The Diocese of Mississauga, Vancouver, and Western Canada Noise Control Feasibility Report

Proposed Development
St. Mark and St. Demiana Church
Mississauga

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300044049.0000

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R.J. Burnside & Associates Limited

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Executive Summary

R.J. Burnside & Associates Limited (Burnside) was retained by The Diocese of Mississauga, Vancouver, and Western Canada to prepare a Noise Control Feasibility Study for the St. Mark and St. Demiana Church Development. The property (300044049.0000) is located at Ninth Line, Mississauga, Ontario.

The proposed development will contain stationary noise sources with potential to impact noise sensitive land uses in the vicinity. The proposed stationary noise sources include refrigerated truck deliveries to the cafeteria and rooftop HVAC equipment. Sound levels from these sources were modelled based on standard MECP data for trucks and conservative estimates of the future development's HVAC requirements. As the mechanical plans are not available at this time, a worst-case predictable location was selected for the HVAC equipment. The ambient noise conditions predicted for the nearby noise sensitive receptors of proposed development were also considered. The resulting estimated future sound levels were compared to the applicable MECP stationary noise limits of a Class 1 Area in order to determine whether any noise control measures are required.

The assessment revealed that the stationary sound levels from the proposed sources within the development, at one point of reception near the proposed development is above the MECP limits for nighttime; therefore, external stationary noise mitigation measures may be required.

To meet the MECP noise standards one of the following conditions must be met by the final mechanical design:

Locate the cooling tower at the worst-case predictable location used for this study but specify a unit with a manufacturer's sound power level rating not exceeding 107 dBA.
Locate the cooling tower at a more favorable location further north of the worst-case predictable location used for this study, specifying either a unit with a manufacturer's sound power level rating not exceeding 107 dBA, or a higher rating verified in writing by a qualified Acoustic Consultant to not result in an exceedance at the selected location.
Locate the cooling tower at any location on the Church building roof and have a qualified Acoustical Consultant determine appropriate noise mitigation measures to be applied to the unit and/or the building structure.
If conventional HVAC units are preferred over a cooling tower for the building, a Detailed Noise Control Study should be prepared by a qualified Acoustical Consultant assessing the proposed locations and HVAC units selected.

All of the conditions are reasonable to implement so the conclusion of this report is that there is no noise related reason the development cannot continue. Confirmation of the final development will be required during detailed design.

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1.0 Introduction

R.J. Burnside & Associates Limited (Burnside) was retained by The Diocese of Mississauga, Vancouver, and Western Canada to prepare a Noise Control Feasibility Study for the new St. Mark and St. Demiana Church Development. The property (300044049.0000) is located at Ninth Line, Mississauga, Ontario.

The purpose of this assessment is to examine a potential noise impact of the new St. Mark and St. Demiana Church onto the neighboring residential properties.

1.1 Objective

This report has been prepared in support of the new St. Mark and St. Demiana Church Development. This report will be included in a submission for a Zoning Bylaw Amendment and Site Plan Application. The ambient noise conditions were modelled using the MECP computer program for road traffic noise assessment, STAMSON. Sound levels were predicted based on current traffic counts for Highway 403, Ninth Line, and Burnhamthorpe Road West (see Table 4). The potential noise impacts were evaluated by comparing predicted sound levels at the representative points of reception with the MECP sound level limits.

1.2 Study Area

The proposed St. Mark and St. Demiana Church Development is located between Ninth Line and Highway 403, south of Burnhamthorpe Road, in Mississauga, Ontario. The site location plan is provided in Figure 1. The Site Plan is provided in Figure 2.

The study area including noise sources and representative points of reception is shown in Figure 3.

2.0 Applicable Noise Criteria

2.1 MECP Noise Policies

Environmental Noise Guideline (Noise Guideline), MECP Publication NPC-300, provides advice, sound level limits and guidance that maybe used when land use planning decisions are made under the Planning Act, and the Niagara Escarpment Planning and Development Act. This guidance is for land use planning authorities, developers and consultants. It is intended to minimize the potential conflict between proposed noise sensitive land uses and sources of noise emissions.

2.1.1 Stationary Noise

The applicable stationary noise criteria are dependent on the Class Area as well as the ambient sound levels present at each point of reception. The applicable criteria are the greater of the exclusion limits, provided in the MECP tables below, or the lowest hourly ambient sound level predicted for a given point of reception.

The proposed St. Mark and St. Demiana Church Development is located in a Class 1 Urban Area.

MECP Table C-5 of NPC-300: Exclusion Limit Values of One-Hour Equivalent Sound Level (L_{eq}, dBA) Outdoor Points of Reception

Time of Day	Class 1 Area	Class 2 Area	Class 3 Area	Class 4 Area
07:00 – 19:00	50 dBA	50 dBA	45 dBA	55 dBA
19:00 – 23:00	50 dBA	45 dBA	40 dBA	55 dBA

MECP Table C-6 of NPC-300: Exclusion Limit Values of One-Hour Equivalent Sound Level (L_{eq}, dBA) Plane of Window of Noise Sensitive Spaces

Time of Day	Class 1 Area	Class 2 Area	Class 3 Area	Class 4 Area
07:00 – 19:00	50 dBA	50 dBA	45 dBA	60 dBA
19:00 – 23:00	50 dBA	50 dBA	40 dBA	60 dBA
23:00 – 07:00	45 dBA	45 dBA	40 dBA	55 dBA

2.2 Regional and Municipal Policies

In addition to the preceding MECP Noise Criteria, the subject development is also subject to the following Regional and Municipal requirements:

2.2.1 Region of Peel Noise Policy

The Region of Peel's 2012 Guidelines for the preparation of Acoustic Reports was reviewed for the preparation of this report. Although Peel's Guidelines do contain various requirements above the NPC-300 requirements, there are no substantive differences to highlight for this proposed development.

2.2.2 City of Mississauga Noise Policy

The City of Mississauga's document "Terms of Reference - Noise Study" was reviewed for the preparation of this report.

