
DETERMINATION OF SOUND POWER LEVELS OF A SUBSTATION TRANSFORMER

Prepared for:

**Windlectric Inc.
Amherst Island Wind Project**

December 14, 2018

1 INTRODUCTION

HGC Engineering was retained by Windlectric Inc. to complete acoustic measurements of the Amherst Island Wind Energy Project substation transformer, to satisfy Condition E3 of the Renewable Energy Approval (“REA”) Number 7123-9W9NH2, issued to the site by the Ontario Ministry of Environment, Conservation and Parks (“MECP”) dated August 24, 2015.

The audit condition in the REA requires the determination of the sound power levels of the substation for comparison with the specification included in the Noise Assessment Report for the project, dated May 4, 2015 [1], completed by others, and Schedule B of the REA. The sound power levels of the transformer were measured on December 11, 2018, utilizing IEEE Standard C57.12.90-2015, titled IEEE Standard Test Code for Liquide-Immersed Distribution, Power and Regulating Transformers – Part 13: Audible Sound Emission [2].

2 SOUND SOURCE UNDER TEST

The acoustically significant components of the substation include a power transformer and the associated cooling fans, manufactured by Virginia Transformer Corporation. The station is situated on Amherst Island, approximately 1.5 km southwest of the town of Stella, Ontario. The substation transformer is nominally rated at 50/66.5/83 MVA. The overall dimensions of the transformer, including the affixed cooling fans and radiators, are approximately 6.0 metres wide, 6.9 metres in length and 4.2 metres in height. The transformer is surrounded by an acoustic barrier 6.0 metres in height, on the east, south and west sides. Photos of the transformer are provided below, as Figures 1 and 2.

Acoustically, the sound of the transformer core was found to be tonal in the nearfield, whereas the transformer fans emitted broadband sound. A tonal sound is defined as one which has a “pronounced audible tonal quality such as a whine, screech, buzz or hum”. A/C transformers typically exhibit a humming character at twice the line frequency (120 Hz) and harmonics thereof

(240 Hz, 360 Hz, 480 Hz, etc.), as a result of magnetostrictive forces in the windings and semiconductors. The sound level measurements indicated tones at 120 Hz and the associated harmonics. The unit was operating normally during the test period.

3 ACOUSTIC ENVIRONMENT

The measurements were conducted outdoors at the Amherst Island Wind Project substation, on Amherst Island, Ontario. The sound of the substation was steady, with little background sound in the vicinity. The weather conditions during the test period remained relatively constant with cloudy skies, an air temperature of approximately 2° Celsius, and negligible wind at the measurement location due to shielding provided by the surrounding acoustic barriers. Accordingly, the environment was suitable to conduct acoustical measurements.

4 INSTRUMENTATION

The sound level measurements were conducted using a Brüel & Kjær Hand-held Analyzer Type 2270, equipped with Sound Intensity software BZ-7233, a Brüel & Kjær model 3654 Sound Intensity Probe and a pair of phase-matched model 4197 microphones. The calibration of instrumentation was field verified before and after the measurements using a Brüel & Kjær model 4231 sound level calibrator with a dual microphone coupler. Laboratory calibration certificates for the equipment are included as Appendix A.

5 MEASUREMENT PROCEDURE

A sketch of the measurement setup is appended as Figure 3. As per the IEEE C57.12.90-2015, measurements of sound intensity were conducted at 1/3 height and 2/3 height of the transformer, at 1-meter intervals around all four sides of the units. Measurements were conducted at an offset distance of 0.3 meters from the tank and radiator surfaces without the cooling fans operating. With the fans operating, the measurements were conducted 2 metres from the tank, fans and radiator surfaces. Note that recent study into methods of measuring sound levels from electrical transformers indicates that measurements completed utilizing sound intensity methods provide results which are more accurate than measurements of sound pressure [3]. Unlike a simple sound level meter with an omni-directional microphone, sound intensity instrumentation utilizes a highly directional probe and sophisticated analyzer to measure both the magnitude and direction of sound. This approach therefore has excellent immunity to background noise, acoustical reflections, near-field reactivity and cross-interference from sources located close together.

6 MEASUREMENT RESULTS

Table I provides the average octave band sound intensity levels of the transformer measured utilizing IEEE C57.12.90-2015. Note that, without the cooling fans operating, measurements were conducted at 23 unique locations around the transformer, and with the cooling fans operating, the transformer was measured at 32 unique locations, as described in the previous section.

Table I: Sound Intensity Levels [dB]

Octave Band Centre Frequency [Hz]	63	125	250	500	1k	2k	4k	8k	Overall [dBA]
Transformer Core	53.6	57.2	56.1	52.0	44.9	27.2	21.8	17.3	52.5
Transformer Core & Fans	66.1	63.9	65.9	65.2	63.5	58.5	50.4	45.3	67.4

Appendix B contains the detailed one-third octave band sound intensity level results.

The conversion from sound intensity level to sound power level is based on the area of the imaginary surface enclosing the source, at the specified reference distance from the equipment. In this case, the enclosing surface areas for the transformer without and with the fans operating are 152 m² and 281 m², respectively.

The overall octave band sound power level calculated from the measured sound intensity levels of the substation are presented in Table II, below.

Table II: Measured Sound Power Levels [dB re 10⁻¹² Watts], Calculated Using Sound Intensity Measurements

Octave Band Centre Frequency [Hz]	63	125	250	500	1k	2k	4k	8k	Overall [dBA]
Transformer Core*	80.4	84.0	82.9	78.8	71.8	54.1	48.7	44.1	79.3
Transformer Fans (core subtracted)	90.5	87.8	90.2	89.6	88.0	83.0	74.9	69.8	91.8
Transformer Substation* (Transformer & Cooling Fans)	90.9	89.4	90.9	89.9	88.1	83.0	74.9	69.8	92.1

*Sound power levels include the +5 dBA tonal adjustment applied to transformer core

Table III shows the sound power levels utilized in the assessment of the transformer substation, as outlined in [1] and Schedule B of the REA.

