City of Ottawa Light Rail Project
Transitway Traffic Diversion to Scott Street
Noise and Vibration Impact Assessment
Ottawa, Ontario

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1. Introduction

Novus Environmental Inc. was retained by Capital Transit Partners to assess potential noise and vibration impacts related to proposed diversion of Transitway vehicles on to Scott St. during construction of the City of Ottawa Light Rail Project (LRT).

This report addresses the potential impacts on noise and/or vibration-sensitive land uses such as residences, in proximity to Scott Street. Both predictive modelling and measurement based techniques (including simulated short-term Transitway vehicle diversion), have been applied in the assessment to establish the expected worst-case changes in sound exposure at the closest sensitive receptors. Details on the measurement and modeling methodology, together with the results from the assessment are provided herein. The anticipated effects are evaluated against generally accepted noise and vibration guidelines related to transit, the City of Ottawa and Provincial guidelines.

Section 2 of the City of Ottawa's *Environmental Noise Control Guidelines* (2006) provides guidance and requirements on evaluating the impacts from capital works projects including LRT systems.[1] The *Guideline* outlines procedures for assessing vehicular traffic and /or bus traffic on City Roads and/or dedicated bus Transitways but further requires that noise due to the construction phase be addressed. As the diversion is anticipated to be present through the construction period for at least 2 years, the assessment applies approaches consistent with both short-term construction as well as longer term transportation corridor assessments.

2. Transitway LRT Construction and BRT Diversion on to Scott St.

The proposed Light Rail Transit (LRT) system, will be constructed as surface rail on the existing Bus Rapid Transit (BRT) transitway west of the west portal to Tunney's Pasture. During construction of the surface rail portions of the LRT in this area, the BRT system must remain operational and vehicles currently using the Transitway will be diverted onto Scott Street/ Albert St. from Smirle Avenue to Empress Avenue.

The study area and proposed diversion is shown in **Figure 1**. Since the diversion relocates vehicles from the Transitway to Scott St., potential increases in noise and/or vibration impacts will be limited to those areas south of Scott St. As such, only receptors south of Scott St. have been assessed.

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[1] www.ottawa.ca/residents/planning/design_plan_guidelines/completed/noise_ctl/noise_control_guidelines_en.pdf

3. Noise and Vibration Sources of Concern

3.1 Noise Sources

The primary noise sources of concern are buses diverted from the existing Transitway on to the Scott Street corridor. Although the Transitway is used by non-bus service vehicles including the Ottawa Police Services, bus activity dominates the Transitway noise emissions in terms of number of vehicles and noise emissions from each vehicle. As such, only buses are considered in the modelling of diverted traffic volumes.

3.2 Vibration Sources

Vibration due to vehicular activity on Scott Street results from uneven road surfaces and wheel impacts on drainage grates or manhole covers. The amplitude of the vibration depends on the forces imparted to the uneven surface which is dependent on the speed of the vehicle as well as its mass.

3.3 Traffic Volumes Pre and Post-Diversion

Table 1 provides estimated daily traffic volumes on Scott Street for pre and post diversion scenarios. These volumes are based on recent weekend traffic counts conducted over the weekends of Sep 9 -12, 2011 and Sep 20 -24, 2011.

Table 1: Scott Street Daily (24-hr) Traffic Volumes

Day – Road Segment	Pre-Diversion (Existing) Traffic Volume (1)				Diversion Traffic Volume (1)			
	Cars	Med Trucks [2]	Hvy Trucks	OC Transpo Buses[3]	Cars	Med Trucks[2]	Hvy Trucks	OC Transpo Buses[3]
Sat – Scott St	8029	95	59	81	8947	109	135	858
Sat – Albert St	10006	144	135	81	9742	128	180	858
Sun – Scott St	6834	25	51	70	7645	86	106	847
Sun – Albert St	8169	118	110	70	5737	64	119	847

Notes:

1) Based on City of Ottawa Traffic counts
2) Med trucks include non-city buses
3) OC Transpo buses based on scheduled service on Rte 16 (Pre Diversion) and combined Rte 16 and Transitway routes (Diversion)
4) See Appendix A for further details including hourly traffic volumes.

4. Assessment Criteria

4.1 Vibration Criteria

The City of Ottawa's *Environmental Noise Guidelines* do not specify vibration criteria. In lieu of requirements by the City, a review of vibration criteria typically applicable to transit system expansions and the Province of Ontario was conducted. This review included the following documents:

- FTA
- Prior Transit EA's (TTC)
- ISO
- U.S. Bureau of Mines (USBM), Report of Investigations 8507, *Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting*, 1989

A summary of recommended vibration limits applicable to the Transitway diversion to Scott Street, are provided in **Tables 2 and 3**.

Table 2 provides criteria applicable to potential damage.

Table 2: Vibration Damage Criteria Applicable to this Assessment

Principal Frequency of Ground Motion[1]	Peak Vibration Velocity Limit (mm/s)
< 10 Hz	15
10 Hz – 40 Hz	20
> 40 Hz	50

Note: 1. Principal frequency as determined from test measurements.

It should be noted that the criteria recommended in **Table 2** are based on threshold limits for the onset of cosmetic damage such as surface cracking in foundations and gypsum board construction in typical residential/commercial buildings, and are not associated with structural failures. More stringent criteria are required at lower frequency ground vibrations due to greater ground displacements associated with a given velocity. Historic or fragile buildings, although not known to be within the site area, would generally require more stringent limits as well.

Table 3 provides criteria applicable to disturbance as recommended by the US Federal Transit Administration. Values are far more stringent than for the **Table 2** damage criteria since perceptible vibration is several orders of magnitude below that needed for building damage. The criteria also address the frequency of occurrence, with more frequently occurring events having more stringent criteria. Currently, scheduled OCTranspo Route 16 buses on Scott Street occur at a rate of 30-70 vehicles per day (occasional events) but a diversion of Transitway buses to Scott St. would realize increases in bus activity to a Frequent Events level of more than 70 events per day.

Table 3: Ground-Borne Vibration Criteria for Various Land Uses

Land Use	Assessment Criteria (VdB re 1 micro-in/sec)		
	Frequent Events[2]	Occasional Events[3]	Infrequent Events[4]
Residences and buildings where people normally sleep.	72 VdB	75 VdB	80 VdB
Institutional land uses with primarily daytime use.	75 VdB	78 VdB	83 VdB
Concert Halls	65 VdB	65 VdB	
TV Studios	65 VdB	65 VdB	
Recording Studios	65 VdB	65 VdB	
Auditoriums	72 VdB	80 VdB	
Theatres	72 VdB	80 VdB	

Notes:
[1] RMS Vibration velocity during vehicle passby
[2] Frequent events are defined as more than 70 vibration events of the same source per day.
[3] Occasional events are defined as between 30 and 70 vibration events of the same source per day.
[4] Infrequent events are defined as less than 30 vibration events of the same kind per day.

The above criteria is consistent with recent light rail transit expansions in Toronto for the Toronto Transit Commission(frequent events, RMS vibration velocity of 0.1 mm/s) and are also consistent with CN/CP Rail and GO Transit Criteria (occasional events, RMS vibration velocity of 0.14 mm/s). International Organization for Standardization (ISO) Standard 2631-2 previously recommended a night-time residential vibration limit of 0.14 mm/s above 8 Hz consistent with the **Table 3** FTA limits of 75 VdB (re 1 micro in/s) for occasional events. For the purposes of the Scott Street Transitway Diversion assessment, the most stringent residential criteria for frequent events of 72 VdB (re 1 micro in/s) (0.1 mm/s RMS velocity) has been applied to assess diverted bus traffic.

4.2 Noise Criteria

The City of Ottawa's *Environmental Noise Control Guidelines* (2006) provides specific guidance regarding the noise impact assessment of capital works projects. The intent of the City's guideline is to examine the long-term effects of projects, and not short term construction effects. As such the guidelines do not specifically apply to the Transitway vehicle diversion on to Scott Street.

However, given the potential duration of the diversion, the Guidelines can be used to show what would generally be considered to be acceptable. Section 2.3 of the City noise guidelines are excerpted below in *italics*.

a) *This* [City of Ottawa Environmental Noise Control] *Guideline applies to outdoor levels in the outdoor living area only.*

b) *The applicable sound level descriptor is the A-Weighted Equivalent Sound Pressure Level, Leq in dBA established for the daytime period from 07:00 to 23:00; also referred to as Leq $_{16hr,}$ dBA.*

c) *The objective for outdoor sound levels is the higher of the L_{eq}16hr 55 dBA or the Leq_{16hr} ambient sound level that may prevail at the start of project construction (referred to in this document as the "established ambient").*

d) *The significance of a noise impact, also referred to as the 'excess' or 'change', will be quantified by comparing the future sound levels with the higher of L_{eq}16hr 55 dBA and/or the established ambient sound level.*

e) *Mitigation will attempt to achieve sound levels as close to the objective level as is technically, economically and administratively feasible.*

f) *The acoustic impact rating, the degree of effort applied and action for mitigation of the noise impact should conform to Table 2.1* [**Table 4** of this report]*.*

g) *Where the future sound level exceeds L_{eq}16hr 55 dBA <u>and</u> the increase in the sound levels above the established ambient exceeds 5 dBA, the City of Ottawa will investigate the feasibility of noise control measures within the right-of-way and introduce appropriate measures such that, where feasible, a minimum attenuation (averaged over the first row of receivers) of 6 dBA can be achieved.*

h) *If the future sound level is greater than L_{eq}16hr 55 dBA and less than or equal to L_{eq}16hr 60 dBA <u>and</u> the excess or change in sound level above the established ambient is either:*

- *less than 5 dBA, then no mitigation is required; or,*
- *exceeds 5 dBA, then the sound level criteria in Clauses a) to f) above will apply at the sole cost of the City and within the City of Ottawa r.o.w.*

i) *If the future sound level is greater than L_{eq}16hr 60 dBA and the excess or change in sound level above the established ambient is less than 5 dBA, the feasibility of noise control measures within the right-of-way will be investigated under the City of Ottawa's Local Improvements policy and guidelines. The barrier(s) will be maintained within the City's r.o.w. The City prefers retrofit sound barrier walls at the flanking ends to be on City owned lands, however if required, property owners at the termination points of the noise abatement wall will be asked to register an easement to the City of Ottawa for the construction and maintenance of a noise wall along a side lot line. The side lot line noise wall will provide protection for the rear yard area of the adjacent property. If the landowner refuses to transfer the* *easement, the City will not attempt to purchase or expropriate the easement but will delete this section of wall from the noise abatement construction project.*

j) Where the dominant noise source is due to transit activities within an LRT or a Transitway terminal, a rail yard facility to accommodate the LRT service yard, or a terminal building containing mechanical systems then the City of Ottawa will use the "Stationary Sources" criteria.

k) Alternative noise control measures shall be considered prior to making the decision to use barriers.

Table 4: Summary Of Impact Rating And Action For Mitigation (Table 2.1 of Environmental Noise Control Guidelines)

<table>
<tr><th>Future Sound Level, Leq $_{16hr}$</th><th>Change Above Ambient, dBA</th><th>Impact Rating</th><th>Mitigation</th></tr>
<tr><td rowspan="4">Greater than 55 dBA and less than or equal to 60 dBA</td><td>0-3</td><td>Insignificant</td><td>None</td></tr>
<tr><td>3-5</td><td>Noticeable</td><td>None</td></tr>
<tr><td>5-10</td><td>Significant</td><td rowspan="2">Investigate noise control measures and mitigate to achieve retrofit criteria (minimum attenuation is 6 dBA)</td></tr>
<tr><td>10+</td><td>Very Significant</td></tr>
<tr><td rowspan="4">Greater than 60 dBA</td><td>0-3</td><td>Insignificant</td><td rowspan="4">Investigate noise control measures and mitigate to achieve retrofit criteria (minimum attenuation is 6 dBA)</td></tr>
<tr><td>3-5</td><td>Noticeable</td></tr>
<tr><td>5-10</td><td>Significant</td></tr>
<tr><td>10+</td><td>Very Significant</td></tr>
</table>

5. Vibration Impact Assessment

5.1 Baseline Vibration Measurements

Measurements were conducted on the weekend of September 9-11, 2011 and September 23-24, 2011. The intent of the measurements was to capture characteristic individual vehicle pass-bys, with primary focus on buses and trucks. Vibration in the vicinity of typical road surface conditions was measured along with worst-case vibration resulting from vehicle passbys over loose drainage gratings.

Surface-level vibration was recorded using Minimate Plus instruments manufactured by Instantel. Data were captured at three locations, as shown in **Figures 2 and 3**. Locations V1 and V2 were in the vicinity of Scott St and Stirling Ave. Location V3 was at the corner of Scott St and Manchester Avenue.

At each of the locations, triaxial transducers were spiked to the ground. At locations V1 and V2 a selected number of simultaneous measurements were conducted, although vibration at location V2 was generally undetectable for vehicle passbys on Scott St. Location V2 was representative of the closest houses to Scott St., which were located on side streets off of Scott St, but which had intervening commercial properties as a buffer zone. Location V3 focused on worst-case (closest house) directly siding or fronting on to Scott Street in proximity to loose drain gratings which Scott Street vehicles could impact during pass-bys.

For each event, the full vehicle passage was recorded. The data were then post-processed to compute peak vibration velocity (PPV) and maximum passby RMS values in sliding one-second windows.

5.2 Findings

Table 5 is a summary of the measured maximum vibration levels at each location.

Table 5: Summary of Measured Vehicle Vibration Levels

Location [1]	Vehicle Type	Distance to Closest lane (m)	Maximum PPV		Maximum RMS[2]	
			mm/s	VdB	mm/s	VdB
V1	Car	4	0.222	79	0.04	64
	Bus		0.81	90	0.143	75
	Truck [3]		0.56	87	0.13	74
V2	Car	23	*Not measured*			
	Bus		< 0.08	< 70	< 0.02	< 57
	Truck [3]		< 0.07	< 69	< 0.02	< 57
V3	Car	3.75	0.159	76	0.029	61
	Bus		1.080	93	0.232	79
	Truck [3]		0.841	90	0.151	75

Notes: [1] See Figure 3 for measurement locations.
[2] Maximum RMS values based on 1 sec sliding window.
[3] Truck vibration data shown is based on trucks using the second closest lane (Lane 2), as trucks were observed to travel primarily in this lane and no data was captured for closest Lane 1 trucks.

Table 6 summarizes the compliance assessment for each major vehicle type based on modelled adjustments to the measured vibration levels at the closest house foundation assuming uneven pavement conditions such as passbys over drain grates.

The results indicate that the disturbance criteria are not met at the closest house foundation for truck and bus activity for the existing traffic scenario as well as the future diverted bus activity.

