2015-04-27

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ZW Project Management Inc. – Carleton University 2017 Residence Building
Traffic Noise Study for Site Plan Approval

Dear Denis,

The proposed student residence building at Carleton University requires a Noise Control Study for site plan approval. This report has been prepared in accordance to the City of Ottawa's Environmental Noise Control Guidelines (ENCG). The City of Ottawa's ENCG states that the road and light railway noise levels inside a living space must be below 45 dBA during the day and must be below 40 dBA inside a bedroom at night.

This report uses traffic information we have gathered from the ENCG in order to assess the noise impact to the future residence. This data was evaluated using the Ontario Ministry of the Environment's traffic noise software, STAMSON. From this we have determined that based on the predicted noise levels and the proposed façade materials, no design changes are required to meet the City of Ottawa's ENCG requirements for indoor sound levels. The City of Ottawa's ENCG does require that:

- Residential units require provisions for forced air heating and central air conditioning, and a Type C warning clause (given in section 3.3 of this report) is required on the lease or purchase and sale agreement.

If you have any questions or concerns please feel free to contact our firm.

Sincerely,

Jeremy Thorbahn, M.Sc.
Acoustical Consultant

Noise Control Study

for

2017 Student Residence
Carleton University

Prepared for:
ZW Project Management Inc.

Prepared by:
State of the Art Acoustik Inc.

April 27, 2015

Contents

1.0 INTRODUCTION

State of the Art Acoustik was commissioned by ZW Project Management Inc. to complete a noise assessment study as part of a site plan application for a proposed student residence building at Carleton University.

This study analyses the predicted noise impact from transportation sources for the proposed site and provides recommendations in order to meet the regulations set out by the City of Ottawa's Environmental Noise Control Guidelines (ENCG).

This study has been completed for all major roadways within 100 meters of the building, all railways within 250 meters of the building and all freeways or provincial highways within 500 meters of the building, as required per the ENCG, section 1.4.

2.0 BACKGROUND INFORMATION

2.1 Project Description

The proposed student residence is located on the Carleton University Campus and will stand 45.7 meters above grade, with 204 residential units.

2.2 Site Plan

Figure 1 shows a site plan view of the proposed building from Vincent P. Colizza Architect Inc. indicating points of reception (POR) where worst-case noise levels would be experienced due to the O-Train rain line and Colonel By Drive. These locations correspond to ground level bedrooms (West and North side) and a lounge (East side).