3.0 Stationary Noise Sources and Receptors

3.1 Internal Stationary Noise

Internal stationary noise is defined as the on-site stationary noise of the proposed development. The potential impact of internal stationary noise is assessed at neighbouring noise sensitive land uses and at noise sensitive locations within the proposed development itself, if appropriate.

3.1.1 Internal Stationary Noise Sources

The proposed development contains the following sources of stationary noise:

- Truck Deliveries:
  - The Church building of the proposed development contains a cafeteria and kitchen. To service the kitchen, a loading zone is located outside of the kitchen at the south side of the building.
  - The kitchen is only equipped to receive a single truck delivery at a time.
  - The worst-case predictable event is a refrigerated truck delivery lasting a full hour.
  - A Sound Power Level of 113 dBA was used for the model. This data was referenced from “Sound Power Levels and Directivity Patterns of Refrigerated Transport Trailers” by RWDI Consulting Engineers as published in the Canadian Acoustics journal (Vol. 45 No. 3 (2017)).
- Cooling Tower:
  - The mechanical details of the proposed development are not yet available. Based on the total square footage of the Church Building Burnside estimated 500 tonnes of cooling are required (assuming 1 tonne per 400 square feet). For a cooling load this large, a cooling tower would typically be specified.
  - For a preliminary assessment, to determine whether any scenario exists where noise control measures would be required, it was assumed that the cooling tower has a sound power level of 111 dBA. This level was measured by Burnside from a chiller of roughly similar size, which did not include any noise control measures.
  - The location of the cooling tower was assumed to be in the center of the southernmost wing of the building. Based on the locations of the mechanical rooms, Burnside determined this location to be the worst-case realistically predictable location for the cooling tower.
  - The cooling tower was assumed to operate for up to 60 minutes per hour during the day, 45 minutes per hour during the evening, and 30 minutes per hour during the night.

3.1.2 Internal Stationary Noise Points of Reception

The proposed St. Mark and St. Demiana Church is in proximity to the following noise sensitive land uses:

- POR 1 – Low Density Single Family Residential Dwelling.
  - 3480 Ninth Line, Mississauga
  - Located directly south-west of the proposed development
- POR 2 – Low Density Single Family Residential Dwelling.
  - 3448 Ninth Line, Mississauga
  - Located directly south of the proposed development
- There are other Low-Density Single Family Residential Dwellings to the north, northeast, and east but they are more than 500 m from the property line across the 403 highway and not expected to be impacted.

4.0 Stationary Noise Impact Assessment

4.1 Methodology

Sound levels associated with stationary noise are predicted with Predictor V2019.3 3D noise modeling software. Predictor follows the ISO 9613 method of sound level calculation.

The following model settings are used:

- 4.5 m calculation height
- 0.5 Default Ground attenuation Factor
- No Barrier effect for direct sight – Active
- Dmax According to ISO 9613 – Active
- Avoid overestimating barrier effect – Active
- Terrain model: Use full DTM
- Temperature: 283.15 K
- Pressure: 101.33 kPa
- Air humidity: 70%

4.2 Predicted Ambient Sound Levels & Applicable Criteria

Ambient sound levels were predicted with MECP traffic noise prediction model ORNAMENT, implemented through a computer program STAMSON (version 5.04). The model calculates expected sound levels based on hourly road and rail traffic, distance to receptor, receptor height, and topographical features.

The hourly traffic data provided to Burnside for this report is included in Appendix A. The traffic data used in the STAMSON calculations are summarized in Table 1.

Sample ambient sound level modeling printout is included in Appendix C.

The following ambient sound levels were determined for each point of reception:

- POR 1: 58 dBA Day, 56 dBA Evening, 48 dBA Night
- POR 2: 62 dBA Day, 60 dBA Evening, 51 dBA Night

Therefore, as the proposed St. Mark and St. Demiana Church is in a Class 1 Area the applicable sound level criteria for stationary noise is as follows:

- POR 1: 58 dBA Day, 56 dBA Evening, 48 dBA Night
- POR 2: 62 dBA Day, 60 dBA Evening, 51 dBA Night

4.3 Predicted Internal Stationary Sound Levels

Using the assumptions stated in Section 3.1.1, the results of the stationary model are as follows:

Table 1: Predicted Stationary Sound Levels (Unmitigated)

POR #	Time of Day	Impact	Criteria	Compliance?
POR1	Daytime	53 dBA	58 dBA	Yes
	Evening	52 dBA	56 dBA	Yes
	Nighttime	50 dBA	48 dBA	Yes
POR2	Daytime	59 dBA	62 dBA	Yes
	Evening	57 dBA	60 dBA	Yes
	Nighttime	55 dBA	51 dBA	No

As seen from the table above, the only predicted excess is at POR 2 during the night. The 4-dB excess is attributable entirely to the cooling tower, as there are no truck deliveries expected during the nighttime.

4.4 Predicted Mitigated Internal Stationary Sound Levels

Reducing the sound power level assumption of the cooling tower from 111 dBA to 107 dBA produces the following compliant results:

Table 2: Predicted Stationary Sound Levels (Mitigated)

POR #	Time of Day	Impact	Criteria	Compliance?
POR1	Daytime	49 dBA	58 dBA	Yes
	Evening	48 dBA	56 dBA	Yes
	Nighttime	46 dBA	48 dBA	Yes
POR2	Daytime	56 dBA	62 dBA	Yes
	Evening	53 dBA	60 dBA	Yes
	Nighttime	51 dBA	51 dBA	Yes

5.0 Noise Mitigation Measures

Based on the predicted sound levels it was determined that, depending on the actual location of and model of HVAC equipment specified, noise mitigation measures may be required for this Development.

5.1 Internal Stationary Noise Mitigation Requirements

The assessment of the proposed St. Mark and St. Demiana Church's internal stationary sources determined that, in order to meet the MECP noise standards, one of the following conditions must be met by the final mechanical design:

1. Locate the cooling tower at worst-case predictable location used for this study but specify a unit with a manufacturer's sound power level rating not exceeding 107 dBA.

2. Locate the cooling tower at a more favorable location further north of the worst-case predictable location used for this study, specifying either a unit with a manufacturer's sound power level rating not exceeding 107 dBA, or a higher rating verified in writing by a qualified Acoustic Consultant to not result in an exceedance at the selected location.

