Elora Battery Energy Storage System, Elora, Ontario – Noise Feasibility Study

Final Report

April 9, 2025

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Executive Summary

Elora BESS LP (Elora BESS) engaged Stantec Consulting Ltd. to assess the noise emissions from the proposed Elora Battery Energy Storage System (BESS) Project (the Project), located south of Fergus, Ontario. The Project site is located approximately 1 kilometre (km) south of the urban boundary of Fergus, at the northeast corner of Lot 11, Concession 3 in the Township of Centre Wellington, in Wellington County (the Site). The Project will consist of battery energy storage units, electrical inverters and transformers, internal access roads, electrical and communication cabling, a transmission substation, and other related electrical and infrastructure facilities. The Project will provide up to 211 Megawatt (MW) capacity of energy storage to increase capacity of Ontario's transmission grid. The Project will utilize approximately 6 hectares of privately leased land.

This Noise Feasibility Study is prepared in support of the Project's design maturation and assesses the impact of the project stationary noise sources such as the battery energy storage units, inverters, and transformers on the surrounding noise sensitive land uses. This study is prepared in accordance with the Ministry of the Environment, Conservation and Parks (MECP) publication entitled, "Environmental Noise Guideline: Stationary and Transportation Sources – Approval and Planning, Publication NPC-300" (NPC-300). This assessment is based on the site plan prepared for the Elora BESS, dated March 12, 2025.

Noise sources considered at the Project includes battery energy storage units, electrical inverters, transformers and Genset (emergency backup generator). Six existing noise-sensitive receptors are considered, to the north, east, south and west of the Project. It is understood that Wellington County Official Plan Amendment Number 126 is currently under review, with plans for future urban expansion adding an Employment Area to the lands directly east of the Project and beyond Highway 6. As an Employment Area, it is not expected at this time to include additional noise-sensitive receptors and thus has not been assessed. Per the "South Fergus Master Environmental & Servicing Plan & Secondary Plan" by MHBC, dated March 2024, the lands directly north of the Project across 2nd Line will be zoned as residential. Three additional future proposed noise-sensitive receptors are considered to the north of the Project representative of the Secondary Plan.

The assessment of the Project stationary noise sources indicates that under the predictable worst-case operating scenario and the proposed attenuation kit in place for the inverters the Project is expected to comply with the applicable noise limits at all existing noise-sensitive receptors, based on the proposed equipment and Stantec's understanding of the operational scenario. Genset testing sound levels are expected to meet noise limits at all existing and potential future noise-sensitive receptors if the chosen Genset meets the sound power levels as assessed herein.

Additionally, with a noise barrier along the north side of the Project, the Project is expected to meet noise limits at all existing and potential future noise-sensitive receptors.

It is recommended to update this noise study as the design progresses and for future approvals, to determine any additional noise mitigation requirements for the Project if needed.

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Acronyms / Abbreviations

BESS	Battery Energy Storage System
dB	Decibel
dBA	Decibel, A-weighted
FPOR	Future Point of Reception
ISO	International Organization for Standardization
$L_{eq\text{-}1hr}$	Energy equivalent sound level over a 1-hour time period
m	Metre(s)
MECP	Ontario Ministry of the Environment, Conservation and Parks
MVA	Megavolt Ampere
MW	Megawatt
NPC	Noise Pollution Control
OPOR	Outdoor Point of Reception
POR	Point of Reception

Glossary

Term	Definition
Background Sound Level	All-encompassing sound that is associated with a given environment, usually a composite of sounds from many sources near and far. Includes noise from all sources other than the sources of interest (i.e., sound other than those being measured or assessed), such as sound from other industrial sources, transportation sources, animals and nature.
Daytime	Defined as the hours from 07:00h to 23:00h for traffic noise impact assessment and 07:00h to 19:00h for stationary noise impact assessment.
Decibel	A logarithmic measure of any measured physical quantity and commonly used in the measurement of sound. The decibel (dB) provides the possibility of representing a large span of signal levels in a simple manner. The difference between the sound pressure for silenced versus a loud sound is a factor of 1:1,000,000 or more and the same in decibel is 0-130 dB, therefore it is less cumbersome to use a small range of equivalent values. A tenfold increase in sound power is equal to +10 dB; a tenfold increase in sound amplitude is equal to +20 dB.
Decibel, A-weighted	A-weighted decibels (dBA). Most common units for expressing sound levels since they approximate the response of the human ear.
Energy Equivalent Sound Level (L_{eq})	An energy-equivalent sound level (L_{eq}) over a specified period of time that would have the same sound energy as the actual (i.e. unsteady) time varying sound over the same period of time. It represents the average sound pressure encountered for the period. The period is often added as a suffix to the label (i.e. $L_{eq(24)}$ for the 24-hour equivalent sound level). A L_{eq} value expressed in dBA is a good, single-value descriptor to use as a measure of annoyance due to noise.
Evening	Defined as the hours from 19:00h to 23:00h for stationary noise impact assessment.

Term	Definition
Ground Absorption Coefficient	A parameter defined based on the noise reflection characteristics of the ground surface. It varies between 0.0 (fully reflective) to 1.0 (fully absorptive).
International Organization for Standardization	An international body that provides scientific standards and guidelines related to various technical subjects and disciplines.
Mitigation	Measures taken to reduce, eliminate, or control impacts on the environment.
Nighttime	Defined as the hours from 23:00h to 07:00h in Ontario
Noise	Any unwanted sound. “Noise” and “sound” are used interchangeably in this document.
Point of Reception	A representative point considered for the purpose of assessment within noise-sensitive receptor such as a residence, campground, daycare, school, church, or hospital.
Point Source	Source that radiates sound spherically (i.e. equally in all directions). Sound levels from a point source decrease at a theoretical rate of 6 dB per doubling of distance.
Predictable Worst-Case Operation	A planned and predictable mode of operation for stationary source(s), during the hour when the noise emissions from the stationary source(s) have the greatest impact at a point of reception, relative to the applicable limit.
Sound	A wave motion in air, water, or other media. It is the rapid oscillatory compression changes in a medium that propagate to distant points. It is characterized by changes in density, pressure, motion, and temperature as well as other physical properties. Not all rapid changes in the medium are due to sound (e.g. wind distortion on a microphone diaphragm).
Sound Level	Generally, sound level refers to the weighted sound pressure level obtained by frequency weighting, usually A- or C-weighted, and expressed in decibels

Term	Definition
Sound Power Level	The total sound energy radiated by a source per unit time (i.e. rate of acoustical energy radiation). The unit of measurement is the Watt. The acoustic power radiated from a given sound source as related to a reference power level (i.e. typically 1E-12 watts, or 1 picowatt) and expressed as decibels. A sound power level of 1 watt = 120 decibels relative to a reference level of 1 picowatt.
Sound Pressure Level	Logarithmic ratio of the root mean square sound pressure to the sound pressure at the threshold of human hearing (i.e., 20 micropascals).

1 Introduction

Elora BESS LP (Elora BESS) engaged Stantec Consulting Ltd. to assess the noise emissions from the proposed Elora Battery Energy Storage System (BESS) Project (the Project) located south of Fergus, Ontario. The Project site is located approximately 1 kilometre (km) south of the urban boundary of Fergus, at the northeast corner of Lot 11, Concession 3 in the Township of Centre Wellington, in Wellington County (the Site). The Site and surrounding area are shown in Figure 1 in Appendix A.

The Project consists of battery energy storage units, electrical inverters and transformers, internal access roads, electrical and communication cabling, a transmission substation, and other associated electrical and infrastructure facilities. An emergency backup generator (Genset) will also be installed at the Project. The Project will provide up to 211 Megawatt (MW) capacity of energy storage to increase capacity of Ontario's transmission grid. The Project will utilize approximately 6 hectares of privately leased land.

This Noise Feasibility Study was prepared in support of the Project's design maturation and assesses the impact of the project stationary noise sources on the surrounding noise-sensitive land uses.

This assessment was based on the site plan titled 'General Layout BESS Site, Issued for 60% Review, prepared for the Elora BESS and dated March 12, 2025 (Appendix B).

2 Site Location and Plan

The area surrounding the Site currently consists of agricultural lands to the north, south and west, and a landscaping supply store to the east. Highway 6 is located to the east beyond the landscaping supply store. The main access to the site is via 2nd Line at the north boundary of the site. A landscaped area with vegetative screening is planned for the Site fronting along 2nd Line with a setback of approximately 193 metres (m), beyond which the Project equipment will be located within a security fence. At the north end of the equipment area is a proposed noise barrier, approximately 97 m long and 3 m height. A transformer substation is located at the south end of the Site. A Genset is located north of the transformer area and southeast of the BESS and inverter equipment, next to a control building. The south boundary of the Site is approximately 500 m south of 2nd Line. The Site and surrounding area features are shown in Figure 1 in Appendix A and the site plan is provided in Appendix B.

The Project Site is located on a slight hill and the terrain in the general area gently rises in elevation to the northeast. The Site is currently designated as agricultural under zoning code A.19.3, per the Township of Centre Wellington Zoning By-Law, consolidated December 2024 (Centre Wellington. 2024). Agricultural lands to the north are zoned for Future Development (FD), while those to the south fall under Environmentally Protected (EP) zoning. A zoning map for the Site and its surrounding area is provided in Appendix C. Existing single-family dwellings are located in the north, east, south and west directions from the Site.

Wellington County Official Plan Amendment Number 126 (County of Wellington 2024) is understood to be currently under review, with plans for future urban expansion adding an Employment Area to the lands directly east of the Project and beyond Highway 6. As an Employment Area, it is not expected at this time to include additional noise-sensitive receptors and thus has not been assessed. Per the “South Fergus Master Environmental & Servicing Plan & Secondary Plan” by MHBC, dated March 2024 (Secondary Plan) (MHBC 2024), in the area north of the Site across 2nd Line are proposed future Low Density Residential and Medium Density Residential areas. The Secondary Plan Preferred Land Use Plan, dated February 13, 2023, is presented in Appendix C. Consideration for the potential future rezoning and development related to this plan has been included in this assessment for completeness. Potential future sensitive land uses nearest to the proposed Site have been included as part of this study, and those further away are expected to have a lesser predicted impact from the proposed Project.

3 Guidelines and Criteria

This Noise Feasibility Study was completed in accordance with the MECP publication entitled "Environmental Noise Guideline: Stationary and Transportation Sources – Approval and Planning Publication NPC-300", August 2013 (NPC-300) (MECP 2013).

The MECP NPC-300 environmental noise guideline establishes exclusion limits for noise levels from stationary sources for both outdoor receptors and plane of window receptors. Sound levels are expressed in terms of one-hour equivalent sound levels (Leq-1hr) at the receptors. It establishes the applicable sound level limit(s) at the receptors, as the higher of the background sound level or MECP exclusionary limit. The background sound level is defined as the lowest hourly sound level established by monitoring performed over a minimum period of 48 hours. As background sound levels in the area were not measured at the time of this study, the exclusion limits will apply to the Project.

Based on the aerial image review of the Site and surrounding area, the existing acoustic environment of the proposed project site and the neighbouring noise-sensitive is representative of a Class 3 Area, which is described in the MECP guidelines as a rural area with an acoustical environment that is dominated by natural sounds having little or no road traffic.

The future proposed development area north 2nd Line will include a Low Density and Medium Density Residential area. This report considers that the area will be developed as per the Official Plan Amendment in a separate modelling scenario. The future proposed development will include noise-sensitive receptors which are assumed to be a Class 2 Area. A Class 2 Area is an acoustic environment that has qualities representative of both Class 1 (Urban) and Class 3 (Rural) areas. Noise limits for Class 2 and Class 3 Area receptors as summarized in Table 1 are used for this assessment.

Table 1 MECP Noise Exclusion Limits – Class 2 and 3 Areas

Receiver Category	Time Period (hh:mm)	Class 2 $L_{eq\text{-}1hr}$ (dBA)[1]	Class 3 $L_{eq\text{-}1hr}$ (dBA)[1]
Outdoor Receptor	Daytime 07:00–19:00	50	45
	Evening 19:00–23:00	45	40
	Nighttime 23:00–07:00	-[2]	-[2]
Plane of Window Receptor	Daytime 07:00–23:00	50	45
	Evening 19:00–23:00	50	40
	Nighttime 23:00–07:00	45	40

Note:

1. Higher of the minimum existing hourly background (ambient) sound level or the exclusion limits. As no background sound levels have been measured, the exclusion limits will apply.
2. Outdoor Receptors are not assessed for the nighttime period.

For testing of emergency equipment such as emergency backup generators, NPC-300 allows for noise levels that are 5 dB greater than the applicable limits. Also, the noise produced by the emergency equipment is to be assessed independently of all other stationary sources of noise. The sound level limit at the receptors due to just the emergency backup generator testing is 55 dBA at Class 2 areas and 50 dBA at Class 3 areas during the daytime period. Operation of these sources in an emergency are not considered for the assessment as are exempt.

4 Points of Reception

In accordance with NPC-300, Project noise impacts are evaluated at points of reception (PORs) located on noise sensitive land uses.

The following noise sensitive land uses are considered as per the guideline:

- Permanent, seasonal, or rental residences,
- Hotels, motels and campgrounds,
- Schools, universities, libraries and daycare centres,
- Hospitals and clinics, nursing/retirement homes, and
- Churches and places of worship.

Six (6) representative existing PORs are considered for the assessment of noise feasibility. Three (3) representative potential future PORs for this assessment have also been assessed to consider future plans for the proposed residential development north of 2nd Line. For the existing dwellings, both plane of window and outdoor PORs are considered. Per NPC-300, the PORs located at the exterior plane of window at the highest floor of the receptor were considered. The receptor heights are defined as 1.5 m for the first floor, and an additional 3 m for each subsequent floor. For the Outdoor POR (OPOR), the receptor was modelled at a height of 1.5 m above ground level, within 30 m of the façade of the dwelling and within the property line of the receptor, in the direction of the Project.

For the potential future dwellings, only plane of window PORs are considered as details are not known. These are assumed as at 4.5 m height for an assumed 2-storey dwelling in the low-density area, and 7.5 m height for a 3-storey building in the medium density area. The future PORs (FPOR) locations are modelled at approximately 15 m north of 2nd Line. Levels in the OPOR areas (at ground level) within the future development area are expected to be the same or lower than at the plane of window POR locations. The PORs considered in this assessment are listed in Table 2 and are shown in relation to the Site in Figure 1.

Based on a review of the surrounding area zoning and lots, no vacant lots were identified that were closer to the Project than the PORs identified herein, and thus noise impacts at vacant lots were not assessed. Provided that the sound level limits due to the Project are met at all identified PORs, it is expected that sound level limits will be met at all noise-sensitive receptors further from the Project.

Table 2 Points of Reception Summary

POR ID	POR Description	Receptor Height
Existing Receptors [1]		
POR01 / OPOR01	6227 Highway 6, 1 storey dwelling	1.5 m / 1.5 m
POR02 / OPOR02	6224 Highway 6, 3 storey dwelling	7.5 m / 1.5 m

POR ID	**POR Description**	**Receptor Height**
Existing Receptors [1]		
POR03 / OPOR03	6235 Guelph Road, 2 storey dwelling	4.5 m / 1.5 m
POR04 / OPOR04	7714 2nd Line, 1 storey dwelling	1.5 m / 1.5 m
POR05 / OPOR05	936 Guelph Road, 1 storey dwelling	1.5 m / 1.5 m
POR06 / OPOR06	7856 2nd Line, 2 storey dwelling	4.5 m / 1.5 m
Potential Future Receptors [2]		
FPOR07	Low Density Residential west of Project Site; assumed 2 storey dwelling	4.5 m [3]
FPOR08	Medium Density Residential northwest of Project Site; assumed 3 storey dwelling	7.5 m [3]
FPOR09	Medium Density Residential north of Project Site; assumed 3 storey dwelling	7.5 m [3]

Notes:

1. Existing noise-sensitive receptors identified per MECP NPC-300.
2. Based on the "South Fergus Master Environmental & Servicing Plan & Secondary Plan" by MHBC, dated March 2024 (Secondary Plan)
3. Receptor height for future receptors assumed based on proposed density of residential area.

5 Stationary Noise Sources

The noise sources associated with the Project were identified from discussions with Elora BESS and review of the Project site plan titled ‘General Layout BESS Site, Issued for 60% Review’ for the Elora BESS, dated March 12, 2025 (Appendix B).

The following significant noise sources were identified for the Project:

- Two hundred and thirty-one (231) Solbank 3.0 CSI-SolBank-S-5016-4h Battery Energy Storage System Units
- Thirty-one (31) Augmentation Batteries – Solbank 3.0 CSI-SolBank-S-5016-4h Battery Energy Storage System Units
- Sixty-six (66) Power Electronics FP4200M Inverters with Attenuation Kit
- Two (2) 110 MVA Transformers
- One (1) Genset for emergency purposes

A summary of the Project noise sources, including details on the types of sources, modelled sound power levels, locations, sound characteristics, and proposed noise control measures is provided in Table 3. The equipment layout is shown in Figure 2 and manufacturer’s noise specifications/test data for the equipment are included in Appendix D.

The proposed Solbank 3.0 CSI-SolBank-S-5016-4h-NA BESS and Augmentation BESS units are expected to operate under 80% load/fan speed during the worst-case predictable operations. The proposed Power Electronics model FP4200M Inverters include an attenuation kit provided by the manufacturer and are expected to operate under 80% load/fan speed during the worst-case predictable operations. The octave band sound power levels for the transformers were based on similar transformers from Stantec’s database, normalized to sound levels provided by Elora BESS.

The Genset is an emergency generator intended to provide power to support telemetry and substation loads in cases of grid outage. The Genset is expected to be operated for testing purposes only during the daytime period only for a period of one hour. As of this assessment the Genset make and model have not been chosen. The sound power level of the Genset has been determined as the maximum sound level such that the operation of the Genset is expected to meet sound level limits at all existing and future PORs, meeting a sound pressure level of 90 dBA at 7 m from the unit.

Each of the BESS units, Augmentation BESS units, Inverters, Transformers and Genset were modelled as point sources.

Truck traffic to the Project is expected to be occasional for maintenance and thus not included as part of this assessment. Small “Connex”, Control and O&M buildings will be located on the Site at the south end of the Project; however, no significant noise sources are expected to be associated with these buildings. No other significant or insignificant noise sources are expected at the Project.

Table 3 Stationary Noise Source Summary

Source ID (Qty)	Source Description	Source Type [1]	Sound Power Level (dBA)	Source Location (I/O) [2]	Sound Characteristics [3]	Noise Control Measures [4]
BESS (231 units)	Solbank 3.0 CSI-SolBank-S-5016-4h-NA Battery Energy Storage System unit (operating at a maximum of 80% load/fan speed)	P	82	O	S	U
AugBESS (31 units)	Augmentation Battery – Solbank 3.0 CSI-SolBank-S-5016-4h-NA Battery Energy Storage System unit (operating at a maximum of 80% load/fan speed)	P	82	O	S	U
Inverter (66 units)	Power Electronics FP4200M with attenuation kit (operating at 80% Fan speed)	P	90	O	S	E
Transformer (2 units)	110 MVA Transformer	P	86 [5]	O	S, T	U
Genset [6] (1 unit)	Emergency Generator	P	112 [7]	O	S	U

Notes:

1. Source Type: P = Point Source, A = Area Source, L = Line Source, VA = Vertical Area Source
2. Source Location: O = Outside of building, I = Inside of building
3. Sound Character: T = Tonal, S = Steady, B = Buzzing, C = Cyclical, Q = Quasi-Steady Impulsive, I = Impulsive
4. Noise Control Measures: S = Silencer/Muffler, A = Acoustic Lining or plenum, U = Uncontrolled, E = Acoustic Enclosure, L = Lagging, B = Barrier.
5. Sound power level for 110 MVA Transformer provided by Elora BESS; 5 dB tonal penalty has been added and is included in the Sound Power Level
6. Genset noise source included only in the emergency generator testing scenario.
7. Sound power level for Genset is presented as a maximum level such that limits are met at all assessed receptors and relates to a sound pressure level of 90 dBA at 7 m from the unit.

The MECP NPC-104 *Sound Level Adjustments* (MECP 1978) guidelines prescribe adjustments for sources with special qualities or characters of sound. They are punitive adjustments which apply to noise sources with subjectively annoying characteristics, including tonal sounds, quasi-impulsive sounds, and beating sounds (i.e., sounds with cyclically varying amplitudes). Based on manufacturer test results, all noise sources associated with the Project are expected to be steady with no special qualities except for the transformer, which is expected to be a tonal noise source. A 5 dB tonal penalty has been applied to the transformer sound power level. A tonal penalty has not been applied to the Genset and it is expected that any chosen Genset will be assessed for tonality based on the manufacturer data and addressed prior to implementation.

6 Assessment Methodology

The battery energy storage units, inverters, and transformers were conservatively modelled as operating continuously during daytime, evening and nighttime periods, although they may cycle on and off at various times under actual use.

Noise modelling was completed using the commercially available software package CADNA/A, published by Datakustik GmbH, which is configured to implement the ISO 9613-2 *Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General method of calculation, December 1996*, (ISO 1996) environmental sound propagation algorithms. The acoustic model account for the following:

- Geometrical divergence (noise attenuation due to distance)
- Barrier effects (noise shielding) of the intervening structures/buildings
- Atmospheric absorption
- Ground absorption
- Local topography

The model also considers a downwind condition, in which for the purpose of analysis the wind direction is always oriented from each source location towards each POR.

Existing topography of the site was included in the model with the Site equipment being located on a slight hill and the elevation rising slightly to the northeast. As specific site grading has not been determined as of this assessment, the existing grading is used. Local barrier effects were included, such as screening and reflection effects from the on-site equipment. The 97 m long and 3 m high noise barrier along the northwest side of the Site is included in the model as an additional scenario due to the closer potential future PORs to the Site.

Within the study and surrounding area, the ground surfaces are predominantly agricultural fields, with some roads. The site and surrounding area were modelled using a ground absorption coefficient of (G=0.7), which is expected to be representative of both the on-site ground conditions (gravel base), and off-site conditions including the agricultural fields and roads. Any bodies of water (such as the on-site pond and the pond near POR02) were modelled as fully reflective (G=0).