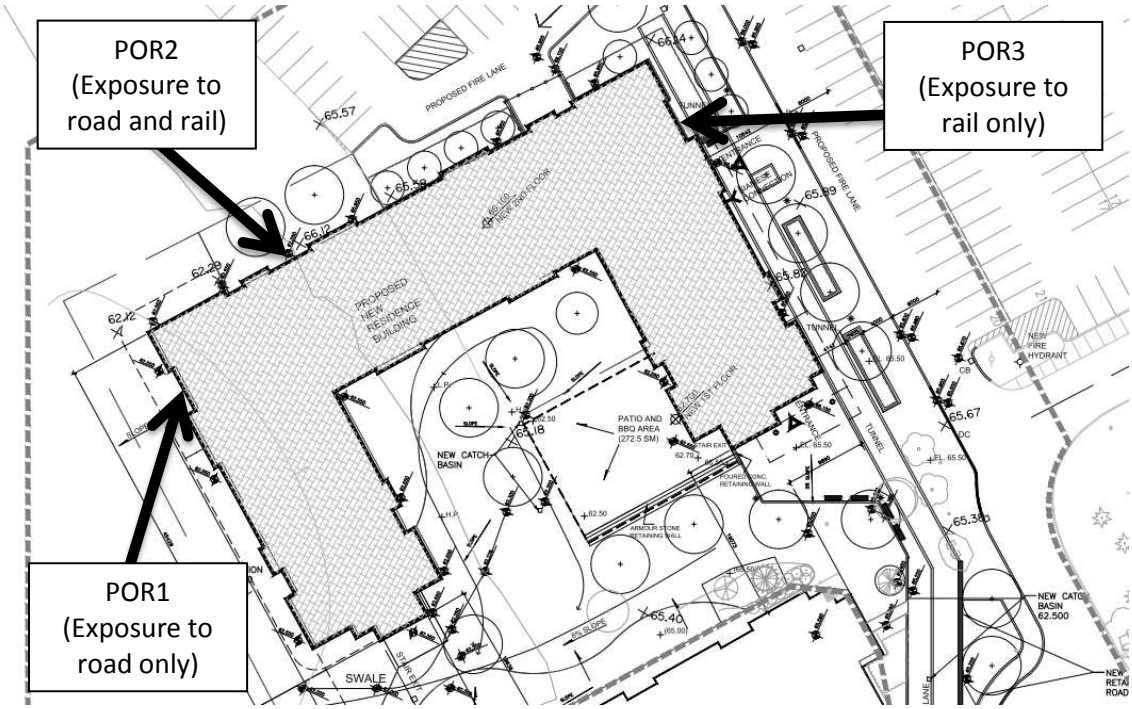


Figure 1 – Proposed Residence – Site Plan

3.0 NOISE IMPACT ASSESSMENT PROCEDURE

3.1 Representative Points of Reception

As the ground level of the proposed development is closest to the nearby transportation noise sources (Colonel By Drive and the O-Train rail line), this level is the most noise prone level assuming a reflective ground surface due to the paved areas around the building, and so it represents the worst case for sensitivity to traffic noise. We have selected points of reception on the 3 sides of the building that are most exposed to either Colonel By Drive or the rail line.

3.2 Procedure Used to Assess Noise Impacts

This assessment uses the City of Ottawa - Environmental Noise Control Guidelines (ENCG), dated May 10, 2006, to assess and mitigate noise from roads, transit ways, railways and aircraft. Summarized in Table 3.1 and 3.2 below are the maximum sound pressure levels for outdoor and indoor living areas taken from table 1.1 of the ENCG.

Source Type	Outdoor Leq Levels		
	Class 1 Area	Class 2 Area	Class 3 Area
Road Traffic and Light Rail (dBA)	**55**	55	55
Rail (heavy) Traffic (dBA)	55	55	55
Aircraft (NEF)	30	30	30

Table 3.1 – Criteria for Outdoor Sound Levels at the Outdoor Living Area

Where :

- **Class 1 refers to the major urban areas in the City of Ottawa** *this applies to this report
- Class 2 refers to remote or smaller suburban areas in Ottawa with acoustic environment combining class 1 & 3
- Class 3 refers to rural areas in the City of Ottawa having little or no road traffic where natural sounds are dominant

Time	Indoor Leq Levels (dBA) Class 1, 2 & 3 Areas
	Road Traffic/Light Rail (dBA)
07:00 – 23:00	45 for Living Quarters
23:00 – 07:00	40 for Bedrooms

Table 3.2 – Criteria for Indoor Living Area Sound Levels

An Outdoor Living Area is defined by the ENCG as an outdoor protected amenity area which is 56m^2 for single family dwellings, 46 m^2 for semi-detached units and 37 m^2 for row housing. These amenities can be backyards, terraces and patios. Balconies may be considered an Outdoor Living Area for the occupant assuming: they are the only outdoor living area for the occupant, the depth is a minimum of 4 meters, and they are outside the exterior building façade and are unenclosed. It was determined that the only such Outdoor Living Area present in the proposed design for the new building is the Patio/BBQ area on the south side of the building. As this area is entirely shielded from any road/rail noise sources by the building itself, it was determined that a further assessment of the noise impact to this area is not required.

An Indoor Area is defined by the City of Ottawa's ENCG as a "Living/dining areas of residences, hospitals, schools, nursing/retirement homes, day-care centers, theatres, places of worship, libraries, individual or semi-private offices, conference rooms, reading rooms, etc."

The ENCG states that noise control studies are to be prepared when the living area is within the follow setback distances from the road, highway and railway noise sources:

- 100m from an arterial road or a major collector
- 500m from a 400-series provincial highway
- 250m for a Light Rail Transit system corridor noise and 75m for its ground-borne vibration assessment

This noise control study is required as the proposed development is less than 250m from the O-Train Light Rail line and less than 100m from Colonel By Drive.