Table 6: Worst-Case Vibration Impacts at Closest House Foundation Setback

Location	Vehicle Type	Distance to Closest lane (m) [3]	Meets Damage Criteria? [1]	Maximum RMS[2]		Meets Disturbance Criteria?
				mm/s	VdB	
Estimated Closest House Foundation	Car	3.1	Yes	0.070	69	Yes
	Bus	3.1	Yes	0.330	82	No
	Truck[3]	3.1	Yes	0.483	86	No

Notes: [1] Measured values of PPV at the V3 measurement setback comply with damage criteria and the criteria is therefore inherently met at the closest house foundation.
[2] Maximum RMS values based on 1 sec sliding window.
[3] All vehicle types assumed to travel in Lane 1 (closest lane)
[4] Assumes vehicle passby over manhole cover or grate.

Table 7 summarizes the compliance assessment for each major vehicle type based on modelled adjustments to the measured vibration levels at the closest house foundation assuming typical even pavement conditions.

The results indicate that the disturbance criteria are also not met at the closest house foundation for truck and bus activity for the existing traffic scenario as well as the future diverted bus activity.

Table 7: Typical Vibration Impacts at Closest House Foundation Setback

Location	Vehicle Type	Distance to Closest lane (m) [3]	Meets Damage Criteria? [1]	Maximum RMS[2]		Meets Disturbance Criteria?
				mm/s	VdB	
Estimated Closest House Foundation	Car	3.1	Yes	0.038	64	Yes
	Bus	3.1	Yes	0.279	81	No
	Truck[3]	3.1	Yes	0.246	80	No

Notes: [1] Measured values of PPV at the closer V3 measurement setback comply with damage criteria and the criteria is therefore inherently met at the closest house foundation .
[2] Maximum RMS values based on 1 sec sliding window.
[3] All vehicle types assumed to travel in Lane 1 (closest lane)
[4] Assumes vehicle on smooth road surface with no potholes, grates or manhole covers

6. Noise Impact Assessment

The potential noise impact was assessed using a combination of two modeling approaches:

a) measurement based modeling; and,

b) noise prediction modeling using Ontario Ministry of the Environment STAMSON/ORNAMENT methods as advocated within the City of Ottawa's *Environmental Noise Control Guidelines* (2006).

to assess the change in sound exposures anticipated with a diversion of Transitway traffic onto Scott Street. Per **Table 4**, the extent of the change indicates the significance of the noise impact.

The measurement based models is considered more accurate in this case as there are limitations on the STAMSON/ORNAMENT model imposed by the site geometry and proximity of receptors. Many of the Scott St. receptors are closer than the 15 m closest setback limitation of the STAMSON/ORNAMENT model.

In addition to the above mentioned model approaches, anticipated changes in sound exposure were assessed by direct measurement when all Transitway bus traffic was rerouted onto Scott Street over a four (4) hour period on Saturday September 20, 2011. Background sound exposures were previously obtained two weekends earlier from Friday September 9 to Monday Sept 12, 2011.

6.1 Measurement Program

Measurements of Scott St. noise were conducted at 4 locations over two weekends in September 2011.

- **Weekend 1 (Sep. 9-12, 2011)**: measurements of existing (i.e., non-diversion) sound exposures.

- **Weekend 2** (**Sep. 23-25, 2011)**: measurements of existing (i.e. non-diversion) sound exposures for much of the period but also featured 4 hours (7 a.m.-9 a.m.) and (12 p.m.-2 p.m.) where all transit way buses were diverted to provide an indication of the anticipated sound exposures under a diversion scenario. OCTranspo was not able to divert transitway vehicles beyond the times indicated without creating operational issues. The diversion was also limited due to operational reasons between Tunney's Pasture (Holland Ave.) and Bayview Rd. and did not extend to beyond Preston Ave as originally anticipated.

Measurements of individual vehicle sound energy contributions were also obtained for all classes of vehicles (i.e., cars, buses, trucks) as part of the measurement program.

Both attended and unattended long-term noise monitoring was conducted at four (4) locations as outlined in **Figure 3**.

Long-term monitors were installed on utility poles at approximately 4.5 m above grade typically, which in much of the area was 2-3 m closer to Scott Street than the closest building faces.

Short-term, attending monitoring was used to capture additional data at residences that were further setback from Scott Street. More importantly, the short-term monitoring was also used to capture and identify noise emissions from individual vehicle and individual vehicle classes (i.e., cars, buses, trucks), accounting for the in-situ topography, vehicle speeds, pavement, setbacks.

Traffic monitors (i.e, counter/classifiers) were installed by the City of Ottawa for the periods in which noise measurements were conducted. These monitors provided information on vehicle movements for each roadway lane, including speed distribution, and vehicle class counts in 15 minute increments throughout the measurement period.

Further details of the measurement program can be found in **Appendix A.**

6.2 Noise Prediction Modelling

6.2.1 Measurement Based Model

The sound exposure over a given time period generated by a roadway can be determined knowing the number of vehicle movements per vehicle class in each lane multiplied by the corresponding average measured sound energy contribution for each vehicle class in each lane for the time period being considered. The average sound energy contribution of a given vehicle class/ lane combination were determined from the measured SEL, (single event levels) and the resulting energy averaged sound exposure levels adjusted for distances other than the measurement setback distance using a line-source propagation assumption.

Using road traffic counts conducted by the City of Ottawa during the measurement periods, a noise prediction model (based on measured vehicle passby emissions) was therefore developed for both a diversion and non-diversion scenario.

Further details of the measurement based model can be found in **Appendix B.**

6.2.2 STAMSON/ORNAMENT Model

Consistent with City of Ottawa Environmental Noise Control Guidelines, a second noise prediction model (i.e., STAMSON / ORNAMENT) was also run. The model has been used to assess road traffic noise in Ontario for well over 20 years. The model accounts for topography, vehicle speed and vehicle class (e.g., cars, trucks) and classifies buses as medium trucks. Since the model has limitations on its use for source to receiver distances of less than 15m, adjustments were made for the noise receptors assessed which had smaller setbacks on the assumption that line source propagation is still valid. While the model's application in this context may not be entirely consistent with its limits, the same assumptions and adjustments were applied to the diversion and non-diversion scenarios and as such, the resulting change should still be accurate.

Further details of the STAMSON/ORNAMENT based model can be found in **Appendix C.**

6.3 Findings

Figures 4, 5 and 6 illustrate the results for Location N1, N2, and N3. Each plot illustrates existing scenarios in blue and diversion scenarios in orange. Dashed lines provide the modeled sound contribution of the buses only while dotted lines provide the modeled overall sound exposure levels (i.e., from all traffic including buses).

Solid lines are the **actual** measured sound exposures based on the two weekend measurement data sets, with the solid orange line representing the measured sound exposures during the four-hour diversion on September 24th..

Both noise prediction models used (i.e., Novus measured SEL based and STAMSON/ORNAMENT,) provide modelled sound exposures which differ from the actual measured values. The Novus measured SEL based model is more accurate and is conservative (i.e., over predicts sound exposure). The STAMSON/ORNAMENT model, under-predicts and differs more from the actual measured sound exposures.

Using the more conservative Novus measured SEL based model, changes in sound exposure (i.e., difference between diversion and non-diversion scenarios,) are predicted that are consistent with those measured during the short-term (4-hour) Transitway diversion. The STAMSON model exhibited larger changes in sound exposure than that observed measurements during the short-term diversion. The Novus measured SEL based model is therefore considered more accurate and forms the basis of the findings outlined in **Table 8**.

Table 8 tabulates the changes in sound exposure between the non-diversion and diversion scenarios. The differences in the tabulated change in sound exposure values have been calculated using the modeled ambient sound exposure values (i.e., existing dotted blue) and the modeled (i.e., future dotted orange diverted) sound exposure values. For those hours where Transitway traffic was diverted on September 24, 2011, the modeled differences (i.e., sound exposure changes,) confirm the accuracy of the modeled impact as the modeled and measured changes are similar.

Table 8: Summary of Sound Exposure Change and Significance

Location (1)	Leq Day(2)		Leq Night(3)		Leq24(4)		Worst-Case Hr (5)	
	Change (dB)	Impact Rating	Change (dB)	Impact Rating	Change (dB)	Impact Rating	Change (dB)	Impact Rating
N1	1.7	Insignificant	1.7	Insignificant	1.7	Insignificant	3.7	Noticeable
N2	1.7	Insignificant	1.8	Insignificant	1.7	Insignificant	3.7	Noticeable
N3	1.2	Insignificant	0.7	Insignificant	1.2	Insignificant	2.7	Insignificant

Notes:

1. See Figure 3 for locations
2. LeqDay – Energy equivalent energy sound level averaged over a 16 hour period from 0700 hrs to 2300 hrs. Leq Day is the recommended evaluation metric advocated under the City of Ottawa Noise Control Guidelines
3. LeqNight – Energy equivalent energy sound level averaged over an 8-hour period from 2300 hrs to 0700 hrs. Although not specified within the City of Ottawa Noise Control Guidelines, it is sometimes used to assess nighttime impacts.
4. Leq24 – Energy equivalent energy sound level averaged over a 24-hour period Although not specified within the City of Ottawa Noise Control Guidelines, it is sometimes used to assess impacts of some road networks, particularly freeways, within Ontario.
5. Worst-case hour is characterized by that hour where the difference in Energy equivalent energy sound level , between the existing and diversion scenarios is greatest. It is an indicator of short-term impacts.

Table 8 indicates that the anticipated changes in sound exposure from existing conditions due to the proposed Transitway diversion are insignificant under assessment criteria used by the City of Ottawa under the City's Noise Control Guideline. Only short-term impacts for the worst-case hour have the potential to be noticeable but remain below the 5 dB change threshold normally applied in considering mitigation.

7. Summary and Conclusions

7.1 Noise

- The diversion of Transitway traffic onto Scott Street during construction of the LRT is expected to result in changes of less than 3 dB to the L_{eq} Day sound levels experienced at Scott Street residences. Impacts are expected to be insignificant at noise-sensitive receptors on the south side of Scott Street.

7.2 Vibration

- Existing bus traffic on Scott Street is classified as occasional and is between 30 to 70 vehicles per day for eastbound traffic. Eastbound buses have the greatest potential effect on properties on the south side of Scott Street under consideration. A criterion of 75 VdB (re 1 micro in/s) has been applied for occasional bus events and is not met for worst –case, closest building setbacks and road conditions, namely vehicle impacts on loose drainage grates. The criterion is also exceeded for closest building setbacks for buildings fronting typical pavement sections of Scott Street.

- Diverting bus traffic from the Transitway onto Scott Street increases the frequency of events and a frequent event criterion for disturbance of 72 VdB (re 1 micro in/s) would be appropriate. The criterion would also be exceeded for bus passbys over loose grates and typical pavement, when assessed at closest building setbacks.

- Maximum vibration levels will remain the same between existing conditions and with the diversion in place.

- It is anticipated that mitigation of loose drainage grates including addition of resilient material (e.g., bridge bearing neoprene) to separate grating covers from the drain, will be sufficient to reduce vibration to criterion levels at most residences except for a few locations where houses, directly front or side onto Scott Street.

- Passby vibration levels currently are, and are expected to remain, well below damage levels with diverted traffic.

8. Recommendations

- To reduce potential noise impacts, diverted bus traffic should, where possible, be distributed on both the curb and centre traffic lanes (i.e., all four lanes). Restricting buses to the curb lanes would increase bus noise by decreasing separation. Distribution of Transitway bus traffic is also consistent with bus operator preferences observed during the short-term diversion.

- Prior to the proposed diversion, consideration should be given to smoothing uneven pavement where it exists on Scott Street. As a minimum this would involve addressing loose drainage grates and/or manhole covers as outlined above.

9. References

City of Ottawa (2006) *Environmental Noise Control Guidelines*
www.ottawa.ca/residents/planning/design_plan_guidelines/completed/noise_ctl/noise_control_guidelines_en.pdf

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FIGURES

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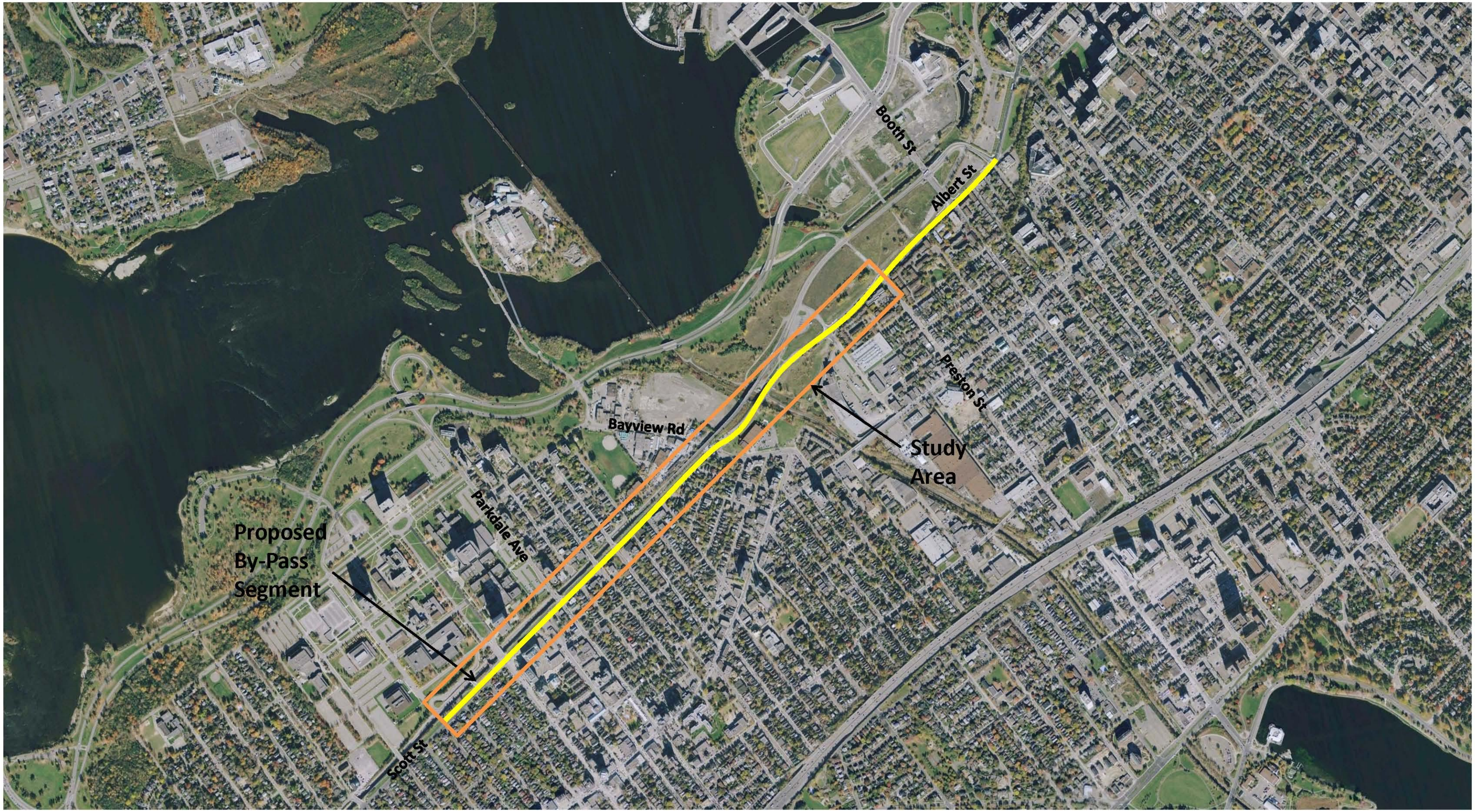