Typical Ontario meteorological parameters were included in the model: a temperature of 10 degrees Celsius and a relative humidity of 70%.

NPC-300 requires that the established sound level limit is compared against the Predictable worst-case operation of the Project. This means the basis of the noise assessment should be the hour when the noise emissions from the stationary source(s) have the greatest impact at a point of reception, relative to the lowest hourly sound level at any hour (applicable limit). The predictable worst-case operation of the Project is considered as the simultaneous operation of all on-site sources during day, evening, and nighttime periods, and is expected to be conservative. The assessment of the emergency generator testing includes the operation of the generator for one hour during the daytime.

7 Noise Assessment

The predicted noise impact from the Project equipment on the representative PORs in the vicinity of the project site was modelled according to the provided worst case operations noted by Elora BESS LP for daytime, evening and nighttime operations under three scenarios as follows:

- **Scenario 1** – Existing Receptors Assessment
    - All Project equipment as listed in Table 3 in operation (except Genset) during the daytime, evening and nighttime periods
    - No noise barrier
- **Scenario 2** – Potential Future Receptors Assessment
    - All Project equipment as listed in Table 3 in operation (except Genset) during the daytime, evening and nighttime periods
    - With north noise barrier in place
- **Scenario 3** – Genset Testing
    - All other Project equipment off, no noise barrier. Generator tested for one full hour during the daytime period only.

These scenarios are presented in the sections below.

7.1 Scenario 1 – Existing Receptors Assessment

Predicted sound levels for Scenario 1 are provided in Table 4. A noise contour for the facility operations under Scenario 1 is presented in Figure 3.

Sound levels at all existing PORs due to the Project are expected to meet the NPC-300 sound level limits during the daytime, evening and nighttime periods without consideration of the proposed noise barrier.

Table 4 Scenario 1 - Predicted Sound Levels at the Existing PORs Without Noise Barrier

POR ID	POR Description	POR Height	Time of Day	Predicted Sound Level at POR (L_{eq-1hr}, dBA)	Sound Level Limit (dBA)	Meets Limits? (Y/N)
POR01	6227 Highway 6	1.5 m	Daytime (07:00-19:00)	38	45	Y
			Evening (19:00-23:00)	38	40	Y
			Nighttime (23:00-07:00)	38	40	Y
OPOR01		1.5 m	Daytime (07:00-19:00)	36	45	Y
			Evening (19:00-23:00)	36	40	Y
POR02	6224 Highway 6	7.5 m	Daytime (07:00-19:00)	39	45	Y
			Evening (19:00-23:00)	39	40	Y

POR ID	POR Description	POR Height	Time of Day	Predicted Sound Level at POR ($L_{eq\text{-}1hr}$, dBA)	Sound Level Limit (dBA)	Meets Limits? (Y/N)
			Nighttime (23:00-07:00)	39	40	Y
OPOR02		1.5 m	Daytime (07:00-19:00)	38	45	Y
			Evening (19:00-23:00)	38	40	Y
POR03	6235 Guelph Road	4.5 m	Daytime (07:00-19:00)	39	45	Y
			Evening (19:00-23:00)	39	40	Y
			Nighttime (23:00-07:00)	39	40	Y
OPOR03		1.5 m	Daytime (07:00-19:00)	39	45	Y
			Evening (19:00-23:00)	39	40	Y
POR04	7714 2nd Line	1.5 m	Daytime (07:00-19:00)	37	45	Y
			Evening (19:00-23:00)	37	40	Y
			Nighttime (23:00-07:00)	37	40	Y
OPOR04		1.5 m	Daytime (07:00-19:00)	36	45	Y
			Evening (19:00-23:00)	36	40	Y
POR05	936 Guelph Road	1.5 m	Daytime (07:00-19:00)	33	45	Y
			Evening (19:00-23:00)	33	40	Y
			Nighttime (23:00-07:00)	33	40	Y
OPOR05		1.5 m	Daytime (07:00-19:00)	32	45	Y
			Evening (19:00-23:00)	32	40	Y
POR06	7856 2nd Line	4.5 m	Daytime (07:00-19:00)	36	45	Y
			Evening (19:00-23:00)	36	40	Y
			Nighttime (23:00-07:00)	36	40	Y
OPOR06		1.5 m	Daytime (07:00-19:00)	36	45	Y
			Evening (19:00-23:00)	36	40	Y

7.2 Scenario 2 – Future Receptors Assessment

Predicted sound levels for Scenario 2 are provided in Table 5 and a noise contour for the facility operations under Scenario 2 is presented in Figure 4.

With the 3 m high and 97 m long noise barrier at the north end of the Project, sound levels at all existing and potential future PORs due to the Project are expected to meet the NPC-300 sound level limits during the daytime, evening and nighttime periods.

Table 5 Scenario 2 - Predicted Sound Levels at the Existing and Future PORs With Noise Barrier

POR ID	POR Description	POR Height	Time of Day	Predicted Sound Level at POR ($L_{eq\text{-}1hr}$, dBA)	Sound Level Limit (dBA)	Meets Limits? (Y/N)
POR01	6227 Highway 6	1.5 m	Daytime (07:00-19:00)	38	45	Y
			Evening (19:00-23:00)	38	40	Y
			Nighttime (23:00-07:00)	38	40	Y
OPOR01		1.5 m	Daytime (07:00-19:00)	36	45	Y
			Evening (19:00-23:00)	36	40	Y
POR02	6224 Highway 6	7.5 m	Daytime (07:00-19:00)	39	45	Y
			Evening (19:00-23:00)	39	40	Y
			Nighttime (23:00-07:00)	39	40	Y
OPOR02		1.5 m	Daytime (07:00-19:00)	38	45	Y
			Evening (19:00-23:00)	38	40	Y
POR03	6235 Guelph Road	4.5 m	Daytime (07:00-19:00)	39	45	Y
			Evening (19:00-23:00)	39	40	Y
			Nighttime (23:00-07:00)	39	40	Y
OPOR03		1.5 m	Daytime (07:00-19:00)	39	45	Y
			Evening (19:00-23:00)	39	40	Y
POR04	7714 2nd Line	1.5 m	Daytime (07:00-19:00)	37	45	Y
			Evening (19:00-23:00)	37	40	Y
			Nighttime (23:00-07:00)	37	40	Y
OPOR04		1.5 m	Daytime (07:00-19:00)	36	45	Y
			Evening (19:00-23:00)	36	40	Y
POR05	936 Guelph Road	1.5 m	Daytime (07:00-19:00)	33	45	Y
			Evening (19:00-23:00)	33	40	Y
			Nighttime (23:00-07:00)	33	40	Y
OPOR05		1.5 m	Daytime (07:00-19:00)	32	45	Y
			Evening (19:00-23:00)	32	40	Y
POR06	7856 2nd Line	4.5 m	Daytime (07:00-19:00)	36	45	Y

POR ID	POR Description	POR Height	Time of Day	Predicted Sound Level at POR ($L_{eq\text{-}1hr}$, dBA)	Sound Level Limit (dBA)	Meets Limits? (Y/N)
			Evening (19:00-23:00)	36	40	Y
			Nighttime (23:00-07:00)	36	40	Y
OPOR06		1.5 m	Daytime (07:00-19:00)	35	45	Y
			Evening (19:00-23:00)	35	40	Y
FPOR07	Future Low Density Residential west of Site	4.5	Daytime (07:00-19:00)	44	50	Y
			Evening (19:00-23:00)	44	50	Y
			Nighttime (23:00-07:00)	44	45	Y
FPOR08	Future Medium Density Residential northwest of Project Site	7.5	Daytime (07:00-19:00)	44	50	Y
			Evening (19:00-23:00)	44	50	Y
			Nighttime (23:00-07:00)	44	45	Y
FPOR09	Future Medium Density Residential north of Project Site	7.5	Daytime (07:00-19:00)	42	50	Y
			Evening (19:00-23:00)	42	50	Y
			Nighttime (23:00-07:00)	42	45	Y

7.3 Scenario 3 – Genset Testing Without Noise Barrier

Predicted sound levels for Scenario 3 are provided in Table 6 and a noise contour for the facility operations under Scenario 3 is presented in Figure 5.

Sound levels at all existing and potential future PORs due to the Project are expected to meet the NPC-300 sound level limits under the Genset testing scenario without the noise barrier during the daytime period. With the noise barrier, the sound levels at the PORs due to the Genset are expected to be the same or lower. As noted, the Genset is expected to have a maximum sound pressure level of 90 dBA at 7 m from the unit and not have tonal qualities in order to meet the sound level limits.

Table 6 Scenario 3 - Predicted Sound Levels at the Existing and Future PORs – Genset Testing, No Noise Barrier

POR ID	POR Description	POR Height	Time of Day [1]	Predicted Sound Level at POR ($L_{eq\text{-}1hr}$, dBA)	Sound Level Limit (dBA)	Meets Limits? (Y/N)
POR01	6227 Highway 6	1.5 m	Daytime (07:00-19:00)	49	50	Y
OPOR01		1.5 m	Daytime (07:00-19:00)	45	50	Y

POR ID	POR Description	POR Height	Time of Day [1]	Predicted Sound Level at POR ($L_{eq\text{-}1hr}$, dBA)	Sound Level Limit (dBA)	Meets Limits? (Y/N)
POR02	6224 Highway 6	7.5 m	Daytime (07:00-19:00)	46	50	Y
OPOR02		1.5 m	Daytime (07:00-19:00)	43	50	Y
POR03	6235 Guelph Road	4.5 m	Daytime (07:00-19:00)	41	50	Y
OPOR03		1.5 m	Daytime (07:00-19:00)	43	50	Y
POR04	7714 2nd Line	1.5 m	Daytime (07:00-19:00)	35	50	Y
OPOR04		1.5 m	Daytime (07:00-19:00)	35	50	Y
POR05	936 Guelph Road	1.5 m	Daytime (07:00-19:00)	32	50	Y
OPOR05		1.5 m	Daytime (07:00-19:00)	33	50	Y
POR06	7856 2nd Line	4.5 m	Daytime (07:00-19:00)	37	50	Y
OPOR06		1.5 m	Daytime (07:00-19:00)	38	50	Y
FPOR07	Future Low Density Residential west of Site	4.5	Daytime (07:00-19:00)	40	55	Y
FPOR08	Future Medium Density Residential northwest of Project Site	7.5	Daytime (07:00-19:00)	41	55	Y
FPOR09	Future Medium Density Residential north of Project Site	7.5	Daytime (07:00-19:00)	41	55	Y

Notes:

1. As the Genset is expected to be tested during the daytime period only, only the daytime results are presented.

8 Conclusions

Elora BESS LP engaged Stantec Consulting Ltd. to conduct a Noise Feasibility Study for the proposed Elora Battery Energy Storage System located approximately 1 km south of the urban boundary of Fergus, Ontario. This Noise Feasibility Study evaluated the impact of the Elora Battery Energy Storage System project stationary noise sources at the nearby noise-sensitive receptors. The assessment indicates that, with the expected operational scenario of the BESS and inverter units at 80% load and proposed attenuation kit for the inverters, the Project is predicted to comply with the NPC-300 noise limit criteria at the existing PORs.

With the noise barrier in place, the Project is predicted to comply with the NPC-300 noise limit criteria at both the existing and future PORs.

The Genset testing scenario is predicted to meet noise limits at all PORs during daytime testing if the chosen Genset meets the sound power level or sound pressure level limits as assessed herein.

No additional noise mitigation is expected to be required for the Project. It is recommended to update this noise study as the design progresses and for future approvals, to determine any additional noise mitigation requirements for the Project if needed, and to verify sound levels of estimated equipment

9 References

Centre Wellington. 2024. "Schedule A." *Township of Centre Wellington Comprehensive Zoning By-Law No. 2009-045 (Circulation Draft).* Township of Centre Wellington, November.

County of Wellington. 2024. "Amendment Number 126 to the Official Plan for the County of Wellington." *County of Wellington General Amendment.* County of Wellington, November.

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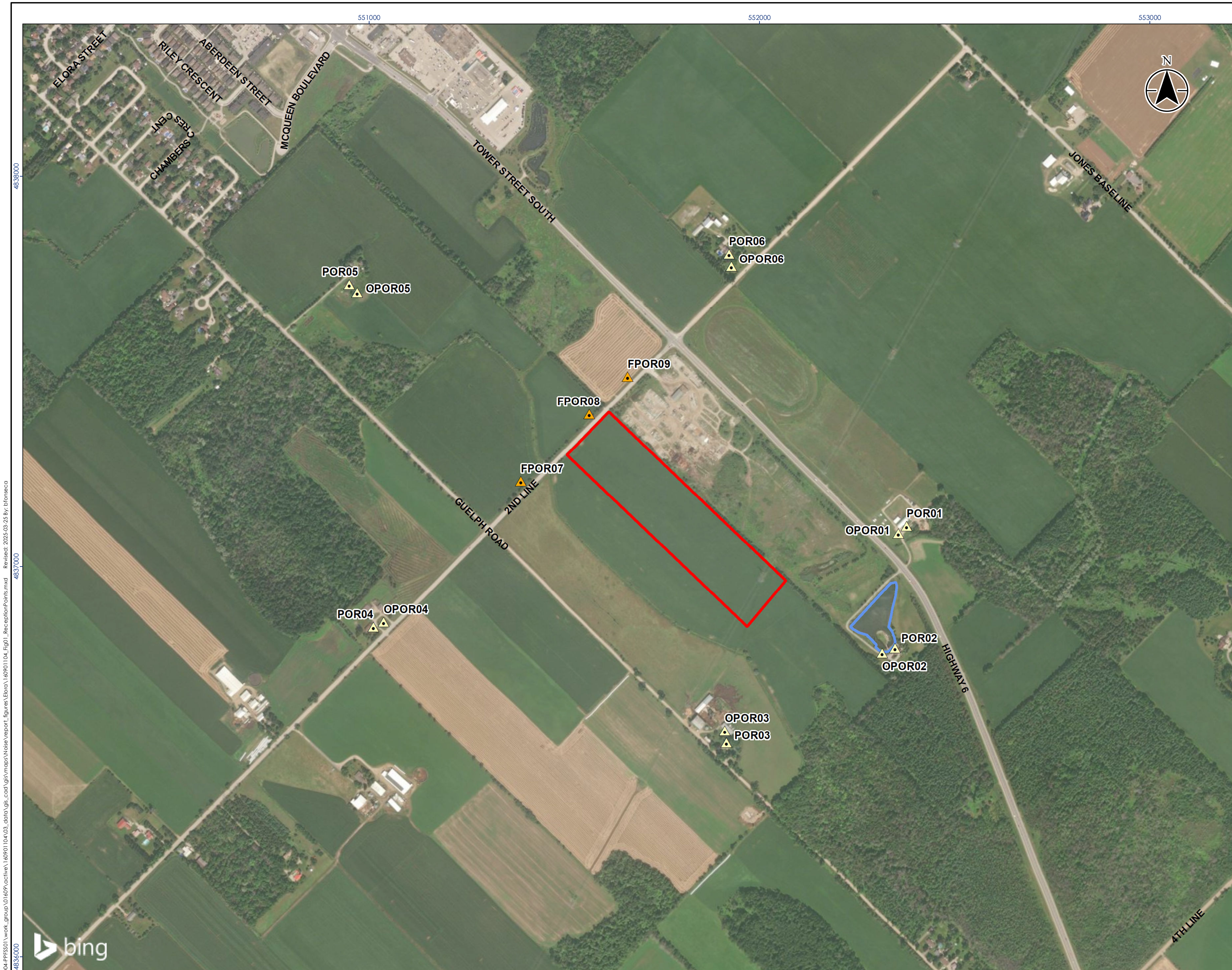
MECP. 2013. "Environmental Noise Guideline, Stationary and Transportation Sources - Approval and Planning." *NPC-300.* August.

MECP. 1978. *NPC-104 Sound Level Adjustments.* Ontario Ministry of the Environment, Conservation and Parks.

MHBC. 2024. *South Fergus Master Environmental & Servicing Plan & Secondary Plan.* Town of Fergus, County of Wellington, Township of Centre Wellington, March.

Appendices

Appendix A Figures



Stantec

Legend

- Existing Points of Reception
- Potential Future Points of Reception
- Pond
- Project Boundary

0 250 500 m

1:10,000 (At original document size of 11x17)

Notes

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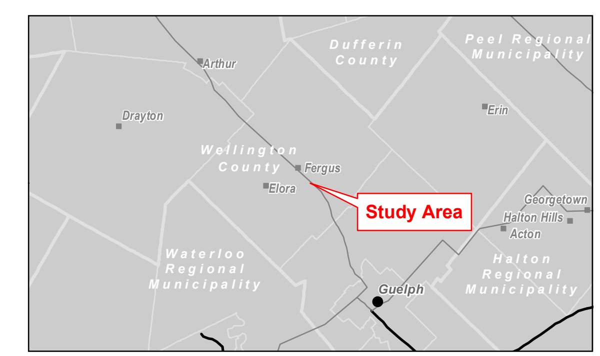

Project Location
Township of Centre Wellington

160901104 REV4
Prepared by BF on 2025-03-25
Technical Review by AW on 2024-06-04

Client/Project
AYPA POWER CANADA LP
NOISE IMPACT STUDY:
PROPOSED ELORA BATTERY ENERGY STORAGE

Figure No.
1

Title
Project Boundary and Points of Reception

Stantec

Legend

- BESS Unit
- Genset
- Inverter with Attenuation Kit
- Transformer
- Noise Barrier – Scenario 2
- Building
- Project Boundary

0 25 50 m

1:1,250 (At original document size of 11x17)

Notes

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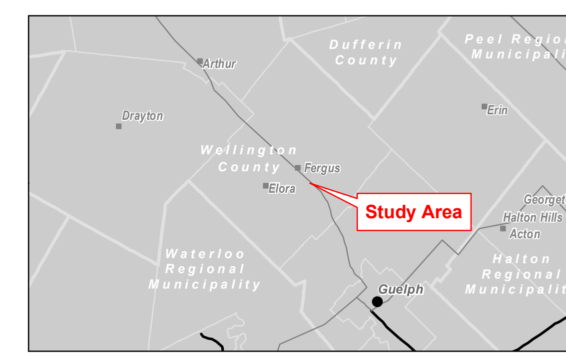


Project Location
Township of Centre Wellington

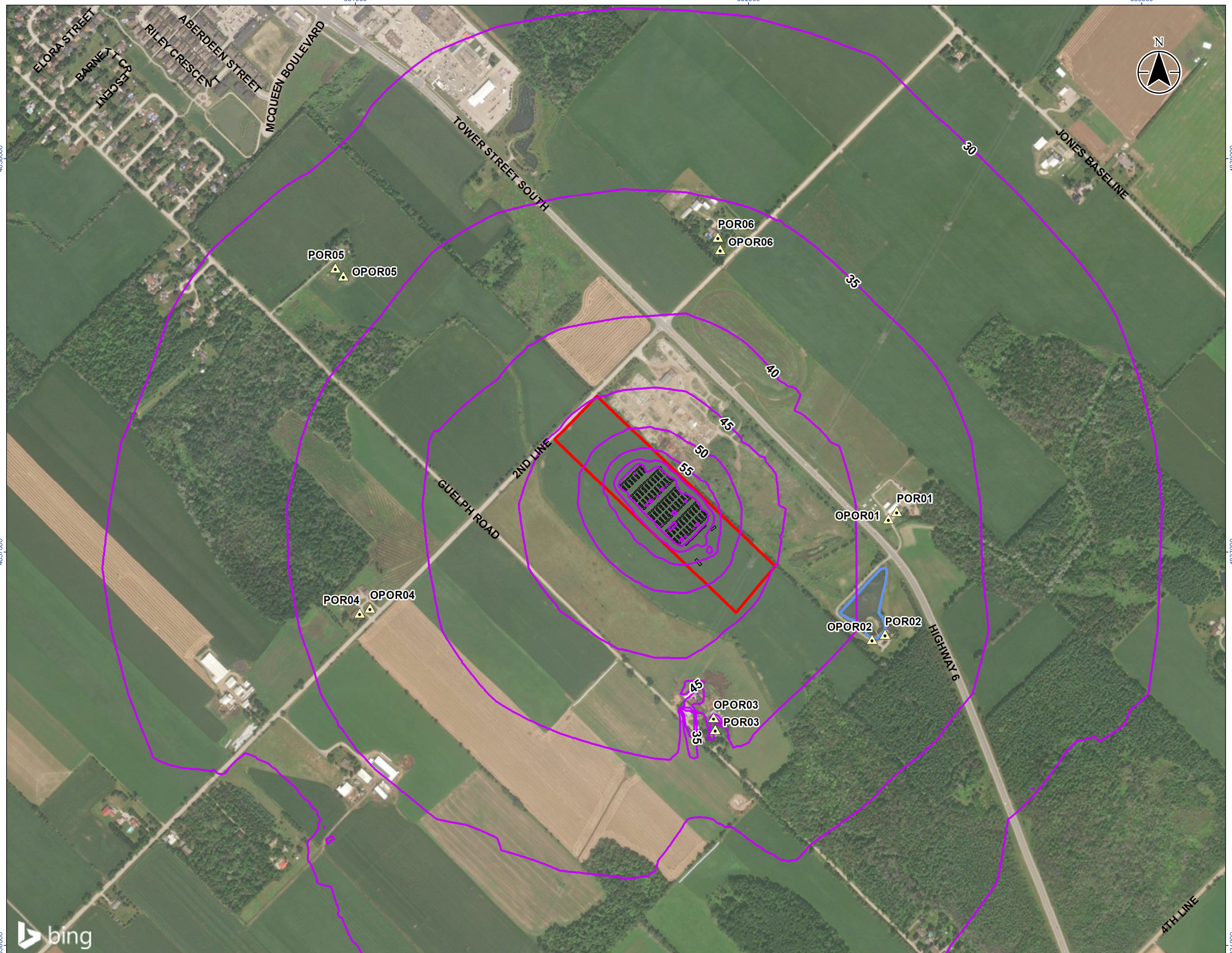
160901104 REV4
Prepared by BF on 2025-04-08
Technical Review by AW on 2024-06-04