3.3 Noise Attenuation Requirements

This section outlines the required warning clauses and when to apply them, as stipulated by the ENCG for placement within purchase agreements.

If sound levels are predicted to be less than the specified criteria no attenuation measures are required on the part of the proponent. If the predicted noise exceeds the criteria, the City of Ottawa recommends several attenuation measures.

These attenuation measures may include any or all of the following:

- construction of a noise barrier wall and/or berm;
- installation of a forced air ventilation system with provision for central air;
- installation of central air;
- acoustically selected building façade components

Where excessive noise levels may adversely affect property or its use, the ENCG requires notices in the form of a Warning Clause to be placed on title in order to alert the buyer or renter of a possible environmental noise condition or a limitation on his/her property rights. The notices on title must be included in the Development Agreement(s) and in the Agreement(s) or Offer(s) of Purchase and Sale.

Table 3.3 describes the building component requirements for various noise levels at the plane of window of the proposed development for road and rail noise sources.

Assessment Location		Sound Level (time as noted)	Building Component Requirement
Plane of Living Room Window	ROAD	L_{eq} 16hr less than or equal to 65 dBA	Building Compliant with Ontario Building Code (OBC)
		L_{eq} 16hr greater than 65 dBA	Building Components (walls, windows, etc.) must be designed to achieve indoor sound level criteria
	RAIL	L_{eq} 16hr less than or equal to 60 dBA	Building Compliant with Ontario Building Code (OBC)
		L_{eq} 16hr greater than 60 dBA	Building Components (walls, windows, etc.) must be designed to achieve indoor sound level criteria
Plane Of Bedroom Window	ROAD	L_{eq} 16hr less than or equal to 60 dBA	Building Compliant with Ontario Building Code (OBC)
		L_{eq} 16hr greater than 60 dBA	Building Components (walls, windows, etc.) must be designed to achieve indoor sound level criteria
	RAIL	L_{eq} 16hr less than or equal to 55 dBA	Building Compliant with Ontario Building Code (OBC)
		L_{eq} 16hr greater than 55 dBA	Building Components (walls, windows, etc.) must be designed to achieve indoor sound level criteria

Table 3.3 – Building Component Requirements

This table shows that depending on daytime and nighttime noise levels from road and rail sources, building components may or may not need to be analyzed and designed to meet indoor sound level criteria.

Table 3.4 outlines the ventilation requirements and warning clauses required various noise levels predicted at the Plane of Window of the proposed development (from ENCG Table 1.10):

Assessment Location	Leq (dBA)	Ventilation Requirements	Outdoor Control Measures	Warning Clause
Outdoor Living Area (OLA)	L_{eq} 16hr less than or equal to 55 dBA	N/A	None required	Not required
	L_{eq} 16hr greater than 55 dBA to less than or equal to 65 dBA	N/A	Control measures (barriers) should be considered	Required if resultant L_{eq} exceeds 55 dBA, Type A
	L_{eq} 16hr greater than 65 dBA	N/A	Control measures (barriers) required to reduce noise to below 60 dBA	Required if resultant L_{eq} exceeds 55 dBA, Type B
Plane Of Living Room Window	Less than 55	None Required	N/A	None Required
	Between 55 and 65	Forced air heating with provision for central air conditioning	N/A	Required Type C
	More than 65	Central Air Conditioning	N/A	Required Type D
Plane Of Bedroom Window	Less than 50	None Required	N/A	None Required
	Between 50 and 60	Forced air heating with provision for central air conditioning	N/A	Required Type C
	More than 60	Central Air Conditioning	N/A	Required Type D

Table 3.4 - Outdoor, Ventilation and Warning Clause Requirements

Table 3.5 summarizes the warning clauses referred to above in Table 3.4 (from ENCG Table 1.13).