Figure No.	1		Scale:	N.T.S.
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			File No.:	10-0042
Ottawa LRT, Scott Street By-pass Ottawa, Ontario			Drawn By:MTL	

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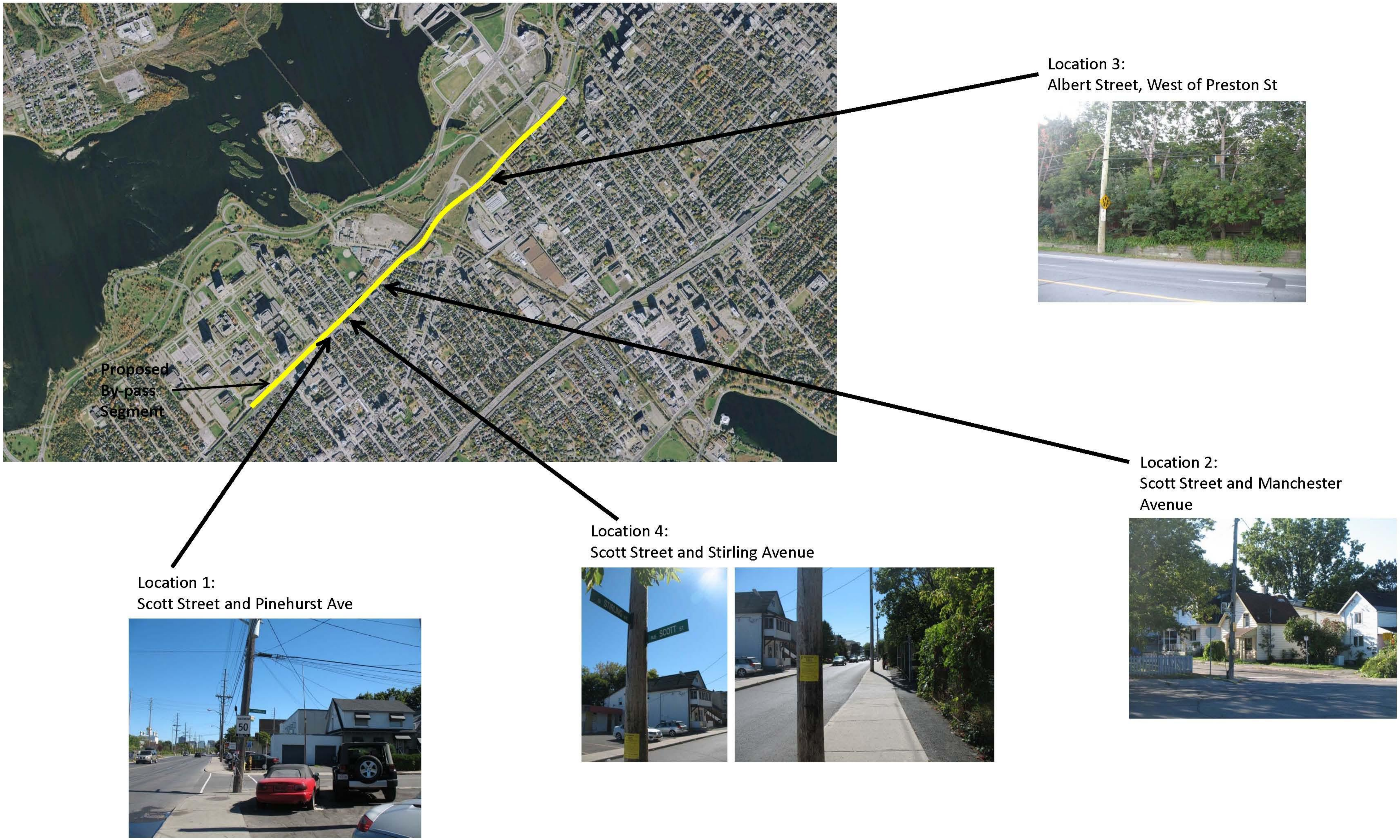
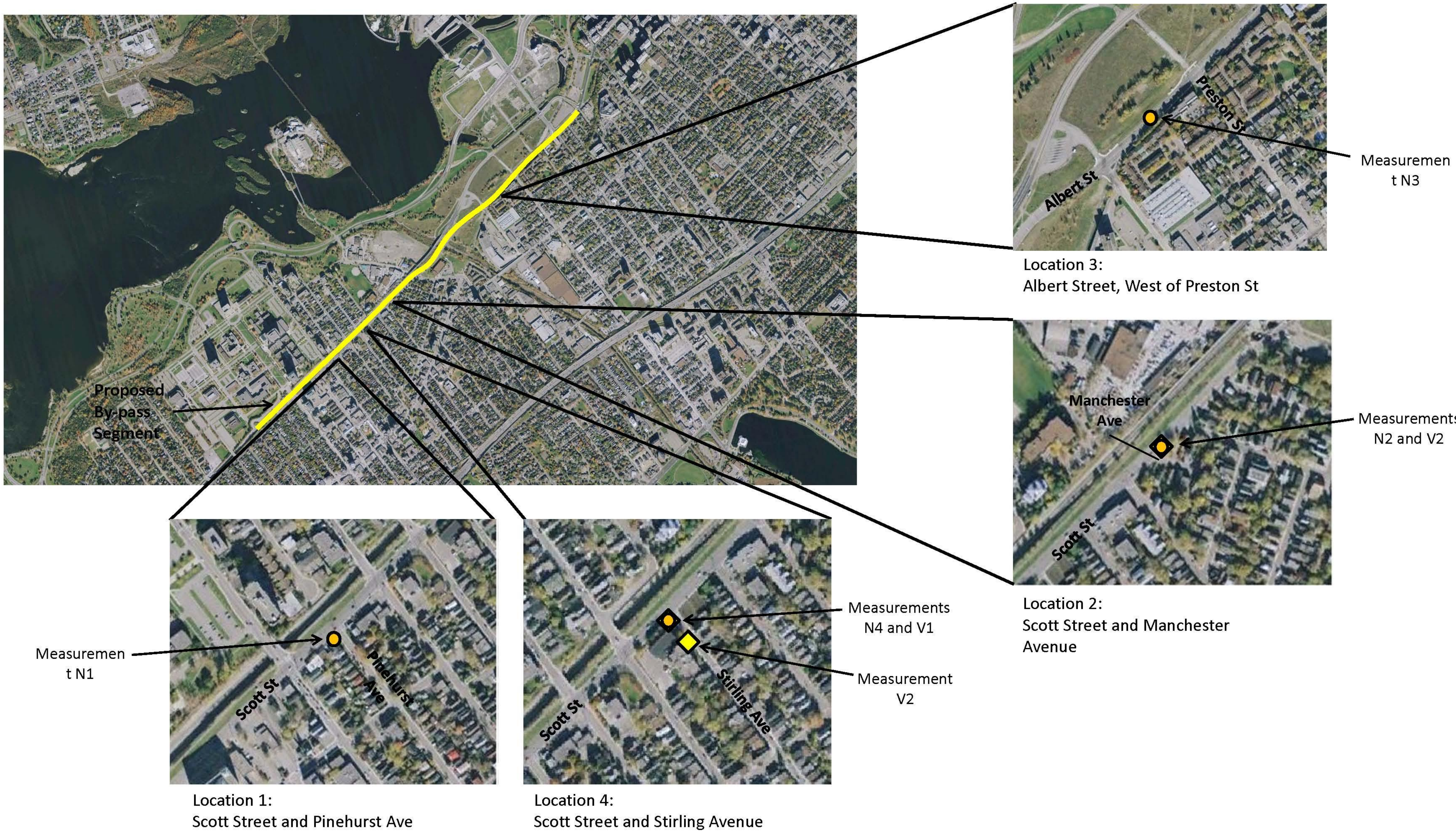


Figure No. **2**	True North	Scale: N.T.S.	novus ENVIRONMENTAL
Measurement and Receptor Locations - Overview		Date: Oct. 14, 2011	150 Research Lane, Suite 105 Guelph, ON, Canada, N1G 4T2 t. 226.706.8080 f.226.706.8081 www.novusenv.com
		File No.: 10-0042	
Ottawa LRT, Scott Street By-Pass **Ottawa, Ontario**		Drawn By:MTL	



Legend

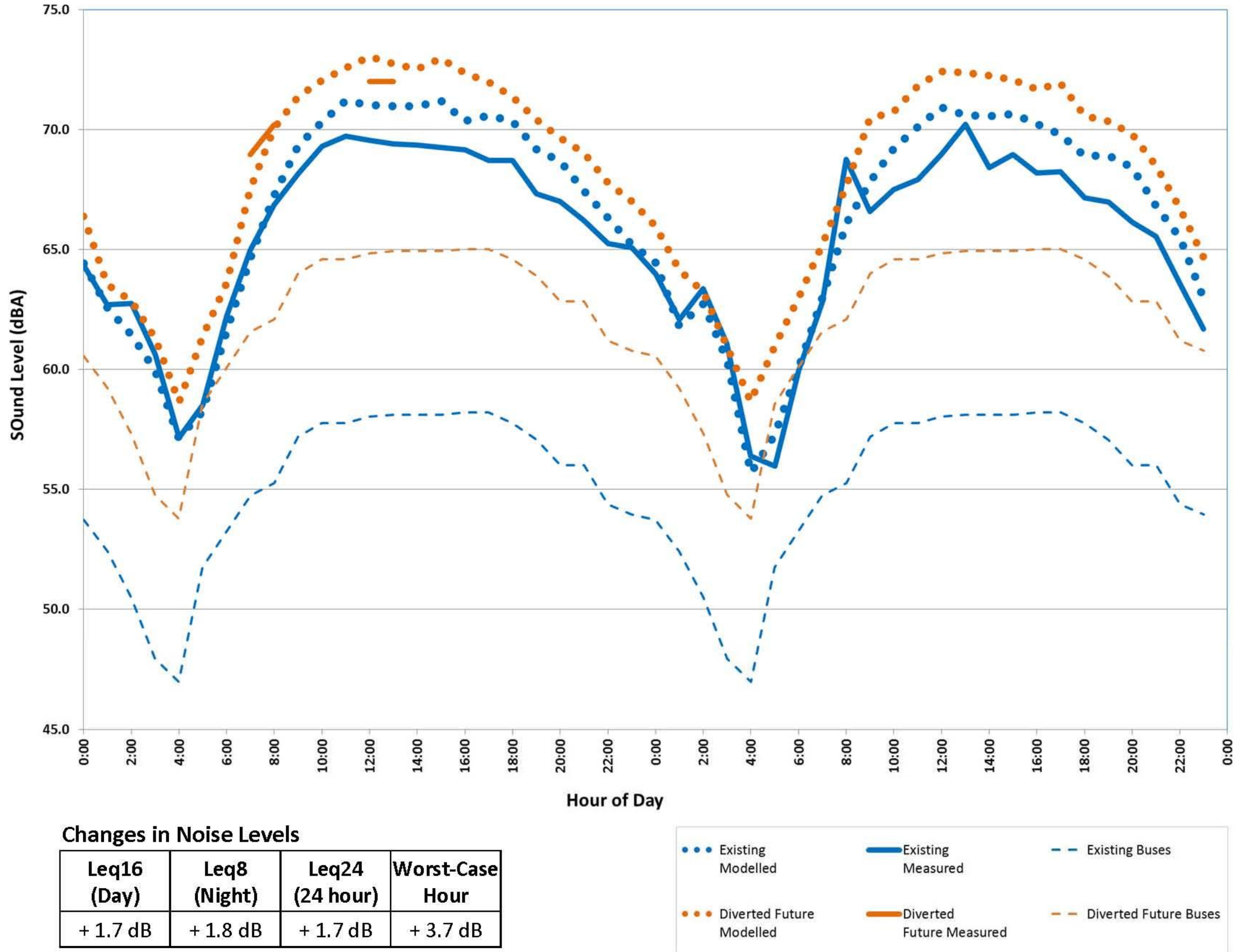
- Noise Measurement Location
- Vibration Measurement Location

Figure No. 3	True North	Scale: N.T.S.	novus ENVIRONMENTAL
Measurement and Receptor Locations - Detailed		Date: Oct. 14, 2011	150 Research Lane, Suite 105 Guelph, ON, Canada, N1G 4T2 t. 226.706.8080 f.226.706.8081 www.novusenv.com
		File No.: 10-0042	
Ottawa LRT, Scott Street By-Pass Ottawa, Ontario		Drawn By:MTL	

Changes in Noise Levels

Leq16 (Day)	Leq8 (Night)	Leq24 (24 hour)	Worst-Case Hour
+ 1.7 dB	+ 1.7 dB	+ 1.7 dB	+ 3.7 dB

Figure No. **4**	Scale: NTS	**novus** ENVIRONMENTAL
Scott St. Diversion Location N1: Scott St / Pinehurst Ave	Date: 11/10/19	150 Research Lane, Suite 105
	File No.: 10-0042	Guelph, ON, Canada, N1G 4T2
Ottawa Light Rail Transit Project Ottawa, Ontario	Drawn By: DCQ	t. 226.706.8080 f.226.706.8081 www.novusenv.com