Table III: Specified Sound Power Level [dB re 10⁻¹² Watts]

Octave Band Centre Frequency [Hz]	63	125	250	500	1k	2k	4k	8k	Overall [dBA]
Transformer Substation	104.0	107.0	105.0	105.0	99.0	94.0	89.0	81.0	105.2

*Sound power levels include the +5 dBA tonal adjustment

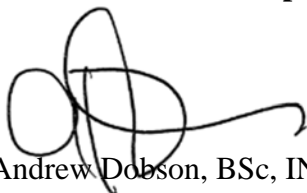
The sound level measurements indicate that the octave band and overall A-weighted sound power levels of the substation meet the specified sound power levels outlined in [1] and Schedule B of the REA.

7 CONCLUSIONS

HGC Engineering completed an Acoustic Audit of Windlectric’s Amherst Island Wind Project substation, located on Amherst Island, Ontario. Sound power level measurements were completed on December 11, 2018 utilizing IEEE Standard C57.12.90-2015. The sound level measurements and subsequent calculations indicate the octave band and overall A-weighted sound power levels of the substation are significantly less than the specified sound levels in the Noise Assessment Report [1] and Schedule B of the REA.

We trust that this information satisfies your current requirements. If you have any questions or require further assistance, please do not hesitate to call.

Howe Gastmeier Chapnik Limited


Andrew Dobson, BSc, INCE

Reviewed by


Ian Bonsma, PEng



REFERENCES

- [1] Hatch, “Noise Assessment Report – Revision 14, Amherst Island Wind Project”, May 4, 2015.
- [2] IEEE Standard C57.12.90-2015, titled IEEE Standard Test Code for Liquide-Immersed Distribution, Power and Regulating Transformers – Part 13: Audible Sound Emission
- [3] Andrew Dobson, “Addressing the Complexities, Limitations and Benefits Involved in Conducting Near-Field Sound Power Measurements of Large Electrical Transformers”, Internoise Innsbruck, September 2013.



Figure 1: Transformer

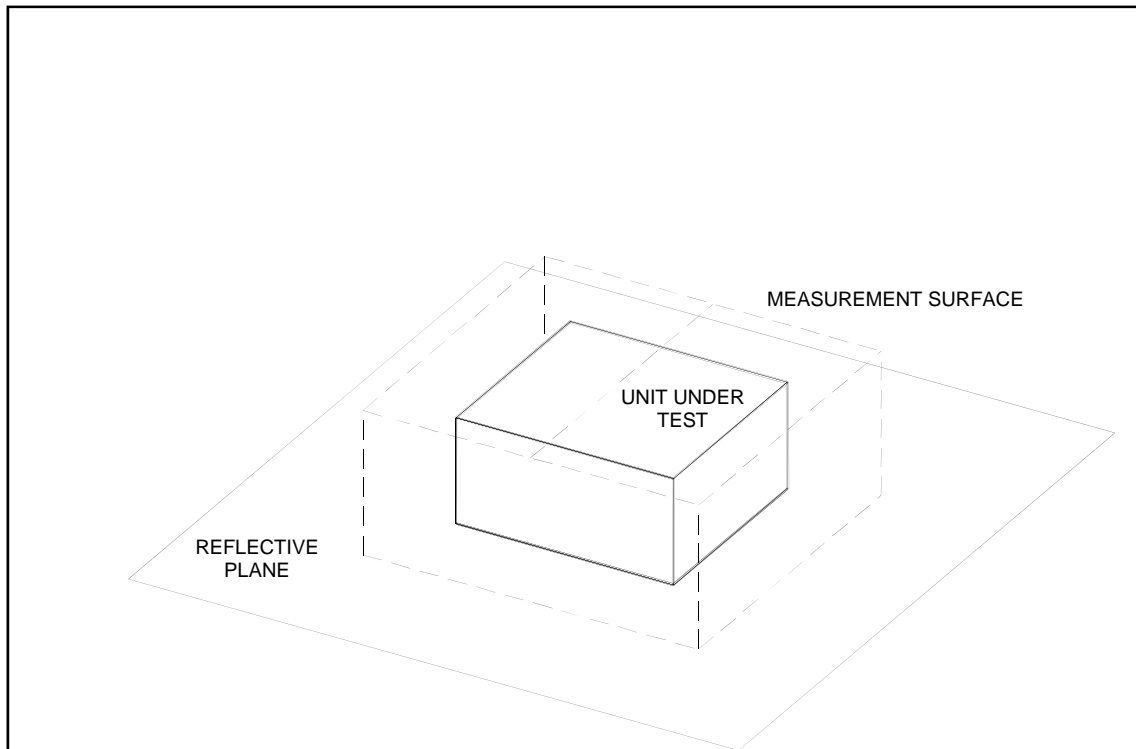
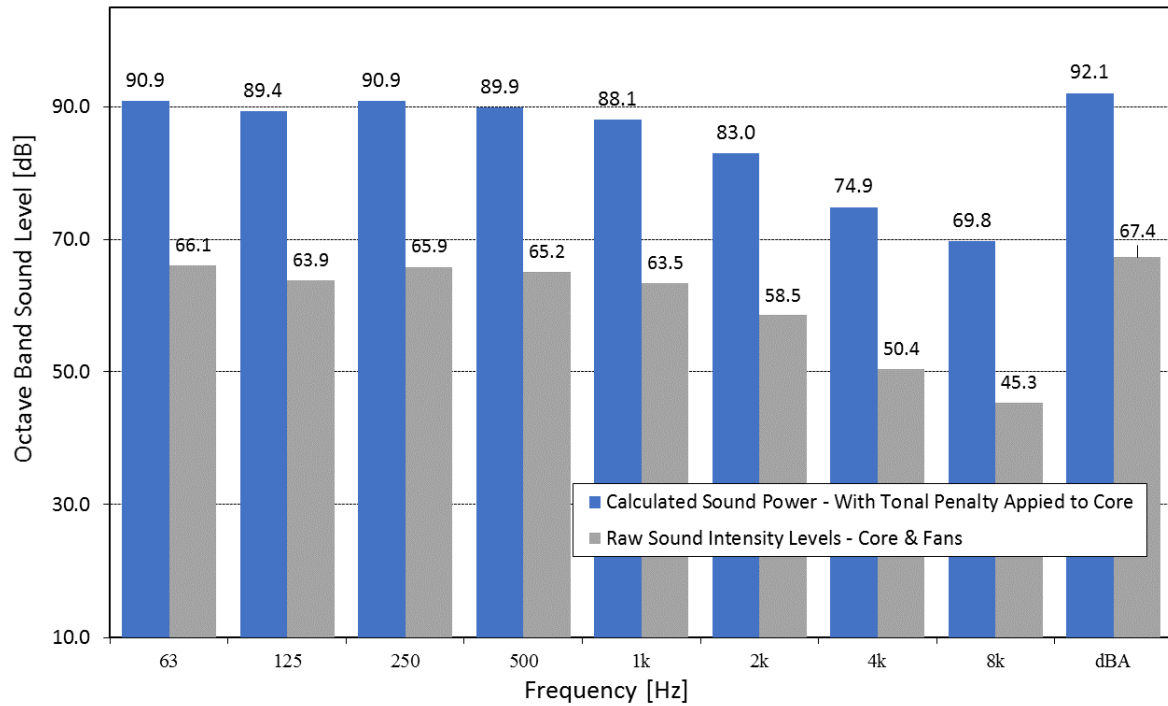