Client/Project
AYPA POWER CANADA LP
NOISE IMPACT STUDY:
PROPOSED ELORA BATTERY ENERGY STORAGE

Figure No.
2

Title
Project Stationary Noise Sources

\\CA0004-PPFSS01\work_group\01609\active\160901104\03_data\gis_cad\gis\maps\Noise\report_figures\Elora\160901104_Fig02_NoiseSources.mxd Revised: 2025-04-08 By: bfonseca



Stantec

Legend

- Existing Points of Reception
- Equivalent Sound Level Contours at 4.5m Height (dBA, Daytime, Evening, Nighttime)
- Building
- Pond
- Project Boundary

0 200 400 m

1:10,000 (At original document size of 11x17)

Notes

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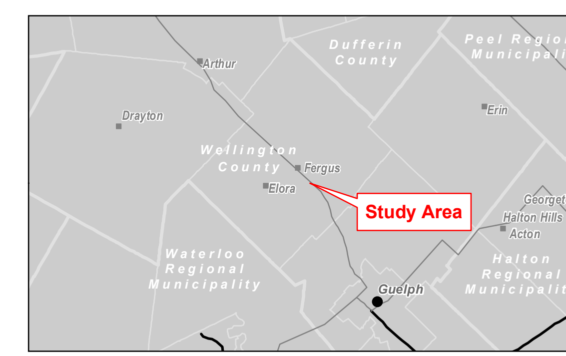


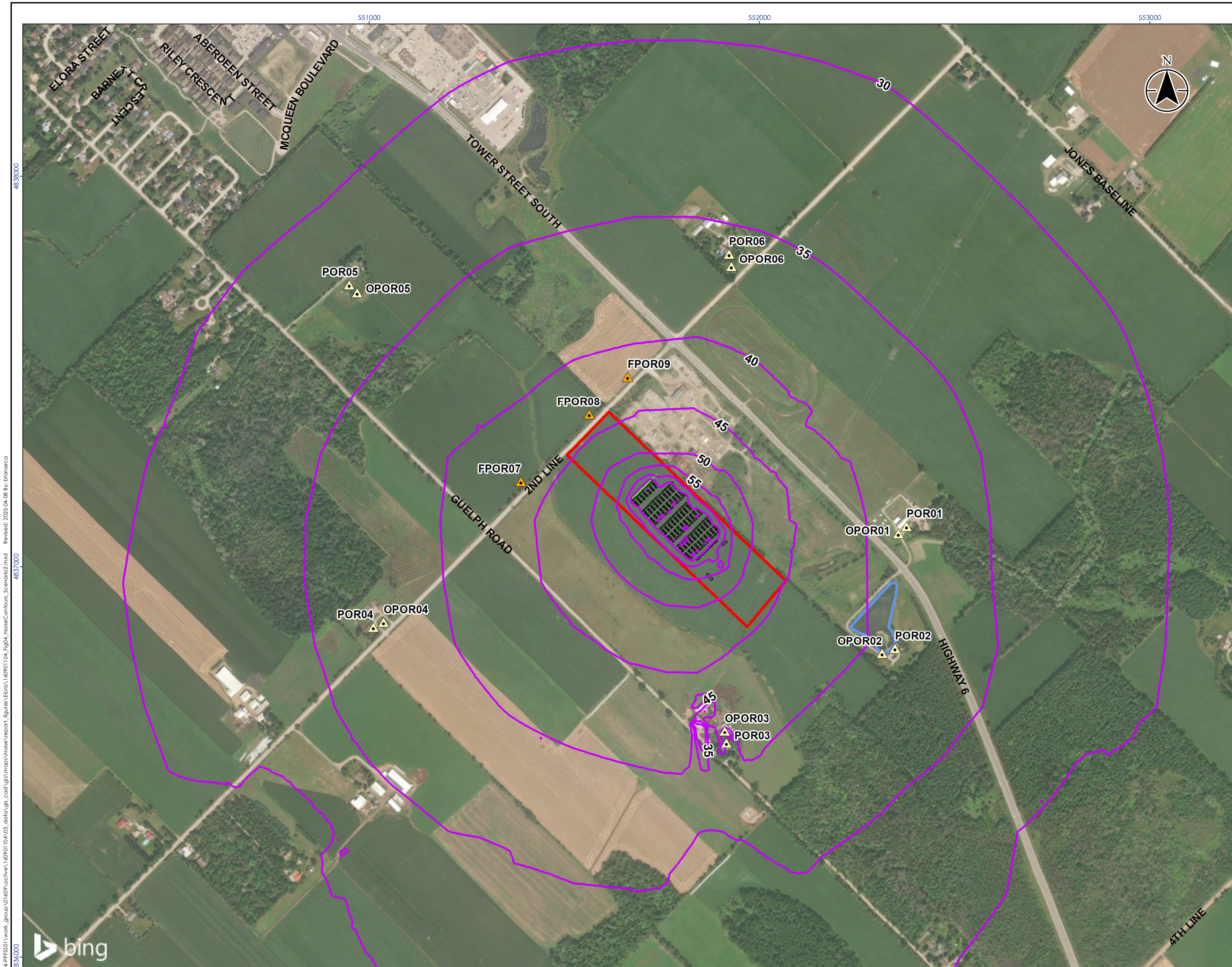
Project Location
Township of Centre Wellington

160901104 REV4
Prepared by BF on 2025-04-08
Technical Review by AW on 2024-06-04

Client/Project
AYPA POWER CANADA LP
NOISE IMPACT STUDY:
PROPOSED ELORA BATTERY ENERGY STORAGE

Figure No.
3

Title
Project Noise Contours – Scenario 1 Existing Receptors (Daytime, Evening, Nighttime)



Stantec

Legend

- Existing Points of Reception
- Potential Future Points of Reception
- Equivalent Sound Level Contours at 4.5m Height (dBA, Daytime, Evening, Nighttime)
- Noise Barrier – Scenario 2
- Building
- Pond
- Project Boundary

0 200 400 m

1:10,000 (At original document size of 11x17)

Notes

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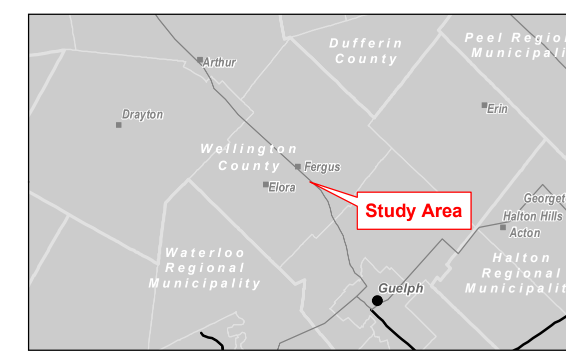


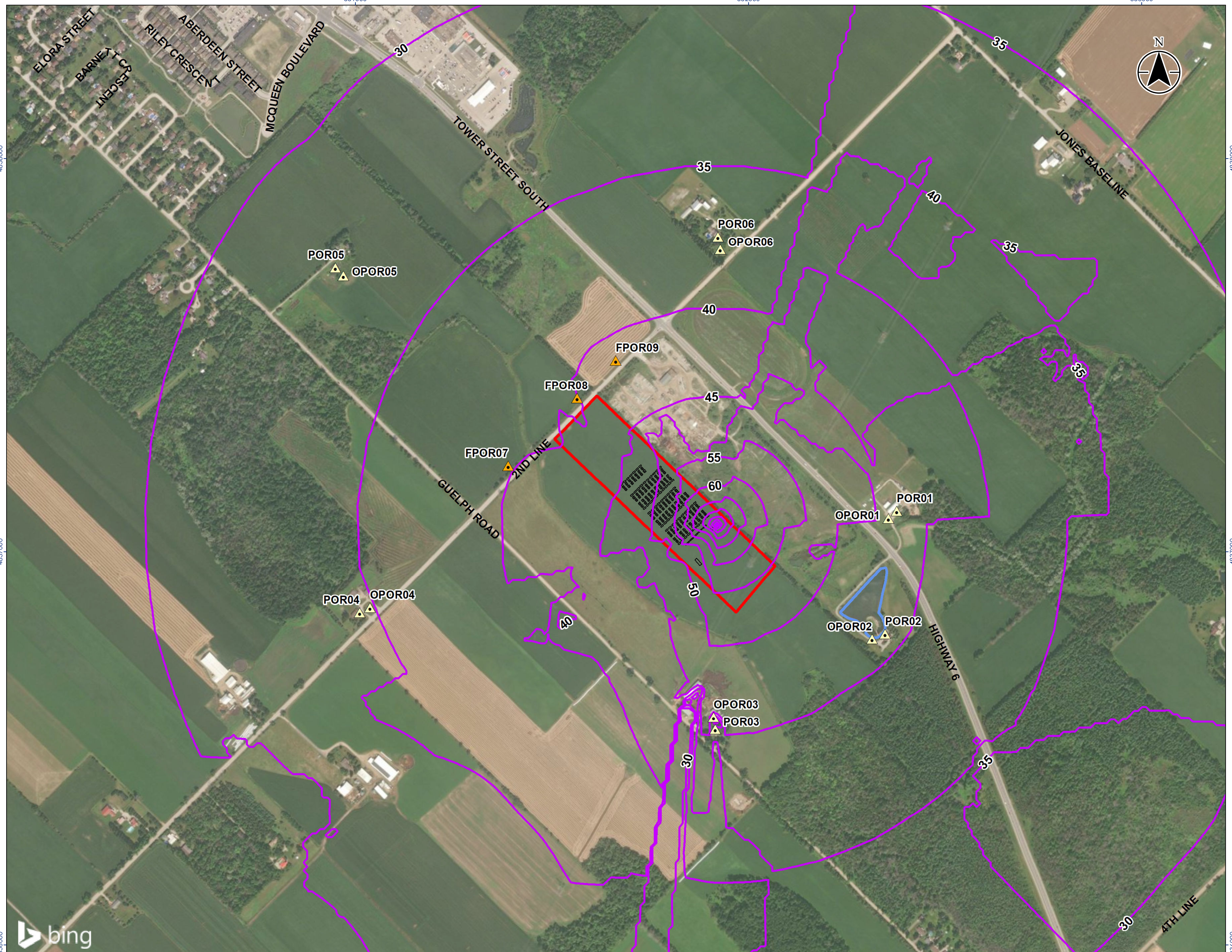
Project Location
Township of Centre Wellington

160901104 REV4
Prepared by BF on 2025-04-08
Technical Review by AW on 2024-06-04

Client/Project
AYPA POWER CANADA LP
NOISE IMPACT STUDY:
PROPOSED ELORA BATTERY ENERGY STORAGE

Figure No.
4

Title
Project Noise Contours – Scenario 2 Existing and Future Receptors (Daytime, Evening, Nighttime)



Stantec

Legend

- Existing Points of Reception
- Potential Future Points of Reception
- Equivalent Sound Level Contours at 4.5m Height (dBA, Daytime)
- Building
- Pond
- Project Boundary

0 200 400 m

1:10,000 (At original document size of 11x17)

Notes

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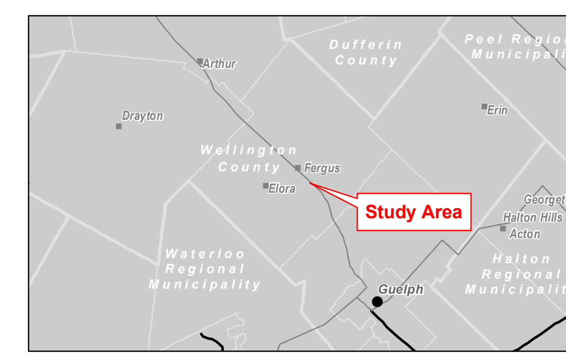


Project Location
Township of Centre Wellington

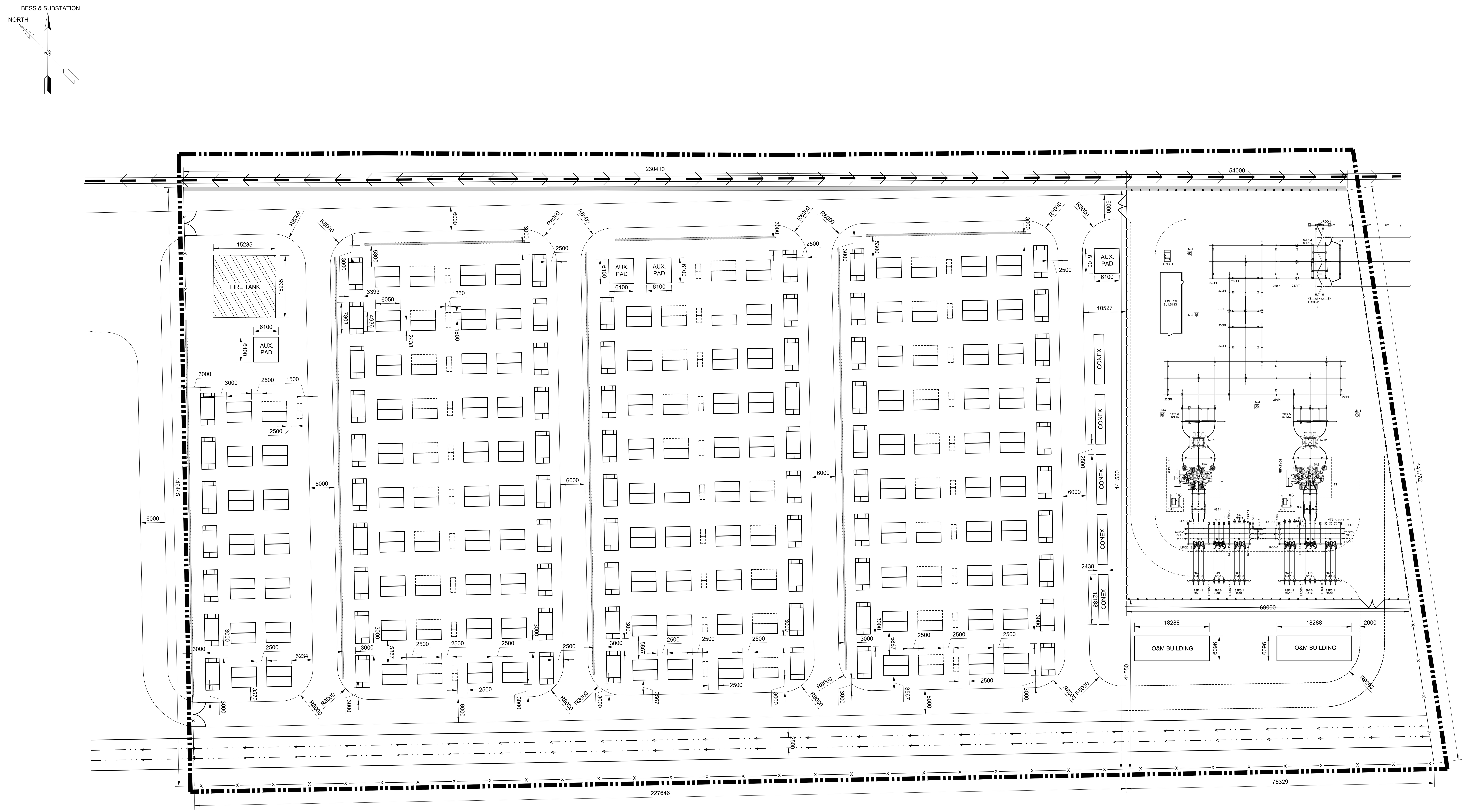
160901104 REV4
Prepared by BF on 2025-04-08
Technical Review by AW on 2024-06-04

Client/Project
AYPA POWER CANADA LP
NOISE IMPACT STUDY:
PROPOSED ELORA BATTERY ENERGY STORAGE

Figure No.
5

Title
Project Noise Contours – Scenario 3 Genset Assessment, Existing and Future Receptors (Daytime Only)

Appendix B Site Plan



NOTES:

1. ALL DIMENSIONS IN MILLIMETERS UNLESS NOTED OTHERWISE.

LEGEND:

- BESS CONTAINER
- AUG. BESS CONTAINER
- DCDC CONVERTER
- AUX. PAD
- NOISE POWER CONVERSION SYSTEM
- POWER CONVERSION SYSTEM
- PROJECT BOUNDARY

TOTAL BESS CONTAINERS - 231
TOTAL AUG. BESS CONTAINERS - 31
TOTAL PCS - 66
TOTAL AUX. - 4

DESIGN NOTES:

D1. SPACING BETWEEN EQUIPMENT TO BE CONFIRMED WITH VENDOR.
D2 . NOISE BARRIERS ARE FOR REPRESENTATION PURPOSES. DETAILS TO BE UPDATED AFTER RECEIVING DETAILS FROM CLIENT.

REFERENCE DRAWINGS

DRAWING NUMBER	DRAWING TITLE
AYPA-ELO-BESS-EL-LAY-0002-1	TYPICAL ELEVATION
AYPA-ELO-SUB-EL-LAY-0001-1	GENERAL LAYOUT

REVISIONS

REV	DATE	DESCRIPTION	DRAWN	DESIGN	CHECK'D	APPRV'D
0A	2025-01-29	ISSUED FOR 30% REVIEW	GS	SK	VP	VP
0B	2025-03-12	ISSUED FOR 60% REVIEW	GS	SK	VP	VP

ENGINEERING STAMP

PERMIT TO PRACTICE STAMP

DRAWN	G. SMADICI
DESIGN	S. KABIR
CHECKED	V. PABBATHI
APPROVED	V. PABBATHI
DATE (YYYY-MM-DD)	2025-01-20
PROJECT	VAL1853
SCALE	1:500

CONSULTANTS: Valard; PHASOR ENGINEERING INC, A QUANTA SERVICES COMPANY

CLIENT: aypa

SUBSTATION: ELORA BESS SITE

DRAWING TITLE: GENERAL LAYOUT BESS SITE

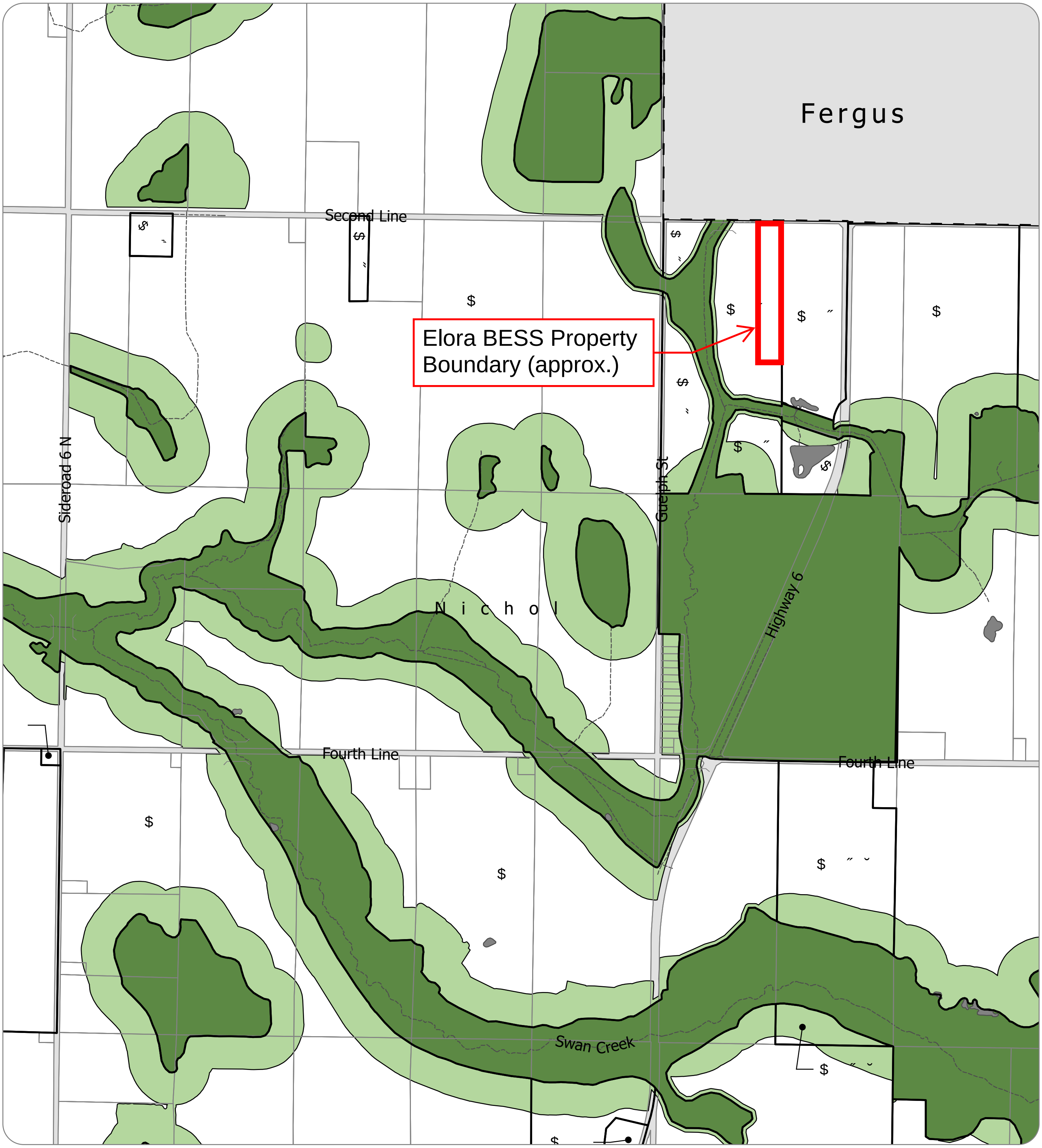
DRAWING NUMBER: AYPA-ELO-BESS-EL-LAY-0001-1

OF SHEET(S): 1

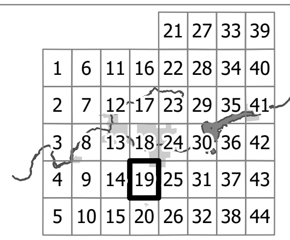
REV: 0B

PAPER SIZE ANSI D (559mm x 864mm)

Appendix C Zoning Map



Zone Boundary
Environmental Protection
Environmental Protection Overlay
Urban Area
Parcel Fabric
Floodplain
Flood Fringe
Waterbody
Watercourse
Road