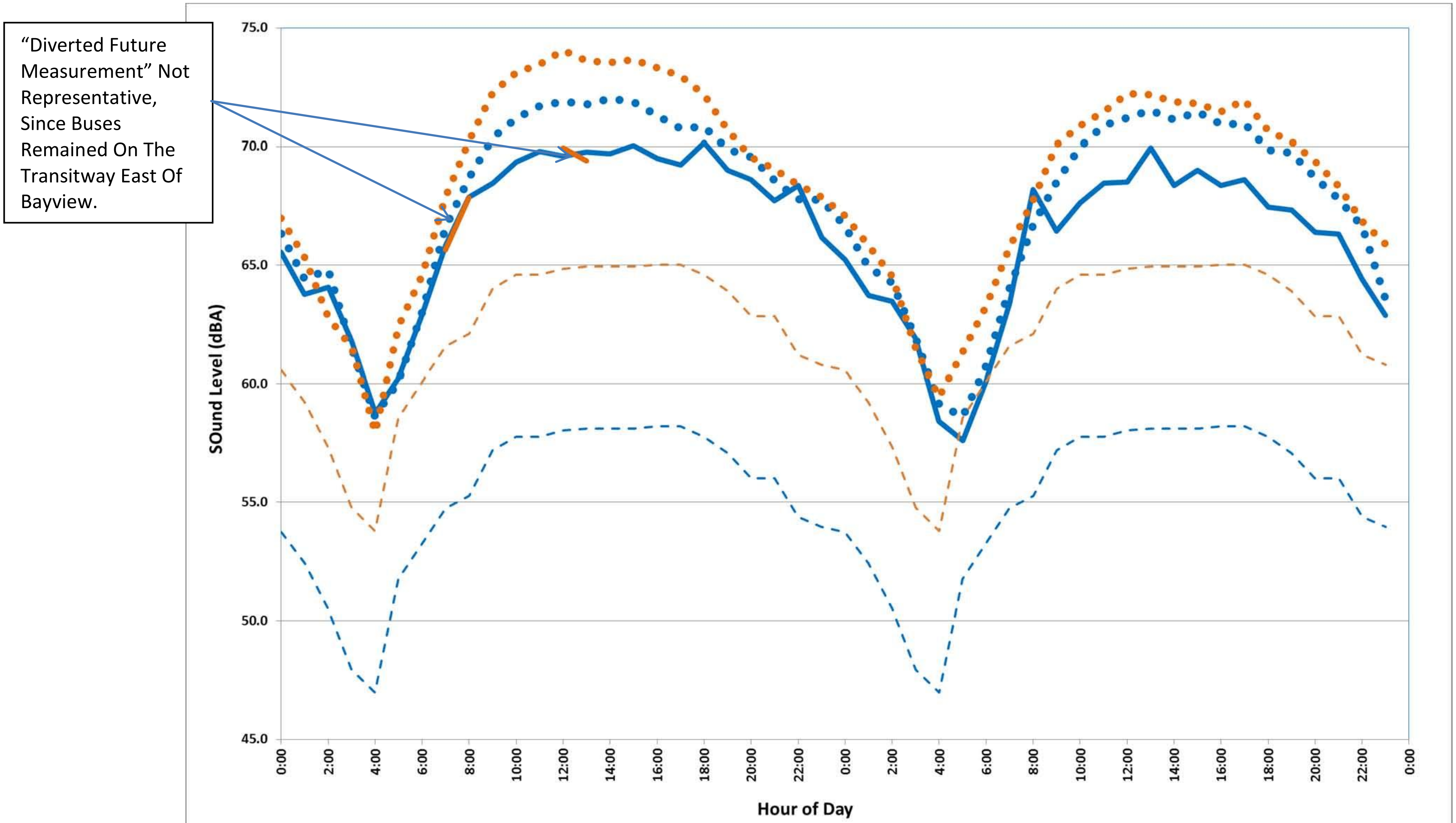


Changes in Noise Levels

Leq16 (Day)	Leq8 (Night)	Leq24 (24 hour)	Worst-Case Hour
+ 1.7 dB	+ 1.8 dB	+ 1.7 dB	+ 3.7 dB

Figure No. **5**	Scale: NTS
Scott St. Diversion **Location N2: Scott St / Manchester Ave**	Date: 11/010/19 File No.: 10-0042
Ottawa Light Rail Transit Project **Ottawa, Ontario**	Drawn By: BAP

NOVUS ENVIRONMENTAL
150 Research Lane, Suite 105
Guelph, ON, Canada, N1G 4T2
t. 226.706.8080 f.226.706.8081
www.novusenv.com



Changes in Noise Levels

Leq16 (Day)	Leq8 (Night)	Leq24 (24 hour)	Worst-Case Hour
+ 1.2 dB	+ 0.7 dB	+ 1.2 dB	+ 2.7 dB

Figure No. **6**	Scale: NTS	
Scott St. Diversion **Location N3: Scott St / Preston St**	Date: 11/010/19 File No.: 10-0042	novus ENVIRONMENTAL 150 Research Lane, Suite 105 Guelph, ON, Canada, N1G 4T2 t. 226.706.8080 f.226.706.8081 www.novusenv.com
Ottawa Light Rail Transit Project **Ottawa, Ontario**	Drawn By: BAP	

APPENDIX A

Table A1: Summary of Traffic Counts – Scott St Ambient (Sep 10 to 11, 2011)

		EB, curb (lane 1)				EB, inside (lane 2)				WB, inside (lane 3)				WB, curb (lane 4)				Totals	% Dist
Date	Hour Starting	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk		
Sat,Sep-10-11	0:00	18	1	0	0	47	4	0	0	59	7	1	0	9	1	0	0	147	1.8%
	1:00	10	0	0	0	29	2	0	0	45	5	1	0	9	1	0	0	102	1.2%
	2:00	9	0	0	0	21	2	0	0	37	4	1	0	3	0	0	0	77	0.9%
	3:00	3	0	0	0	22	2	0	0	26	3	0	0	3	0	0	0	59	0.7%
	4:00	2	0	0	0	10	1	0	0	13	2	0	0	1	0	0	0	29	0.4%
	5:00	1	0	0	0	12	1	0	0	16	2	0	0	2	0	0	0	34	0.4%
	6:00	4	0	0	0	28	2	0	0	33	4	1	0	6	1	0	0	79	1.0%
	7:00	16	0	0	0	56	4	1	0	60	7	1	0	12	1	0	0	158	1.9%
	8:00	27	1	0	0	103	8	1	0	100	12	2	1	25	3	0	1	284	3.5%
	9:00	43	1	0	1	174	14	2	1	122	14	2	1	36	4	1	1	417	5.1%
	10:00	67	2	1	1	189	15	2	1	186	21	3	1	38	4	1	1	533	6.5%
	11:00	98	3	1	2	203	16	2	1	222	25	4	1	57	7	1	1	644	7.9%
	12:00	90	3	1	1	202	16	2	1	219	25	4	1	61	7	1	2	636	7.8%
	13:00	88	3	1	1	210	17	2	1	196	23	3	1	67	8	1	2	624	7.6%
	14:00	90	3	1	1	175	14	2	1	230	26	4	1	77	9	1	2	637	7.8%
	15:00	101	3	1	2	193	16	2	1	199	23	3	1	80	9	1	2	637	7.8%
	16:00	89	3	1	1	142	11	1	1	192	22	3	1	54	6	1	1	529	6.5%
	17:00	89	3	1	1	186	15	2	1	174	20	3	1	44	5	1	1	547	6.7%
	18:00	79	2	1	1	171	14	2	1	174	20	3	1	57	7	1	1	535	6.5%
	19:00	58	2	1	1	125	10	1	1	128	15	2	1	40	5	1	1	392	4.8%
	20:00	40	1	0	1	119	10	1	1	135	16	2	1	32	4	1	1	365	4.5%
	21:00	26	1	0	0	102	8	1	0	112	13	2	1	27	3	0	1	297	3.6%
	22:00	30	1	0	0	76	6	1	0	76	9	1	0	23	3	0	1	227	2.8%
	23:00	12	0	0	0	64	5	1	0	84	10	1	0	15	2	0	0	194	2.4%
Sun,Sep-11-11	0:00	18	1	0	0	39	3	0	0	68	8	1	0	16	2	0	0	156	2.2%
	1:00	7	0	0	0	26	2	0	0	37	4	1	0	6	1	0	0	84	1.2%
	2:00	6	0	0	0	34	3	0	0	58	7	1	0	4	0	0	0	113	1.6%
	3:00	2	0	0	0	20	2	0	0	32	4	1	0	5	1	0	0	67	1.0%
	4:00	1	0	0	0	10	1	0	0	4	1	0	0	2	0	0	0	19	0.3%
	5:00	2	0	0	0	7	1	0	0	12	1	0	0	1	0	0	0	24	0.3%
	6:00	0	0	0	0	21	2	0	0	24	3	0	0	3	0	0	0	53	0.8%
	7:00	11	0	0	0	43	3	0	0	29	3	0	0	10	1	0	0	100	1.4%
	8:00	30	1	0	0	85	7	1	0	60	7	1	0	13	1	0	0	206	3.0%
	9:00	30	1	0	0	110	9	1	1	108	12	2	1	25	3	0	1	304	4.4%
	10:00	55	2	1	1	126	10	1	1	128	15	2	1	48	6	1	1	399	5.7%
	11:00	75	2	1	1	142	11	1	1	192	22	3	1	50	6	1	1	510	7.3%
	12:00	87	3	1	1	187	15	2	1	218	25	4	1	69	8	1	2	625	9.0%
	13:00	66	2	1	1	185	15	2	1	210	24	3	1	68	8	1	2	590	8.5%
	14:00	84	3	1	1	154	12	1	1	201	23	3	1	70	8	1	2	566	8.1%
	15:00	94	3	1	1	175	14	2	1	184	21	3	1	56	6	1	1	564	8.1%
	16:00	85	3	1	1	145	12	1	1	173	20	3	1	55	6	1	1	509	7.3%
	17:00	74	2	1	1	142	11	1	1	141	16	2	1	49	6	1	1	450	6.5%
	18:00	54	2	1	1	108	9	1	1	131	15	2	1	27	3	0	1	357	5.1%
	19:00	41	1	0	1	134	11	1	1	130	15	2	1	42	5	1	1	387	5.6%
	20:00	44	1	0	1	108	9	1	1	113	13	2	1	35	4	1	1	335	4.8%
	21:00	30	1	0	0	81	7	1	0	94	11	2	1	16	2	0	0	246	3.5%
	22:00	17	1	0	0	73	6	1	0	73	8	1	0	13	1	0	0	194	2.8%
	23:00	9	0	0	0	39	3	0	0	40	5	1	0	6	1	0	0	104	1.5%

Table A2: Summary of Traffic Counts – Albert St Ambient (Sep 10 to 11, 2011)

		EB, curb (lane 1)				EB, inside (lane 2)				WB, inside (lane 3)				WB, curb (lane 4)				Totals	% Dist
Date	Hour Starting	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk		
Sat,Sep-10-11	0:00	18	1	0	1	65	7	1	0	65	8	1	1	41	3	0	1	213	2.1%
	1:00	13	1	0	0	44	5	1	0	52	6	1	1	22	2	0	0	148	1.4%
	2:00	19	1	0	1	35	4	0	0	51	6	1	1	22	2	0	0	143	1.4%
	3:00	7	0	0	0	25	3	0	0	34	4	1	0	9	1	0	0	84	0.8%
	4:00	4	0	0	0	12	1	0	0	20	2	0	0	5	0	0	0	44	0.4%
	5:00	6	0	0	0	14	2	0	0	19	2	0	0	11	1	0	0	55	0.5%
	6:00	14	1	0	0	30	3	0	0	35	4	1	0	17	1	0	0	106	1.0%
	7:00	27	1	0	1	58	6	1	0	64	8	1	1	49	4	1	1	223	2.2%
	8:00	38	2	1	1	98	11	1	1	111	13	3	1	85	7	1	2	376	3.7%
	9:00	50	2	1	2	147	16	2	1	152	18	3	2	139	11	2	3	551	5.4%
	10:00	70	3	1	2	165	18	2	1	199	24	5	2	167	13	2	4	678	6.6%
	11:00	84	3	1	3	182	20	3	1	213	26	5	2	185	14	2	4	748	7.3%
	12:00	82	3	1	3	183	20	3	1	242	29	5	3	203	16	2	4	800	7.8%
	13:00	79	3	1	3	189	21	3	1	213	26	5	2	204	16	2	4	772	7.5%
	14:00	98	4	1	3	183	20	3	1	236	29	5	3	193	15	2	4	800	7.8%
	15:00	87	4	1	3	181	20	3	1	224	27	5	3	199	16	2	4	780	7.6%
	16:00	84	3	1	3	143	16	2	1	179	22	4	2	186	15	2	4	667	6.5%
	17:00	60	2	1	2	150	17	2	1	174	21	4	2	156	12	2	3	609	5.9%
	18:00	71	3	1	3	149	16	2	1	152	18	3	2	143	11	2	3	580	5.6%
	19:00	48	2	1	2	124	14	2	1	138	17	3	2	116	9	1	2	482	4.7%
	20:00	50	2	1	2	115	13	2	1	128	15	3	1	99	8	1	2	443	4.3%
	21:00	38	2	1	1	95	10	1	1	97	12	2	1	89	7	1	2	360	3.5%
	22:00	32	1	0	1	86	9	1	0	100	12	2	1	64	5	1	1	316	3.1%
	23:00	33	1	1	1	73	8	1	0	119	14	3	1	46	4	1	1	307	3.0%
Sun,Sep-11-11	0:00	26	1	0	1	50	6	1	0	81	10	2	1	46	4	1	1	231	2.8%
	1:00	15	1	0	1	34	4	0	0	61	7	1	1	23	2	0	0	150	1.8%
	2:00	12	0	0	0	50	5	1	0	50	6	1	1	20	2	0	0	148	1.8%
	3:00	7	0	0	0	29	3	0	0	36	4	1	0	13	1	0	0	94	1.1%
	4:00	5	0	0	0	14	2	0	0	20	2	0	0	4	0	0	0	47	0.6%
	5:00	2	0	0	0	11	1	0	0	17	2	0	0	6	0	0	0	39	0.5%
	6:00	4	0	0	0	22	2	0	0	20	2	0	0	13	1	0	0	64	0.8%
	7:00	10	0	0	0	44	5	1	0	37	4	1	0	27	2	0	1	132	1.6%
	8:00	18	1	0	1	77	8	1	0	52	6	1	1	63	5	1	1	236	2.8%
	9:00	42	2	1	1	89	10	1	0	107	13	2	1	76	6	1	2	354	4.2%
	10:00	62	3	1	2	110	12	2	1	144	17	3	2	103	8	1	2	473	5.6%
	11:00	71	3	1	2	155	17	2	1	176	21	4	2	142	11	2	3	613	7.3%
	12:00	74	3	1	3	170	19	2	1	183	22	4	2	146	11	2	3	646	7.7%
	13:00	83	3	1	3	168	19	2	1	218	26	5	3	153	12	2	3	702	8.4%
	14:00	79	3	1	3	150	17	2	1	190	23	4	2	136	11	2	3	627	7.5%
	15:00	86	3	1	3	184	20	3	1	189	23	4	2	145	11	2	3	680	8.1%
	16:00	76	3	1	3	127	14	2	1	188	23	4	2	133	10	2	3	592	7.1%
	17:00	74	3	1	3	133	15	2	1	185	22	4	2	145	11	2	3	606	7.2%
	18:00	52	2	1	2	99	11	1	1	148	18	3	2	122	10	1	3	476	5.7%
	19:00	60	2	1	2	110	12	2	1	126	15	3	1	112	9	1	2	459	5.5%
	20:00	40	2	1	1	100	11	1	1	104	13	2	1	82	6	1	2	368	4.4%
	21:00	31	1	0	1	73	8	1	0	112	13	3	1	60	5	1	1	311	3.7%
	22:00	21	1	0	1	63	7	1	0	73	9	2	1	43	3	1	1	227	2.7%
	23:00	8	0	0	0	34	4	0	0	45	5	1	1	22	2	0	0	122	1.5%