TYPE	WARNING CLAUSE
Type A	"Purchasers/tenants are advised that sound levels due to increasing (road) (Transitway) (rail) (air) traffic may occasionally interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the Municipality and the Ministry of the Environment."
Type B	"Purchasers/tenants are advised that despite the inclusion of noise control features in the development and within the building units, sound levels due to increasing (road) (Transitway) (rail) (air) traffic may on occasions interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the Municipality and the Ministry of the Environment."
Type C	**"This dwelling unit has been designed with the provision for adding central air conditioning at the occupant's discretion. Installation of central air conditioning by the occupant in low and medium density developments will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."**
Type D	"This dwelling unit has been supplied with a central air conditioning system which will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."
Type E	"Purchasers/tenants are advised that due to the proximity of the adjacent industry (facility) (utility), sound levels from the industry (facility) (utility) may at times be audible."
[1] These warnings are the standard clauses from the MOE and are subject to change at the discretion of the City, Airport Authority, CN or other applicable agencies, as required. Additional warnings pertaining to aircraft noise are also included on page D-4	

Table 3.5 - Warning Clause Statements from the City of Ottawa

In summary, a forced air heating system with provision for a central air conditioning system is required if the daytime noise levels are between 55 and 65 dBA and/or the night time noise levels are between 50 and 60 dBA. The criteria shall be modified to require installation of a central air conditioning system when the daytime noise level exceeds 65 dBA and/or the night time noise level exceeds 60 dBA; furthermore, the exterior building components must be analyzed to ensure the indoor sound level targets are achieved. This includes analysis of the exterior wall, door, window and/or glazing system specifications as appropriate.

The Warning Clauses are to be placed on the title and included in both the Development Agreement and within the Offer of Purchase and Sale. The appropriate clause is selected and included in the conclusions section of this report.

3.4 Building Component Assessment (AIF Analysis)

As mentioned in the previous section and according to Table 1.8 of the ENCG, when noise levels exceed 65 dBA at the Plane of Windows (POW) of a living area (daytime) or 60 dBA at the POW of a bedroom (nighttime) the exterior cladding system of the building envelope must be acoustically designed to ensure the indoor noise criteria is achieved. The City of Ottawa recognizes the Acoustic Insulation Factor (AIF[1]) method as an appropriate analysis technique.

To comply with the City of Ottawa policies, the building envelope will require a minimum AIF rating to provide the indoor noise level required for living, dining and bedrooms of residential dwellings as described below.

The City of Ottawa's ENCG outlines the following maximum indoor Leq limits:

- maximum daytime indoor L_{eq} for living spaces should be 45 dBA
- maximum nighttime indoor L_{eq} for bedrooms should be 40 dBA

For the overall exterior wall of any room, the required AIF for road and rail transportation noise is:

Required AIF = Outside L_{eq} - Indoor L_{eq} (Req) + 2dB **(1)**

When the exterior is built up of multiple components, then the AIF required of each component is determined by the following equation[1]:

Required AIF = Outside L_{eq} - Indoor L_{eq} (Req) + 10 $\log_{10}$ (Number of Components) + 2dB **(2)**

The required AIF is based on the Outside L_{eq}, Indoor L_{eq} required and the total number of exterior façade components. The AIF method allows for the number of components to be reduced if any component significantly exceeds the required AIF[1]:

"If the AIF of any component exceed the required AIF by 10 or more, the calculation should be repeated for the other components with the 'total number of components' reduced by one. This reduction in the number of components lowers the required AIF for the others."

[1] J.D. Quirt, Building Research Note: Acoustic Insulation Factor: A Rating for the Insulation of Buildings against Outdoor Noise, National Rearch Council [Revised June 1980]

4.0 Noise Sources and Analysis

The following sections describe the characteristics of the noise sources.

4.1 Road and Railway Traffic Information

For this study, the major noise sources considered are roads and railway.

The sources considered are:

1) O-Train line
2) Colonel By Drive

Table 4.1 summarizes the roadway's parameters obtained by Table 1.7, p. 15 of The City of Ottawa Environmental Noise Control Guidelines, "Traffic and Road Parameters to be used for Sound Level Prediction" for the respective roadway class. Medium/Heavy Truck traffic volumes were adjusted to zero as trucks are not permitted on Colonel By Drive.