Figure 2: Sketch of Measurement Surface

Figure 3: Sound Power and Sound Intensity Levels
 Transformer Substation, Measured December 12, 2018



APPENDIX A
Instrument Calibration Certificates



ACOUSTICS



NOISE



VIBRATION

CERTIFICATE of CALIBRATION

Make : Bruel & Kjaer

Reference # : 151175

Model : 4197

Customer : HGC Engineering
Mississauga, ON

Descr. : Microphone pair sound intensity 1/2"

Serial # : 2462193

P. Order : Sean Richardson

Asset # : NAN

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Jan 02, 2018

By :

Cal. Due : Jan 02, 2019

J. Raposo

Temperature : $23^{\circ}\text{C} \pm 2^{\circ}\text{C}$ Relative Humidity : 30% to 70%

Standards used : J-163 J-216

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

6375 Dixie Rd. Mississauga, ON, L5T 2E7
Phone : 905 565 1584

Fax: 905 565 8325

<http://www.navair.com>
e-Mail: service@navair.com

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CERTIFICATE of CALIBRATION

Make : Bruel & Kjaer

Reference # : 151191

Model : 2270

Customer : HGC Engineering
Mississauga, ON

Descr. : Sound Level Meter Type 1 2ch

Serial # : 3003000

P. Order : Sean Richardson

Asset # : 1

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Dec 29, 2017

By : 
J. Raposo

Cal. Due : Dec 29, 2018

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-216 J-303 J-512

Navair Technologies

REPAIR AND CALIBRATION TRACEABLE TO NRC AND NIST

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CERTIFICATE of CALIBRATION

Make : Bruel & Kjaer

Reference # : 151197

Model : 4231

Customer : HGC Engineering
Mississauga, ON

Descr. : Sound cal 94/114dB 1KHz Type 1

Serial # : 2309241

P. Order : Sean Richardson

Asset # : BK CAL 3

Cal. status : Received in spec's, no adjustment made.

Navair Technologies certifies that the above listed instrument was calibrated on date noted and was released from this laboratory performing in accordance with the specifications set forth by the manufacturer.

Unless otherwise noted in the calibration report a 4:1 accuracy ratio was maintained for this calibration.

Our calibration system complies with the requirements of ISO-17025 standard, working standards used for calibration are certified by or traceable to the National Research Council of Canada or the National Institute of Standards and Technology.

Calibrated : Dec 28, 2017

By :



Cal. Due : Dec 28, 2018

J. Raposo

Temperature : 23 °C ± 2 °C Relative Humidity : 30% to 70%

Standards used : J-163 J-261 J-282 J-508

Navair Technologies

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APPENDIX B
Detailed Measurement Results & Equipment Drawings