Table A3: Summary of Traffic Counts – Scott St Diverted (Sep 24 to 25, 2011)

		EB, curb (lane 1)				EB, inside (lane 2)				WB, inside (lane 3)				WB, curb (lane 4)				Totals	% Dist
Date	Hour Starting	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk		
Sat,Sep-24-11	0:00	18	0	0	1	49	4	1	0	66	8	1	0	15	0	0	1	164	1.8%
	1:00	8	0	0	0	31	2	0	0	33	4	1	0	9	0	0	0	88	1.0%
	2:00	7	0	0	0	26	2	0	0	41	5	1	0	5	0	0	0	87	0.9%
	3:00	5	0	0	0	23	2	0	0	28	3	0	0	5	0	0	0	66	0.7%
	4:00	1	0	0	0	11	1	0	0	13	2	0	0	5	0	0	0	33	0.4%
	5:00	6	0	0	0	11	1	0	0	17	2	0	0	1	0	0	0	38	0.4%
	6:00	7	0	0	0	26	2	0	0	34	4	1	0	3	0	0	0	77	0.8%
	7:00	36	1	0	1	58	5	1	0	60	7	1	0	30	1	1	2	204	2.2%
	8:00	83	2	1	2	120	9	1	1	104	12	2	1	37	1	1	2	379	4.1%
	9:00	97	2	1	3	161	13	2	1	171	20	3	1	40	1	1	2	519	5.6%
	10:00	117	3	1	4	191	15	2	1	176	21	3	1	49	1	1	3	589	6.4%
	11:00	125	3	1	4	210	17	2	1	231	28	4	2	82	2	1	4	717	7.8%
	12:00	143	3	1	4	237	19	3	1	243	29	4	2	112	3	2	6	812	8.8%
	13:00	119	3	1	4	221	17	2	1	225	27	4	2	117	3	2	6	754	8.2%
	14:00	122	3	1	4	188	15	2	1	222	27	4	2	85	2	2	5	685	7.5%
	15:00	153	3	1	5	225	18	2	1	230	28	4	2	70	2	1	4	749	8.1%
	16:00	122	3	1	4	215	17	2	1	186	22	3	1	58	2	1	3	641	7.0%
	17:00	110	2	1	3	179	14	2	1	193	23	3	1	58	2	1	3	596	6.5%
	18:00	85	2	1	3	163	13	2	1	146	17	2	1	57	2	1	3	499	5.4%
	19:00	59	1	0	2	145	11	2	1	135	16	2	1	34	1	1	2	413	4.5%
	20:00	57	1	0	2	102	8	1	1	114	14	2	1	32	1	1	2	339	3.7%
	21:00	42	1	0	1	89	7	1	1	108	13	2	1	32	1	1	2	302	3.3%
	22:00	20	0	0	1	82	6	1	0	99	12	2	1	25	1	0	1	251	2.7%
	23:00	27	1	0	1	61	5	1	0	70	8	1	0	13	0	0	1	189	2.1%
Sun,Sep-25-11	0:00	18	0	0	1	47	4	1	0	54	6	1	0	8	0	0	0	140	1.8%
	1:00	8	0	0	0	28	2	0	0	60	7	1	0	9	0	0	0	115	1.5%
	2:00	10	0	0	0	29	2	0	0	44	5	1	0	5	0	0	0	96	1.2%
	3:00	6	0	0	0	18	1	0	0	27	3	0	0	5	0	0	0	60	0.8%
	4:00	2	0	0	0	11	1	0	0	13	2	0	0	2	0	0	0	31	0.4%
	5:00	1	0	0	0	12	1	0	0	18	2	0	0	2	0	0	0	36	0.5%
	6:00	3	0	0	0	26	2	0	0	25	3	0	0	2	0	0	0	61	0.8%
	7:00	9	0	0	0	37	3	0	0	46	5	1	0	11	0	0	1	113	1.4%
	8:00	18	0	0	1	82	6	1	0	80	10	1	1	16	0	0	1	217	2.8%
	9:00	62	1	0	2	139	11	1	1	139	17	2	1	42	1	1	2	422	5.4%
	10:00	70	2	1	2	134	11	1	1	129	15	2	1	52	1	1	3	426	5.4%
	11:00	105	2	1	3	172	14	2	1	202	24	3	1	55	1	1	3	590	7.5%
	12:00	101	2	1	3	202	16	2	1	255	30	4	2	93	2	2	5	721	9.2%
	13:00	116	3	1	3	190	15	2	1	225	27	4	2	85	2	2	5	683	8.7%
	14:00	106	2	1	3	198	16	2	1	233	28	4	2	62	2	1	3	664	8.5%
	15:00	106	2	1	3	190	15	2	1	193	23	3	1	79	2	1	4	626	8.0%
	16:00	91	2	1	3	154	12	2	1	200	24	3	1	49	1	1	3	548	7.0%
	17:00	101	2	1	3	192	15	2	1	185	22	3	1	56	1	1	3	589	7.5%
	18:00	64	1	0	2	120	9	1	1	151	18	2	1	43	1	1	2	417	5.3%
	19:00	65	1	0	2	120	9	1	1	131	16	2	1	47	1	1	3	401	5.1%
	20:00	59	1	0	2	110	9	1	1	121	14	2	1	35	1	1	2	360	4.6%
	21:00	44	1	0	1	84	7	1	0	82	10	1	1	17	0	0	1	250	3.2%
	22:00	25	1	0	1	46	4	0	0	67	8	1	0	14	0	0	1	168	2.1%
	23:00	11	0	0	0	34	3	0	0	47	6	1	0	1	0	0	0	103	1.3%

Table A4: Summary of Traffic Counts – Albert St Diverted (Sep 24 to 25, 2011)

		EB, curb (lane 1)				EB, inside (lane 2)				WB, inside (lane 3)				WB, curb (lane 4)				Totals	% Dist
Date	Hour Starting	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk	Cars	Pick-ups	Med Trk	Hvy Trk		
Sat,Sep-24-11	0:00	32	3	1	1	78	2	1	1	0	0	0	0	30	1	1	2	153	2.1%
	1:00	28	3	0	1	47	1	0	0	0	0	0	0	20	1	0	1	102	1.4%
	2:00	13	1	0	0	36	1	0	0	0	0	0	0	16	0	0	1	68	0.9%
	3:00	11	1	0	0	37	1	0	0	0	0	0	0	7	0	0	0	57	0.8%
	4:00	4	0	0	0	14	0	0	0	0	0	0	0	3	0	0	0	21	0.3%
	5:00	12	1	0	0	12	0	0	0	24	3	0	0	5	0	0	0	30	0.4%
	6:00	18	2	0	0	22	1	0	0	37	4	1	0	10	0	0	1	54	0.7%
	7:00	41	4	1	1	48	2	0	0	77	8	1	1	28	1	1	2	129	1.7%
	8:00	90	8	2	2	107	3	1	1	102	11	2	1	46	1	1	3	265	3.6%
	9:00	153	14	3	4	153	5	1	1	174	19	3	2	63	2	1	3	403	5.4%
	10:00	199	18	3	5	161	5	1	1	214	23	4	2	92	2	2	5	494	6.7%
	11:00	211	19	4	5	199	6	1	2	230	25	4	2	92	2	2	5	548	7.4%
	12:00	248	23	4	6	224	7	1	2	258	28	5	2	115	3	2	6	641	8.6%
	13:00	195	18	3	5	225	7	1	2	260	28	5	2	107	3	2	6	574	7.7%
	14:00	206	19	3	5	219	7	1	2	229	25	4	2	98	3	2	5	570	7.7%
	15:00	214	20	4	5	218	7	1	2	237	26	4	2	105	3	2	6	587	7.9%
	16:00	198	18	3	5	207	7	1	2	186	20	3	2	94	2	2	5	544	7.3%
	17:00	170	16	3	4	186	6	1	2	194	21	4	2	95	3	2	5	493	6.6%
	18:00	157	14	3	4	169	5	1	1	91	10	2	1	77	2	1	4	438	5.9%
	19:00	115	11	2	3	140	4	1	1	0	0	0	0	52	1	1	3	334	4.5%
	20:00	92	8	2	2	102	3	1	1	0	0	0	0	45	1	1	2	260	3.5%
	21:00	66	6	1	2	95	3	1	1	0	0	0	0	53	1	1	3	233	3.1%
	22:00	57	5	1	1	103	3	1	1	0	0	0	0	57	2	1	3	235	3.2%
	23:00	61	6	1	1	75	2	0	1	0	0	0	0	39	1	1	2	190	2.6%
Sun,Sep-25-11	0:00	45	4	1	1	69	2	0	1	0	0	0	0	27	1	0	1	152	2.6%
	1:00	37	3	1	1	47	1	0	0	0	0	0	0	21	1	0	1	113	1.9%
	2:00	23	2	0	1	46	1	0	0	0	0	0	0	15	0	0	1	89	1.5%
	3:00	12	1	0	0	34	1	0	0	0	0	0	0	9	0	0	0	57	1.0%
	4:00	9	1	0	0	14	0	0	0	0	0	0	0	7	0	0	0	31	0.5%
	5:00	7	1	0	0	17	1	0	0	0	0	0	0	5	0	0	0	31	0.5%
	6:00	17	2	0	0	21	1	0	0	1	0	0	0	7	0	0	0	48	0.8%
	7:00	27	2	0	1	35	1	0	0	1	0	0	0	22	1	0	1	90	1.5%
	8:00	54	5	1	1	73	2	0	1	0	0	0	0	25	1	0	1	164	2.8%
	9:00	99	9	2	2	102	3	1	1	0	0	0	0	62	2	1	3	287	4.8%
	10:00	118	11	2	3	134	4	1	1	0	0	0	0	63	2	1	3	343	5.8%
	11:00	139	13	2	3	179	6	1	1	0	0	0	0	72	2	1	4	423	7.1%
	12:00	176	16	3	4	187	6	1	2	0	0	0	0	93	2	2	5	497	8.4%
	13:00	157	14	3	4	207	7	1	2	0	0	0	0	99	3	2	5	504	8.5%
	14:00	156	14	3	4	167	5	1	1	0	0	0	0	91	2	2	5	451	7.6%
	15:00	148	14	2	3	180	6	1	2	0	0	0	0	89	2	2	5	454	7.7%
	16:00	133	12	2	3	173	5	1	1	0	0	0	0	77	2	1	4	414	7.0%
	17:00	167	15	3	4	169	5	1	1	0	0	0	0	81	2	1	4	453	7.7%
	18:00	108	10	2	2	131	4	1	1	0	0	0	0	71	2	1	4	337	5.7%
	19:00	101	9	2	2	123	4	1	1	0	0	0	0	55	1	1	3	303	5.1%
	20:00	83	8	1	2	104	3	1	1	0	0	0	0	45	1	1	2	252	4.3%
	21:00	56	5	1	1	83	3	1	1	0	0	0	0	37	1	1	2	192	3.2%
	22:00	42	4	1	1	50	2	0	0	0	0	0	0	35	1	1	2	139	2.3%
	23:00	34	3	1	1	40	1	0	0	0	0	0	0	15	0	0	1	96	1.6%

Table A5: Summary of Bus Totals (Route 94 to 98)

Hour Starting	Count	% Distr
0	19	2%
1	14	2%
2	9	1%
3	5	1%
4	4	1%
5	12	2%
6	17	2%
7	24	3%
8	27	3%
9	42	5%
10	48	6%
11	48	6%
12	51	7%
13	52	7%
14	52	7%
15	52	7%
16	53	7%
17	53	7%
18	48	6%
19	41	5%
20	32	4%
21	32	4%
22	22	3%
23	20	3%

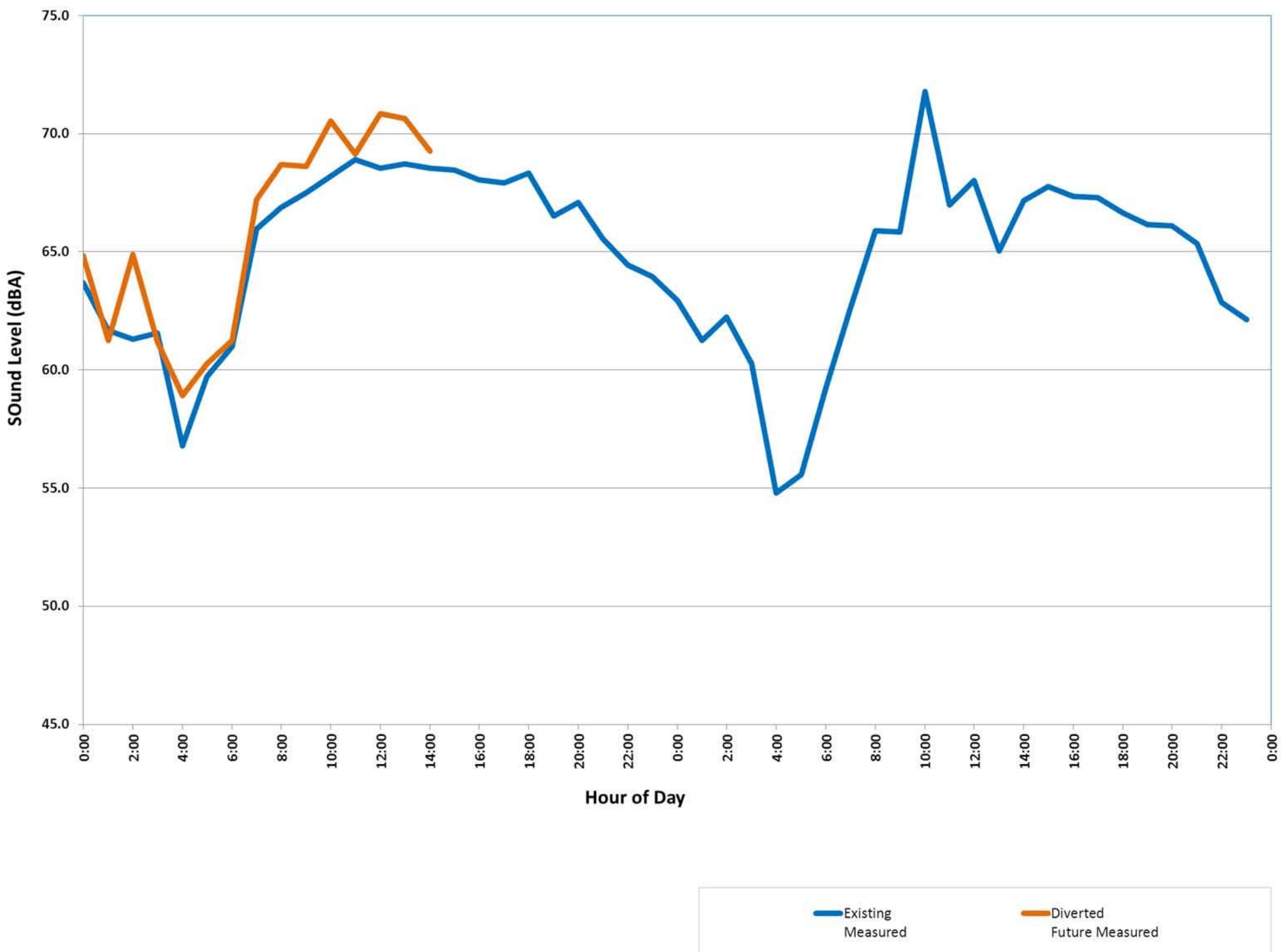
Table A5: Summary of Bus Totals (Route 16, Weekend Traffic)