Roadway	Implied Roadway Class	Annual Average Daily Traffic (AADT) Veh/Day	Day/Night Split (%)	Medium/Heavy Truck (%)	Posted Speed
Colonel By Drive	2-Lane Urban Arterial	15,000	92/8	0/0	60kph

Table 4.1 – Summary of Major Roadway Noise Sources

The following railway volume has been verified by the City of Ottawa OCTranspo Superintendent of Light Rail on February 21, 2013. On peak days, the total train volume is 141 passes from 6:30AM to midnight. This translated to 128 trips during the day (16hours) and 13 trips during the night (1.5 hours). For the purposes of having an accurate peak traffic volume for the night time, the software required that we state the night volume to be 64 trains over 8 hours at night.

Railway	Railway Type	Annual Average Daily Traffic (AADT) Types/Day	Number of Rail Cars	Number of Active Cabooses	Maximum Allowed Speed
CPR Line #27 – 29	Light Rail	128/64	4	1	85 kph

Table 4.2 – Summary of Railway (Light and Heavy) Noise Sources

Figure 2 illustrates the location of the noise sources with respect to the building:

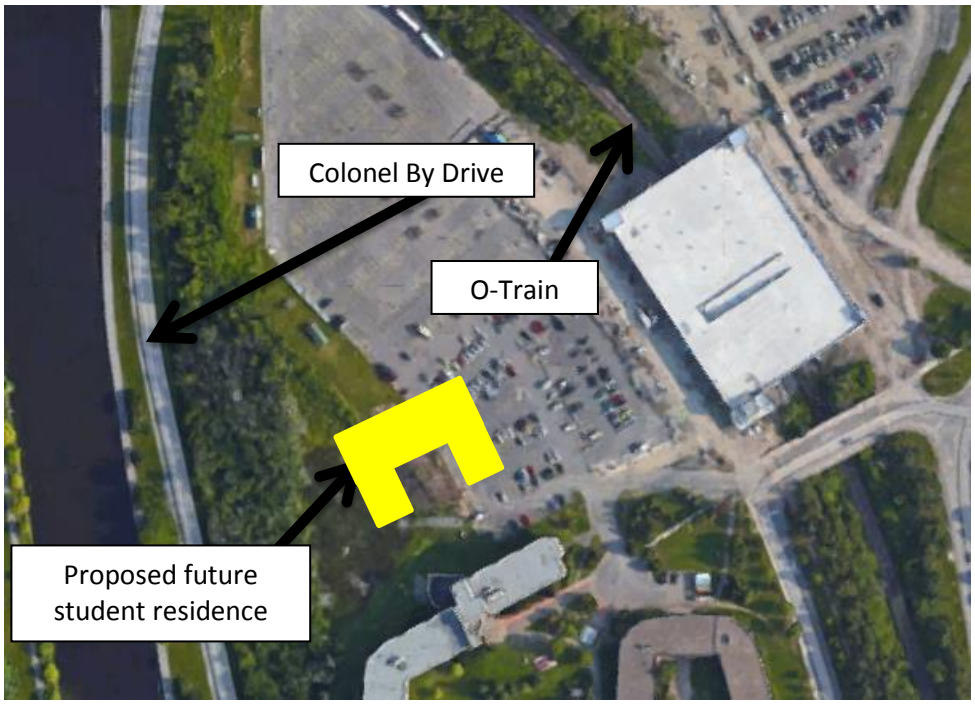


Figure 2 – The noise sources impacting the proposed building.

4.2 Other Potential Noise Sources

The current and future parking garages adjacent to the proposed development were identified by the City of Ottawa as potential sources of traffic noise. As parking garages contain only low-speed traffic that is partially shielded to the exterior by the building structure and no large trucks, we have determined that noise from parking garages would be insignificant compared to the road and rail noise sources and no adverse effects on the residents of the proposed building are anticipated.

4.3 Procedure Used for Road and Railway Analysis

In order to calculate the road and railway noise impact 101 Champagne Avenue, we utilized the Ministry of Environment's STAMSON modeling software version 5.04. This program allows us to input variables of a road or railway such as traffic volume, types of vehicles, speed, barrier locations and topography to find the environmental noise impact at a point of reception a given distance away.

