.8	81.1	75.2	81.8	85.7	85.1	85.3	85.5	85.2	85.4	83.5	82.6	83.5	81.1	81.4	81.5	79.3	78.9	72.2	66.7	60.7	**95.7**
6	61.0	62.3	66.2	71.3	74.2	78.0	81.2	79.6	83.6	86.6	86.8	87.4	87.7	87.6	87.9	86.3	85.4	85.8	83.9	83.6	83.5	81.3	80.6	74.1	68.4	61.1	**97.8**
7	62.5	64.2	68.3	73.0	76.3	79.7	82.4	85.2	86.1	87.8	88.8	89.7	90.2	90.4	90.8	89.7	89.0	88.9	87.6	86.4	86.0	83.7	83.1	76.4	70.4	62.3	**100.5**
8	63.9	65.8	70.2	74.4	78.2	81.3	83.7	90.2	88.6	89.1	90.8	92.0	92.7	93.1	93.6	92.9	92.3	91.8	91.0	89.2	88.4	86.1	85.4	78.6	72.5	63.5	**103.2**
9	65.1	67.2	71.7	75.7	79.8	82.6	84.7	93.8	90.4	90.1	92.2	93.7	94.6	95.0	95.7	95.3	94.8	93.9	93.6	91.2	90.2	87.8	87.2	80.2	74.0	64.5	**105.3**
10	66.2	68.9	73.2	76.9	80.9	83.6	85.5	94.3	90.7	90.2	92.2	93.7	94.6	95.1	95.8	95.5	95.2	94.3	94.0	91.5	90.3	87.9	87.6	80.3	74.0	65.0	**105.5**
11	67.9	71.4	75.3	78.8	82.5	84.9	86.7	94.4	91.0	90.1	92.0	93.5	94.4	94.8	95.6	95.4	95.2	94.6	94.1	91.7	90.3	87.7	87.9	80.1	73.7	65.6	**105.5**
12	69.3	73.5	77.1	80.4	83.8	86.0	87.6	94.4	91.2	90.1	91.7	93.3	94.1	94.5	95.4	95.3	95.3	94.8	94.2	91.8	90.2	87.6	88.1	79.8	73.5	66.2	**105.5**

The predictions have been conducted without a penalty for the presence of tonal characteristics. To provide certainty with respect to tonality, it is recommended that a guarantee is sought from the manufacturer that the final turbine selections do not result in a penalty when assessed in accordance with the New Zealand Standard.

The octave band sound power levels of the transformer have been derived from the *Australian/New Zealand Standard AS/NZS 60076.10:2009*[6]*.* Table 5 lists the octave band sound power levels used to predict the transformer noise.

Table 5: 540MVA Transformer, Sound Power Levels (dB(A))

Octave Band Centre Frequency (HZ)	63	125	250	500	1000	2000	4000	8000	Total
SWL (dB(A))	83.4	91.5	99.0	101.4	93.6	90.8	83.6	79.5	104.3

It is recommended that a guarantee is sought as part of the procurement process that the transformer/s combined with ancillary equipment achieves the above sound power levels.

ISO 9613-2:1996

Noise predictions were conducted using the propagation model, ISO 9613-2:1996 "Acoustics – Attenuation of sound during propagation outdoors" (ISO 9613). This noise propagation model is widely accepted as an appropriate model for the assessment of wind farms when appropriate inputs are used. The ISO 9613 model has the ability to take into account the distance between the source and receiver, topography, hardness of the ground and atmospheric absorption at different frequencies.

The ISO-9613 model is based on "*meteorological conditions favourable to propagation… These conditions are for downwind propagation…..or, equivalently, propagation under a well developed moderate ground based temperature inversion*" (ISO-9613).

[6]Australian/New Zealand Standard AS/NZS 60076.10:2009, *Power Transformers Part 10: Determination of sound levels (IEC 60076-10, Ed.1 (2001) MOD).*

The assessment has been based on the following inputs, agreed upon by UK experts[7] in a joint paper:

- Warranted sound power levels;
- 10°C temperature;
- 70% relative humidity;
- 50% acoustically hard ground and 50% acoustically soft ground;
- barrier attenuation of no greater than 2 dB(A);
- 4m receiver height; and
- Application of a 3 dB(A) correction where a "concave" ground profile exists.