Township of Centre Wellington

Zoning By-Law

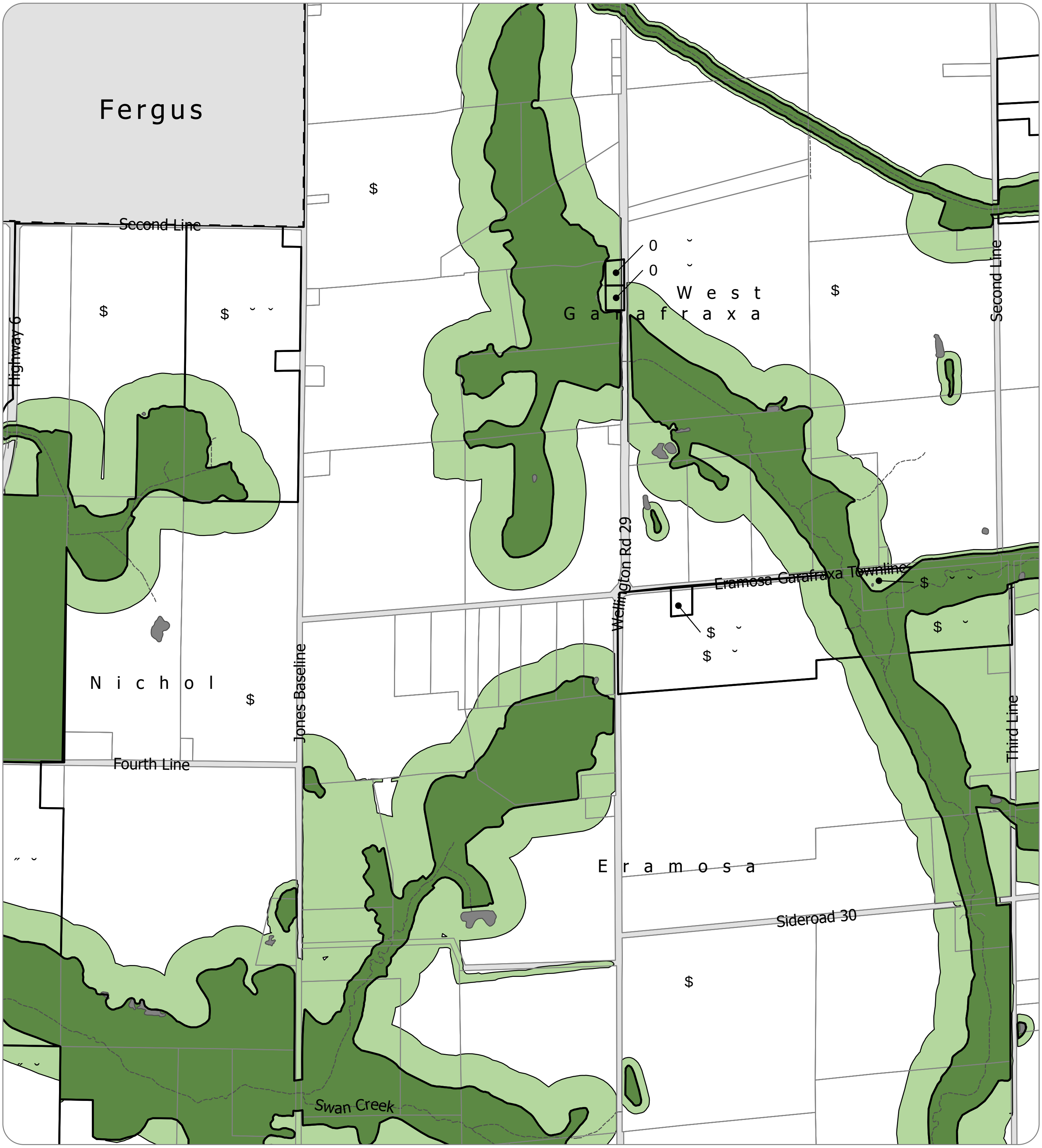
Schedule "A"

Map 19

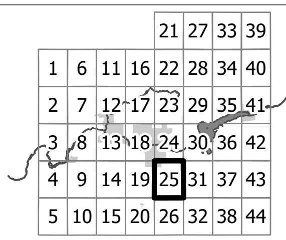
Nichol

1:20,000

Author: GWolowich
Date Saved: 2023-09



- Zone Boundary
- Environmental Protection
- Environmental Protection Overlay
- Urban Area
- Parcel Fabric
- Floodplain
- Flood Fringe
- Waterbody
- Watercourse
- Road



Township of Centre Wellington
Zoning By-Law
Schedule "A"

Map 25

Nichol-WG-Eramosa

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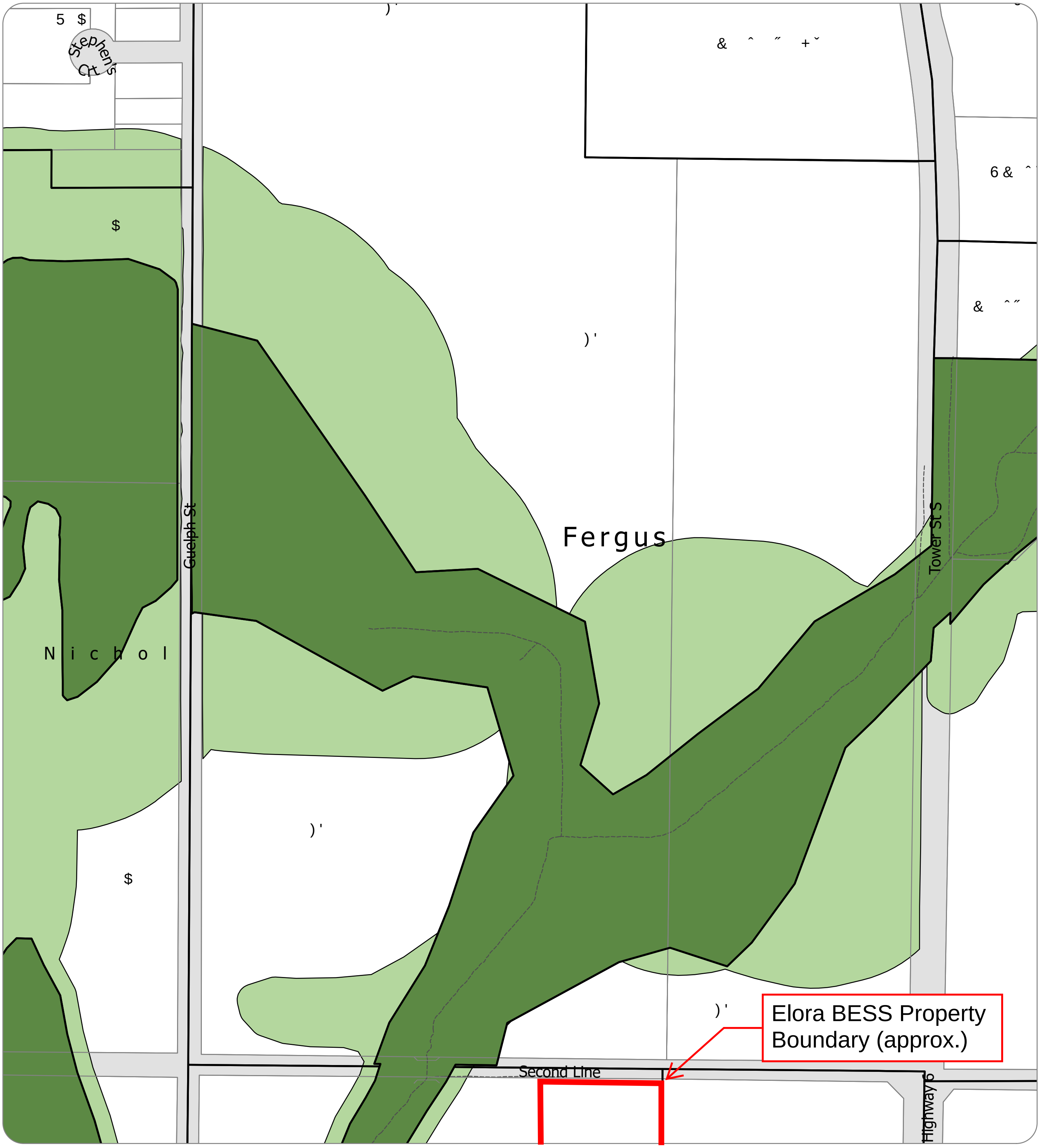
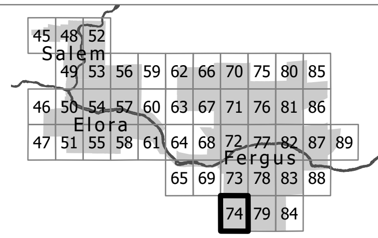
Author: GWolowich
Date Saved: 2023-09



Zone Boundary
Environmental Protection
Environmental Protection Overlay
Heritage Area Overlay
Parcel Fabric
Floodplain
Flood Fringe
Waterbody
Watercourse
Road



Township of Centre Wellington

Zoning By-Law

Schedule "A"

Map 74

Fergus

Sources: May include data from the Grand River Conservation Authority, County of Wellington, Teranet (2004) and © 2024 of the Queens Printer For Ontario. Data provided herein is derived from sources with varying levels of accuracy and currency. This is not a survey product. The Township of Centre Wellington disclaims all responsibility for the accuracy or completeness of information contained herein. The Township of Centre Wellington accepts no responsibility for errors arising from use of these mapping products.
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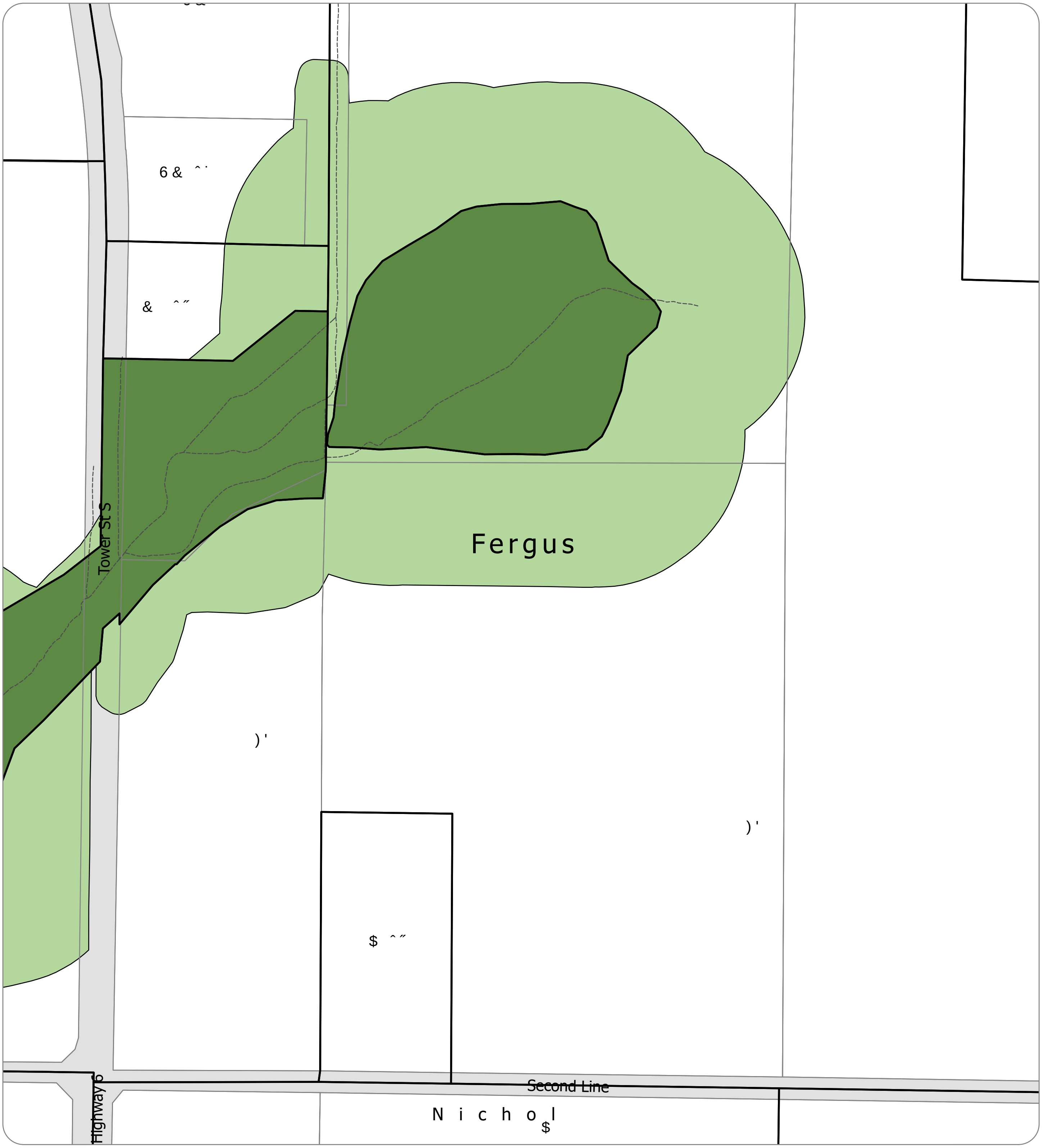
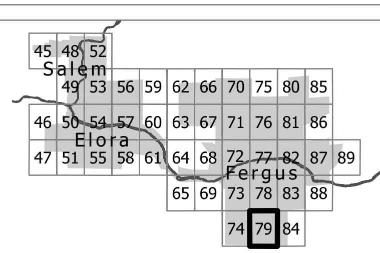
Author: GWolowich
Date Saved: 2024-12



- Zone Boundary
- Environmental Protection
- Environmental Protection Overlay
- Heritage Area Overlay
- Parcel Fabric
- Floodplain
- Flood Fringe
- Waterbody
- Watercourse
- Road



Township of Centre Wellington

Zoning By-Law

Schedule "A"

Map 79

Fergus

1:5,000

Author: GWolowich

Date Saved: 2024-12

Figure #15
Preferred Land Use Plan

South Fergus MESP and Secondary Plan
Town of Fergus
Township of Centre Wellington
County of Wellington

Legend
- South Fergus Planning Area
- Property Lines (Approximate)
- Natural Heritage Features
- 30 m Natural Heritage Feature Buffer
- Creek
- Natural Hazard Limit

Proposed Land Use
- Low Density Residential
- Medium Density Residential
- Mixed Use Corridor
- Gateway Commercial
- Natural Heritage
- Highway Commercial
- Future School Location
- Community Park Location
- Neighbourhood Park Locations
- Preliminary SWM Locations
- Trail Corridor
- Proposed Collector Roads
- Potential Roundabout
- Future Intersection Improvements
- Property of Cultural Heritage Value or Interest

DATE: February 13, 2023	north
SCALE: N.T.S	
FILE: 19144A	
DRAWN: JB	

K:\19144A - South Fergus MESP and Secondary Plan\CP

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE

FRICORP ECOLOGICAL SERVICES

TATHAM ENGINEERING

Appendix D Manufacturer Equipment Data

Noise Measurement Test Report

CSI-SolBank-S-5016-4h

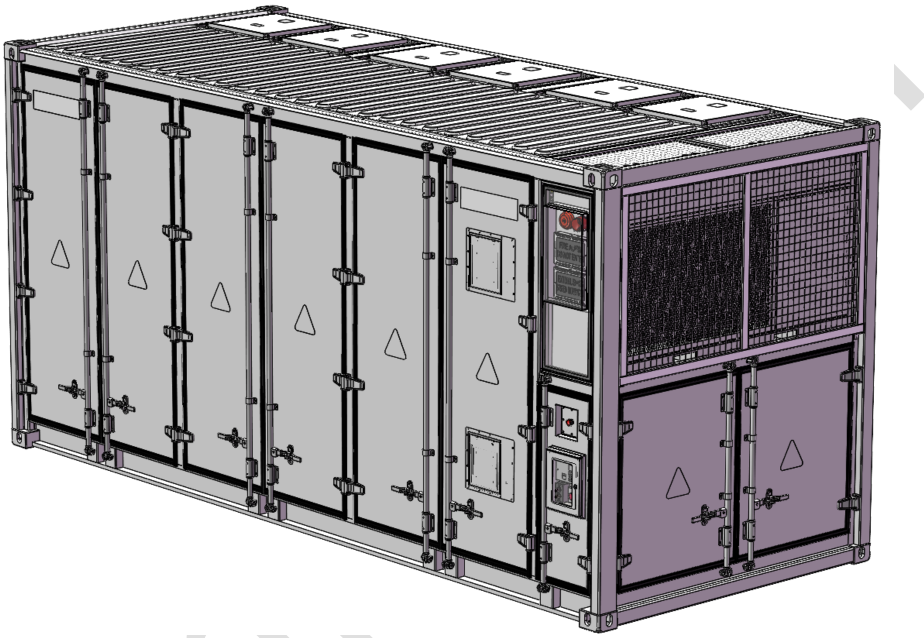
2024.9.10

Version	Date	Content Revision	Drafted/Revised by	Reviewed by	Approved by
A	2024.8.5	Initial	Zhangcheng.Cao		
B	2024.9.10	Update the chiller parameter vs. battery output power	Zhangcheng.Cao		

Table of contents

1 Scope

This report refers to the test methods and requirements of ISO 3746:2010 to assess the noise levels of components in operating of SolBank product.



Please note that considering that the main source of noise in SolBank operation is the chiller, the SolBank model and configuration may be different, and the chiller supplier or model used may be different. This report is applicable to **CSI-SolBank-S-5016-4h** products with **Kelvin/BTMS-250-ES** installed. For reports of other models or configurations, please contact e-Storage.

2 Test Preview

2.1 Technical characteristics

SolBank 3.0
System Parameter

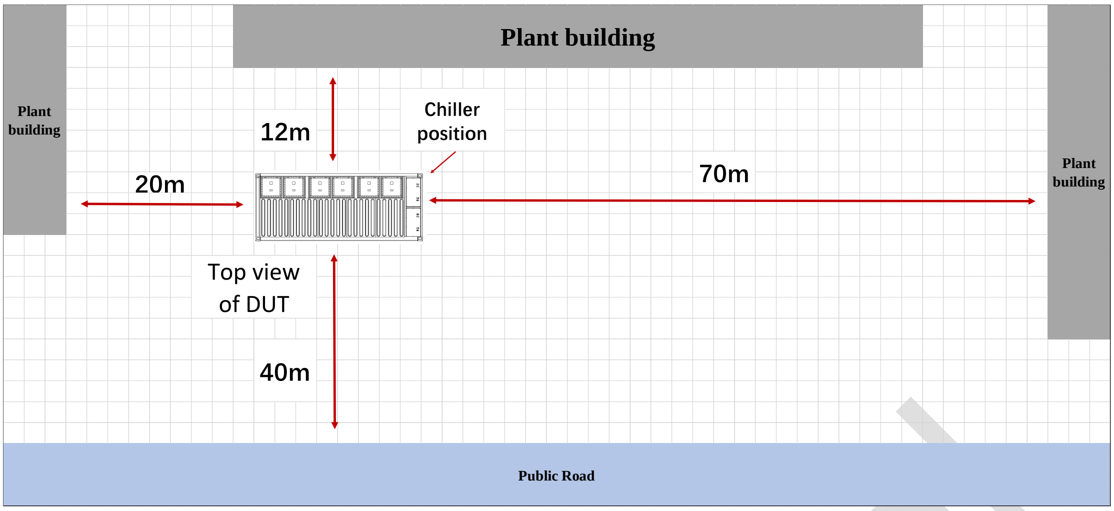
General		
Product Model	CSI-SolBank-S-5016-2h-NA	
	CSI-SolBank-S-5016-4h-NA	
Battery Chemistry	Lithium Iron Phosphate (LFP)	
Pack Configuration	1P104S (104 Cells)	
Rack Configuration	1P416S (4 Packs)	
System Configuration	12P416S (12 Racks)	
Nominal DC Voltage	1331.2 V	
Operation DC Voltage Range	1164.8 V ~ 1497.6 V	
Performance		
Charging/Discharging Mode	0.5 P / 0.5 P	0.25 P / 0.25 P
Rated DC Power	2350 kW	1200 kW
Initial Storage Capacity	4700 kWh	4800 kWh
Duration @Rated DC Power	2hrs	4hrs
Round Trip Efficiency (RTE)	93%	94%
Auxiliary Load (Standby/Peak)	1.5 kVA / 50 kVA	1.5 kVA / 22 kVA
Max. Short Circuit Current	10 kA*12	10 kA*12
Operating Temperature (Ambient)	-30 °C to 55 °C (derating from 45°C to 55°C)	
Relative Humidity	≤95% (non-condensing)	
Altitude	≤4000 m (derating from 2000 m to 4000 m)	
Noise Sound Pressure Level (LPA) at 1 meter distance	≤75 dB(A)	

Chiller

Model / 型号	BTMS-250-ES
Cooling Capacity / 额定制冷量 kW	25(Ambit Temperature 45℃,LWT 20℃)
Heating Capacity / 额定加热量 kW	16
Total Power Supply / 供电电压 V	480V (323~528V)
Frequency / 频率 Hz	50/60
Phase / 相	3
No. of Wires / 进线数量	5
Total A – Cooling / 制冷额定电流 A	25
Maximum Operating Current / 最大运行电流 A	38
Total A – Heating / 制热额定电流 A	30
Refrigerant, Type / 制冷剂类型	R513a
Amount / 充注量 oz	113
Design Pressure / 设计压力	-
High Side / 高压 psig (MPa)	319 (2.2)
Low Side / 低压 psig (MPa)	217 (1.5)
Operating Ambient Temperature / 运行环境温度 ℃	-30~55
Coolant Outlet Temperature / 冷却液温度 ℃	5~35(Cooling); ＜50(Heating)
Rate Of Flow / 流量(50%乙二醇溶液) L/Min	250(@70kPa
Altitude / 海拔 m	0~4000
IP / 防护等级	IP26(Unit) ; IP67(Electrical component)
Sound / 噪音dB(A)	≤75（JB/T 4330）
Cabinet Outer Enclosure / 机组框架	
Length / 长度 mm (max)	2100
Depth / 厚度 mm	550
Height / 高度 mm (max)	1230
Thickness / 面板厚度 mm (min)	2.5
Corrosion Protection (Method) / 防腐措施	Coating / C5M
Material / 材质	Aluminum / 铝
Weight / 机组重量 kg	≤350
Color / 颜色	RAL9003

2.2 Test bench

To avoid the environment influence in the noise measurements, the DUT had been placed at the outside of the plant, at the outside concrete esplanade without any object at least at 10m of distance. Also, the measurements was performed in the moment of the day in which there is less noise at the outside environment (production and traffic noise). The chiller was guaranteed to run normally by the aux power cable（380V）.