4.4 Parameters Used for Analysis

The parameters used in STAMSON for the noise impact at the three points of reception are below in Table 4.3.

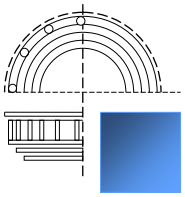
Parameter	Values Used
Roadway:	**Colonel By Drive**
Time Period	16h/8h
Topography	Flat/gentle slope; no barrier
Rows of Houses	0
Intermediate Surface	Reflective
Receiver Height (m)	1.5
Source Receiver Distance (POR1) (m)	48
Source Receiver Distance (POR2) (m)	61
Source Receiver Distance (POR3) (m)	N/A
Railway:	**CPR Line (O-Train)**
Time Period	16h/8h
Topography	Flat/gentle slope with barrier
Rows of Houses	0
Intermediate Surface	Reflective
Receiver Height (m)	1.5
Barrier Height (m)	6
Receiver Ground Elevation	6
Source Receiver Distance (POR1) (m)	N/A
Source Receiver Distance (POR2) (m)	172
Source Receiver Distance (POR3) (m)	116

Table 4.3 – Parameters used in STAMSON model

As the rail line runs in a trench 6-10m below grade level, we have modeled it as being behind a 6m barrier and with the receiver location elevated relative to the noise source.

4.5 Road and Railway Noise Levels and Required Measures

The following table summarizes the predicted sound pressure levels at the points of reception on the west, north and east faces of the building, from the results of the STAMSON environmental noise software (Appendix A).



Sound Pressure Levels L_{eq} (dBA) due to Road and Rail Noise Sources						
Point of Reception	Daytime Level			Nighttime Level		
	Road	Rail	**Total**	Road	Rail	**Total**
POR1 (West)	58.6	-	58.6	51.0	-	51.0
POR2 (North)	54.6	40.7	54.8	47.0	40.7	47.9
POR3 (East)	-	45.6	45.6	-	45.6	45.6

Table 4.4 – Predicted Road and Railway Noise Level (Leq) Summary for Day and Night

According to the ENCG and as shown in Table 3.3 of this report, since the levels do not exceed 65 dBA during the day or 60 dBA at night from road sources, and do not exceed 60 dBA during the day or 55 dBA at night from rail sources, it is not required to analyze the exterior building components to ensure the indoor sound level targets are achieved. The only building component requirement is that the building is compliant with the Ontario Building Code. As the sound level at the plane of the bedroom window (on the West face of the building at POR1) is predicted between 50 and 60 dBA, **the Type C Warning Clause is required:**

"This dwelling unit has been designed with the provision for adding central air conditioning at the occupant's discretion. Installation of central air conditioning by the occupant in low and medium density developments will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."

The Warning Clause is to be placed on the title and included in both the Development Agreement and within the lease or Offer of Purchase and Sale.

5.0 Conclusion

Based on our noise level predictions for the proposed student residence at Carleton University, there will be sufficient sound isolation to meet the City of Ottawa Environmental Noise Control Guidelines without any changes to the building design. Due to the level of noise at the plane of the window during the day and night, the City of Ottawa ENCG stipulates that:

- Residential units require provisions for forced air heating and central air conditioning, and a Type C warning clause (given in section 3.3 of this report) is required on the lease or purchase and sale agreement.

No other mitigation measures are required. Should you have any questions regarding this report, please do not hesitate to contact us.

Prepared by:

Jeremy Thorbahn, M.Sc.
Acoustical Consultant
State of the Art Acoustik Inc.

Reviewed by:

Claude Fortier, Ph.D.
Principal
State of the Art Acoustik Inc.