3. Locate the cooling tower at any location on the Church building roof and have a qualified Acoustical Consultant determine appropriate noise mitigation measures to be applied to the unit and/or the building structure.

4. If conventional HVAC units are preferred over a cooling tower for the building, a Detailed Noise Control Study should be prepared by a qualified Acoustical Consultant assessing the proposed locations and HVAC units selected.

6.0 Implementation Procedures

The following implementation procedures are recommended to ensure that each requirement of this study is implemented at the correct stage of the development process:

- Prior to Site Plan Approval an Acoustical Consultant should be retained to conduct a Detailed Noise Control Study. A Detailed Noise Control Study requires proposed building locations and a proposed grading plan to be completed. The recommendations of this Noise Control Feasibility Study are preliminary estimates to ensure the viability of the proposed development. A Detailed Noise Control Study will finalize most of the acoustic requirements of the development.
- Prior to occupancy, the development should be certified by a qualified Acoustics Engineer for compliance with the requirements of the Detailed Noise Control Study.

7.0 Conclusion

Results of St. Mark and St. Demiana Church Development's Noise Control Feasibility Study demonstrate that if one of the noise mitigation alternatives in Section 5.1 are implemented, sound levels at all points of reception will meet the Ministry of the Environment, Conservation and Parks noise guideline requirements. The Implementation Procedures of Section 6.0 should be followed carefully to ensure that no requirements of the Noise Study are overlooked during the development and construction process.

8.0 References

Computer Program STAMSON Version 5.04. Ministry of the Environment, Conservation and Parks.

Environmental Noise Guideline. Stationary and Transportation Sources – Approval and Planning. Publication NPC-300. Ministry of the Environment, Conservation and Parks, August 2013 (released October 21, 2013).

ORNAMENT – Ontario Road Noise Analysis Method for Environment and Transportation. Technical Document. Ministry of the Environment, Conservation and Parks, October 1989.

General Guidelines for the Preparation of Acoustical Reports in the Region of Peel, Region of Peel, November 2012.

Terms of Reference – Noise Study, The Corporation of the City of Mississauga, Transportation & Works Department, Infrastructure Planning & Engineering Services Division, March 6th, 2019.

Roy, Jessie, AND VanDelden, Peter. "Sound Power Levels and Directivity Patterns of Refrigerated Transport Trailers" *Acoustics Week in Canada* (2017): n. pag. Web. 12 Dec. 2019 Retrieved from https://awc.caa-aca.ca/index.php/AWC/awc17/paper/view/549/269

Table 3: Current Traffic Volumes

Road	Minimum Hourly Traffic Volumes			
	Total (Day/Evening/ Night)	# of Light Vehicles (Day/Evening/ Night)	# of Medium Trucks (Day/Evening/ Night)	# of Heavy Trucks (Day/Evening/ Night)
Burnhamthorpe Rd.	500 / 400 / 30	482 / 385 / 39*	12 / 10 / 1	6 / 5 / 0
Ninth Line	453 / 362 / 27	431 / 345 / 38*	13 / 11 / 1	8 / 7 / 1
Highway 403 – EB	2642 / 1678 / 234	2114 / 1342 / 187	396 / 252 / 35	132 / 84 / 12
Highway 403 – WB	2642 / 1678 / 234	2114 / 1342 / 187	396 / 252 / 35	132 / 84 / 12

*Number inflated to bring total count to the minimum 40 vehicles required by STAMSON for hourly calculations. This alteration has no effect on the result of any calculations.

The minimum hourly traffic volumes were determined by distributing the provided current AADT counts along an hourly distribution curve of a similar road type from Burnside's database. This process is documented in Appendix B alongside the STAMSON calculations of the minimum hourly ambient sound levels.

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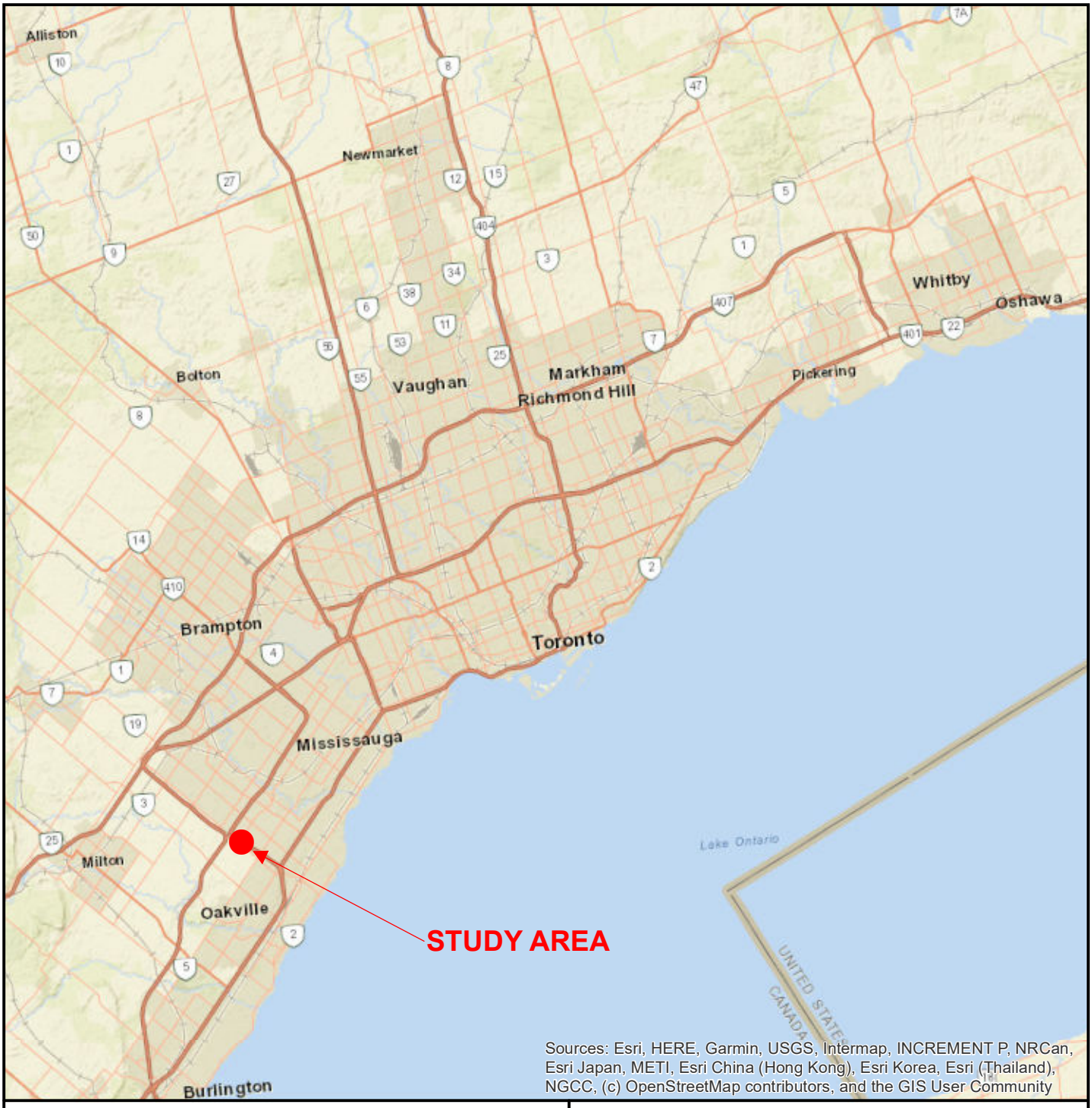
Figures