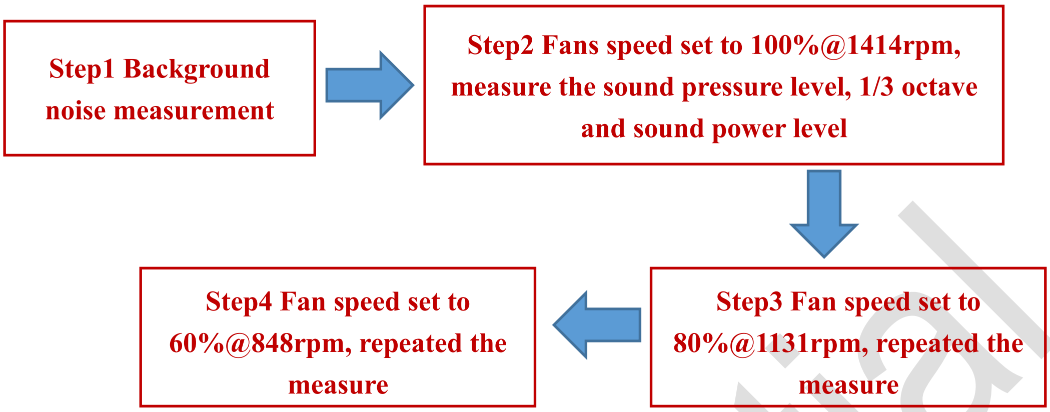


Test location

Meteorological condition

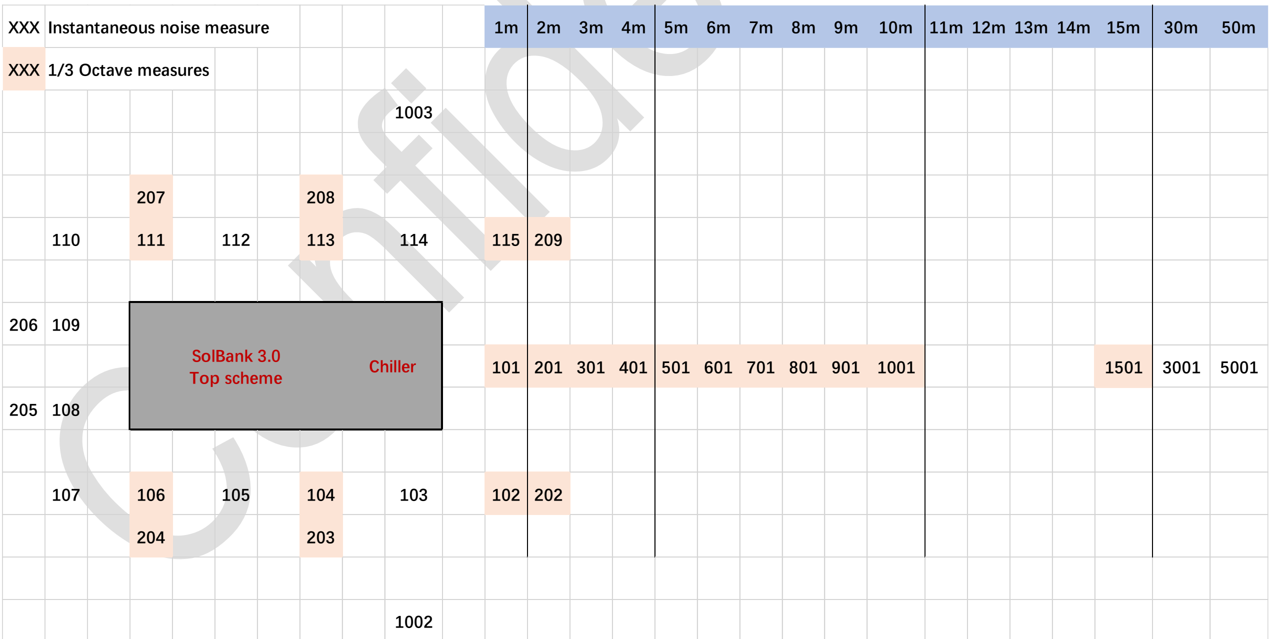
DATE	Max. Temperature	Min. Temperature	Avg. Temperature	Wind speed	Humidity
[YYYY-MM-DD]	[℃]	[℃]	[℃]	[km/h]	[%]
2024.7.23	35	29	33	7	60%±20%

2.3 Measurement flow



2.4 Measurement points

Measurements were conducted at the following points



Note:

a) Marking the measuring points are 2D plane positions.

b) Sound power level 3D measurement points are not included here.

c) XXX: The distance between the measuring point and the DUT surface and the serial number of the measuring point, for example, 1003 represents the third measurement point 10m from the DUT surface.

d) XXX : The 1/3 octave spectrum analysis data of the measuring point is available.

3 Noise Test Result

3.1 Noise Correction

Due to the impact of the measurement environment and background noise, the sound pressure level measurement results need to be corrected.

3.1.1 Correction of background noise

The background noise corrections, K_{1A}, shall be calculated using Equation:

$$K_{1A} = -10 \lg\left(1 - 10^{-0,1\Delta L_{pA}}\right) \text{dB}$$

where

$$\Delta L_{pA} = \overline{L'_{pA(ST)}} - \overline{L_{pA(B)}}$$

in which

$\overline{L'_{pA(ST)}}$ is the A-weighted time-averaged sound pressure level from the array of microphone positions over the measurement surface, with the noise source under test in operation, in decibels,

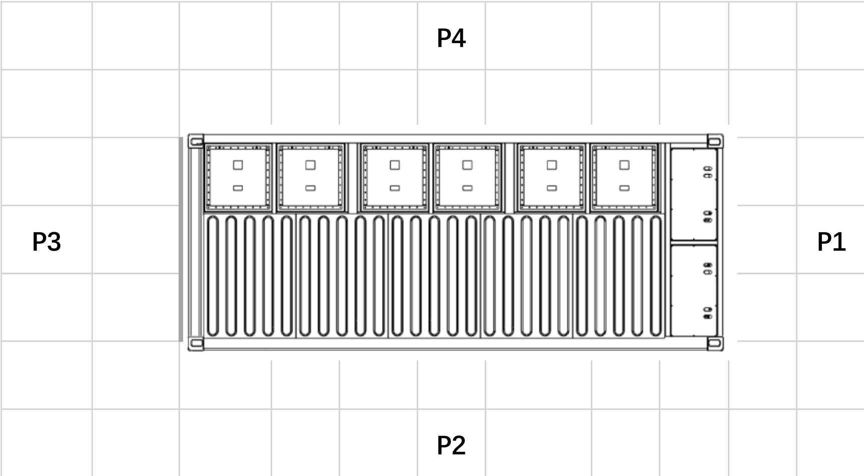
$\overline{L_{pA(B)}}$ is the mean A-weighted time-averaged sound pressure level of the background noise from the array of microphone positions over the measurement surface, in decibels.

If $\Delta L_{pA} > 10$ dB, K_{1A} is assumed equal to zero.

For 3 dB $\leqslant \Delta L_{pA} \leqslant$ 10 dB, corrections shall be calculated in accordance with Equation

The accuracy of the result(s) is reduced and the value of K_{1A} to be applied in this case is 3 dB(the value for Δ L pA = 3 dB). In this case, the data from the test represent an upper boundary to the sound power level of the noise source under test.

Background noise measurement points and results as below



	Points				
	1	2	3	4	unit
L_{pA} (B)	54.6	55.1	54.4	54.7	dB
$\overline{L}_{pA}$ (B)	54.70				dB

3.1.2 Determination of environmental correction

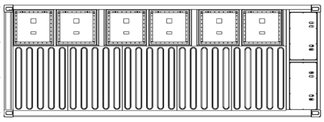
The test environment conditions correction is not necessary in this test case due to the test was performed at the outside of the installations, so, the correction factor K_{2A} is equal to 0.

3.2 Sound pressure level

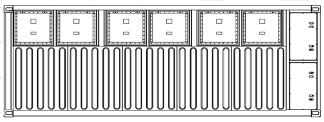
SPL measured and corrected values as follows

Fan speed 100% @ 1414rpm

Measured data:

							1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	15m	30m	50m
10m						59													
2m			56		59.7														
1m		57.1	57.8	59	59.6	62.2	66.5	64.5											
	56.6	56.2																	
							74.7	70.4	67.4	65.2	63.3	61.8	61	59.5	59.3	59.4	59.3	57.2	55.1
	54.9	56.9																	
1m		57.1	57	59	57.7	62.6	66.6	67.5											
2m			55.4		56.6														
10m						55.2													

Background noise correction:

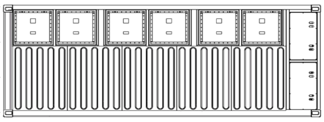
							1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	15m	30m	50m
10m						57.0													
2m			53		58.0														
1m		54.1	54.9	57.0	57.9	61.3	66.5	64.0											
	53.6	53.2																	
							74.7	70.4	67.4	65.2	62.65	60.86	59	57.75	57.45	57.6	57.45	54.2	52.1
	51.9	53.9																	
1m		54.1	54	57.0	54.7	61.8	66.6	67.5											
2m			52.4		53.6														
10m						52.2													

Based on the corrected sound pressure level measurements, in the condition of 100% fans speed, 0.25P SolBank3.0 noise (L_{PA}) @1m =69.3 dB(A) , maximum value 74.7dB (A).

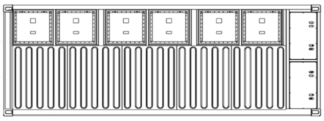
Note: L_{PA} calculation selected the average of 3 higher noises at 1m in front of the chiller.

Fan speed 80% @ 1131rpm

Measured data：

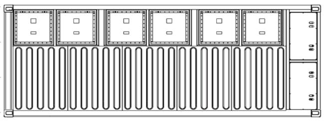
												1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	15m	30m	50m
10m										57.1														
2m				54.6				55.2																
1m		54.5		54.8		55.4		56.1		56.7		60.5	60.1											
	54.5	55.6																						
												68.5	64.1	61.2	59.4	58.2	57.4	57	56.9	56.8	56.7	59.3	57.2	55.1
	53.4	53.4																						
1m		52.1		53.7		57.1		57.2		58		60.4	61.1											
2m				53				55.8																
10m										54.8														

Background noise correction：

												1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	15m	30m	50m
10m										54.1														
2m				51.6				52.2																
1m		51.5		51.8		52.4		53.1		53.7		59.2	58.6											
	51.5	52.6																						
												68.5	63.57	60.1	57.6	55.63	54.4	54	53.9	53.8	53.7	57.45	54.2	52.1
	50.4	50.4																						
1m		49.1		50.7		54.1		54.2		55.3		59.0	60.0											
2m				50				52.8																
10m										51.8														

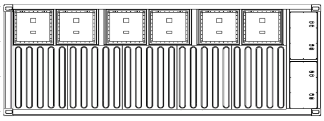
Fan speed 60% @ 848rpm

Measured data：



												1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	15m	30m	50m
10m										55.9														
2m				54.9				54.6																
1m		54.2		56.2		55		54.9		55.4		56.3	55.1											
	53.8	54.2																						
												61.4	57.6	56.7	55.4	55.2	54.7	55	54.6	55.4	54.6	54.3	54.5	51.6
	54	53.1																						
1m		53.7		53.8		54.7		54.5		55.1		56.3	55.4											
2m				52.2				54.9																
10m										53.4														

Background noise correction：



												1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	15m	30m	50m
10m										52.9														
2m				51.9				51.6																
1m		51.2		53.2		52.0		51.9		52.4		53.3	52.1											
	50.8	51.2																						
												60.36	54.6	53.7	52.4	52.2	51.7	52	51.6	52.4	51.6	51.3	51.5	51.6
	51	50.1																						
1m		50.7		50.8		51.7		51.5		52.1		53.3	52.4											
2m				49.2				51.9																
10m										50.4														

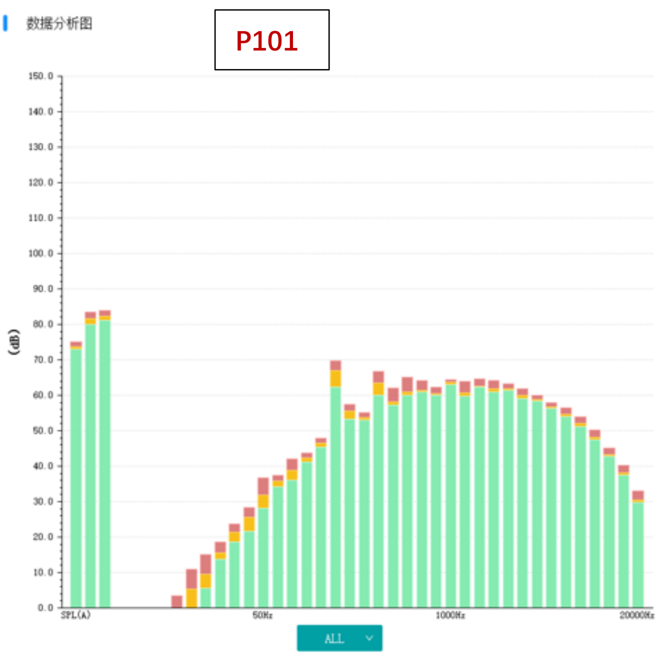
3.3 1/3 octave spectrum analysis data

This report only shows parts of the 1/3 octave spectrum of the points in section 2.4, if you need all the locations please contact e-Storage to obtain.

Fan speed 100% @ 1414rpm

数据列表 20240723059_1

数据分析图



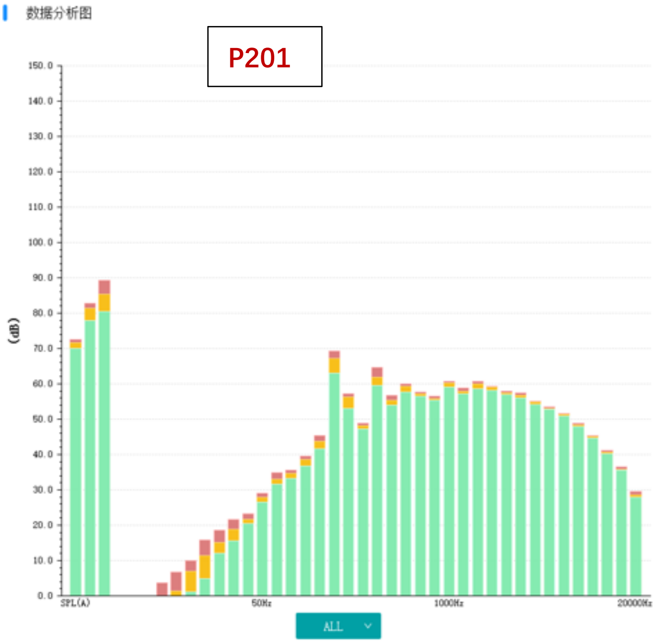
分析列表

测点名: 20240723059
测量方式: 1/3OCT分析
测量开始时间: 2024-07-23 22:34:25
Ts: 00 : 00 : 10
Tm: 00 : 00 : 10
仪器型号: AWA6292
机号: 391513
校准时间: 2023-09-06 10:09:13
灵敏度级: -28.8 dB
校准声压级: 93.8 dB
计权: A/S
经度: 120.502228
纬度: 31.328353
language: zh
测量范围: 20.0 dBA ~ 143.0 dBA

频率	Lmax	Lmin	Leq,T
SPL(A)	74.9	72.8	73.6
SPL(C)	83.4	79.8	81.6
SPL(Z)	83.8	81.0	82.2
5Hz	-25.3	-41.0	-30.0
6.3Hz	-18.4	-34.5	-23.2

数据列表 20240723066_1

数据分析图

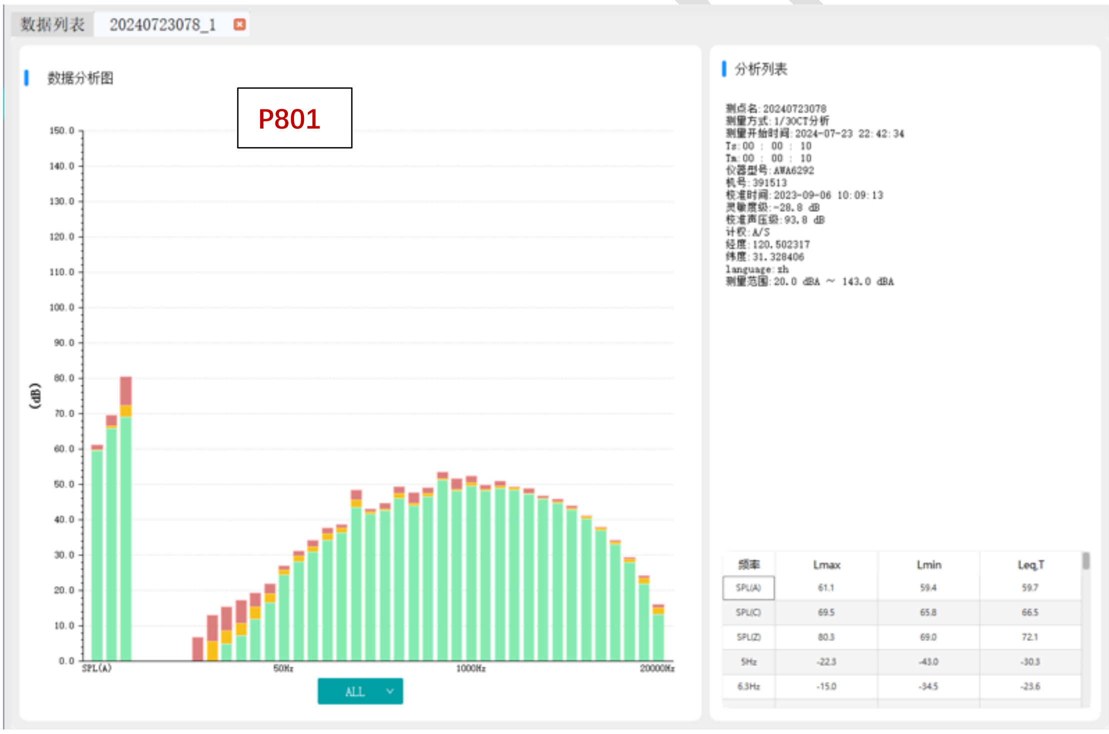


分析列表

测点名: 20240723066
测量方式: 1/3OCT分析
测量开始时间: 2024-07-23 22:37:46
Ts: 00 : 00 : 10
Tm: 00 : 00 : 10
仪器型号: AWA6292
机号: 391513
校准时间: 2023-09-06 10:09:13
灵敏度级: -28.8 dB
校准声压级: 93.8 dB
计权: A/S
经度: 120.502463
纬度: 31.327880
language: zh
测量范围: 20.0 dBA ~ 143.0 dBA

频率	Lmax	Lmin	Leq,T
SPL(A)	72.4	70.0	71.6
SPL(C)	82.7	77.8	81.2
SPL(Z)	89.1	80.4	85.3
5Hz	-9.3	-29.6	-16.8
6.3Hz	-2.4	-26.7	-9.1

频率	Lmax	Lmin	Leq,T
SPL(A)	71.8	63.4	64.1
SPL(C)	76.4	69.9	71.5
SPL(Z)	79.9	72.0	73.8
5Hz	-25.6	-45.4	-32.8
6.3Hz	-17.0	-35.6	-24.7

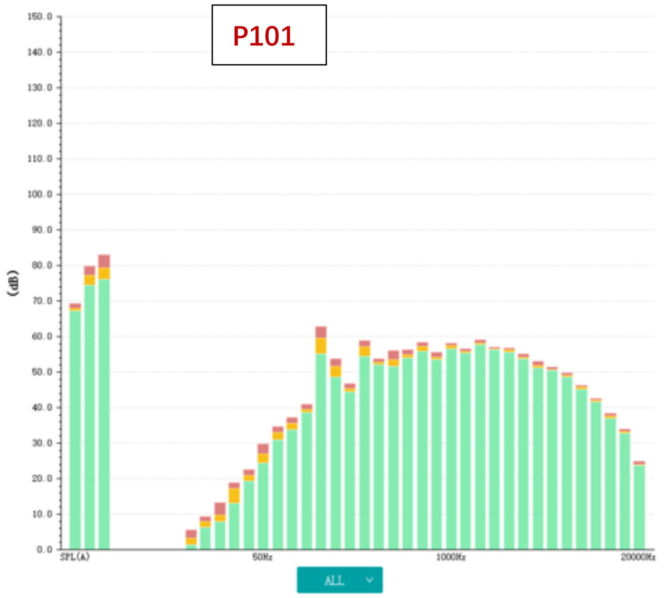


频率	Lmax	Lmin	Leq,T
SPL(A)	61.1	59.4	59.7
SPL(C)	69.5	65.8	66.5
SPL(Z)	80.3	69.0	72.1
5Hz	-22.3	-43.0	-30.3
6.3Hz	-15.0	-34.5	-23.6