Approved by:

Don Buchan, P.Eng.
Buchan Lawton Parent Ltd.
Principal

LICENSED PROFESSIONAL ENGINEER
D. E. BUCHAN
PROVINCE OF ONTARIO

Appendix A
STAMSON Calculations

STAMSON 5.0 NORMAL REPORT Date: 24-04-2015 16:53:43
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: west.te Time Period: Day/Night 16/8 hours
Description:

Road data, segment # 1: COLENELBY (day/night)

Car traffic volume	: 13800/1200	veh/TimePeriod
Medium truck volume	: 0/0	veh/TimePeriod
Heavy truck volume	: 0/0	veh/TimePeriod
Posted speed limit	: 60	km/h
Road gradient	: 0	%
Road pavement	: 1	(Typical asphalt or concrete)

Data for Segment # 1: COLENELBY (day/night)

Angle1 Angle2	: -90.00 deg	90.00 deg
Wood depth	: 0	(No woods.)
No of house rows	: 0 / 0	
Surface	: 2	(Reflective ground surface)
Receiver source distance	: 48.00 / 48.00	m
Receiver height	: 1.50 / 1.50	m
Topography	: 1	(Flat/gentle slope; no barrier)
Reference angle	: 0.00	

Results segment # 1: COLENELBY (day)

Source height = 0.50 m

ROAD (0.00 + 58.63 + 0.00) = 58.63 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	63.68	0.00	-5.05	0.00	0.00	0.00	0.00	58.63

Segment Leq : 58.63 dBA

Total Leq All Segments: 58.63 dBA

Results segment # 1: COLENELBY (night)

Source height = 0.50 m

ROAD (0.00 + 51.04 + 0.00) = 51.04 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	56.09	0.00	-5.05	0.00	0.00	0.00	0.00	51.04

Segment Leq : 51.04 dBA

Total Leq All Segments: 51.04 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 58.63
(NIGHT): 51.04

STAMSON 5.0 NORMAL REPORT Date: 24-04-2015 16:52:35
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: north.te Time Period: Day/Night 16/8 hours
Description:

Rail data, segment # 1: LightRail (day/night)

Train Type	Trains	Speed (km/h)	# loc /Train	# Cars /Train	Eng type	Cont weld
1. LightRail	128.0/64.0	85.0	1.0	4.0	Elec	No

Data for Segment # 1: LightRail (day/night)

Angle1 Angle2	: 0.00 deg	90.00 deg
Wood depth	: 0	(No woods.)
No of house rows	: 0 / 0	
Surface	: 2	(Reflective ground surface)
Receiver source distance	: 172.00 / 172.00 m	
Receiver height	: 1.50 / 1.50 m	
Topography	: 2	(Flat/gentle slope; with barrier)

No Whistle

Barrier angle1	: 0.00 deg	Angle2 : 90.00 deg
Barrier height	: 6.00 m	
Barrier receiver distance	: 162.00 / 162.00 m	
Source elevation	: 0.00 m	
Receiver elevation	: 6.00 m	
Barrier elevation	: 0.00 m	
Reference angle	: 0.00	

Results segment # 1: LightRail (day)

Barrier height for grazing incidence

Source Height (m)	Receiver Height (m)	Barrier Height (m)	Elevation of Barrier Top (m)
4.00	1.50	4.20	4.20
0.50	1.50	0.91	0.91

LOCOMOTIVE (0.00 + 37.12 + 0.00) = 37.12 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	59.22	-10.59	-3.01	0.00	0.00	-8.50	37.12

WHEEL (0.00 + 38.25 + 0.00) = 38.25 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	66.21	-10.59	-3.01	0.00	0.00	-14.36	38.25

Segment Leq : 40.73 dBA

Total Leq All Segments: 40.73 dBA

Results segment # 1: LightRail (night)

Barrier height for grazing incidence

Source Height (m)	Receiver Height (m)	Barrier Height (m)	Elevation of Barrier Top (m)
4.00	1.50	4.20	4.20
0.50	1.50	0.91	0.91

LOCOMOTIVE (0.00 + 37.12 + 0.00) = 37.12 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	59.22	-10.59	-3.01	0.00	0.00	-8.50	37.12

WHEEL (0.00 + 38.25 + 0.00) = 38.25 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	66.21	-10.59	-3.01	0.00	0.00	-14.36	38.25

Segment Leq : 40.73 dBA

Total Leq All Segments: 40.73 dBA

Road data, segment # 1: COLENELBY (day/night)