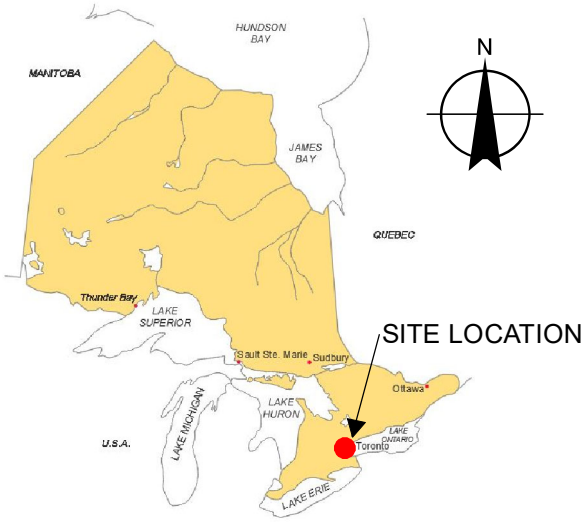


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Figure Title:

NOISE CONTROL FEASIBILITY REPORT

SITE LOCATION MAP

Drawn	Checked	Date	Figure No.
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Scale		Project No.	
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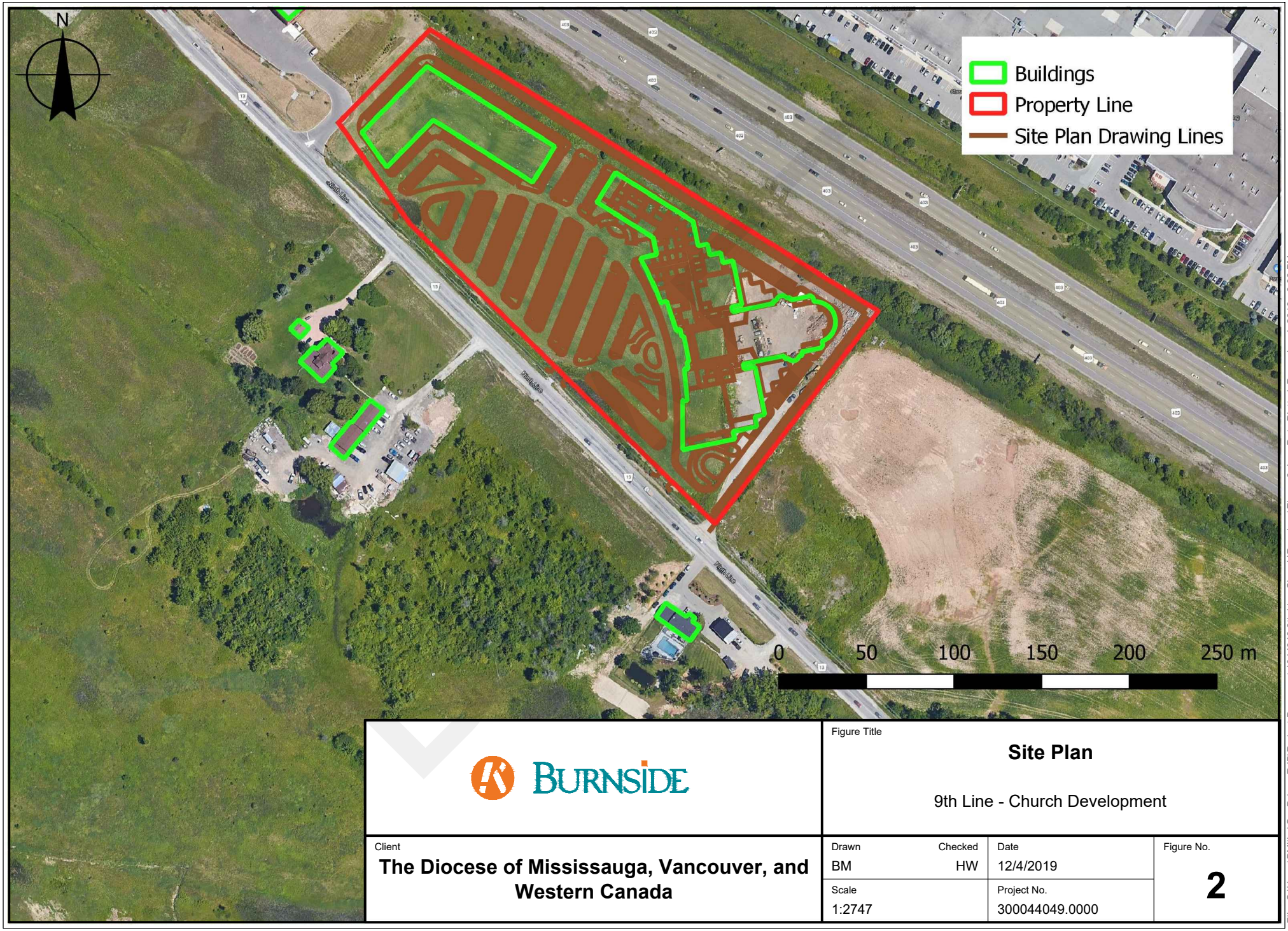