ACOUSTICS



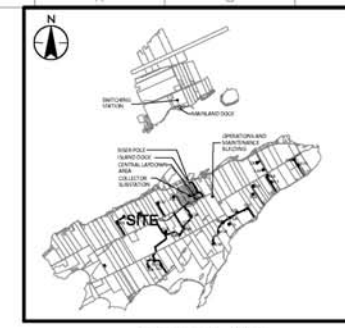
NOISE



VIBRATION

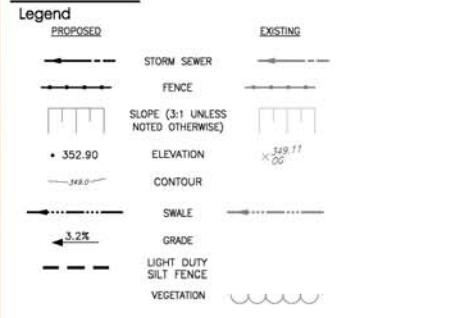
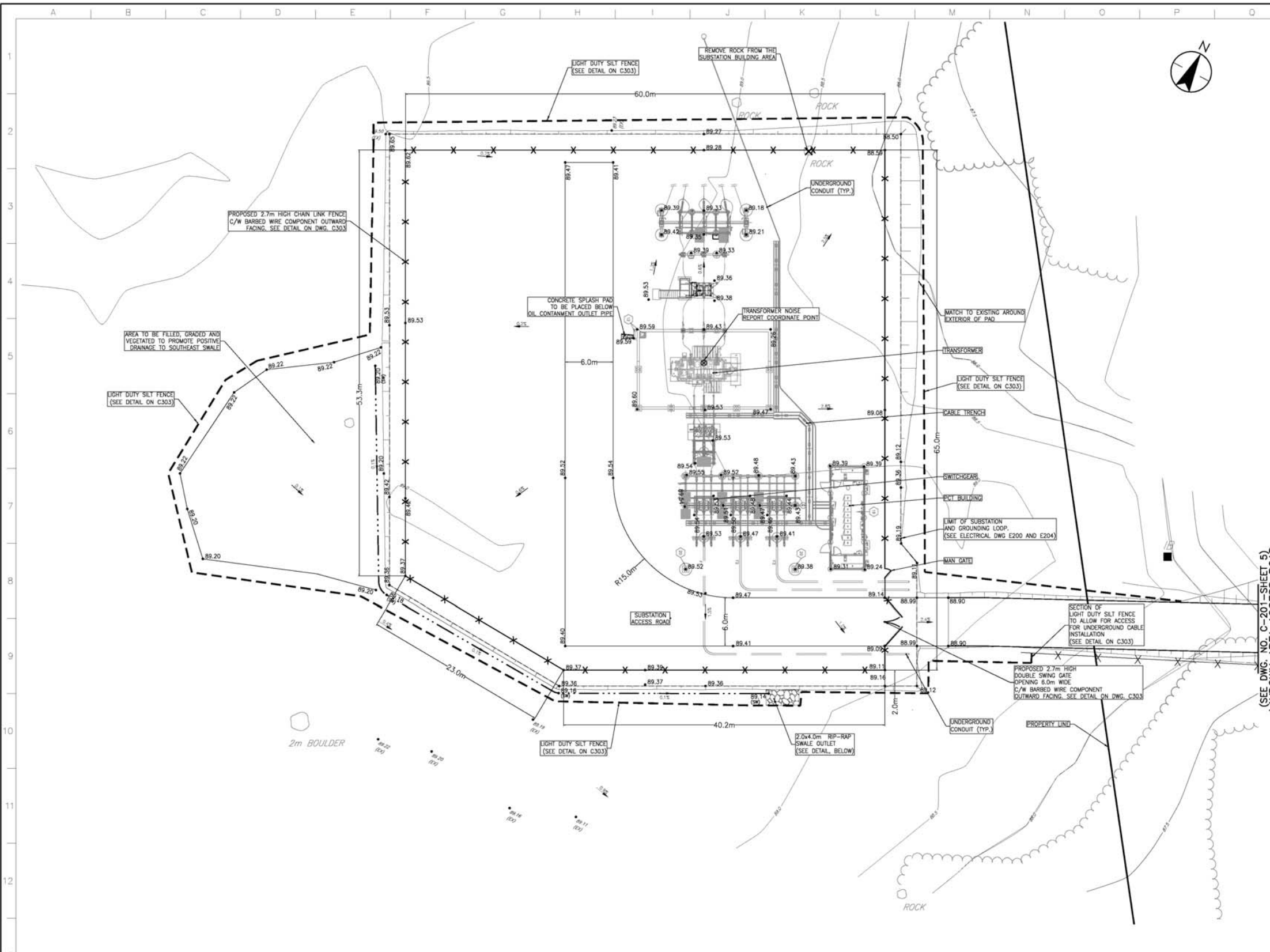
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- Notes**
1. TOPOGRAPHIC SURVEY COMPLETED BY MONTOSH PERRY CONSULTING ENGINEERS DATED 2015 (UTM ZONE 18 NAD83 (CRSR)1997.0). GEOTECHNICAL INFORMATION PROVIDED BY STANTEC MEMO, DATED JUNE 2015.
 2. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER DRAWINGS IN THIS SET PREPARED BY STANTEC CONSULTING LTD.
 3. THE CONTRACTOR MUST VERIFY DIMENSIONS; OBTAIN ALL UTILITY LOCATES AND OBTAIN ALL REQUIRED PERMITS/LICENSES AND VERIFY ELEVATIONS OF EXISTING SERVICES BEFORE PROCEEDING WITH ANY WORK.
 4. ALL CONSTRUCTION WORK SHALL BE CARRIED OUT IN ACCORDANCE WITH THE REQUIREMENTS OF THE OCCUPATIONAL HEALTH AND SAFETY ACT AND REGULATIONS FOR CONSTRUCTION PROJECTS (LATEST EDITION).
 5. ENCROACHMENT ON NON-PARTICIPATING PROPERTIES IS STRICTLY PROHIBITED. THE CONTRACTOR AND/OR THEIR REPRESENTATIVES ARE TO BE AWARE OF ALL PARTICIPATING LAND OWNERS ON THE PROJECT AND THE PROJECT'S CONSTRUCTIBLE LIMITS. ALL CONSTRUCTION ACTIVITY BEYOND THE CONSTRUCTIBLE LIMITS IS STRICTLY PROHIBITED.
 6. THE CONTRACTOR IS RESPONSIBLE FOR RESTORATION OF ALL DAMAGED AND/OR DISTURBED PROPERTY WITHIN THE MUNICIPAL RIGHT-OF-WAY TO THE CURRENT MUNICIPAL STANDARDS AND SHALL CONFORM TO ROAD USE AGREEMENT.
 7. THE CONTRACTOR IS TO BE RESPONSIBLE FOR ALL DRAINAGE AND MEASURES TO CONTROL STORM WATER. THE SITE IS TO BE FINE GRADED/LEVELLED LEAVING THE SITE IN A NEAT APPEARANCE SUCH THAT POSITIVE DRAINAGE IS ACHIEVED.
 8. CONSTRUCTION TURNING RADII LIMITS IDENTIFY AREAS WHERE ADDITIONAL ROAD WIDTH IS REQUIRED TO ALLOW FOR ADEQUATE CLEARANCE FOR CONSTRUCTION VEHICLES.
 9. ALL DISTURBED AREAS ARE TO BE RE-VEGETATED USING NATIVE TOPSOIL AND SEED AS PER REA APPROVAL. MIX AND APPLICATION RATE/METHOD TO BE APPROVED PRIOR TO IMPLEMENTATION.
 10. CLEARING AND GRUBBING AND REMOVALS TO BE COMPLETED IN ACCORDANCE WITH OPSS 808.
 11. GRADING TO BE COMPLETED IN ACCORDANCE WITH OPSS 206.
 12. GRANULAR MATERIAL TO BE USED IN ACCORDANCE WITH OPSS 1010.
 13. ALL CULVERTS TO BE CONSTRUCTED IN ACCORDANCE WITH OPSS 421 AND AS PER OPSS 902.010.