Car traffic volume : 13800/1200 veh/TimePeriod
Medium truck volume : 0/0 veh/TimePeriod
Heavy truck volume : 0/0 veh/TimePeriod
Posted speed limit : 60 km/h
Road gradient : 0 %
Road pavement : 1 (Typical asphalt or concrete)

Data for Segment # 1: COLENELBY (day/night)

Angle1 Angle2 : 0.00 deg 90.00 deg
Wood depth : 0 (No woods.)
No of house rows : 0 / 0
Surface : 2 (Reflective ground surface)
Receiver source distance : 61.00 / 61.00 m
Receiver height : 1.50 / 1.50 m
Topography : 1 (Flat/gentle slope; no barrier)
Reference angle : 0.00

Results segment # 1: COLENELBY (day)

Source height = 0.50 m

ROAD (0.00 + 54.58 + 0.00) = 54.58 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	63.68	0.00	-6.09	-3.01	0.00	0.00	0.00	54.58

Segment Leq : 54.58 dBA

Total Leq All Segments: 54.58 dBA

Results segment # 1: COLENELBY (night)

Source height = 0.50 m

ROAD (0.00 + 46.99 + 0.00) = 46.99 dBA

Angle1	Angle2	Alpha	RefLeq	P.Adj	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
0	90	0.00	56.09	0.00	-6.09	-3.01	0.00	0.00	0.00	46.99

Segment Leq : 46.99 dBA

Total Leq All Segments: 46.99 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 54.76
(NIGHT): 47.91

STAMSON 5.0 NORMAL REPORT Date: 24-04-2015 16:50:58
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: east.te Time Period: Day/Night 16/8 hours
Description:

Rail data, segment # 1: LightRail (day/night)

Train Type	Trains	Speed (km/h)	# loc /Train	# Cars /Train	Eng type	Cont weld
1. LightRail	128.0/64.0	85.0	1.0	4.0	Elec	No

Data for Segment # 1: LightRail (day/night)

```
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      1       (Wood depth 30 to less than 60
metres)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  : 116.00 / 116.00 m
Receiver height           :   1.50 / 1.50   m
Topography                :      2       (Flat/gentle slope; with
barrier)
No Whistle
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :   6.00 m
Barrier receiver distance : 106.00 / 106.00 m
Source elevation          :   0.00 m
Receiver elevation        :   6.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

Results segment # 1: LightRail (day)

Barrier height for grazing incidence

Source Height (m)	Receiver Height (m)	Barrier Height (m)	Elevation of Barrier Top (m)
4.00	1.50	4.30	4.30
0.50	1.50	1.10	1.10

LOCOMOTIVE (0.00 + 42.03 + 0.00) = 42.03 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	59.22	-8.88	0.00	-5.00	0.00	0.00	45.34
-90	90	0.00	59.22	-8.88	0.00	0.00	0.00	-8.31	42.03

WHEEL (0.00 + 43.09 + 0.00) = 43.09 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	66.21	-8.88	0.00	-5.00	0.00	0.00	52.33
-90	90	0.00	66.21	-8.88	0.00	0.00	0.00	-14.24	43.09

Segment Leq : 45.60 dBA

Total Leq All Segments: 45.60 dBA

Results segment # 1: LightRail (night)

Barrier height for grazing incidence

Source Height (m)	Receiver Height (m)	Barrier Height (m)	Elevation of Barrier Top (m)
4.00	1.50	4.30	4.30
0.50	1.50	1.10	1.10

LOCOMOTIVE (0.00 + 42.03 + 0.00) = 42.03 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	59.22	-8.88	0.00	-5.00	0.00	0.00	45.34
-90	90	0.00	59.22	-8.88	0.00	0.00	0.00	-8.31	42.03

WHEEL (0.00 + 43.09 + 0.00) = 43.09 dBA

Angle1	Angle2	Alpha	RefLeq	D.Adj	F.Adj	W.Adj	H.Adj	B.Adj	SubLeq
-90	90	0.00	66.21	-8.88	0.00	-5.00	0.00	0.00	52.33
-90	90	0.00	66.21	-8.88	0.00	0.00	0.00	-14.24	43.09

Segment Leq : 45.60 dBA

Total Leq All Segments: 45.60 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 45.60
(NIGHT): 45.60