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Figure Title

Site Plan

9th Line - Church Development

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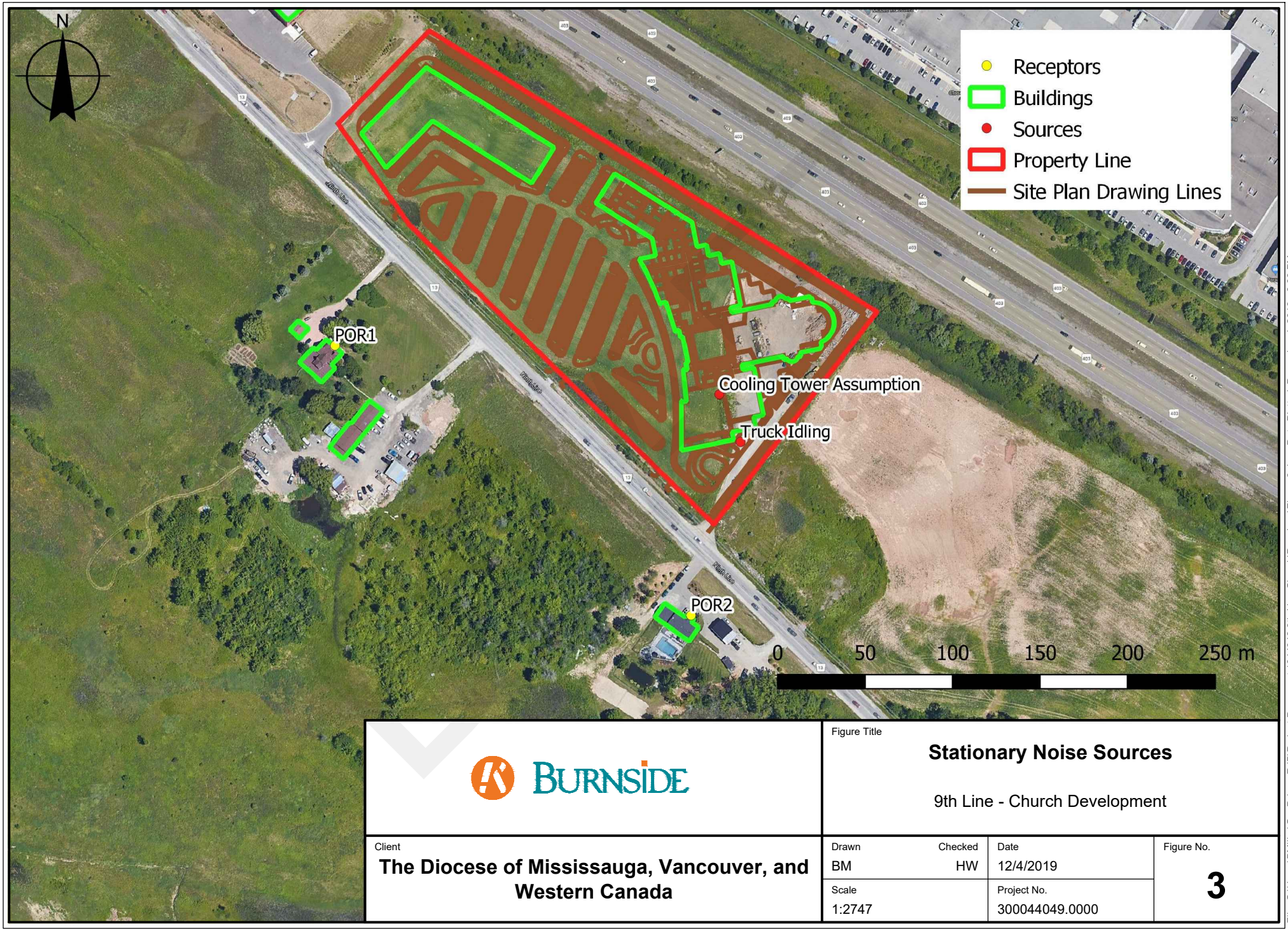

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Figure Title

Stationary Noise Sources

9th Line - Church Development

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Appendix A

Traffic Data

APPENDIX A

Summary of the traffic data:

Road	Ninth Line	Burnhamthorpe Road	Highway 403
Location	South of Burhamthorpe Road	West of Ninth Line	Between 407 and Dundas Street West
Current Minimum Hourly Traffic (Day / Evening / Night)	453 / 362 / 27	500 / 400 / 30	2642 / 1678 / 234
Current Daily Traffic AADT	13,730	15,170	99,000
No. of Lanes	2	2	5
Posted Speed	60 km/h	60 km/h	100 km/h
Trucks (Med/Heavy)	3.0% / 1.9%	2.5% / 1.2 %	15% / 5%
Day/Night Split	97% / 3%	97% / 3%	66.7% / 33.3%
Road Gradient	2%	2%	2%

Burnhamthorpe Rd @ Ninth Line

Municipality: Halton Region
Major Road: Burnhamthorpe Rd
Minor Road: Ninth Line

Date: Jun 15, 2015

Major Road Runs: East/West
Weather Conditions: Cloudy, Rain
Person No. 1 Margaret
Person No. 2 Frank