[7] Institute of Acoustics Vol 34 No2 March/April 2009, “Prediction and Assessment of Wind Turbine Noise – Agreement about relevant factors for noise assessment from wind energy projects”

RESULTS

Background Noise Levels

Table 6 summarises the number of remaining data points at each monitoring location, following the removal procedure detailed in the "Methodology" section. It is noted that the New Zealand Standard requires a minimum of 10 days of logging, which typically results in 1440 useable data points.

Table 6: Useable Data Points at Monitoring Location

Residence ID	Number of Remaining Data Points
H41	4699
H42	4356
H57	4348
H65	4718
H155	4335
H160	4352
H161	4718

The resultant background noise data collected at the monitoring locations were correlated with extrapolated wind speed data at the proposed hub height of 137m. A least squares regression analysis of the data was undertaken to determine the line of best fit for the correlations in accordance with the New Zealand Standard. The data and the regression curves are shown in Appendix D.

The regression curves show two distinct groups of data in most cases. Further analysis has been conducted with the data being split into day and night periods. For all residences, a lower noise level was measured at night time in comparison to the day for the same wind speed. This indicates the background noise level has limited correlation to the wind speed at hub height during the night period and explains the grouping of data in the regression curves.

Based on the regression analysis, the background noise level ($L_{A90,10min}$) at a range of wind speeds within the operating range of the turbines is shown in Table 7 below.

Table 7: Background Noise Levels at Monitoring Location (dB(A))

137m AGL Wind Speed (m/s)	3	4	5	6	7	8	9	10	11	12
H41	32	32	33	33	34	34	35	35	35	34
H42	28	27	27	28	28	30	31	32	34	35
H57	22	23	23	24	26	27	29	30	31	31
H65	31	31	31	32	32	32	32	32	32	31
H155	26	25	25	26	27	28	29	30	31	32
H160	20	21	21	22	23	25	26	28	29	30
H161	21	23	25	27	28	28	29	30	30	30

From the above, the assessment criteria at each residential location have been determined and summarised in Appendix E. The results do not increase the project's criteria above the baseline noise level of 40 dB(A) provided by the New Zealand Standard. That is, the noise levels from the wind farm must be 40 dB(A) or less at every landowner without a commercial agreement.

Predicted Turbine Noise Levels

The predicted noise from the wind farm has been assessed against the criteria provided by the New Zealand Standard.

Appendix E lists the predicted noise from the turbines and the criteria for each residence at each relevant wind speed.

The predicted noise achieves the criteria at all assessed locations, and as such the proposed wind farm will not adversely impact on the amenity of residences.

Substation

Residence H161 is the closest to the proposed substation location at approximately 1000m. The predicted substation noise level is less than 29 dB(A) at this location. The level achieves the criterion of 36 dB(A) recommended by the NIRV, and as such will not adversely impact on the amenity of residences.

CONCLUSION

An environmental noise assessment of the proposed Murra Warra Wind Farm has been made.

The assessment considers the proposal comprising up to 116 wind turbine generators and a single substation.

The wind farm has been assessed at residences against the “baseline” criteria developed from the New Zealand Standard.

The predicted noise levels achieve the requirements of New Zealand Standard at all residences.

A final noise assessment will be conducted to confirm compliance with the project criteria when the final WTG and transformer selections are known and guaranteed sound power levels are provided by the manufacturers at the procurement stage. The final noise assessment will be submitted to the relevant authorities prior to the commencement of construction.

RECOMMENDATIONS

The currently proposed wind farm layout and turbine selection is predicted to achieve the project criteria at all residences within the vicinity with no specific acoustic treatment or mitigation measures.

Notwithstanding the above, a final assessment should be conducted for the final wind turbine selection and layout to ensure compliance with the criteria prior to construction of the wind farm commencing.