Fan speed 80% @ 1131rpm

数据列表 20240723124_1

数据分析图



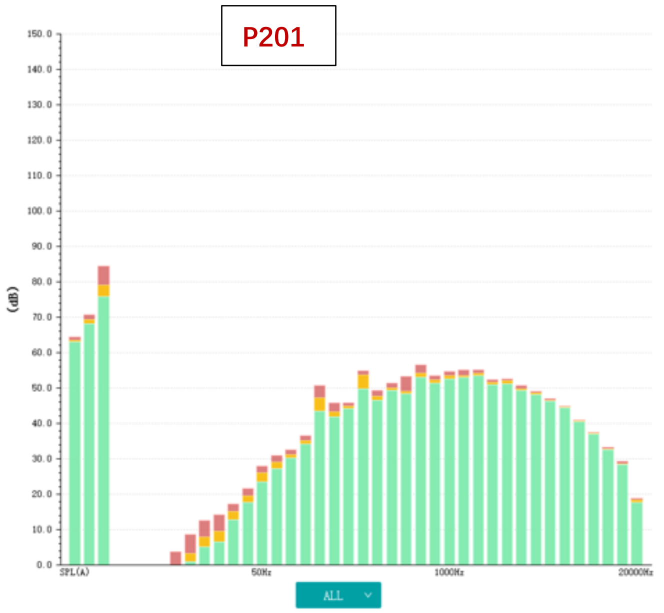
分析列表

测点名: 20240723124
测量方式: 1/3OCT分析
测量开始时间: 2024-07-23 23:18:10
Ts: 00 : 00 : 10
Tm: 00 : 00 : 10
仪器型号: AWA6292
机号: 391513
校准时间: 2023-09-06 10:09:13
灵敏度级: -28.8 dB
校准声压级: 93.8 dB
计权: A/S
经度: 120.502298
纬度: 31.328265
language: zh
测量范围: 20.0 dBA ~ 143.0 dBA

频率	Lmax	Lmin	Leq,T
SPL(A)	69.1	67.1	67.9
SPL(C)	79.7	74.3	77.1
SPL(Z)	82.8	76.0	79.3
5Hz	-24.6	-37.4	-30.4
6.3Hz	-19.8	-32.2	-24.6

数据列表 20240723131_1

数据分析图



分析列表

测点名: 20240723131
测量方式: 1/3OCT分析
测量开始时间: 2024-07-23 23:20:48
Ts: 00 : 00 : 10
Tm: 00 : 00 : 10
仪器型号: AWA6292
机号: 391513
校准时间: 2023-09-06 10:09:13
灵敏度级: -28.8 dB
校准声压级: 93.8 dB
计权: A/S
经度: 120.502240
纬度: 31.328340
language: zh
测量范围: 20.0 dBA ~ 143.0 dBA

频率	Lmax	Lmin	Leq,T
SPL(A)	64.3	62.9	63.4
SPL(C)	70.6	68.1	69.3
SPL(Z)	84.4	75.8	78.9
5Hz	-18.4	-30.8	-24.9
6.3Hz	-12.1	-27.4	-20.2

频率	Lmax	Lmin	Leq,T
SPL(A)	65.3	59.5	59.9
SPL(C)	70.3	66.5	67.0
SPL(Z)	77.5	70.0	74.7
5Hz	-23.4	-37.1	-28.0
6.3Hz	-18.4	-33.2	-24.2

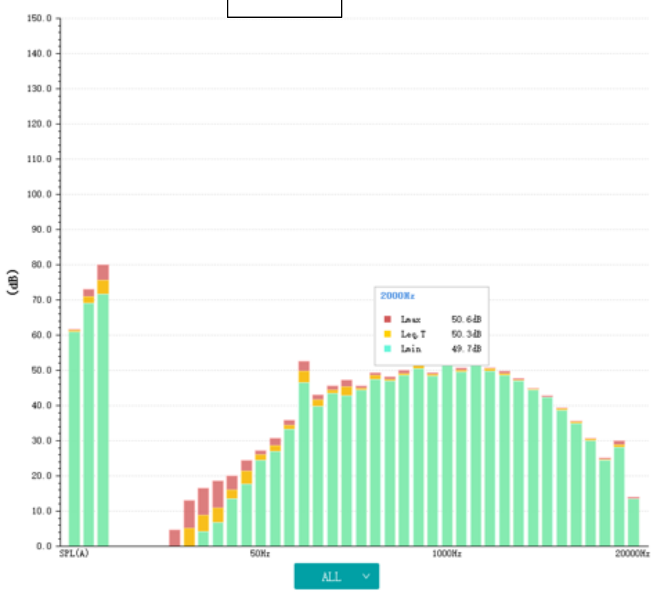
频率	Lmax	Lmin	Leq,T
SPL(A)	59.1	57.1	57.6
SPL(C)	67.6	65.5	66.3
SPL(Z)	76.9	68.6	72.5
5Hz	-26.8	-38.7	-31.9
6.3Hz	-19.6	-34.9	-23.6

Fan speed 60% @ 848rpm

数据列表 20240723187_1

数据分析图

P101



分析列表

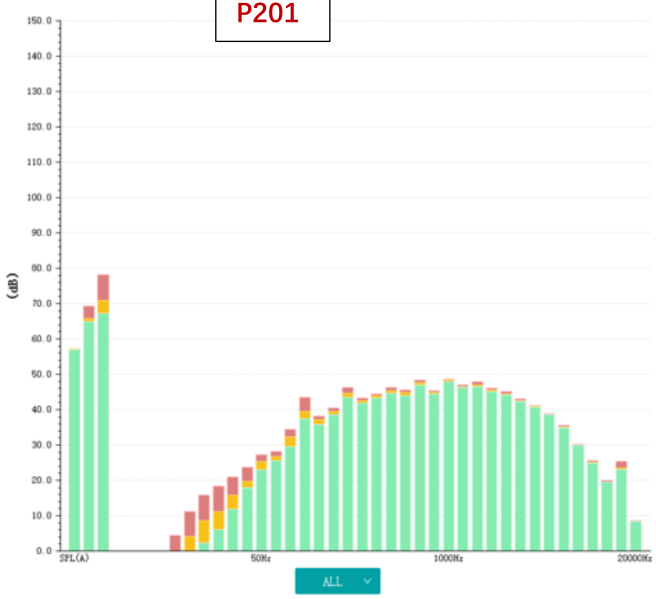
测点名: 20240723187
测量方式: 1/3OCT分析
测量开始时间: 2024-07-23 23:48:49
Ts: 00 : 00 : 10
Tm: 00 : 00 : 10
仪器型号: AWA6292
机号: 391513
校准时间: 2023-09-06 10:09:13
灵敏度级: -28.8 dB
校准声压级: 93.8 dB
计权: A/S
经度: 120.502338
纬度: 31.328376
language: zh
测量范围: 20.0 dBA ~ 143.0 dBA

频率	Lmax	Lmin	Leq,T
SPL(A)	61.6	60.8	61.2
SPL(C)	72.9	69.0	70.9
SPL(Z)	79.8	71.6	75.5
5Hz	-22.7	-40.2	-29.7
6.3Hz	-14.6	-35.7	-22.3

数据列表 20240723194_1

数据分析图

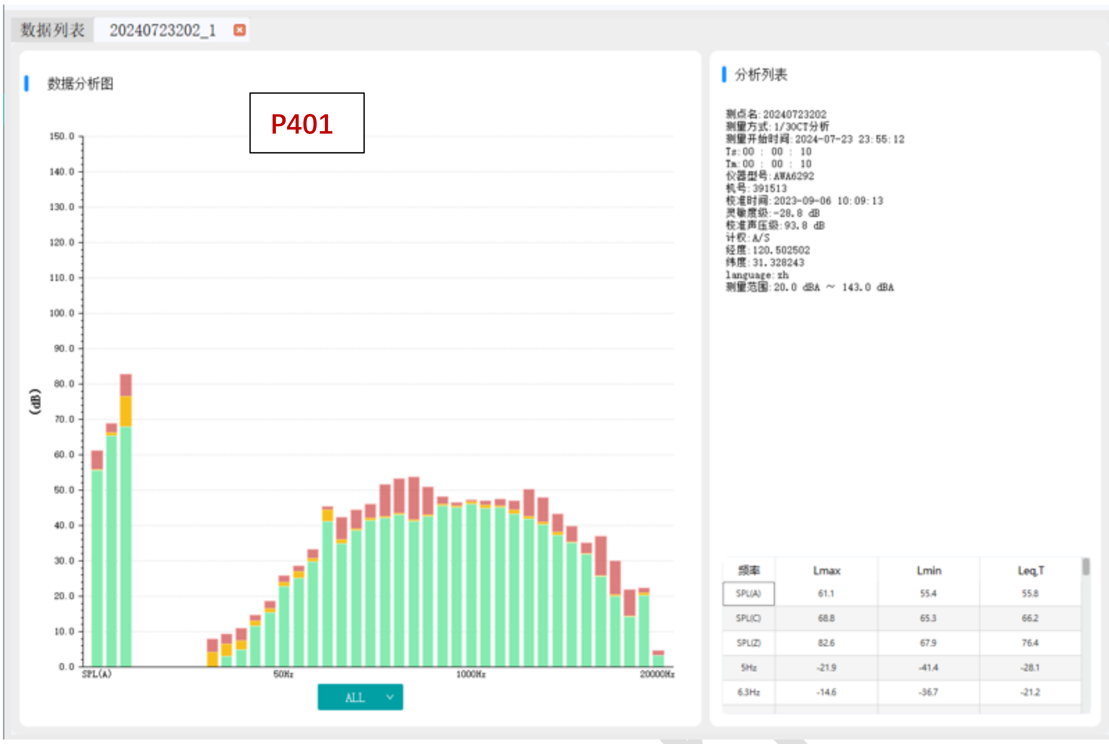
P201



分析列表

测点名: 20240723194
测量方式: 1/3OCT分析
测量开始时间: 2024-07-23 23:51:34
Ts: 00 : 00 : 10
Tm: 00 : 00 : 10
仪器型号: AWA6292
机号: 391513
校准时间: 2023-09-06 10:09:13
灵敏度级: -28.8 dB
校准声压级: 93.8 dB
计权: A/S
经度: 120.502467
纬度: 31.328331
language: zh
测量范围: 20.0 dBA ~ 143.0 dBA

频率	Lmax	Lmin	Leq,T
SPL(A)	57.2	56.8	57.0
SPL(C)	69.1	64.7	65.6
SPL(Z)	78.1	67.0	70.9
5Hz	-25.4	-45.2	-33.1
6.3Hz	-16.3	-37.2	-24.6



频率	Lmax	Lmin	Leq,T
SPL(A)	61.1	55.4	55.8
SPL(C)	68.8	65.3	66.2
SPL(Z)	82.6	67.9	76.4
5Hz	-21.9	-41.4	-28.1
6.3Hz	-14.6	-36.7	-21.2

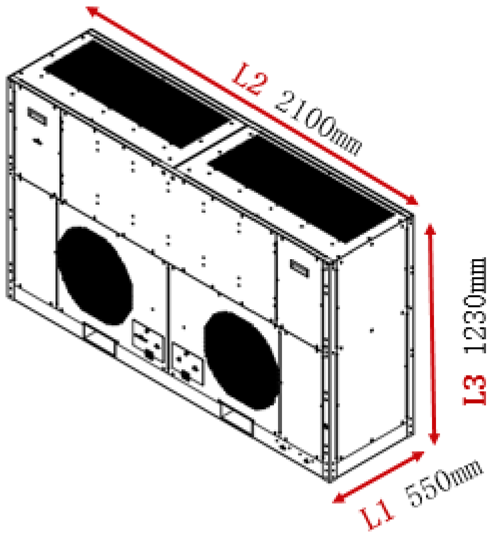
频率	Lmax	Lmin	Leq,T
SPL(A)	55.4	54.9	55.1
SPL(C)	66.3	65.1	65.6
SPL(Z)	82.1	70.7	76.7
5Hz	-23.9	-35.6	-28.3
6.3Hz	-19.4	-26.5	-23.8

3.4 Sound power level

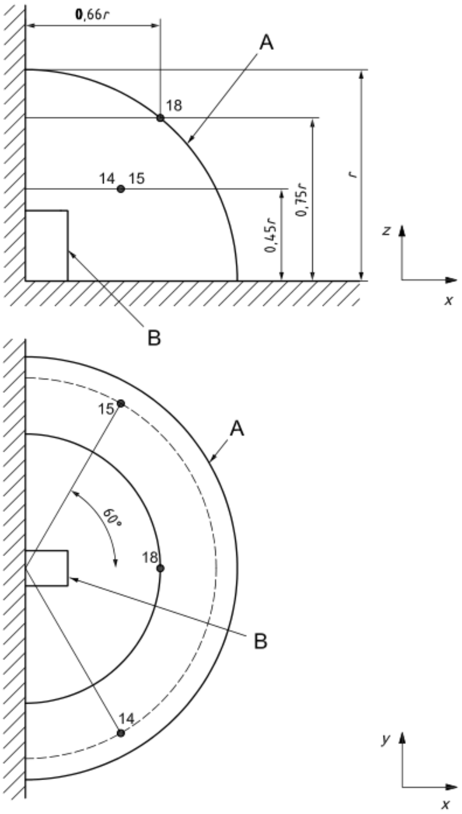
According to the SPL measurement results, the noise propagation of SolBank (Chiller) is consistent with the noise propagation characteristics of the two reflectors, and the sound power level measurement is carried out with a 1/2 hemisphere measuring surface.

3.4.1 Hemispherical measurement surface

$$\mathrm{r} = 2d_0 = \sqrt{l1^2 + l2/2^2 + l3^2} = 3.4m$$



3.4.2 Measurement points



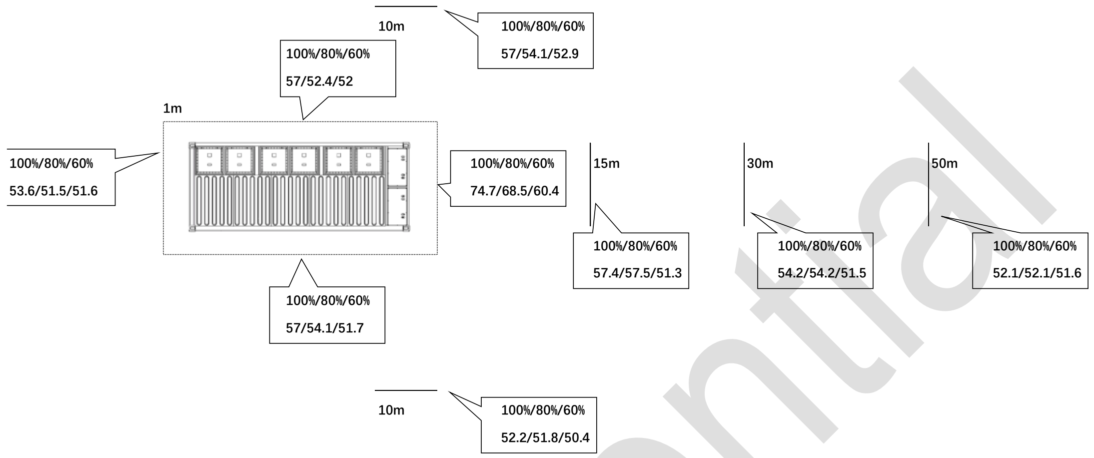
Key
- ● microphone positions (14, 15, 18)
- A measurement surface
- B reference box
- *r* radius of measurement surface

3.4.3 Measurement and calculation result

Item		100%			80%			60%		
		14#	15#	18#	14#	15#	18#	14#	15#	18#
L_{pA}	Measured value	64.2	67.3	68.6	59.2	59.3	62.1	54.6	54.5	56.8
	After correction	63.7	67.3	68.6	57.3	57.5	61.2	51.6	51.5	53.8
`L_{pA} (dBA)		66.6			58.7			52.3		
L_{WA}(dBA)		82.2			74.3			67.9		

4 Conclusion

Reducing the fans speed of chiller from 100% to 80% and 60%, the noise level reduction are as follows:



5 Equipment

The measurements will be taken with the AWA6292 spectrum analyzer. This device allows to get the 1/3 octave attenuation measurements with different ponderation curves to the frequency measurement. According to the ISO 3746 the measurements will be taken with the ponderation curve A. The peak values of the attenuation (dB) will be recorded.

- Measurement bandwidth : 10 Hz - 23.0 kHz
- Level resolution: 0.1 dB
- Accuracy (RMS calculation): Level 1
- Range: 20-143 dB(A)
- Type Curve: A
- Measurement speed: Low

More about instruments: https://www.hzaihua.com/products_cont.html?id=115#d3

Annex

A1. Chiller parameter vs. battery output power

25kW Chiller（Kelvin）							
Operation condition	Fan speed %	Fan speed RPM	Noise dB（A）	Volume air flow m3/h	Refrigerating capacity kW	P-rate of SolBank3.0	Operating mode
W22/L-30	100%	1414	69.46	8000	36.4	0.25	Free cooling
	80%	1131	64.89	6500	32.8	0.25	
	60%	848	59.88	4590	24.5	0.25	
W22/L-25	100%	1414	69.46	8000	33.3	0.25	
	80%	1131	64.89	6500	30.3	0.25	
	60%	848	59.88	4590	22.2	0.22	
W22/L-20	100%	1414	69.46	8000	29.8	0.25	
	80%	1131	64.89	6500	27.6	0.25	
	60%	848	59.88	4590	19.8	0.20	
W22/L-15	100%	1414	69.46	8000	26.4	0.25	
	80%	1131	64.89	6500	25.1	0.25	
	60%	848	59.88	4590	15.9	0.16	
W22/L-10	30%	443	61.98	1965	26.6	0.25	Combined refrigeration
W22/L-5	40%	531	62.35	2350	26.5	0.25	
W22/L0	45%	620	62.88	2752	26.0	0.25	
W22/L5	100%	1414	70.57	8000	44.3	0.25	
	80%	1131	67.13	6500	42.2	0.25	
	60%	848	63.02	4590	27.8	0.25	
W22/L10	100%	1414	70.57	8000	36.1	0.25	
	80%	1131	67.05	6500	34.5	0.25	
	60%	848	63.79	4590	26.8	0.25	
W22/L15	100%	1414	69.93	8000	30.0	0.25	
	80%	1131	65.68	6500	26.6	0.25	
	60%	848	63.85	4590	25.9	0.25	
W22/L20	100%	1414	69.93	8000	26.4	0.25	Compressor refrigeration
	80%	1131	65.68	6500	26.2	0.25	
	60%	848	63.89	4590	25.7	0.25	
W22/L25	100%	1414	69.93	8000	26.0	0.25	
	80%	1131	65.68	6500	25.7	0.25	
	60%	848	65.26	4590	25.5	0.25	
W22/L30	100%	1414	70.03	8000	26.2	0.25	
	80%	1131	65.68	6500	26.0	0.25	
	60%	848	66.88	4590	25.5	0.25	
W22/L35	100%	1414	70.57	8000	26.5	0.25	

	80%	1131	67.05	6500	26.2	0.25	
	60%	848	66.93	4590	24.4	0.24	
W22/L40	100%	1414	70.57	8000	25.9	0.25	
	80%	1131	67.05	6500	25.2	0.25	
	60%	848	65.73	4590	23.5	0.24	
W22/L45	100%	1414	70.57	8000	25.3	0.25	
	80%	1131	67.05	6500	24.1	0.24	
	60%	848	64.53	4590	17.9	0.18	
W22/L50	100%	1414	70.57	8000	22.1	0.22	
	80%	1131	66.8	6500	21.0	0.21	
	60%	848	61.69	4590	14.4	0.14	
W22/L55	100%	1414	70.36	8000	19.1	0.19	
	80%	1131	65.22	6500	18.4	0.18	
	60%	848	60.57	4590	12.0	0.12	

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August 2024

TECHNICAL NOTE

TN0058DI

Noise Reduction for PCSM GEN3 Inverters

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Rev: D
Date: 07/08/2024

Document Revision History		
Revision	Date	Changes
A	09/18/2023	Creation.
B	09/02/2024	50% fan speed data removed.
C	25/04/2024	Noise levels updated according to updated report. Silence mode definitions updated.
D	07/08/2024	1 m sound pressure measures added.

CONTENT

1. Introduction

The purpose of this technical note is to provide an in-depth explanation of the newly developed noise attenuation kit for Power Electronics inverters.

The kit has been specifically designed to reduce noise levels in the Freemaq PCSM/K storage inverters.

By effectively mitigating noise, the kit aims to enhance the overall performance and reliability of the inverters, meeting the evolving requirements and market trends in the energy sector.

In order to meet regulatory standards and ensure optimal acoustic performance, a comprehensive analysis of the acoustic results on is essential. This technical note serves as a guide to understand the functionality, components and benefits of the noise attenuation kit.

With the continuous advancement in Power Electronics' inverter models, it is crucial to consider any potential impact on the acoustic results. This note focuses on first version of the noise attenuation kit. In case future iterations introduce new features or modifications that may influence the noise characteristics, a subsequent version of this document will be released to address those changes accordingly.

Furthermore, in parallel with the explanation of the noise attenuation kit, this document will also include information regarding the results obtained from conducting tests with fans at different speeds to evaluate sound performance.

2. Fan Speed Analysis and Sound Performance Evaluation

In this section, we will delve into the analysis of fan speed and its impact on the sound performance of the PCSM GEN3 inverters.

By examining the relationship between fan speed and sound emission, we aim to gain insights into optimizing the operation and design of the inverters for enhanced acoustic performance.

Through a series of tests conducted at different percentages of fan speed, we will evaluate the resulting sound levels and assess their compliance with applicable noise standards and requirements.

The findings presented in this section provide valuable information for achieving a balance between effective cooling and minimizing noise in the inverters.

2.1. Noise Reduction Results

Below, the results of sound measurements obtained at different fan speeds are presented.

Fan speed	100%	80%	60%
Sound power Lwa (dBA)	97.7	95.3	89.7
Sound pressure L'pa(ST) (dBA)	70.2	67.9	62.5

Table 1. PCSM noise levels at different fan speeds w/o the kit.

Above 40 °C, the fan speed of the power modules must be 100% to provide the declared maximum power. The fan speed of the power modules can be limited to 80% above 40 °C, but in this case the inverter will not be able to provide the maximum declared power (according to the official power vs ambient temperature curve). Review section 2.2.

2.2. Derating at Different Fan Speeds

In this section, we will explore the impact of reducing ventilation speed on the power derating of the equipment.

The derating phenomenon occurs when the power output of the system is intentionally limited to ensure reliable operation under certain conditions, such as high temperatures or reduced cooling capabilities.