Hour	Sat				Sun			
Starting	DirA	SwitchDir	Total	%	DirA	SwitchDir	Total	%
0			0	0%			0	0%
1			0	0%			0	0%
2			0	0%			0	0%
3			0	0%			0	0%
4			0	0%			0	0%
5			0	0%			0	0%
6			0	0%			0	0%
7	2	2	4	5%			0	0%
8	3	2	5	6%	1	1	2	3%
9	2	2	4	5%	1	2	3	4%
10	2	3	5	6%	1	2	3	4%
11	2	4	6	7%	2	4	6	9%
12	2	4	6	7%	2	4	6	9%
13	2	4	6	7%	2	4	6	9%
14	2	4	6	7%	2	4	6	9%
15	2	4	6	7%	2	4	6	9%
16	2	4	6	7%	2	4	6	9%
17	2	4	6	7%	2	4	6	9%
18	2	3	5	6%	2	2	4	6%
19	2	2	4	5%	2	2	4	6%
20	2	2	4	5%	2	2	4	6%
21	1	2	3	4%	2	2	4	6%
22	1	2	3	4%	1	1	2	3%
23	1	1	2	2%	1	1	2	3%

Long Term Monitoring

- Sound level measurements were completed from the evening of Sept 9, 2011 to the morning of Sept 12, 2011 to capture existing road traffic noise
- Sound level measurements were completed from the evening of Sept 23, 2011 to the afternoon of Sept 24, 2011 to capture the transitway bypass condition noise.
- The location of the noise monitoring equipment (Location N1, N2 and N3) is shown in the Figures Section of the Report.
- Measurement conditions for both periods were appropriate for noise measurements (low wind, relative humidity below 95%) .
- Larson Davis 820 Sound Level Meters were used at Locations 1 and 2. A Larson Davis 824 Sound Level meter was used at Location 3.
- The instruments were calibrated at the beginning and end of the measurement periods.
- Sound level measurements were not completed at Location 2 on Sept 24, 2011 due to equipment vandalism. Measurement data could not be presented for this location.
- The results of the Long Term Monitoring is shown in **Figures A.1, A.2 and A.3** for Locations N1, N2 and N3, respectively.

Figure A.1: Location N1 - Scott Street and Pinehurst Ave



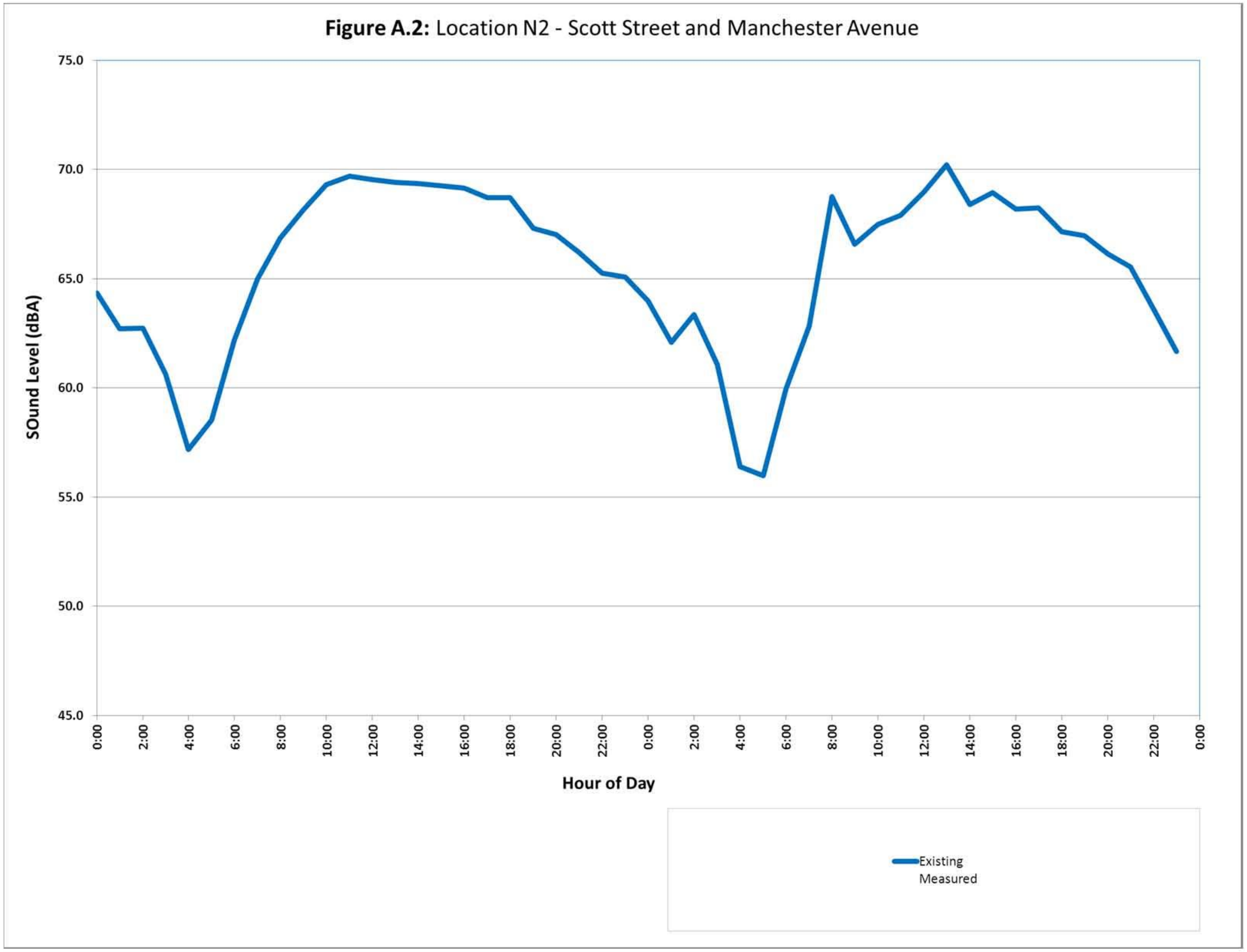
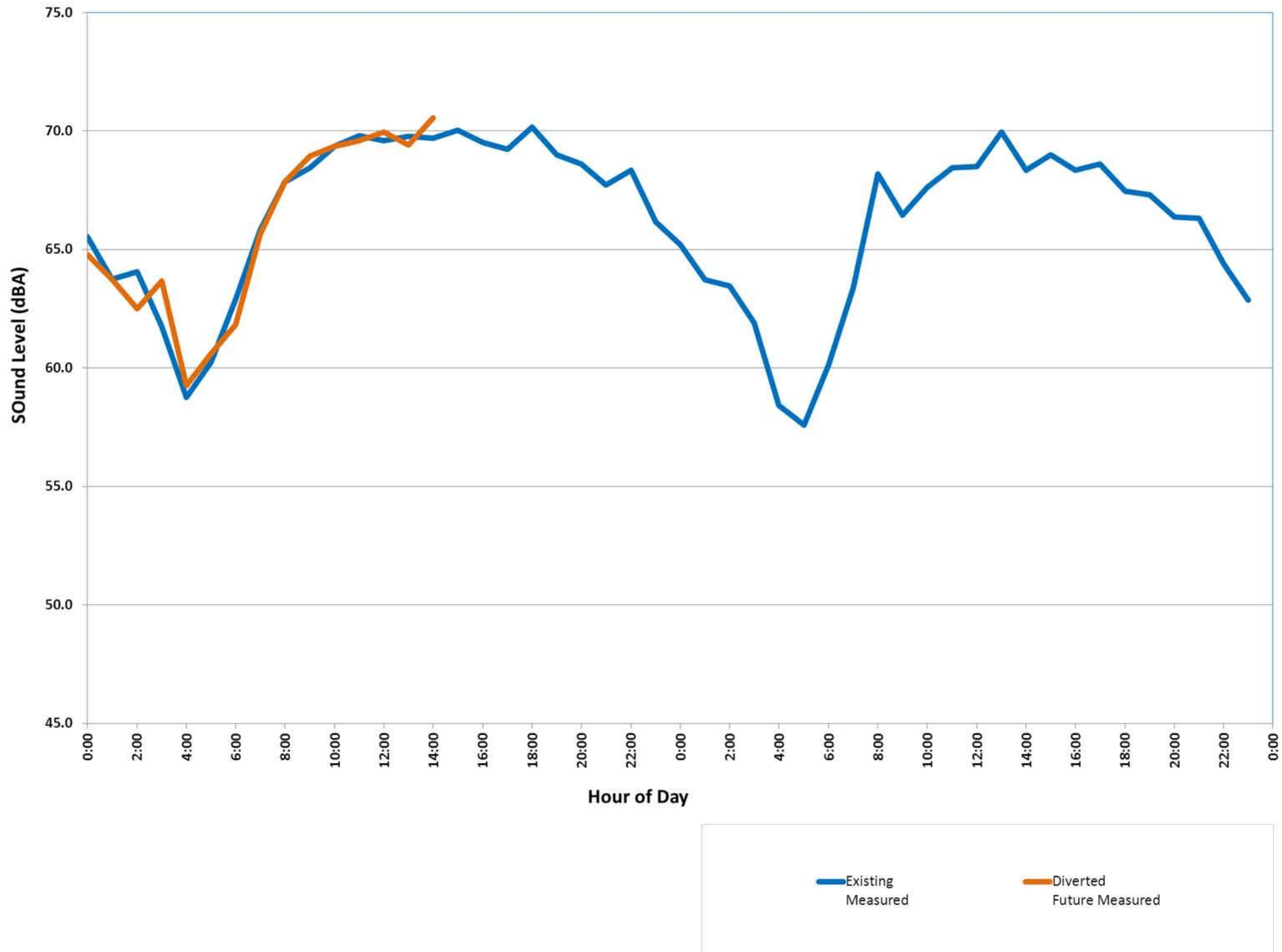


Figure A.2: Location N2 - Scott Street and Manchester Avenue
75.0
70.0
65.0
60.0
55.0
50.0
45.0
SOund Level (dBA)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Hour of Day
Existing Measured

Figure A.3: Location N3 - Albert Street, west of Preston Street



Short Term Monitoring

- Sound level measurements were completed on Sept 10 and 11, 2011 and again on Sept 24, 2011 to capture isolated vehicle pass-bys.
- Measurements were completed to capture sound levels for individual vehicle types (eg. car, truck, bus, etc.). An average value was calculated for each vehicle type and adjusted to assess impacts for each lane. The Average SELs, by vehicle type, are as follows:
    - Cars: 80.5 dBA at 4.2 m
    - Pickup Truck: 83.5 dBA at 4.2 m
    - Medium Truckk: 85.1 dBA at 4.2 m
    - Heavy Truck: 91.6 dBA at 4.2 m
    - Bus: 85.9 dBA at 4.2 m
    - But on Transitway: 76.6 dBA at 36.6 m
- Individual vehicles were captured with a combination logging (triggered by a threshold value) and individual vehicle pass-bys
- The measurement location (Location N4) is shown in Figure A.1.
- Measurement conditions for both periods were appropriate for noise measurements (low wind, relative humidity below 95%) .
- Larson Davis 824 Sound Level meters were used at Location N4.
- The instruments were calibrated at the beginning and end of the measurement periods.

APPENDIX B

SEL Modelling Approach

- Noise impact modeling was completed based on the Average Sound Exposure Levels (SEL) for each vehicle type, which includes cars, pick-up trucks, medium trucks, heavy trucks, buses, and buses on transitway, as discussed in **Appendix A**.
- Overall impacts at each measurement location were determined based on the individual SEL impacts for each vehicle type and lane.
- Traffic volumes were taken from the City of Ottawa traffic counts, shown in **Appendix A**.
- Traffic noise impacts were modelled for the ambient condition and the by-pass condition, where the by-pass condition considers all transitway buses operating along Scott Street/Albert Street for the entire 48-hour period.
- Figures showing the SEL modelled noise impacts and the Measured Sound Levels at each measurement location (Locations N1, N2, and N3) are shown in **Figures B.1, B.2 and B.3**, respectively.
- The SEL modelled noise impact for the school, near measurement location N4 is shown in **Figure B.4**. Note: These impacts were modelled at a setback distance equivalent to the School Façade with windows.

Comparison of SEL Modelled Impacts and Measured Sound Levels

- Based on a comparison of the ambient measured sound levels and ambient SEL modelled sound levels, a good correlation is generally shown
- The predicted difference between ambient and by-pass condition is consistent with the measured difference of approximately 2 dB during the by-pass periods.