NOTE: REFER TO DRAWING E200, E204 AND C201 FOR ELECTRICAL AND TRANSPORTATION DETAILS

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH DRAWING C303 FOR ADDITIONAL DETAILS AND NOTES



CONTROLLED

Revision	By	Appd.	YY.MM.DD
0.	ISSUED FOR CONSTRUCTION	DMS	TN 17.07.28

Permit-Seal

Client/Project

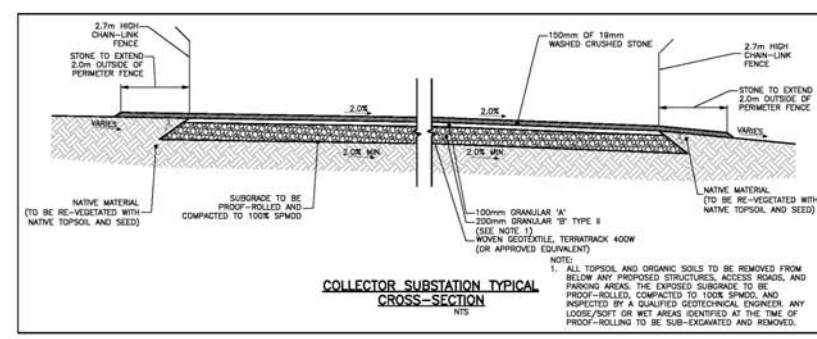
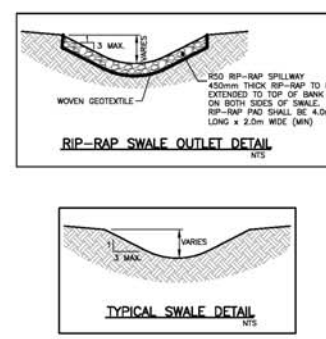
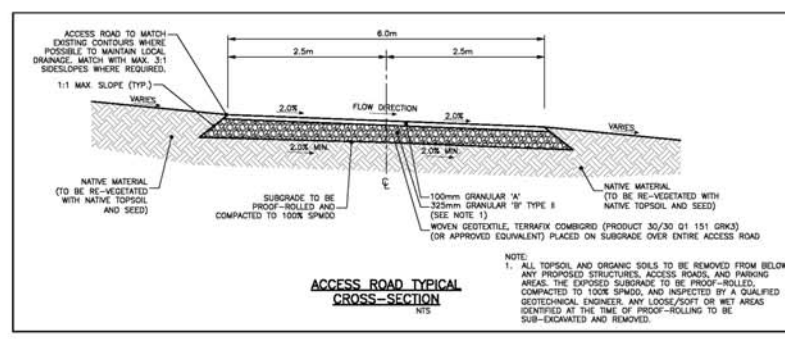
PENNECON HEAVY CIVIL

AMHERST ISLAND WIND PROJECT
75MW WIND FARM
Amherst Island, Loyalist Township, Ontario

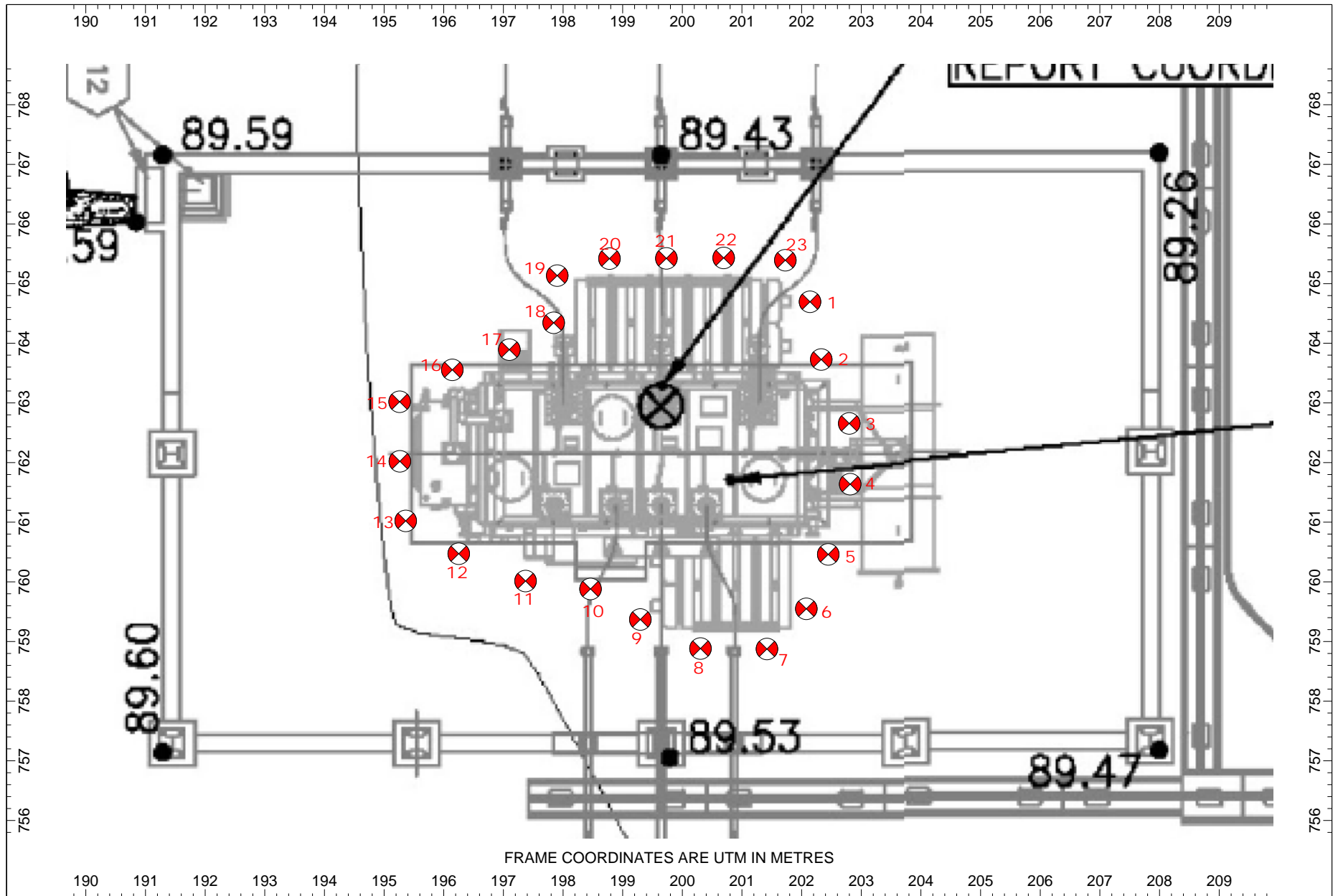
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COLLECTOR SUBSTATION GRADING AND SEDIMENT AND EROSION CONTROL PLAN