APPENDICES

Appendix A: Location of Operational Noise Sources

Turbine ID	Coordinates (UTM WGS84 54H)	
	Easting	Northing
T13	618601	5963999
T14	615376	5963992
T15	615826	5963992
T16	616276	5963992
T17	616726	5963992
T19	618029	5963996
T21	615376	5964532
T22	615826	5964532
T23	616276	5964532
T28	613485	5965072
T29	613963	5965072
T30	614476	5965072
T31	614926	5965072
T32	615376	5965072
T33	615826	5965072
T40	613484	5965612
T41	613963	5965612
T42	614476	5965612
T43	614926	5965612
T44	615376	5965612
T50	613484	5966141
T51	613963	5966141
T52	614476	5966152
T53	614926	5966152
T54	615376	5966152
T58	620755	5968829
T59	621205	5968829
T65	614476	5966728
T66	614926	5966733

Turbine ID	Coordinates (UTM WGS84 54H)	
	Easting	Northing
T67	615376	5966729
T69	620280	5968829
T74	614926	5967332
T75	619434	5968828
T76	619830	5968829
T82	618201	5968644
T83	618730	5968644
T85	614973	5968482
T101	617176	5963992
T102	612584	5966152
T103	612584	5965612
T104	612584	5965073
T107	619380	5968289
T108	619830	5968289
T109	620280	5968289
T110	620755	5968289
T114	619830	5967749
T115	620280	5967749
T116	620750	5967749
T120	619978	5967146
T145	619051	5964000
T151	615423	5968484
T152	615873	5968484
T153	616323	5968484
T154	616773	5968484
T155	617223	5968484
T156	615423	5967885
T157	615873	5967944
T158	616323	5967944

Turbine ID	Coordinates (UTM WGS84 54H)	
	Easting	Northing
T161	615376	5967334
T162	615873	5967404
T190	612584	5964533
T195	614476	5964532
T196	614926	5964532
T198	614926	5963992
T214	613034	5966152
T215	613034	5965612
T216	613034	5964533
T217	613484	5964533
T218	613963	5964532
T219	612134	5964533
T220	612134	5963993
T221	612584	5963993
T222	613034	5963993
T223	613484	5963993
T224	613963	5963992
T225	614476	5963992
T226	619829	5969373
T227	620278	5969373
T228	620737	5969378
T229	621179	5969377
T230	621627	5969369
T231	622253	5969023
T232	622705	5969019
T233	622253	5969531
T234	622709	5969531
T235	619837	5969917
T236	620282	5969913
T237	620729	5969920
T238	621182	5969913
T239	621627	5969913

Turbine ID	Coordinates (UTM WGS84 54H)	
	Easting	Northing
T240	622249	5970075
T241	622717	5970059
T242	623178	5970051
T243	623634	5970047
T244	620345	5970611
T245	620798	5970627
T246	621303	5970623
T247	621773	5970607
T248	622217	5970631
T249	622697	5970619
T250	620381	5971191
T251	620829	5971183
T252	621313	5971183
T253	621785	5971178
T254	622221	5971170
T255	620816	5971722
T256	621308	5971722
T257	621769	5971714
T258	620361	5971717
T259	619900	5970619
T260	623146	5969021
T261	623158	5969534
T262	623608	5969527
T263	621186	5968269
T264	621730	5968695
T265	621727	5968152
Substations		
540MVA	618353	5967265

Appendix B: Residence Locations

Residence ID	Coordinates (UTM WGS84 54H)	
	Easting	Northing
Associated Residences		
H32	609929	5964165
H33	608876	5963475
H37	613325	5963497
H40	621613	5965564
H42	617405	5962523
H47	623616	5972980
H61	618770	5966114
H65	613196	5968127
H83	618025	5961376
H154	618942	5961384
Unoccupied		
H35	611145	5964724
H272	618372	5971895

Residence ID	Coordinates (UTM WGS84 54H)	
	Easting	Northing
Residences		
H31	609849	5965075
H34	610022	5962639
H38	621382	5965014
H41	613316	5962130
H43	621731	5961377
H44	626360	5967309
H45	624691	5967192
H46	624607	5967875
H55	620332	5976059
H56	619624	5975615
H57	619031	5972440
H66	611106	5967832
H72	608860	5968610
H73	608806	5966730
H78	615072	5971149
H80	615698	5961530
H116	609224	5961337
H117	609101	5960120
H118	612028	5959547
H155	610457	5966643
H156	612731	5971540
H159	626447	5965333
H160	622812	5967041
H161	617959	5966346
H163	623051	5964331
H190	624924	5974660
H318	609682	5961902
Unoccupied		
H268	620273	5960803
H317	609331	5963170

Appendix C: Photographs of Logger Locations

H41

H42

H57

H65

H155

H160

H161