Figure B.1: Location N1 - Scott Street and Pinehurst Ave

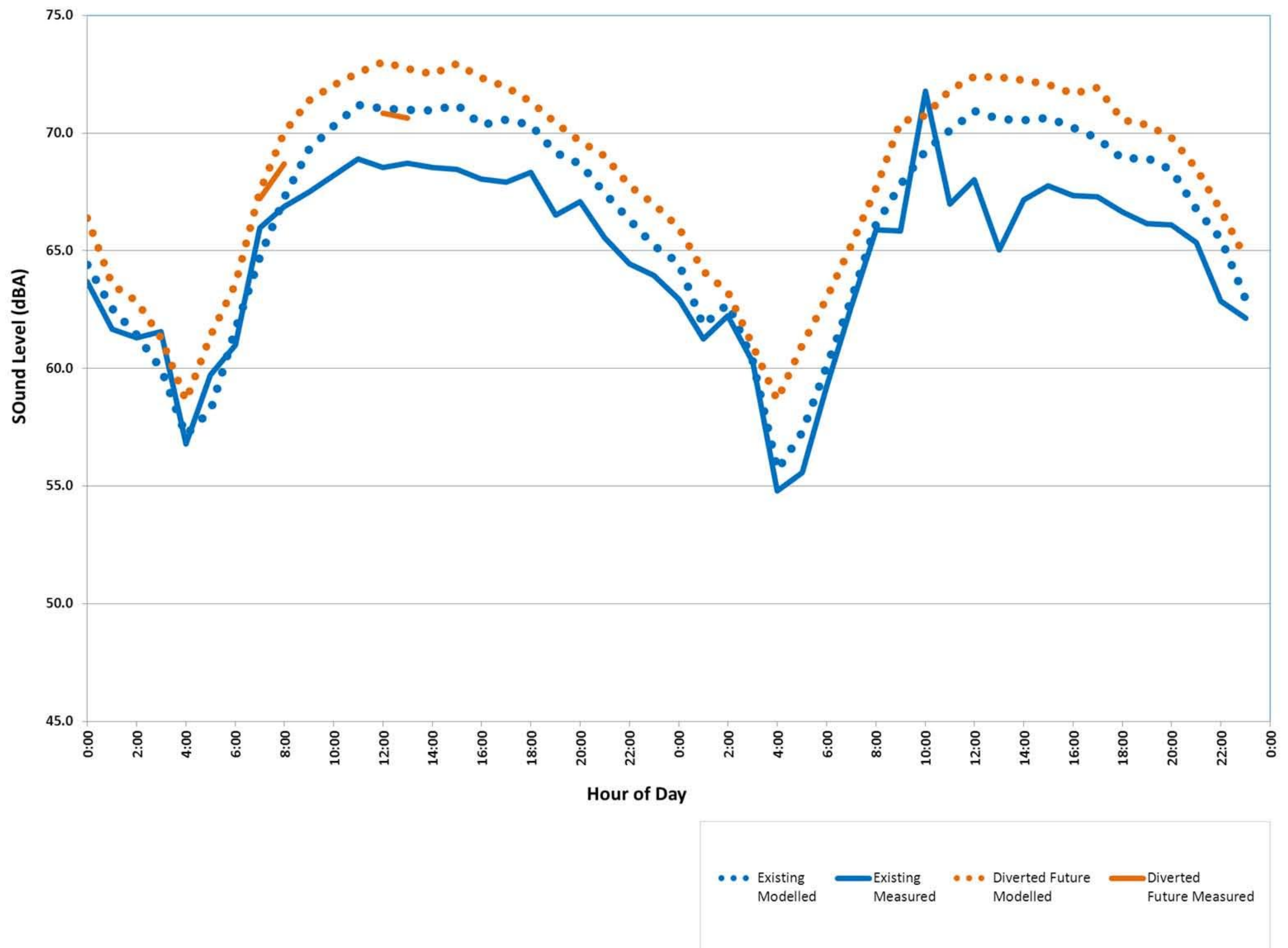
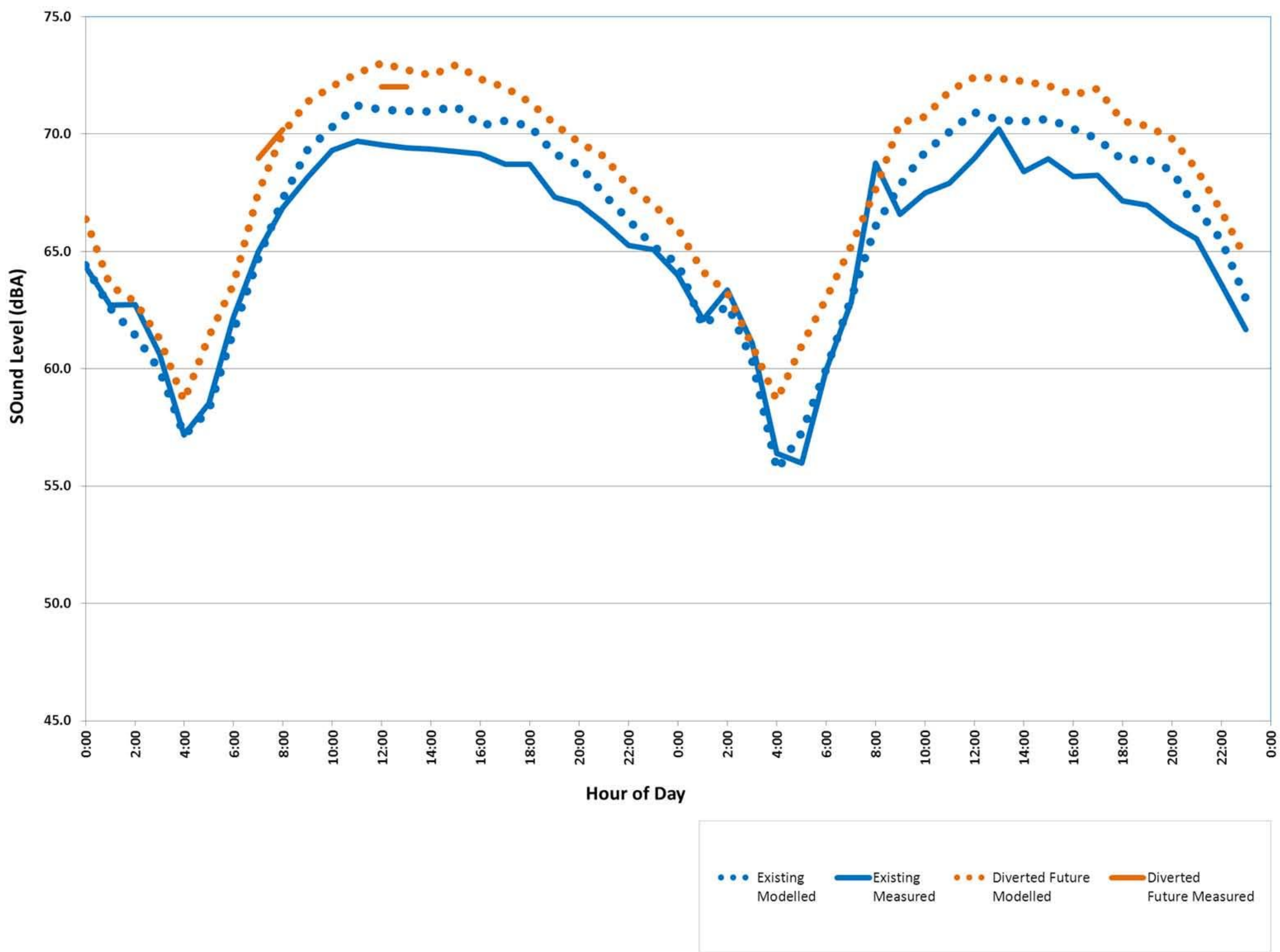


Figure B.2: Location N2 - Scott Street and Manchester Avenue



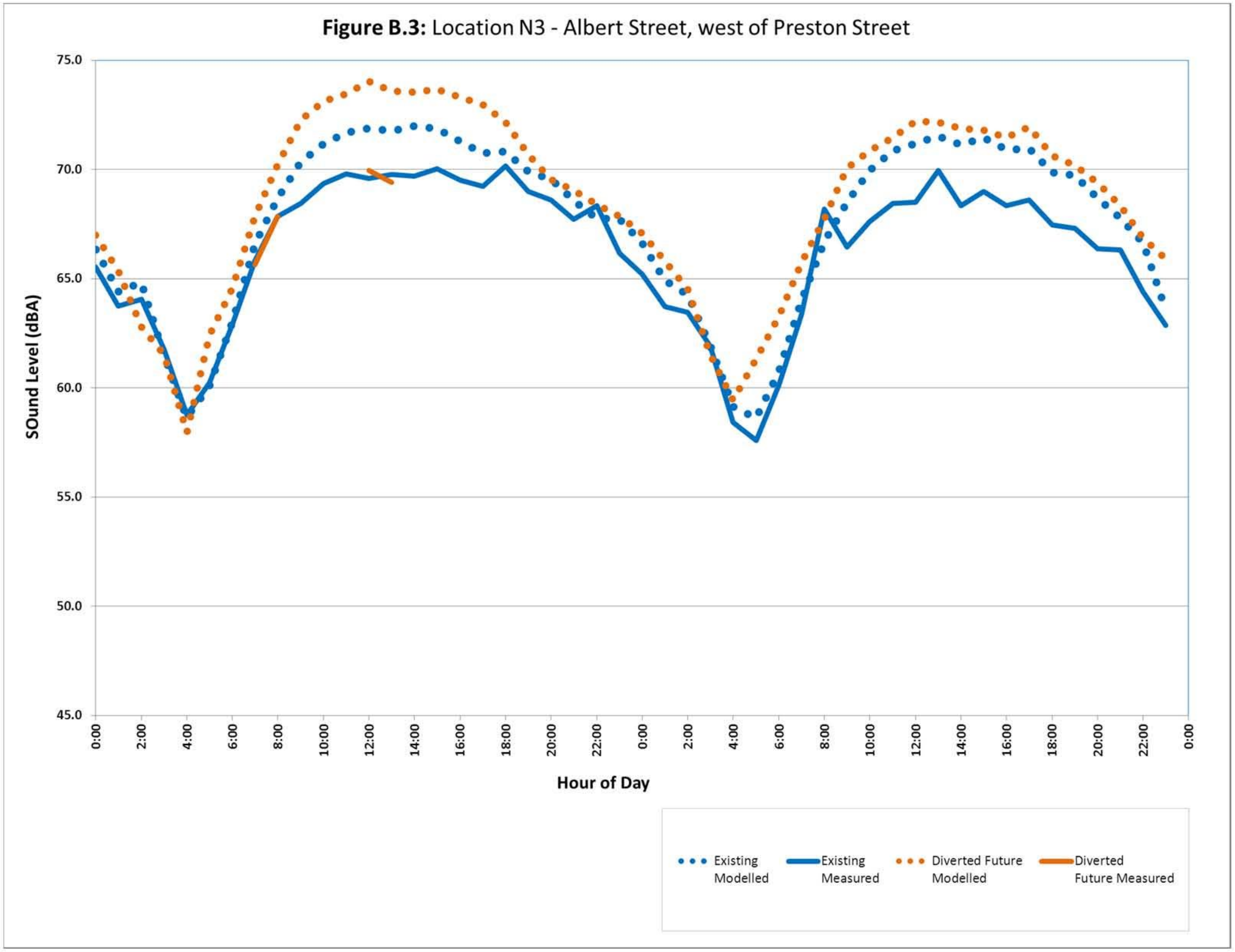


Figure B.3: Location N3 - Albert Street, west of Preston Street
75.0
70.0
65.0
60.0
55.0
50.0
45.0
SOund Level (dBA)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Hour of Day
Existing Modelled
Existing Measured
Diverted Future Modelled
Diverted Future Measured

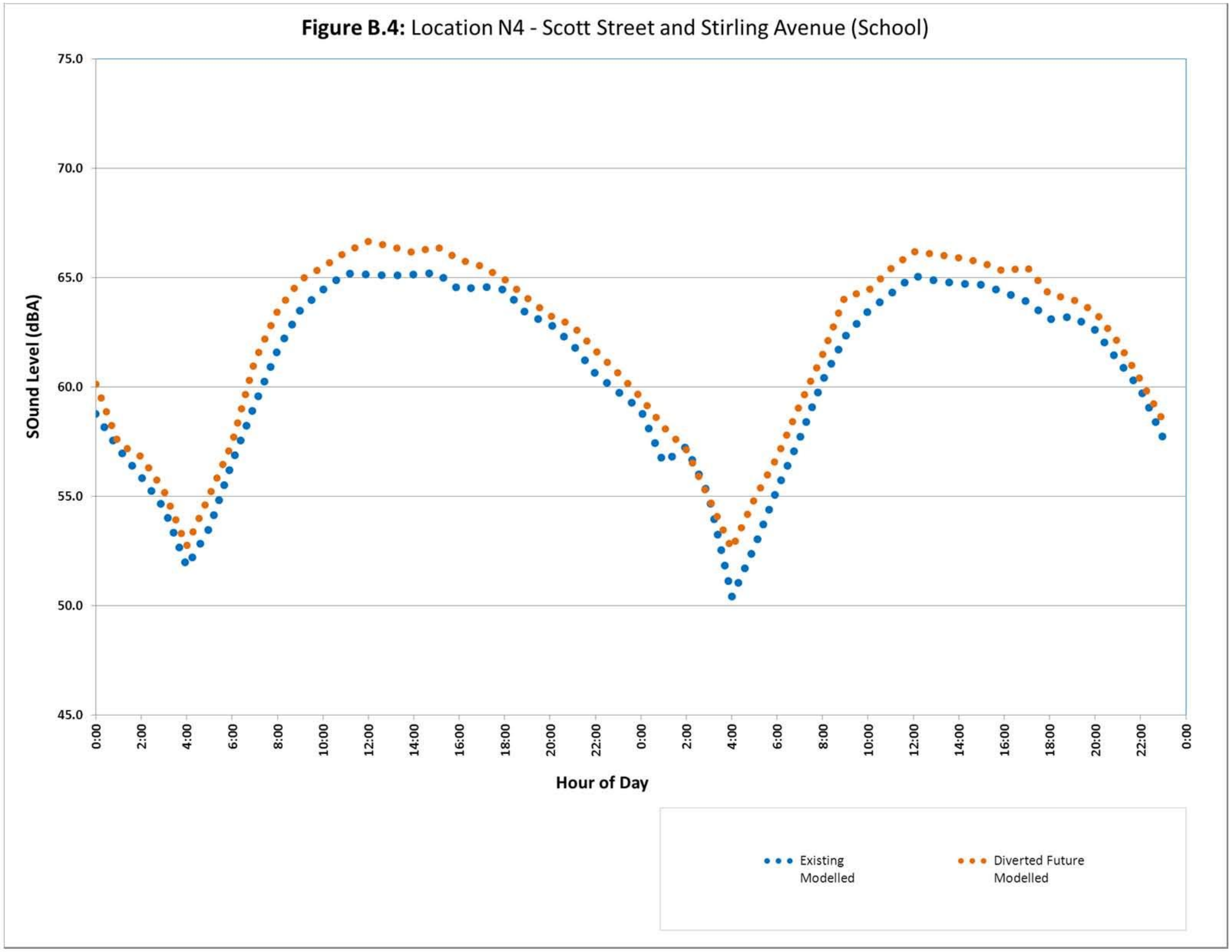


Figure B.4: Location N4 - Scott Street and Stirling Avenue (School)
75.0
70.0
65.0
60.0
55.0
50.0
45.0
SOund Level (dBA)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Hour of Day
Existing Modelled
Diverted Future Modelled