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133560100	1:250	
Drawing No.	Sheet	Revision
C101	1 of 1	0



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Microphone Positions Around Transformer (fans not operating)
 Microphone Height = 1.4 Metres & 2.8 Metres, Offset = 0.3 Metre

One-Third Octave Frequency [Hz]	Measured Transformer Sound Intensity Levels [dB] - Core Only (fans off)																						
	2/3 Height Microphone Position (Height = 2.8 Metres Above Grade)																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
25	nil	nil	nil	nil	nil	nil	nil	nil	nil	62	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	
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ACOUSTICS



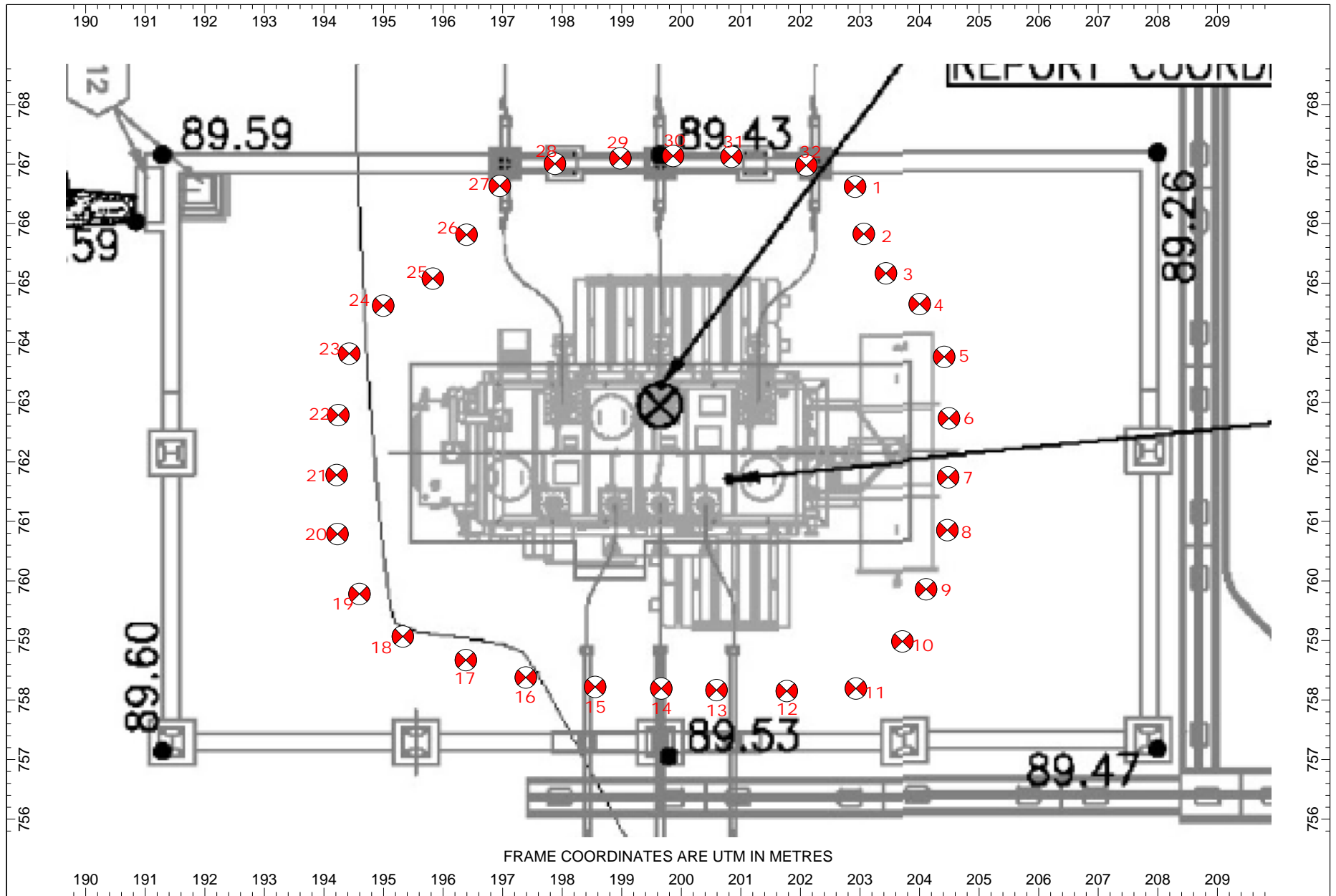
NOISE



VIBRATION

One-Third Octave Frequency [Hz]	Measured Transformer Sound Intensity Levels [dB] - Core Only (fans off)																						
	1/3 Height Microphone Position (Height = 1.4 Metres Above Grade)																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
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200	25	42	42	50	41	39	37	36	32	36	46	40	41	51	48	nil	46	51	nil	44	40	40	
250	35	56	58	64	51	52	51	51	48	49	60	50	57	66	62	nil	60	59	nil	59	45	54	
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630	42	45	37	42	49	44	46	43	45	32	47	46	39	47	41	nil	49	nil	54	46	nil	42	
800	43	47	42	47	52	47	43	38	34	nil	50	51	44	48	47	39	49	42	45	39	nil	27	
1000	32	34	38	31	37	22	24	25	26	30	41	nil	nil	30	31	22	33	34	42	30	nil	26	
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2000	nil	14	17	18	38	8	16	11	9	15	nil	19	nil	nil	nil	13	17	16	18	14	18	19	
2500	nil	7	17	nil	36	nil	nil	nil	nil	20	nil	nil	nil	6	nil	11	15	nil	20	nil	20	18	
3150	nil	nil	10	nil	35	8	13	nil	15	15	nil	nil	nil	4	nil	nil	15	16	17	11	23	19	
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6300	nil	nil	nil	nil	17	nil	nil	11	13	20	nil	9	nil	10	nil	nil	15	11	11	18	26	nil	
8000	0	nil	9	nil	19	11	nil	12	9	nil	nil	11	nil	4	nil	nil	nil	14	0	22	10	16	
10000	nil	nil	nil	nil	nil	11	16	nil	nil	18	nil	10	nil	nil	7	17	15	15	13	20	13	nil	
A-Weighted	45	53	52	57	57	50	49	48	50	46	56	54	52	58	55	50	55	54	55	53	42	48	





Microphone Positions Around Transformer (fans operating)

Microphone Height = 1.4 Metres & 2.8 Metres, Offset = 2 Metres (1 metre around south radiator)



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NOISE



VIBRATION

One-Third Octave Frequency [Hz]	Measured Transformer Sound Intensity Levels [dB] - Core & Fans 2/3 Height Microphone Position (Height = 2.8 Metres Above Grade)																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
25	nil	72	nil	nil	55	nil	nil	nil	nil	63	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
32	nil	nil	nil	nil	nil	nil	nil	nil	58	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil
40	58	63	72	68	nil	66	63	nil	nil	66	nil	74	76	nil	nil	nil	nil	nil	nil	nil	nil	58	63	56	nil	71	75	nil	78	nil	nil	78	
50	65	nil	nil	69	nil	nil	nil	61	57	nil	58	59	68	nil	52	nil	nil	nil	nil	nil	64	53	nil	nil	54	66	69	nil	nil	nil	66	nil	
63	nil	nil	nil	nil	54	nil	nil	nil	nil	nil	nil	68	nil	69	nil	nil	nil	nil	nil	nil	53	nil	60	nil	63	62	44	65	61	nil	62	nil	
80	nil	nil	67	nil	67	nil	nil	nil	nil	59	nil	70	55	67	nil	nil	nil	nil	nil	54	nil	55	68	68	56	63	69	63	nil	nil	71	59	
100	60	nil	nil	nil	59	nil	53	48	53	59	57	63	63	56	nil	nil	54	nil	nil	45	56	57	59	55	nil	59	62	58	58	55	57	nil	
125	64	62	66	63	58	59	nil	54	nil	nil	53	66	64	63	nil	nil	47	nil	nil	64	62	nil	48	49	60	62	64	62	54	62	nil	43	
160	64	65	66	64	63	57	62	63	61	55	56	nil	56	58	58	62	55	54	63	59	48	59	58	58	51	60	64	62	60	56	59	62	
200	61	64	64	64	62	59	57	58	61	56	50	58	58	55	58	58	nil	53	58	57	51	58	55	58	59	60	62	61	60	60	61	63	
250	63	66	66	66	64	62	58	61	63	63	64	64	62	64	64	62	58	58	58	56	57	59	57	60	62	63	64	62	63	62	64	64	
315	62	65	66	65	62	59	58	59	60	61	56	64	63	60	61	60	59	57	58	56	54	56	58	59	61	60	58	59	59	61	60	62	
400	62	65	65	64	61	60	59	60	59	59	58	58	59	61	61	60	59	59	59	56	54	56	57	60	61	62	56	57	56	59	58	63	
500	63	65	66	65	62	59	60	60	60	61	62	60	59	63	62	62	59	59	59	56	52	53	56	59	61	61	57	59	59	59	61	63	
630	62	64	65	64	63	59	60	60	60	60	59	58	60	63	62	62	59	58	59	55	51	54	56	59	60	59	54	55	56	57	60	62	
800	60	63	64	64	61	59	58	59	60	60	58	57	58	61	62	62	59	58	58	54	50	53	55	58	59	58	54	54	54	55	59	61	
1000	60	63	64	63	61	58	59	60	60	60	57	53	59	61	62	61	59	59	58	54	49	53	55	58	59	58	53	53	54	57	58	61	
1250	59	62	63	63	60	57	57	58	59	59	55	52	58	60	62	61	58	58	58	54	47	51	53	56	57	58	52	52	53	56	58	60	
1600	57	60	61	60	59	56	55	56	57	57	52	53	57	58	61	60	57	57	56	52	43	47	51	54	55	55	50	49	52	55	56	58	
2000	54	57	58	57	55	53	51	52	53	53	49	50	54	55	57	56	53	52	52	49	41	44	47	50	51	51	46	48	48	51	53	55	
2500	52	54	55	54	53	49	48	48	49	48	45	46	51	52	54	53	50	49	49	46	37	41	44	46	47	46	42	44	44	48	50	52	
3150	50	51	52	52	49	46	46	47	47	47	42	43	48	50	51	51	47	47	46	43	33	40	42	45	46	45	40	42	42	46	48	50	
4000	48	49	50	49	47	44	44	44	45	45	40	42	47	49	50	49	46	45	44	41	31	36	39	41	43	42	37	38	39	44	46	48	
5000	47	48	48	48	45	42	40	41	39	38	36	38	46	48	48	44	43	43	39	30	30	34	36	35	34	33	35	37	43	45	47		
6300	45	46	46	46	44	40	38	38	37	35	34	36	44	46	47	46	42	41	40	37	28	26	30	33	32	31	31	33	35	42	44	46	
8000	44	44	45	44	42	38	35	35	32	32	30	34	43	45	46	47	40	39	38	35	24	19	23	26	27	26	28	30	33	41	44	45	
10000	43	43	43	43	41	38	34	33	31	30	30	34	42	43	44	45	39	37	36	34	24	21	20	25	25	25	29	31	34	40	42	43	
A-Weighted	69	71	72	72	70	67	66	67	68	68	66	66	67	69	70	70	67	66	66	63	59	61	63	66	67	67	63	64	64	66	67	69	