Period	North Approach							East Approach							South Approach							West Approach							Veh. Summary	
	Cars			Trucks			Ped.	Cars			Trucks			Ped.	Cars			Trucks			Ped.	Cars			Trucks			Ped.		
Ending	Left	Thru	Right	Left	Thru	Right	Cross.	Left	Thru	Right	Left	Thru	Right	Cross.	Left	Thru	Right	Left	Thru	Right	Cross.	Left	Thru	Right	Left	Thru	Right	Cross.	15	60
7:15	49	110	3	0	4	0	0	11	26	10	0	0	2	0	8	38	19	0	1	2	0	4	164	19	0	3	0	0	473	
7:30	68	117	5	1	1	0	0	26	52	20	0	0	0	0	9	53	24	1	4	1	0	10	183	24	0	2	0	0	601	
7:45	77	140	5	1	1	0	0	14	49	17	0	6	0	0	11	92	35	0	6	0	0	14	262	27	1	10	2	0	770	
8:00	91	123	14	0	1	0	1	14	54	32	0	1	3	0	15	126	34	0	6	0	0	15	237	14	1	3	1	0	785	2629
8:15	68	136	4	1	5	1	0	12	53	28	0	1	0	0	9	119	33	0	6	2	0	20	271	35	3	5	2	0	814	2970
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8:45	104	127	19	4	7	0	0	26	67	46	0	3	4	0	12	118	27	1	5	1	0	15	257	22	0	5	0	0	870	3274
9:00	77	111	7	4	5	0	0	35	56	43	1	9	7	0	15	114	33	0	5	3	0	10	226	11	0	5	0	0	777	3266
11:15	18	31	8	0	5	0	0	17	45	17	2	0	0	0	7	32	8	0	5	0	0	7	44	6	0	2	0	0	254	
11:30	22	47	9	0	6	0	0	14	61	20	1	2	3	0	10	37	8	0	4	0	0	5	53	9	0	0	0	0	311	
11:45	24	40	4	2	6	0	0	31	69	28	3	2	0	0	14	45	7	1	3	0	0	4	53	8	0	2	0	0	346	
12:00	28	45	6	2	6	0	0	33	74	38	3	4	6	0	10	61	8	0	4	1	0	8	54	10	3	5	0	0	409	1320
12:15	29	42	6	1	3	0	0	15	68	29	0	0	2	0	11	61	12	0	1	0	0	6	77	10	0	1	0	0	374	1440
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13:15	22	58	5	0	4	0	0	12	52	25	1	1	0	0	14	61	8	0	2	1	0	5	60	7	0	0	0	0	338	1591
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15:15	35	119	18	3	5	1	0	34	94	51	2	3	6	0	16	71	17	0	9	2	0	12	74	14	0	7	3	0	596	
15:30	25	90	11	5	8	1	1	34	94	58	1	4	0	0	19	83	22	4	0	0	0	8	78	12	0	6	2	0	565	
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17:45	34	92	11	4	3	1	0	21	199	103	1	1	1	0	23	107	11	1	0	1	0	10	65	15	0	5	0	0	709	2826
18:00	34	89	15	1	4	2	2	27	176	91	2	1	0	2	15	105	12	0	5	0	0	6	64	11	0	0	0	0	660	2748

TECHNICAL MANUALS

- Ontario Provincial Standards
- Traffic Volumes
- Revision Info Sheets
- CDED
- Special Provisions
- MTO Drawings
- Electrical CDED *
- Electrical CDED MTOD *
- Electrical CDED SP *
- Electrical ATMS CDED *
- Electrical ATMS CDED MTOD *
- Electrical ATMS CDED SP *
- Structural Standard Drawings
- Environmental Standards and Practices

* Special Note: All the Electrical Documents are now available within following menus items: CDED, Special Provisions and MTO Drawings.

Ontario Provincial Highways Traffic Volumes On Demand

The follow page is broken down into two sections. Section 1: allows you to dynamically filter traffic volumes down to a segment of a highway and if available report on both that segment's distance in kilometers and the annual average daily traffic volumes (AADT). Section 2: contains traffic volumes in PDF format for downloading.

1. Dynamic traffic volumes lookup for the year 2016

Complete steps 1 and 2 in sequential order to report on different sections of highways. Repeat steps 1 and 2 to review additional highways and their sections. Use step 3 to navigate the sections of highway and finally uses step 4 to isolate segments of each section.

1. Select a **highway** that you would like to report on: 403
2. Click on the following link to render all the available sections within highway selected in the step above.
3. Isolate each **available section** within the **highway** that you selected in step 1 by using the navigation links provided or using the **location from** drop down selection box.

Showing section 8 of 29 for highway 403 previous | next

Location from:
DUNDAS ST. IC-MISSISSAUGA-OAKVILLE LTS

Location to:
UPPER MIDDLE RD IC DISCONTINUITY (OVERLAP HWY QEW)

Distance (km):
2

Annual Average Daily Traffic (AADT):
99, 000

2. Traffic Volume documents available for downloading in portable document format (PDF)

Please note that depending on your browser's settings, PDF documents will either download to your workstation or open in a PDF reader. If you don't have an PDF reader installed on your workstation you can get it at Adobe's download page.

As outlined in the OPS Accessible Customer Service Policy, we are committed to providing accessible customer service. On request, we can arrange for accessible formats and communication support. Please contact us.

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Appendix B

Sample Transportation Noise Modelling Printouts

STAMSON 5.0 NORMAL REPORT Date: 03-12-2019 11:23:13
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: daypor2.te Time Period: 1 hours
Description: HOURLY AMBIENT - POR2 - DAY

Road data, segment # 1: Ninth Line

Car traffic volume : 431 veh/TimePeriod
Medium truck volume : 13 veh/TimePeriod
Heavy truck volume : 8 veh/TimePeriod
Posted speed limit : 60 km/h
Road gradient : 2 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: Ninth Line

Angle1 Angle2 : -90.00 deg 90.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 1 (Absorptive ground surface)
Receiver source distance : 30.00 m
Receiver height : 1.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

↟
Road data, segment # 2: 403East1

Car traffic volume : 2114 veh/TimePeriod
Medium truck volume : 396 veh/TimePeriod
Heavy truck volume : 132 veh/TimePeriod
Posted speed limit : 100 km/h
Road gradient : 2 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 2: 403East1

Angle1 Angle2 : -90.00 deg 0.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0
Surface : 1 (Absorptive ground surface)
Receiver source distance : 275.00 m
Receiver height : 1.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