The following results provide valuable insights into the trade-off between acoustic performance and power derating, allowing for informed decision-making regarding the optimal balance between system capacity and noise reduction.

Below 40 °C ambient temperature, the maximum speed required is 80%, which is why 100% data is not provided. The LC filter fan must operate at 80% above 25 °C to provide the required cooling up to 50 °C.

Ambient temp.	50 °C			45 °C			40 °C		30 °C		25 °C	
Fan speed power modules / DC cabinet	100%	80%	60%	100%	80%	60%	80%	60%	80%	60%	80%	60%
Fan speed LC filter	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	60%
Maximum power	93%	84%	75%	97%	92%	78%	100%	80%	100%	90%	100%	90%

Table 2. PCSM power derating at different fan speeds.

The base power (100%) is the maximum power (the maximum power at 40 °C in the datasheet).

2.3. Silent Mode

The silent mode can be activated remotely via Modbus and is divided into two levels, independent and exclusive, mode 1 and mode 2.

The first table shows the 80% limitation on fan speed and the second one shows the 60% limitation.

There is a peculiarity in the 60% speed mode. In this case, if the ambient temperature is lower than 25 °C, the fan speed will be automatically set to 60% (for all fans). If the ambient temperature is higher than 25 °C, the LC filter fan speed will be automatically adjusted to 80%. This is to provide the required cooling up to 50 °C.

The maximum power will be limited depending on the ambient temperature.

Amb. temp.	≤ 20 °C	25 °C	30 °C	40 °C	45 °C	50 °C	> 50 °C
Max. power 80%	100%	100%	100%	100%	92%	84%	0%
Max. power 60%	95%	90%	90%*	80%*	78%*	75%*	0%

Table 3. Maximum power in Silent Mode at different ambient temperatures.

** For temperatures above 25 °C, the LC filter fan speed will automatically change from 60% to 80% to provide the required cooling up to 50 °C.*

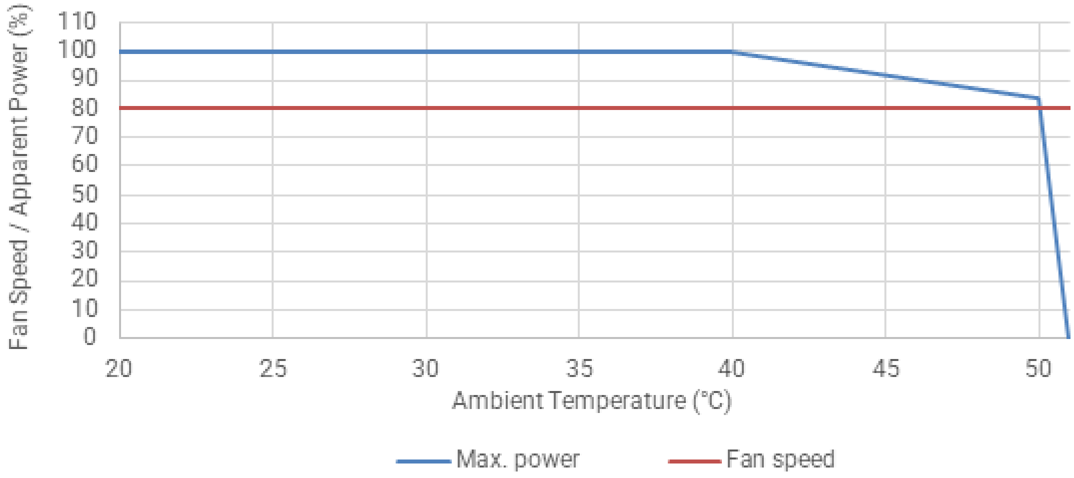

Figure 1. Silent Mode at 80% fan speed.

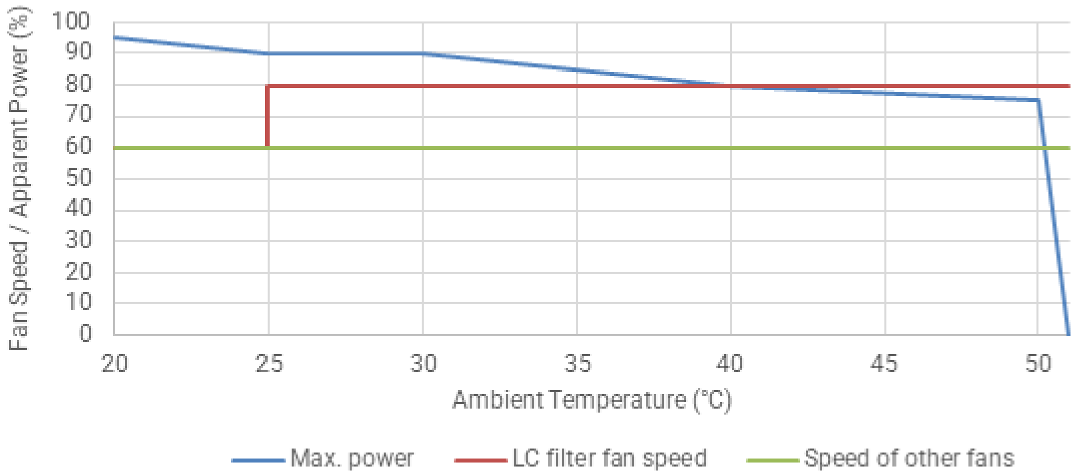

Figure 2. Silent Mode at 60% fan speed (LC filter fan speed of 60% up to 25ºC and 80% above 25ºC).

3. Noise Attenuation Kit

This section will provide a comprehensive overview of the sound attenuation kit, its composition, functionality and the benefits it offers. By addressing the noise-related challenges, the kit aims to enhance the acoustic performance of Power Electronics inverters, ultimately contributing to a quieter and more efficient operational environment.

Figure 3. PCSM with the attenuation kit.

3.1. Drawings of the Kit

Below are the drawings of the noise reduction kit design.

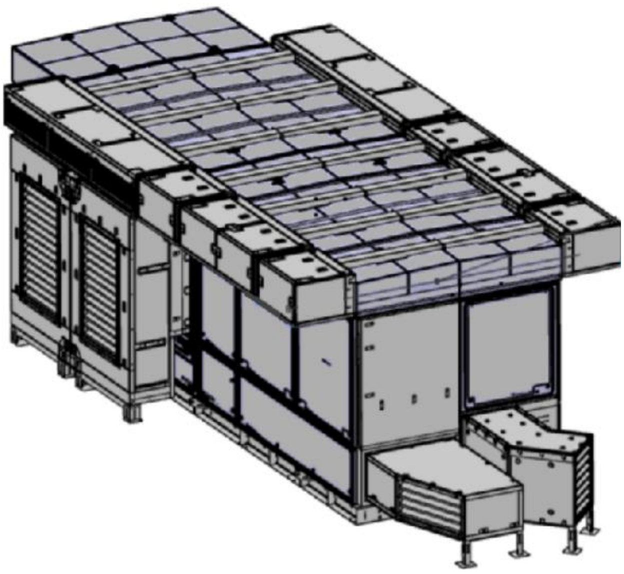

Figure 4. PCSM isometric view.

The following drawings show the dimensions of inverter (in millimeters) with the kit.

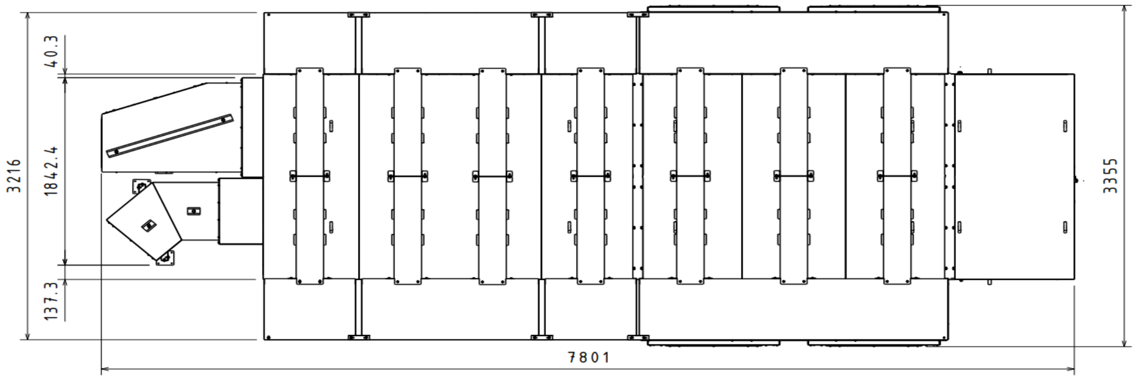

Figure 5. PCSM top view.

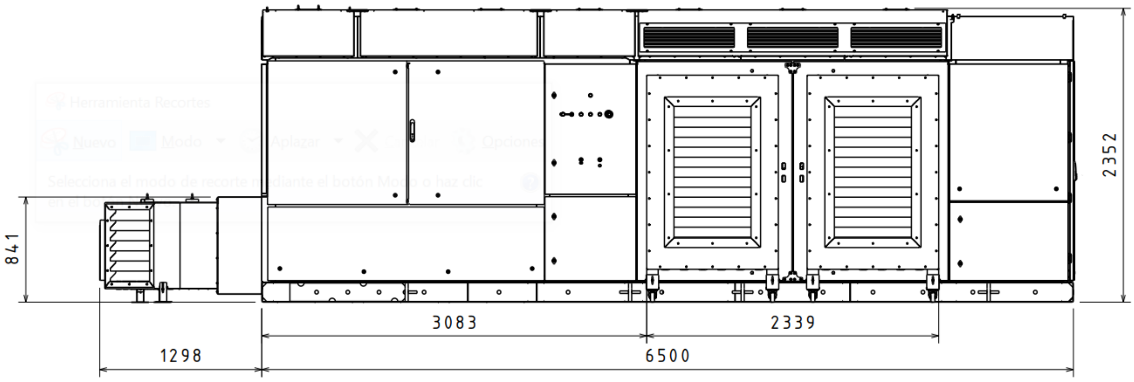

Figure 6. PCSM front view.

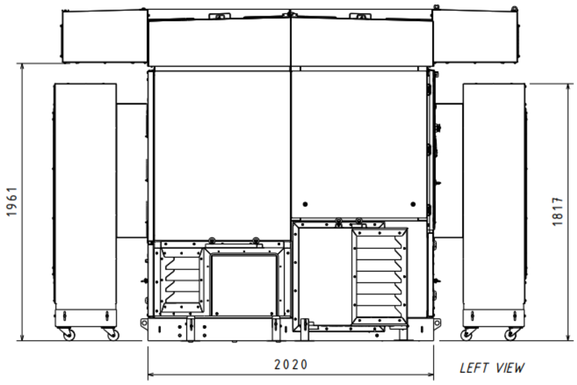

Figure 7. PCSM lateral view.

3.2. Testing Conditions

To assess the effectiveness of the sound attenuation kit, sound measurements were conducted on the inverter both with and without the attenuation kit in place. These measurements were carried out in accordance with the ISO 3744 standard, which provides guidelines for sound power determination in industrial environments.

To capture a comprehensive representation of the sound emissions, a distribution of measurement points was established around the inverter, in a hemispherical measuring surface, according to ISO 3744 (paragraph 7.2.3). A hemisphere radius of 10 meters around the inverter meets the conditions of ISO 3744.

The following graphic illustrates the layout of the measurement points:

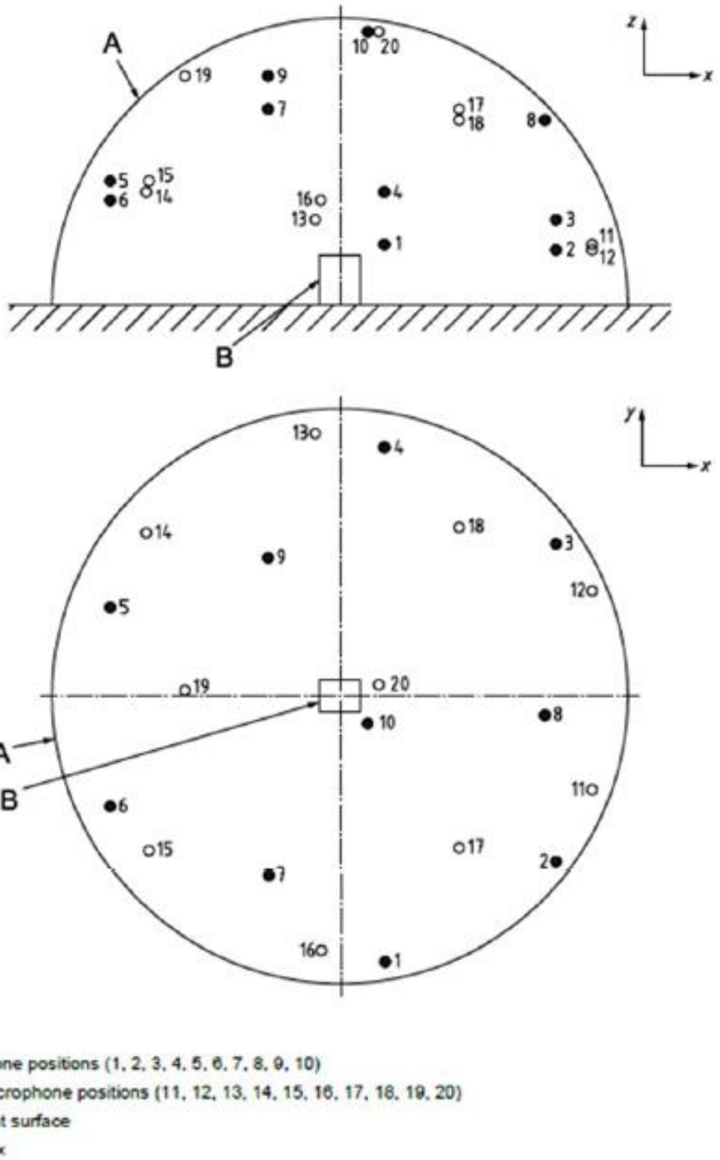

Figure 8. Measurement points.

By adhering to the ISO 3744 standard and implementing a robust measurement methodology, Power Electronics have been able to gather precise sound data for both scenarios: with and without the sound attenuation kit.

These measurements form the basis for evaluating the effectiveness of the kit in reducing sound emissions and provide valuable insights into the impact of the kit on the acoustic performance of the inverter.

For more information on the PCSM noise measurements consult the reports “Inverter acoustic characterisation report PCSM (ISO 3744) 2024-Feb -FDO” and “Inverter acoustic characterisation report PCSM (ISO 3744) 2024-Feb ANNEX -FDO”.

The following sections will include processed data based on the theoretical model specified in ISO 3744 by using A-weighting to calculate sound power (Lwa).

3.3. Noise Attenuation Kit Measurement Results

Fan speed power modules	**100%**	**80%**	**60%**
Sound power Lwa (dBA)	92.7	90.7	85.0
Sound pressure L'pa(ST) (dBA)	65.2	63.4	58.4
Max. power at 50 °C(*)	93%	84%	75%
Max. power at 40 °C	N/A	100%	80%
Max. power at 30 °C	N/A	100%	90%

Table 4. PCSM noise attenuation kit measurement results.

The base power (100%) is the maximum power (the maximum power at 40 °C in the datasheet). The attenuation kit do not introduce any additional power derating.

Note that results shown above corresponds to the average weighted sound pressure and sound power, which are two fundamental concepts in understanding the characteristics of sound.

Sound pressure refers to the variation in air pressure caused by sound waves and represents the strength or intensity of sound at a specific location, typically measured in decibels.

On the other hand, sound power represents the total amount of acoustic energy radiated by a sound source per unit of time and is independent of the distance from the source, typically measured in watts or decibels.

3.4. Conclusions

Based on the reference information provided in the report and the results obtained at 80% fan speed with the installed attenuation solution, it can be concluded that the direct reduction under the same conditions corresponds to a 5.8 dB decrease in sound pressure and a 3.7 dB decrease in sound power.

These findings demonstrate the effect of the attenuation solution on reducing both sound pressure and power levels.

Fan speed power modules	100%			80%			60%		
	w/o kit	with kit	Δ	w/o kit	with kit	Δ	w/o kit	with kit	Δ
Sound power Lwa (dBA)	97.7	92.7	5	95.3	90.7	4.6	89.7	85.0	4.7
Sound pressure (dBA)	70.2	65.2	5	67.8	63.4	4.4	62.5	58.4	4.1
Maximum power at 50 °C	93%			84%			75%		
Maximum power at 40 °C	N/A			100%			80%		
Maximum power at 30 °C	N/A			100%			90%		

Table 5. PCSM noise levels / power derating at 100%, 80%, 60% fan speed.

In addition, from the measurements above, the sound pressure values at 1 meter distance of the inverter can be calculated. For this calculation, the hemispherical measuring surface is not applied, as each point is not 1 meter far from the inverter. The geometry is adapted to the main geometry of the inverter, a cuboid geometry.

Fan speed power modules	100%			80%			60%		
	w/o kit	with kit	Δ	w/o kit	with kit	Δ	w/o kit	with kit	Δ
Sound pressure at 1m (dBA)	76.8	70.7	6.1	74.4	68.7	5.7	68.8	63.0	5.8

Table 6. PCSM sound pressure values at 1 meter.

4. Additional Sound Reduction Measures

In addition to the specific measures related to Power Electronics inverters, clients can implement various project-level strategies to further mitigate noise and create a quieter environment.

These strategies go beyond the scope of individual inverters and encompass broader considerations. Here are some options to consider:

- **Noise Walls:** Install noise walls around the entire project area or specific noise-generating sources. These physical barriers can effectively block and absorb sound, preventing its propagation to neighboring areas. Careful planning and design are crucial to ensure the effectiveness of noise walls, considering factors such as height, material and placement.

- **Site Layout and Design:** Optimize the project's layout and design to minimize the impact of noise on sensitive areas. Consider locating noise-emitting equipment, such as inverters, away from noise-sensitive zones such as residential or quiet workspaces. By strategically positioning equipment and infrastructure, sound transmission can be reduced.

- **Landscaping and Vegetation:** Utilize natural features such as trees, shrubs and greenery to create a buffer zone that absorbs and deflects sound waves. Well-designed landscaping can act as a natural barrier, reducing the propagation of noise between the project and its surroundings.

ANNEX A - 1/3 OCTAVE BAND DATA (A-WEIGHTED)

<u>Without attenuation kit, 100%</u>

MEAN TIME-AVERAGED SOUND PRESSURE LEVEL FROM THE ARRAY OF MICROPHONE POSITIONS OVER THE MEASUREMENT SURFACE (ISO 3744, sections 8.2.2.1, 8.2.3 & 8.2.4)

A-WEIGHTED SOUND POWER LEVEL FROM MID-BAND FREQUENCIES OF ONE-THIRD OCTAVE BANDS (ISO 3744, Annex E)

Mid-band frequencies of octave bands (Hz)	$\overline{L'_p}(ST)$	$\overline{L_p}(B)$	ΔL_p	K_1	K_2	Coef. C_k	$\overline{L_{pk}}$	L_{Wk}	$L_{Wk} - C_k$
12.5	68,9	53,5	15,4						
16	66,4	53,5	12,9	0,2303					
20	64,4	55,2	9,2	0,5535					
25	64,1	63,1	1,0	1,3000					
31.5	63,9	54,9	9,0	0,5835					
40	63,6	58,3	5,2	1,3000					
50	63,3	57,0	6,3	1,1462	3,1635	-30,2	59,00	86,99	56,79
63	63,4	52,1	11,3	0,3329	2,0243	-26,2	61,06	89,04	62,84
80	61,5	50,6	11,0	0,3630	1,4982	-22,5	59,68	87,66	65,16
100	61,5	48,4	13,1	0,2176	0,1095	-19,1	61,16	89,14	70,04
125	65,5	46,7	18,7		1,0525	-16,1	64,42	92,40	76,30
160	61,6	48,2	13,4	0,2014	0,4731	-13,4	60,95	88,94	75,54
200	61,8	48,2	13,6	0,1944	0,1490	-10,9	61,44	89,42	78,52
250	67,4	46,7	20,7		0,2933	-8,6	67,13	95,12	86,52
315	69,3	47,3	22,0		0,5997	-6,6	68,65	96,63	90,03
400	62,9	45,5	17,4		0,6836	-4,8	62,20	90,18	85,38
500	61,7	45,5	16,2		0,7335	-3,2	60,96	88,94	85,74
630	59,4	45,8	13,7	0,1915	0,8044	-1,9	58,42	86,41	84,51
800	57,7	45,5	12,2	0,2728	0,6687	0,8	56,76	84,74	85,54
1k	61,6	44,4	17,2		0,2141		61,36	89,34	89,34
1.25k	57,6	42,4	15,2		0,1106	0,6	57,53	85,51	86,11
1.6k	57,3	39,9	17,4		0,3938	1	56,87	84,86	85,86
2k	56,2	37,7	18,5		0,7997	1,2	55,36	83,34	84,54
2.5k	56,1	36,3	19,7		0,6858	1,3	55,38	83,36	84,66
3.15k	54,7	36,1	18,7		0,6429	1,2	54,11	82,09	83,29
4k	53,5	40,1	13,4	0,2053	0,1194	1	53,13	81,11	82,11
5k	52,5	38,8	13,7	0,1895	-0,6347	0,5	52,90	80,88	81,38
6.3k	51,1	28,3	22,8		-0,9664	-0,1	52,04	80,02	79,92
8k	49,0	20,5	28,5		-1,9054	-1,1	50,95	78,93	77,83
10k	47,5	16,2	31,3		-2,8112	-2,5	50,31	78,29	75,79
12.5k	44,7	14,3	30,4		-4,2102				
16k	41,7	15,7	26,1		-6,0448				

	$\overline{L'_p}(ST)$	$\overline{L_p}(B)$	ΔL_p	K_1	K_2
A-weighted	70,2	53,3	16,9		0,3100

$$\overline{L_{pk}} = \overline{L'_{pk}}(ST) - K_{1k} - K_{2k}$$

$$L_{Wk} = \overline{L_{pk}} + 10lg\frac{S}{S_0}$$

$$L_{WA} = 10lg\sum_{k=k_{min}}^{k_{max}} 10^{0.1(L_{Wk}+C_k)}$$

SOUND POWER LEVEL FROM THE SOUND PRESSURE LEVEL, IN dB(A)

$$\overline{L_p} = \overline{L'_p}(ST) - K_1 - K_2 \qquad L_W = \overline{L_p} + 10lg\frac{S}{S_0}$$