APPENDIX C

STAMSON Modelling Approach

- Noise impact modeling was completed using the ORNAMENT algorithms implemented in the MOE STAMSON software.
- Traffic volumes were taken from the City of Ottawa traffic counts, shown in **Appendix A**.
- In comparison to the SEL modelling approach, the vehicle traffic volumes were adjusted to combine the Cars and Pick-up Trucks, and Buses and Medium Trucks to accommodate the ORNAMENT vehicle types of Cars, Medium Trucks and Heavy Trucks.
- Due to distance limitations of the ORNAMENT/STAMSON modelling software, each lane of traffic was modelled individually and adjusted for distance based on a line-source propagation calculation (reflective ground was assumed). The individual lane impacts were cumulated to predict the overall roadway impact at a receptor.
- Vehicle speeds for each lane were provided in the City of Ottawa traffic counts. The Model vehicle speed was used to predict individual lane impacts.
- Traffic noise impacts were modelled for the ambient condition and the diversion condition, where the diversion condition considers all transitway buses operating along Scott Street/Albert Street for the entire 48-hour period.
- Figures showing the STAMSON/ORNAMENT modelled noise impacts and the Measured Sound Levels at each measurement location (Locations N1, N2, and N3) are shown in **Figures C.1, C.2 and C.3**, respectively.
- The STAMSON/ ORNAMENT modelled noise impact for the school, near measurement location N4 is shown in **Figure C.4**. Note: These impacts were modelled at a setback distance equivalent to the School Façade with windows.

Comparison of STAMSON Modelled Impacts and Measured Sound Levels

- Based on a comparison of the ambient measured sound levels and ambient STAMSON/ORNAMENT modelled sound levels, the results generally do not correlate well .
- This is likely due to the use of STAMSON/ORNAMENT outside of the recommended parameters.

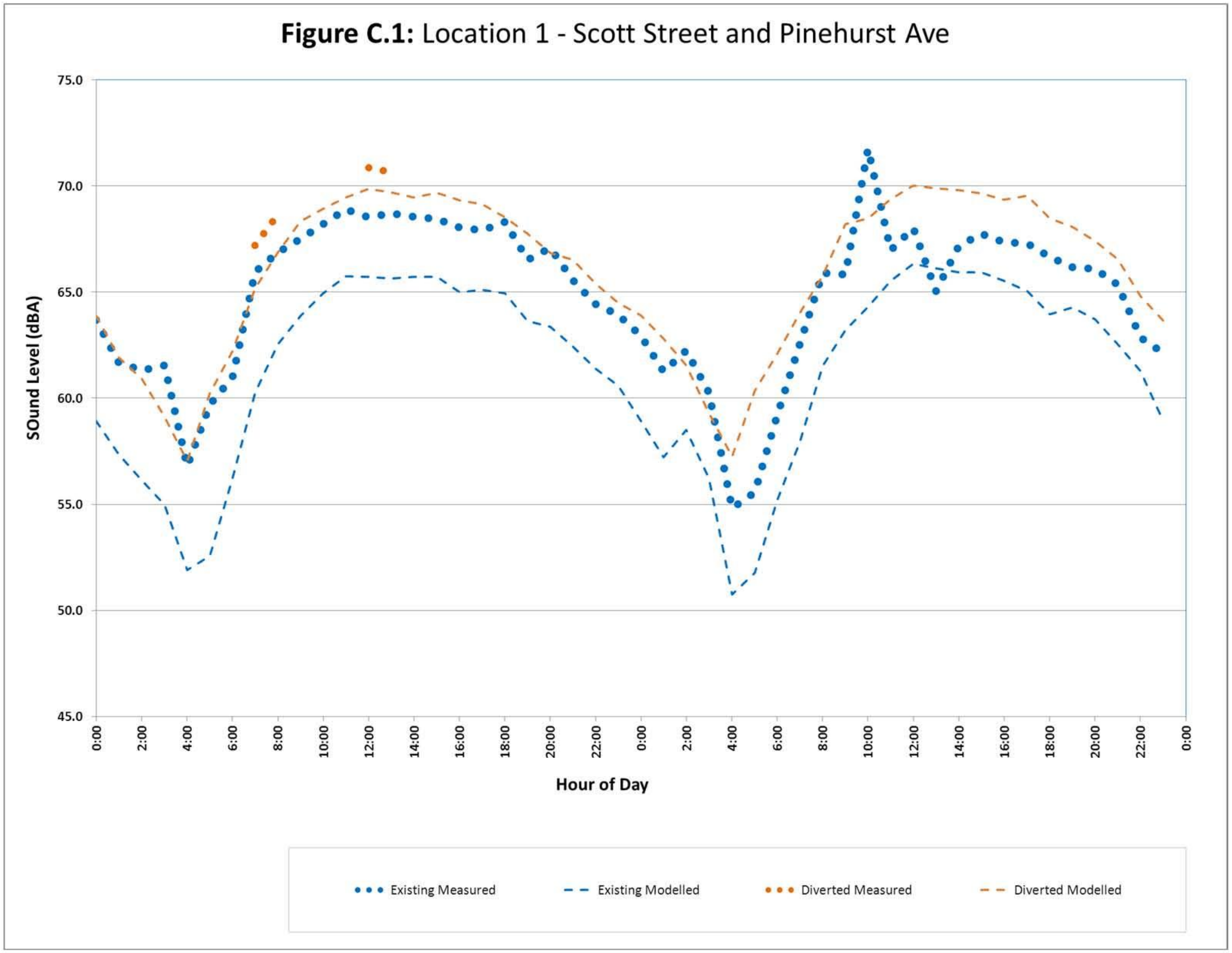


Figure C.1: Location 1 - Scott Street and Pinehurst Ave
75.0
70.0
65.0
60.0
55.0
50.0
45.0
SOund Level (dBA)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Hour of Day
Existing Measured
Existing Modelled
Diverted Measured
Diverted Modelled

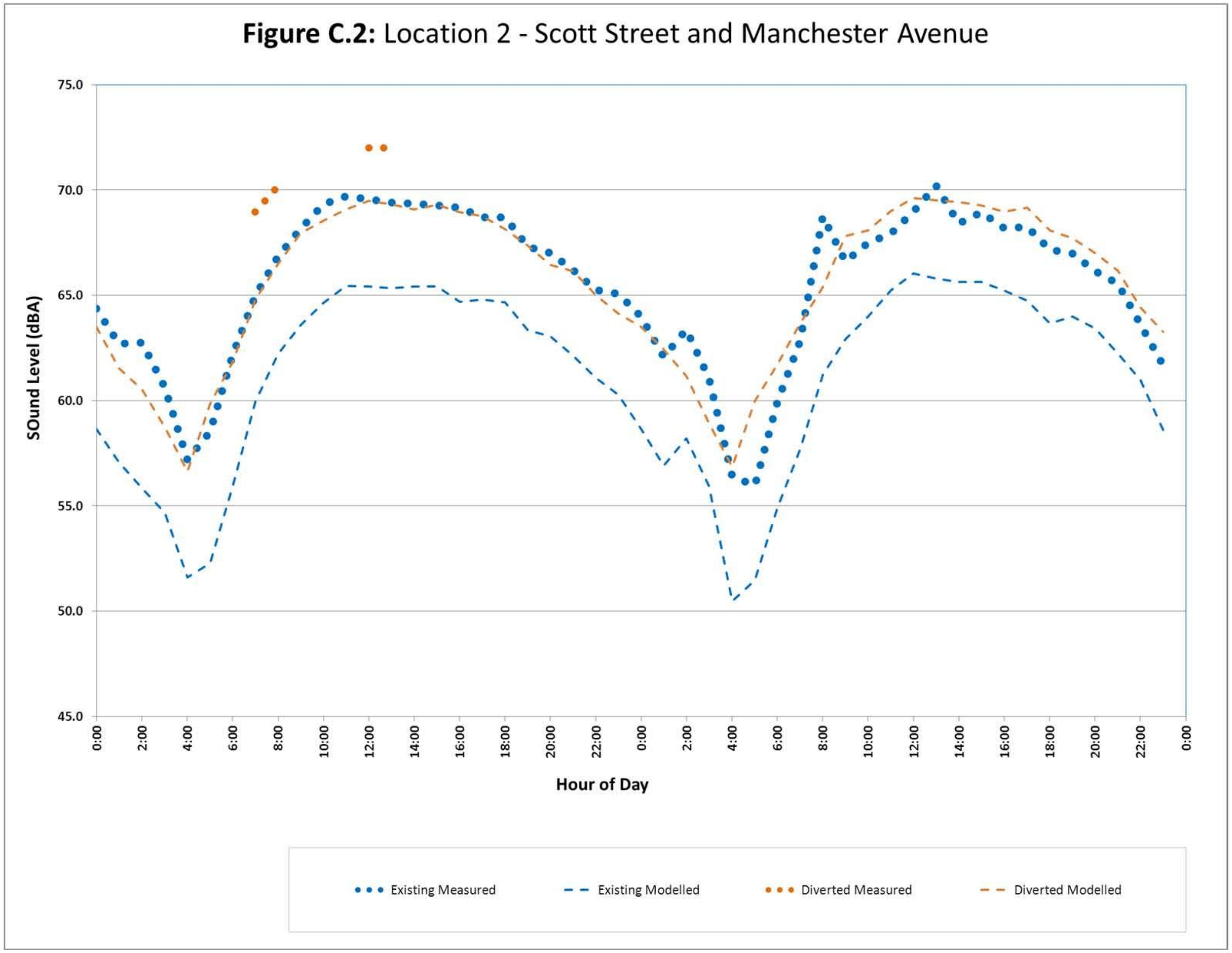


Figure C.2: Location 2 - Scott Street and Manchester Avenue
75.0
70.0
65.0
60.0
55.0
50.0
45.0
SOund Level (dBA)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
Hour of Day
Existing Measured
Existing Modelled
Diverted Measured
Diverted Modelled

Figure C.3: Location 3 - Albert Street, west of Preston Street

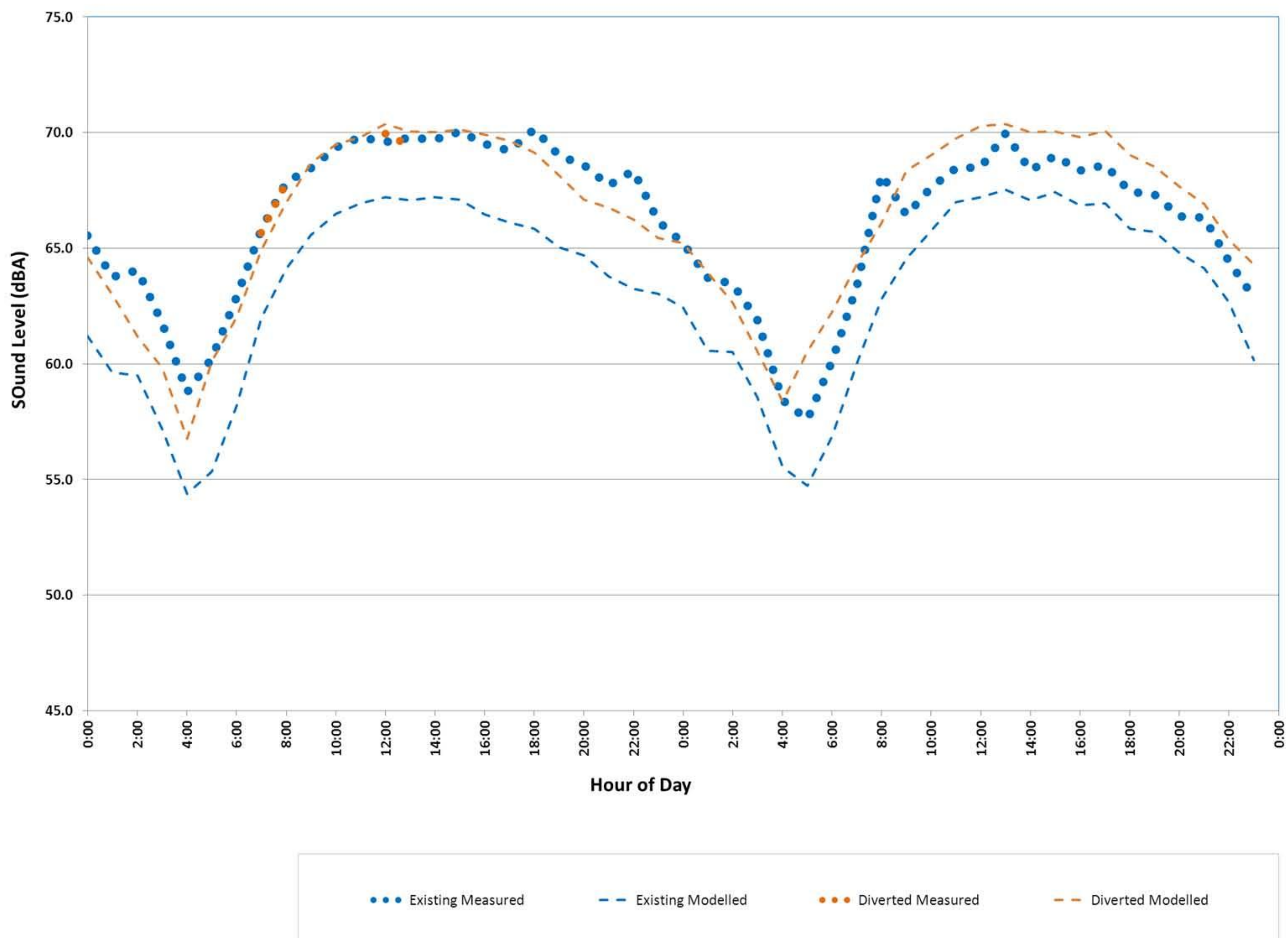


Figure C.4: Location 4 - Scott Street and Stirling Avenue (School)