↟
Road data, segment # 3: 403West1

```
--------------------------------
Car traffic volume  :  2114 veh/TimePeriod
Medium truck volume :   396 veh/TimePeriod
Heavy truck volume  :   132 veh/TimePeriod
Posted speed limit  :   100 km/h
Road gradient       :     2 %
Road pavement       :     1 (Typical asphalt or concrete)

Data for Segment # 3: 403West1
--------------------------------
Angle1   Angle2           : -90.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  : 250.00 m
Receiver height           :   1.50 m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00

🠉
Results segment # 1: Ninth Line
--------------------------------

Source height = 1.15 m

ROAD (0.00 + 58.27 + 0.00) = 58.27 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
-------------------------------------------------------------------------------
   -90     90   0.66  64.73   0.00  -5.00  -1.46   0.00   0.00   0.00  58.27
-------------------------------------------------------------------------------

Segment Leq : 58.27 dBA

🠉
Results segment # 2: 403East1
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 55.34 + 0.00) = 55.34 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
-------------------------------------------------------------------------------
   -90      0   0.66  80.78   0.00 -20.97  -4.47   0.00   0.00   0.00  55.34
-------------------------------------------------------------------------------

Segment Leq : 55.34 dBA

🠉
Results segment # 3: 403West1
--------------------------------
```

Source height = 1.50 m

ROAD (0.00 + 56.03 + 0.00) = 56.03 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	0	0.66	80.78	0.00	-20.28	-4.47	0.00	0.00	0.00	56.03

Segment Leq : 56.03 dBA

Total Leq All Segments: 61.51 dBA

TOTAL Leq FROM ALL SOURCES: 61.51

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Appendix C

Sample Predictor Inputs and Results

Appendix C: Predictor Inputs

Point Source Limit of 100

Group	Item ID	Grp	ID	Date	Name	Desc.	Shape	X	Y	Height	Rel.H	Terrain L	HDef.	Type
--		2153	0	#####	Ex001	Rooftop	Point	6E+05	4819311	3	3	9.6	Relative to	Normal poi
--		2154	0	#####	Trk1	Refridg	Point	6E+05	4819284	3	3	0	Relative	Normal poi

Grid Limit of 20

Group	Item ID	Grp	ID	Date	1st Kid	Kid Cn	Name	Desc.	Shape	X1	Y1	Height	Rel.H	Terrain L
--		2157	0	#####	######	1536	Grid		Polygon	604142.9	4819086	4.5	4.5	0

Receiver Limit of 88

Group	Item ID	Grp	ID	Date	1st Kid	Kid Cn	Name	Desc.	Shape	X	Y	Terrain L	HDef.	Height A
--		2155	0	#####	######	1	POR1	Reside	Point	603927.3	4819339	0	Relative	4.5
--		2156	0	#####	-13	1	POR2	Reside	Point	604130.7	4819185	0	Relative	4.5

Building Limit of 100

Group	Item ID	Grp	ID	Date	Name	Desc.	Shape	X1	Y1	Height	Rel.H	Terrain L	HDef.	Nr Points
--		186	0	#####			Polygo	6E+05	4819318	6	6	0	Relative	8
--		187	0	#####			Polygo	6E+05	4819274	3	3	0	Relative	6
--		188	0	#####			Polygo	6E+05	4819353	3	3	0	Relative	4
--		189	0	#####			Polygo	6E+05	4819170	6	6	0	Relative	8
--		190	0	#####			Polygo	6E+05	4819580	0	0	0	Relative	8
--		191	0	#####			Polygo	6E+05	4819437	9.6	9.6	0	Relative	98
--		192	0	#####			Polygo	6E+05	4819460	16.4	16.4	0	Relative	6

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Appendix D

Stationary Sound Level Data References

SOUND POWER LEVELS AND DIRECTIVITY PATTERNS OF REFRIGERATED TRANSPORT TRAILERS

Jessie Roy [*1] and Peter VanDelden[†2]
[1]RWDI Consulting Engineers and Scientists, Toronto, Ontario, Canada.
[2]RWDI Consulting Engineers and Scientists, Calgary, Alberta, Canada.

1 Introduction

Refrigerated transport trailers are part of the daily operation of many food processing facilities, distribution centers, grocery stores and some pharmaceutical facilities. Refrigeration units mounted on the front of the trailers are used to maintain the trailer temperature. An example of a refrigeration unit mounted on a transport trailer is pictured on the left-hand side of Figure 1.

The type of refrigeration unit described in this paper is autonomous, typically comprised of a diesel engine, a compressor, a condenser and an evaporator. The most common manufacturers, Carrier and Thermo King, each have several models. They are generally constructed with one or more fresh air intakes at the front or side. Heat rejection and combustion exhaust are emitted from the top. Each of these primary sound emission locations is shown in Figure 2. This paper treats the unit as a single source rather than separating each of the emission points.

One of the challenges with including this type of equipment in facility noise models is that the specific model and manufacturer of refrigeration units can vary on a day-to-day basis. Manufacturer data can also be difficult to obtain or is unavailable. The trailers at the facility often are operated by a shipping or logistics company instead of the facility owner. In such cases the benefits of any specific model of refrigeration unit (e.g. low noise package) cannot be reliably used in predictive modelling.

Detailed sound power data for this type of equipment are also infrequently available. Generic or average sound power information is of value in these circumstances. This paper presents a summary of measured sound power levels and directivity patterns for refrigerated transport trailers based on measurements conducted by RWDI between 2003 and 2016.

2 Method

The sound power levels presented in Table 1 have been calculated from sound pressure level measurements of sixteen distinct refrigeration units collected between 2003 and 2016. In each case the unit was operating without a truck connected to the trailer, while the trailer is parked at a loading dock or in a parking lot. Situations where a refrigeration unit was close to other sources were not included in this analysis. The surface of the ground in all cases was considered to be hard and reflective. The sound from the front of the unit has the highest overall level and has been used to develop the average sound power level.