ACOUSTICS



NOISE



VIBRATION

One-Third Octave Frequency [Hz]	Measured Transformer Sound Intensity Levels [dB] - Core & Fans 1/3 Height Microphone Position (Height = 1.4 Metres Above Grade)																																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
25	nil	nil	67	nil	nil	nil	nil	nil	nil	nil	nil	67	68	72	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	nil	70	nil	nil	nil	nil	nil
32	60	nil	nil	nil	nil	nil	71	65	65	nil	67	68	nil	nil	nil	nil	69	nil	nil	nil	nil	nil	nil	nil	61	nil	nil	nil	nil	nil	nil	nil	nil
40	nil	nil	73	68	63	59	69	nil	nil	nil	nil	60	71	nil	nil	nil	70	nil	nil	65	59	63	nil	66	68	73	nil	nil	73	63	nil	nil	nil
50	nil	nil	61	nil	66	59	63	nil	44	nil	69	65	nil	nil	66	64	nil	nil	59	nil	nil	51	nil	70	nil	65	66	nil	nil	nil	nil	61	61
63	64	62	59	nil	65	nil	59	nil	60	nil	60	61	nil	nil	52	nil	48	50	nil	58	nil	57	nil	57	63	60	66	62	59	nil	61	68	
80	55	62	nil	53	54	61	nil	65	62	nil	53	66	59	63	nil	nil	nil	53	nil	53	66	68	68	71	67	69	nil	nil	nil	nil	61	68	
100	54	59	55	nil	nil	nil	54	60	nil	nil	57	64	58	57	nil	nil	nil	57	59	nil	58	54	49	54	nil	58	43	61	nil	nil	nil	nil	
125	53	65	66	55	61	nil	60	59	nil	nil	64	66	62	61	nil	60	58	nil	53	61	55	58	50	54	57	66	62	59	57	56	61	59	
160	62	64	64	64	60	53	nil	60	48	53	58	60	61	56	58	57	58	nil	55	nil	57	58	56	57	60	63	61	59	59	62	57	53	
200	61	65	65	63	60	62	58	59	60	59	61	57	58	61	58	56	57	57	56	56	56	54	57	59	62	64	61	61	60	60	60	60	
250	63	65	66	65	62	61	59	61	64	64	65	62	60	62	62	61	60	55	58	59	55	56	60	60	63	64	64	63	62	62	62	62	
315	60	64	64	63	60	59	59	59	60	61	59	62	61	59	61	60	60	59	59	58	53	57	58	60	60	59	59	60	62	60	60	62	
400	61	64	64	62	59	58	58	59	61	62	59	58	59	61	61	60	59	58	55	56	56	57	58	59	62	61	55	56	56	58	60	63	
500	62	65	65	64	60	60	59	60	62	63	62	61	60	62	62	59	59	51	56	55	56	59	59	61	61	58	58	57	59	61	63	63	
630	61	63	64	63	59	58	58	59	60	61	60	60	60	62	62	60	60	58	51	54	51	55	57	59	60	59	54	56	55	57	60	62	
800	60	63	64	62	59	58	58	59	60	60	58	57	58	61	61	61	59	58	53	53	50	54	56	57	59	58	53	55	54	55	59	61	
1000	60	62	63	62	58	57	59	59	59	60	56	53	59	61	61	60	58	58	54	55	49	54	56	58	59	56	52	54	54	56	58	60	
1250	59	62	62	61	57	57	57	57	59	58	54	56	58	60	61	60	58	57	54	53	48	52	55	56	57	54	51	52	55	56	58	60	
1600	57	60	60	60	56	55	54	56	57	56	52	55	56	58	60	59	57	56	52	51	46	49	52	54	55	51	49	51	53	53	56	58	
2000	54	57	57	56	52	51	50	51	53	53	50	53	55	55	56	55	53	52	49	47	41	45	48	50	51	49	46	49	49	51	53	55	
2500	51	54	54	53	49	47	47	47	49	48	45	47	51	52	53	52	50	48	46	44	38	42	45	46	47	45	42	45	46	48	50	52	
3150	49	51	52	50	46	46	45	46	48	48	43	46	49	50	49	47	46	43	42	35	41	44	44	46	43	41	42	44	46	48	50		
4000	47	49	49	48	43	44	43	43	45	45	41	43	47	49	48	47	45	44	41	39	32	38	41	42	43	40	37	40	42	44	47	48	
5000	46	47	48	46	42	40	39	39	36	39	38	41	46	48	47	46	44	43	40	38	31	34	36	36	35	33	33	36	39	43	46	47	
6300	45	45	46	44	39	37	35	36	33	37	35	39	45	46	45	43	42	40	38	37	29	31	33	33	32	30	31	34	38	42	45	46	
8000	44	44	44	43	38	35	30	32	nil	35	32	38	44	45	44	42	41	38	37	36	27	26	27	25	26	25	28	32	35	40	44	44	
10000	43	43	43	41	39	35	29	30	nil	32	30	37	43	43	42	41	40	37	37	35	27	24	22	22	24	21	29	31	34	39	42	43	
A-Weighted	68	71	72	70	67	66	66	67	68	68	66	66	67	69	69	69	67	66	62	63	59	62	65	66	67	66	63	64	65	67	69		



ACOUSTICS



NOISE



VIBRATION