Area of measurement surf. [S] = 628,32 m2 S_0 = 1m²

L_W = 97,8 dB(A)

L_{WA} = 97,7 dB(A)

With attenuation kit, 100%

MEAN TIME-AVERAGED SOUND PRESSURE LEVEL FROM THE ARRAY OF MICROPHONE POSITIONS OVER THE MEASUREMENT SURFACE (ISO 3744, sections 8.2.2.1, 8.2.3 & 8.2.4)

A-WEIGHTED SOUND POWER LEVEL FROM MID-BAND FREQUENCIES OF ONE-THIRD OCTAVE BANDS (ISO 3744, Annex E)

Mid-band frequencies of octave bands (Hz)	$\overline{L'_p}(ST)$	$\overline{L_p}(B)$	ΔL_p	K_1	K_2	Coef. C_k	$\overline{L_{pk}}$	L_{Wk}	$L_{Wk} - C_k$
12.5	54,7	50,8	3,9	1,3000					
16	57,4	50,9	6,6	1,0815					
20	59,4	50,6	8,7	0,6221					
25	60,2	65,9	-5,7	1,3000					
31.5	61,4	60,7	0,7	1,3000					
40	62,9	54,4	8,5	0,6666					
50	62,5	55,7	6,8	1,0208	3,1635	-30,2	58,32	86,30	56,10
63	63,4	51,5	11,9	0,2909	2,0243	-26,2	61,07	89,05	62,85
80	62,1	49,3	12,8	0,2364	1,4982	-22,5	60,37	88,35	65,85
100	61,2	48,0	13,2	0,2109	0,1095	-19,1	60,89	88,87	69,77
125	63,0	47,5	15,5		1,0525	-16,1	61,92	89,90	73,80
160	59,7	53,3	6,5	1,1125	0,4731	-13,4	58,16	86,15	72,75
200	58,1	56,3	1,8	1,3000	0,1490	-10,9	56,64	84,62	73,72
250	63,1	50,3	12,8	0,2340	0,2933	-8,6	62,53	90,52	81,92
315	64,2	47,6	16,6		0,5997	-6,6	63,64	91,62	85,02
400	57,6	46,5	11,1	0,3508	0,6836	-4,8	56,55	84,53	79,73
500	53,5	46,1	7,4	0,8788	0,7335	-3,2	51,84	79,82	76,62
630	52,8	43,8	8,9	0,5919	0,8044	-1,9	51,36	79,34	77,44
800	52,8	41,6	11,2	0,3401	0,6687	0,8	51,78	79,77	80,57
1k	53,0	41,6	11,4	0,3248	0,2141		52,45	80,43	80,43
1.25k	52,6	41,9	10,8	0,3815	0,1106	0,6	52,12	80,10	80,70
1.6k	51,5	41,9	9,7	0,4975	0,3938	1	50,64	78,62	79,62
2k	50,6	39,5	11,0	0,3572	0,7997	1,2	49,42	77,40	78,60
2.5k	50,7	39,9	10,8	0,3807	0,6858	1,3	49,58	77,57	78,87
3.15k	49,7	38,5	11,2	0,3445	0,6429	1,2	48,73	76,72	77,92
4k	51,2	35,2	16,1		0,1194	1	51,11	79,09	80,09
5k	51,4	33,7	17,6		-0,6347	0,5	52,02	80,00	80,50
6.3k	50,8	32,9	18,0		-0,9664	-0,1	51,81	79,79	79,69
8k	50,8	29,0	21,8		-1,9054	-1,1	52,73	80,71	79,61
10k	50,0	29,5	20,5		-2,8112	-2,5	52,79	80,77	78,27
12.5k	48,7	24,5	24,1		-4,2102				
16k	45,4	21,8	23,6		-6,0448				

	$\overline{L'_p}(ST)$	$\overline{L_p}(B)$	ΔL_p	K_1	K_2
A-weighted	65,2	46,5	18,6		0,3100

$$\overline{L_{pk}} = \overline{L'_{pk}}(ST) - K_{1k} - K_{2k}$$

$$L_{Wk} = \overline{L_{pk}} + 10lg\frac{S}{S_0}$$

$$L_{WA} = 10lg\sum_{k=k_{min}}^{k_{max}} 10^{0.1(L_{Wk}+C_k)}$$

SOUND POWER LEVEL FROM THE SOUND PRESSURE LEVEL, IN dB(A)

$$\overline{L_p} = \overline{L'_p}(ST) - K_1 - K_2 \qquad L_W = \overline{L_p} + 10lg\frac{S}{S_0}$$

Area of measurement surf. [S] = 628,32 m2 $S_0 = 1 m^2$

L_W =	**92,8**	**dB(A)**

L_{WA} =	**92,7**	**dB(A)**

Without attenuation kit, 80%

MEAN TIME-AVERAGED SOUND PRESSURE LEVEL FROM THE ARRAY OF MICROPHONE POSITIONS OVER THE MEASUREMENT SURFACE (ISO 3744, sections 8.2.2.1, 8.2.3 & 8.2.4)

Mid-band frequencies of octave bands (Hz)	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
12.5	65,1	53,5	11,6	0,3116	
16	62,9	53,5	9,4	0,5311	
20	62,0	55,2	6,8	1,0160	
25	61,8	63,1	-1,3	1,3000	
31.5	62,0	54,9	7,0	0,9566	
40	61,2	58,3	2,9	1,3000	
50	61,2	57,0	4,2	1,3000	3,1635
63	60,5	52,1	8,4	0,6700	2,0243
80	59,7	50,6	9,1	0,5743	1,4982
100	60,4	48,4	12,0	0,2833	0,1095
125	65,6	46,7	18,9		1,0525
160	60,4	48,2	12,2	0,2719	0,4731
200	62,0	48,2	13,8	0,1867	0,1490
250	68,6	46,7	21,9		0,2933
315	67,4	47,3	20,1		0,5997
400	57,1	45,5	11,6	0,3083	0,6836
500	58,6	45,5	13,1	0,2177	0,7335
630	57,1	45,8	11,4	0,3280	0,8044
800	56,4	45,5	10,8	0,3758	0,6687
1k	55,4	44,4	11,0	0,3569	0,2141
1.25k	55,7	42,4	13,3	0,2098	0,1106
1.6k	54,9	39,9	15,1		0,3938
2k	53,7	37,7	16,0		0,7997
2.5k	52,6	36,3	16,3		0,6858
3.15k	51,9	36,1	15,8		0,6429
4k	51,3	40,1	11,2	0,3461	0,1194
5k	49,3	38,8	10,5	0,4008	-0,6347
6.3k	48,7	28,3	20,5		-0,9664
8k	46,8	20,5	26,3		-1,9054
10k	44,7	16,2	28,4		-2,8112
12.5k	42,3	14,3	27,9		-4,2102
16k	39,2	15,7	23,5		-6,0448

	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
A-weighted	67,9	53,3	14,6	0,1517	0,3100

SOUND POWER LEVEL FROM THE SOUND PRESSURE LEVEL, IN dB(A)

$$\overline{L_p} = \overline{L'_p}(ST) - K_1 - K_2 \qquad L_W = \overline{L_p} + 10lg\frac{S}{S_0}$$

Area of measurement surf. [S] = 628,32 m2 $S_0 = 1 m^2$

L_W = 95,4 dB(A)

A-WEIGHTED SOUND POWER LEVEL FROM MID-BAND FREQUENCIES OF ONE-THIRD OCTAVE BANDS (ISO 3744, Annex E)

Coef. C_k	$\overline{L_{pk}}$	L_{Wk}	$L_{Wk} - C_k$
-30,2	56,63	84,68	54,48
-26,2	57,85	85,84	59,64
-22,5	57,58	85,56	63,06
-19,1	59,98	87,96	68,86
-16,1	64,59	92,57	76,47
-13,4	59,61	87,60	74,20
-10,9	61,62	89,60	78,70
-8,6	68,27	96,25	87,65
-6,6	66,79	94,77	88,17
-4,8	56,11	84,09	79,29
-3,2	57,66	85,64	82,44
-1,9	56,02	84,00	82,10
0.8	55,32	83,30	84,10
	54,87	82,85	82,85
0,6	55,38	83,36	83,96
1	54,53	82,51	83,51
1,2	52,90	80,88	82,08
1,3	51,91	79,90	81,20
1,2	51,27	79,25	80,45
1	50,79	78,77	79,77
0,5	49,54	77,52	78,02
-0,1	49,70	77,68	77,58
-1,1	48,70	76,68	75,58
-2,5	47,47	75,45	72,95

$$\overline{L_{pk}} = \overline{L'_{pk}}(ST) - K_{1k} - K_{2k}$$

$$L_{Wk} = \overline{L_{pk}} + 10lg\frac{S}{S_0}$$

$$L_{WA} = 10lg \sum_{k=k_{min}}^{k_{max}} 10^{0.1(L_{Wk}+C_k)}$$

L_{WA} = 95,3 dB(A)

With attenuation kit, 80%

MEAN TIME-AVERAGED SOUND PRESSURE LEVEL FROM THE ARRAY OF MICROPHONE POSITIONS OVER THE MEASUREMENT SURFACE (ISO 3744, sections 8.2.2.1, 8.2.3 & 8.2.4)

Mid-band frequencies of octave bands (Hz)	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
12.5	52,8	50,8	2,0	1,3000	
16	54,9	50,9	4,0	1,3000	
20	55,8	50,6	5,2	1,3000	
25	58,4	65,9	-7,5	1,3000	
31.5	59,5	60,7	-1,2	1,3000	
40	59,6	54,4	5,2	1,3000	
50	59,8	55,7	4,0	1,3000	3,1635
63	61,3	51,5	9,8	0,4797	2,0243
80	58,8	49,3	9,5	0,5191	1,4982
100	58,8	48,0	10,8	0,3749	0,1095
125	61,1	47,5	13,6	0,1928	1,0525
160	58,2	53,3	4,9	1,3000	0,4731
200	57,8	56,3	1,5	1,3000	0,1490
250	64,1	50,3	13,9	0,1822	0,2933
315	62,7	47,6	15,1		0,5997
400	51,6	46,5	5,1	1,3000	0,6836
500	51,8	46,1	5,7	1,3000	0,7335
630	50,9	43,8	7,1	0,9408	0,8044
800	51,2	41,6	9,6	0,5028	0,6687
1k	50,6	41,6	9,0	0,5818	0,2141
1.25k	50,8	41,9	8,9	0,5967	0,1106
1.6k	49,9	41,9	8,0	0,7422	0,3938
2k	48,6	39,5	9,0	0,5839	0,7997
2.5k	48,2	39,9	8,3	0,6956	0,6858
3.15k	46,9	38,5	8,3	0,6926	0,6429
4k	49,9	35,2	14,7	0,1488	0,1194
5k	48,3	33,7	14,6	0,1539	-0,6347
6.3k	46,8	32,9	13,9	0,1786	-0,9664
8k	47,2	29,0	18,2		-1,9054
10k	46,1	29,5	16,7		-2,8112
12.5k	43,4	24,5	18,9		-4,2102
16k	40,6	21,8	18,9		-6,0448

	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
A-weighted	63,4	46,5	16,9		0,3100

SOUND POWER LEVEL FROM THE SOUND PRESSURE LEVEL, IN dB(A)

$$\overline{L_p} = \overline{L'_p}(ST) - K_1 - K_2 \qquad L_W = \overline{L_p} + 10lg\frac{S}{S_0}$$

Area of measurement surf. [S] = 628,32 m2 $S_0 = 1m^2$

Lw = 91,1 dB(A)

A-WEIGHTED SOUND POWER LEVEL FROM MID-BAND FREQUENCIES OF ONE-THIRD OCTAVE BANDS (ISO 3744, Annex E)

Coef. C_k	$\overline{L_{pk}}$	L_{Wk}	$L_{Wk} - C_k$
-30,2	55,29	83,27	53,07
-26,2	58,80	86,78	60,58
-22,5	56,81	84,79	62,29
-19,1	58,31	86,29	67,19
-16,1	59,89	87,87	71,77
-13,4	56,46	84,44	71,04
-10,9	56,36	84,34	73,44
-8,6	63,65	91,63	83,03
-6,6	62,11	90,10	83,50
-4,8	49,65	77,63	72,83
-3,2	49,78	77,76	74,56
-1,9	49,16	77,15	75,25
0,8	50,00	77,99	78,79
	49,79	77,77	77,77
0.6	50,06	78,05	78,65
1	48,78	76,76	77,76
1,2	47,17	75,15	76,35
1,3	46,81	74,79	76,09
1,2	45,52	73,50	74,70
1	49,61	77,59	78,59
0,5	48,80	76,78	77,28
-0,1	47,60	75,58	75,48
-1,1	49,15	77,13	76,03
-2,5	48,92	76,90	74,40

$$\overline{L_{pk}} = \overline{L'_{pk}}(ST) - K_{1k} - K_{2k}$$

$$L_{Wk} = \overline{L_{pk}} + 10lg\frac{S}{S_0}$$

$$L_{WA} = 10lg\sum_{k=k_{min}}^{k_{max}} 10^{0.1(L_{Wk}+C_k)}$$

LWA = 90,7 dB(A)

Without attenuation kit, 60%

MEAN TIME-AVERAGED SOUND PRESSURE LEVEL FROM THE ARRAY OF MICROPHONE POSITIONS OVER THE MEASUREMENT SURFACE (ISO 3744, sections 8.2.2.1, 8.2.3 & 8.2.4)

Mid-band frequencies of octave bands (Hz)	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
12.5	69,0	53,5	15,5		
16	66,7	53,5	13,2	0,2133	
20	64,7	55,2	9,5	0,5118	
25	63,8	63,1	0,7	1,3000	
31.5	61,5	54,9	6,5	1,0897	
40	60,4	58,3	2,0	1,3000	
50	59,9	57,0	3,0	1,3000	3,1635
63	58,9	52,1	6,8	1,0062	2,0243
80	56,7	50,6	6,1	1,2136	1,4982
100	58,0	48,4	9,6	0,5001	0,1095
125	66,5	46,7	19,7		1,0525
160	61,7	48,2	13,8	0,1959	0,4731
200	64,6	48,2	16,4		0,1490
250	60,3	46,7	13,6	0,1925	0,2933
315	56,6	47,3	9,4	0,5357	0,5997
400	54,5	45,5	9,0	0,5778	0,6836
500	53,3	45,5	7,8	0,7860	0,7335
630	51,8	45,8	6,0	1,3000	0,8044
800	51,3	45,5	5,7	1,3000	0,6687
1k	50,9	44,4	6,5	1,1108	0,2141
1.25k	52,0	42,4	9,5	0,5107	0,1106
1.6k	49,5	39,9	9,7	0,4973	0,3938
2k	48,0	37,7	10,4	0,4202	0,7997
2.5k	47,8	36,3	11,4	0,3235	0,6858
3.15k	46,2	36,1	10,1	0,4458	0,6429
4k	44,0	40,1	3,9	1,3000	0,1194
5k	42,7	38,8	4,0	1,3000	-0,6347
6.3k	41,7	28,3	13,4	0,2013	-0,9664
8k	38,9	20,5	18,4		-1,9054
10k	36,1	16,2	19,9		-2,8112
12.5k	33,8	14,3	19,5		-4,2102
16k	33,0	15,7	17,4		-6,0448

	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
A-weighted	62,5	53,3	9,2	0,5517	0,3100

SOUND POWER LEVEL FROM THE SOUND PRESSURE LEVEL, IN dB(A)

$$\overline{L_p} = \overline{L'_p}(ST) - K_1 - K_2 \qquad L_W = \overline{L_p} + 10lg\frac{S}{S_0}$$

Area of measurement surf. [S] = 628,32 m2 $S_0 = 1m^2$

L_W =	89,6	dB(A)

A-WEIGHTED SOUND POWER LEVEL FROM MID-BAND FREQUENCIES OF ONE-THIRD OCTAVE BANDS (ISO 3744, Annex E)

Coef. C_k	$\overline{L_{pk}}$	L_{Wk}	$L_{Wk} - C_k$
-30,2	55,46	83,44	53,24
-26,2	55,91	83,90	57,70
-22,5	54,00	81,98	59,48
-19,1	57,41	85,39	66,29
-16,1	65,40	93,38	77,28
-13,4	61,08	89,06	75,66
-10,9	64,47	92,45	81,55
-8,6	59,84	87,82	79,22
-6,6	55,50	83,48	76,88
-4,8	53,25	81,23	76,43
-3,2	51,79	79,78	76,58
-1,9	49,65	77,63	75,73
0,8	49,28	77,26	78,06
	49,55	77,53	77,53
0,6	51,36	79,34	79,94
1	48,63	76,61	77,61
1,2	46,81	74,80	76,00
1,3	46,75	74,73	76,03
1,2	45,11	73,10	74,30
1	42,57	70,55	71,55
0,5	42,05	70,03	70,53
-0,1	42,48	70,47	70,37
-1,1	40,85	68,83	67,73
-2,5	38,93	66,91	64,41

$$\overline{L_{pk}} = \overline{L'_{pk}}(ST) - K_{1k} - K_{2k}$$

$$L_{Wk} = \overline{L_{pk}} + 10lg\frac{S}{S_0}$$

$$L_{WA} = 10lg\sum_{k=k_{min}}^{k_{max}} 10^{0.1(L_{Wk}+C_k)}$$

L_{WA} =	89,7	dB(A)

With attenuation kit, 60%

MEAN TIME-AVERAGED SOUND PRESSURE LEVEL FROM THE ARRAY OF MICROPHONE POSITIONS OVER THE MEASUREMENT SURFACE (ISO 3744, sections 8.2.2.1, 8.2.3 & 8.2.4)

A-WEIGHTED SOUND POWER LEVEL FROM MID-BAND FREQUENCIES OF ONE-THIRD OCTAVE BANDS (ISO 3744, Annex E)

Mid-band frequencies of octave bands (Hz)	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2	Coef. C_k	$\overline{L_{pk}}$	L_{Wk}	$L_{Wk} - C_k$
12.5	55,4	50,8	4,6	1,3000					
16	56,4	50,9	5,5	1,3000					
20	55,5	50,6	4,9	1,3000					
25	56,9	65,9	-9,1	1,3000					
31.5	58,3	60,7	-2,4	1,3000					
40	59,1	54,4	4,7	1,3000					
50	57,1	55,7	1,4	1,3000	3,1635	-30,2	52,65	80,64	50,44
63	58,5	51,5	7,0	0,9668	2,0243	-26,2	55,51	83,49	57,29
80	56,0	49,3	6,7	1,0463	1,4982	-22,5	53,49	81,47	58,97
100	56,6	48,0	8,7	0,6371	0,1095	-19,1	55,87	83,85	64,75
125	64,9	47,5	17,4		1,0525	-16,1	63,81	91,79	75,69
160	59,5	53,3	6,2	1,2008	0,4731	-13,4	57,79	85,77	72,37
200	60,2	56,3	3,9	1,3000	0,1490	-10,9	58,70	86,69	75,79
250	56,7	50,3	6,4	1,1304	0,2933	-8,6	55,23	83,21	74,61
315	52,8	47,6	5,2	1,3000	0,5997	-6,6	50,91	78,89	72,29
400	49,9	46,5	3,4	1,3000	0,6836	-4,8	47,88	75,86	71,06
500	47,7	46,1	1,6	1,3000	0,7335	-3,2	45,68	73,66	70,46
630	46,4	43,8	2,6	1,3000	0,8044	-1,9	44,32	72,30	70,40
800	45,9	41,6	4,4	1,3000	0,6687	0,8	43,96	71,94	72,74
1k	45,8	41,6	4,2	1,3000	0,2141		44,30	72,28	72,28
1.25k	45,9	41,9	4,1	1,3000	0,1106	0,6	44,53	72,51	73,11
1.6k	44,4	41,9	2,6	1,3000	0,3938	1	42,73	70,71	71,71
2k	43,3	39,5	3,7	1,3000	0,7997	1,2	41,16	69,14	70,34
2.5k	42,9	39,9	3,0	1,3000	0,6858	1,3	40,95	68,93	70,23
3.15k	42,1	38,5	3,6	1,3000	0,6429	1,2	40,16	68,14	69,34
4k	42,1	35,2	7,0	0,9765	0,1194	1	41,02	69,00	70,00
5k	42,0	33,7	8,3	0,6953	-0,6347	0,5	41,98	69,96	70,46
6.3k	41,2	32,9	8,3	0,6890	-0,9664	-0,1	41,47	69,46	69,36
8k	39,8	29,0	10,8	0,3759	-1,9054	-1,1	41,34	69,32	68,22
10k	38,9	29,5	9,4	0,5278	-2,8112	-2,5	41,15	69,13	66,63
12.5k	36,6	24,5	12,1	0,2748	-4,2102				
16k	34,1	21,8	12,3	0,2631	-6,0448				

	$\overline{L'_p(ST)}$	$\overline{L_p(B)}$	ΔL_p	K_1	K_2
A-weighted	58,4	46,5	11,8	0,2934	0,3100

$$\overline{L_{pk}} = \overline{L'_{pk}}(ST) - K_{1k} - K_{2k}$$

$$L_{Wk} = \overline{L_{pk}} + 10 lg \frac{S}{S_0}$$

$$L_{WA} = 10 lg \sum_{k=k_{min}}^{k_{max}} 10^{0.1(L_{Wk}+C_k)}$$

SOUND POWER LEVEL FROM THE SOUND PRESSURE LEVEL, IN dB(A)

$$\overline{L_p} = \overline{L'_p}(ST) - K_1 - K_2 \qquad L_W = \overline{L_p} + 10 lg \frac{S}{S_0}$$

Area of measurement surf. [S] = 628,32 m2 S_0 = 1 m²

L_W =	85,8	dB(A)

L_{WA} =	85,0	dB(A)