The source directivity in the horizontal plane was quantified at facilities where sufficient space was available. Sound pressure levels were collected at multiple angles from the refrigeration unit. For documenting directivity, we are defining zero degrees as straight out from the refrigeration unit (e.g. directly in-front of the refrigeration unit), and ninety degrees as perpendicular to the direction of travel of the transport trailer.

Figure 1: Example of a refrigerated transport trailer

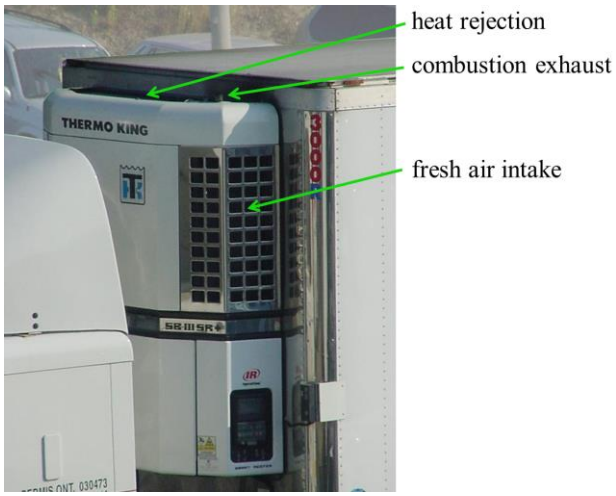

Figure 2: Primary sound emission locations

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Table 1: Average sound power level and standard deviation

	Frequency (Hz)								
	31.5	63	125	250	500	1000	2000	4000	8000
Average	97	111	105	102	97	96	94	89	83
Standard Deviation	3.7	4.5	5.5	5.5	5.0	5.5	5.1	5.4	6.1

3 Results

3.1 Octave band sound power levels

The average sound power level from in-front of the refrigeration units is 102 dBA, with a standard deviation of 4.7 dB. Variation in manufacturer, model and operation setting contributed to a range from 93 dBA to 109 dBA. The average linear octave band sound power levels from in-front of the refrigeration units and standard deviations are shown in Table 1. The octave band sound power level data are presented in Figure 3.

3.2 Directivity

The sound from refrigeration units does not project uniformly in all directions. To present directivity consistently we have normalized the levels at angles other than zero degrees to the sound power at zero degrees for each unit. The directivity has been assumed to be symmetric along an axis along the length of the trailer, with the zero angle defined as the direction of normal trailer travel. An average directivity pattern is proposed in Table 2. The directivity for non-zero angles is based on a smaller sample set, but indicates a general trend.

Table 2: Average directivity pattern

Angle	63	125	250	500	1000	2000	4000	8000
0°	0	0	0	0	0	0	0	0
45°	-5.3	+2.7	+1.9	+1.1	+0.2	-1.0	-1.0	-1.1
90°	-7.5	-5.1	-3.1	-1.1	-2.6	-3.5	-3.9	-4.5
135°	-2.3	-4.7	-4.8	-2.8	-6.0	-8.2	-10.4	-11.2

4 Discussion

Sound from the refrigeration units show a large variation in level from one unit to another. However, the spectral shape is relatively consistent for all of the units measured at zero degrees. From Figure 3, it can be observed that for most of the units tested the 63 Hz band is dominant; however, this does not necessarily mean that the sound is tonal. As an internal combustion engine, the concentration of sound at 63 Hz covers a wider range of frequencies.

Some of the units show elevated levels at both the 63 Hz and 125 Hz octave bands. Factors influencing this characteristic and the overall sound level were not readily apparent. Information on factors such as the number of years the equipment had been in service, operating settings, and whether the manufacturer's low noise package was installed (if one was available) were not available for the units measured, but would be interesting to examine in future studies.

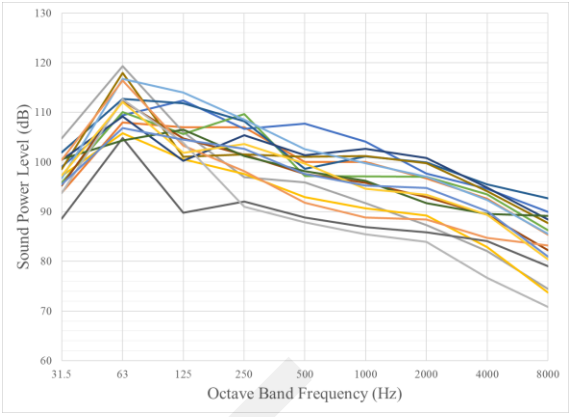

Figure 3: Trailer refrigeration unit sound power levels

As shown in Table 2, the sound levels generally decrease at angles away from zero degrees. The average directivity pattern should be primarily considered indicative of a trend. Additional data sets should be considered to develop a more definitive directivity pattern.

The adoption of standards and certification schemes for rating noise emissions of transportation refrigeration equipment, such as AHRI 1120 [1] in the United States, NFR 10-304 [2] in France, DIN 8958 [3] in Germany, and the PIEK certification scheme [4] (which originated in Holland and has been adopted in several other countries) are improving the availability of sound power data for new transport trailer refrigeration equipment. Nevertheless, documentation is still typically limited to only an overall A-weighted sound power level rating on most North American new product documentation.

5 Conclusion

Octave band sound power levels for sixteen different transport trailers' refrigeration units are developed into an average sound level spectrum. The spectrum is generic in that no differentiation between manufacturer, feature or operating condition is provided. The spectral shape is relatively consistent for all of the units tested at zero degrees, the typical direction of travel. At frequencies above 500 Hz, the sound levels show a pattern of becoming quieter with increasing angle.

References

[1] Air-Conditioning, Heating, and Refrigeration Institute. 2007 Standard for Acoustical Test Methods and Sound Power Rating Procedures for Transport Refrigeration Equipment. AHRI1120-2007.

[2] Association Francaise de Normalisation. Road Vehicles - Determination of Sound Power Level for Refrigeration Units Fitted to Thermal Goods Transport Vehicles. NFR 10-304:1994.

[3] Deutsches Institut für Normung. Testing of Cooling Equipment for Insulated Means of Transportation. DIN 8958:2011-08.

[4] PIEK-Keur. International. PIEK Certification Scheme Website. http://www.piek-international.com