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Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Noise Control Plan – Site 5A, 5B, 5C – February 15, 2017
Combined Sewage Storage Tunnel (CSST)
City of Ottawa Contract No. ISD14-2036
Ottawa, Ontario

Submitted to:

Dragados-Tomlinson Joint Venture
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Submitted by

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Noise Monitoring

Hugh Williamson Associates have been engaged by Explotech to provide the acoustical consulting services in relation to the preparation and implementation of the required Noise Control Plan to meet the requirements of Contract Specification 02482 for the CSST project.

The Noise Control Plan recommends noise mitigation specific to each site to ensure noise impacts from operations at nearby noise sensitive land uses are in compliance with relevant noise criteria contained in Contract Specification 02482. In addition the Noise Control Plan describes the noise monitoring protocol and notification procedures to be followed prior to and following commencement of the works at each site. Attached to this report as an appendix is the *Noise Control Plan for Combined Sewage Storage Tunnel – Site 5 Stanley Park & Vicinity.* Noise Control Plan information for remaining project sites will be prepared on an as required basis.

The Noise Control Plan detailed above represents a substantial and comprehensive program to assist in on site noise control and to facilitate resolution of any concerns or complaints which may arise over the course of the project. Should you require any additional information or clarification with regards to the above plan, please do not hesitate to contact our office at your leisure.

Kindest Regards,

Mitch Malcomson, P.Eng

HUGH WILLIAMSON ASSOCIATES INC.
Ottawa Ontario Canada

NOISE CONTROL PLAN FOR THE COMBINED SEWAGE STORAGE TUNNEL

SITE 5
STANLEY PARK & VICINITY

CITY OF OTTAWA

Prepared for

Explotech Engineering Ltd.

Prepared by

Hugh Williamson Associates Inc.

15th February 2017

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NOISE CONTROL PLAN FOR THE COMBINED SEWAGE STORAGE TUNNEL

SITE 5 STANLEY PARK & VICINITY

CITY OF OTTAWA

1.0 Introduction

Explotech Engineering Ltd. (Explotech) is providing Noise and Vibration Control recommendations and Monitoring Services to meet the requirements of the City of Ottawa specification Section 02482, for the Combined Sewage Storage Tunnel (CSST), Contract No. ISD14-2036, being constructed by Dragados-Tomlinson Joint Venture in the City of Ottawa. Hugh Williamson Associates has been engaged by Explotech to provide the acoustical consulting services in relation to the preparation of the required Noise Control Plan for each site.

This Noise Control Plan is based on a study of noise from equipment which is proposed for use at the Site 5, Staging Areas 5A, 5B and 5C, see Figure 1. City of Ottawa Specification 02482 sets thresholds for noise impacts due to site operations at nearby noise sensitive land uses. Where and if needed, the Noise Control Plan puts forward noise mitigation options based on the noise modelling and the relevant noise thresholds.

Noise monitoring will take place at various locations near Staging Areas 5A, 5B and 5C, before and during construction activities. Should the monitored noise data indicate that noise thresholds are being exceeded, then as per Specification 02482, the Contract Authority will be informed and noise control measures introduced or modified as needed. A more detailed description of noise monitoring procedures is contained in the Noise Control Plan for Site 10A.

Staging Areas 5A and 5B are located in Stanly Park. The closest and most affected points of reception (POR's) for activities at 5A and 5B are residences along the west side of Stanley Avenue plus residences and noise sensitive institutions (including Gary Armstrong Hospital and the Embassy of the Peoples Republic of China) to the south and west of Stanley Park.

Staging Area 5C is located at the intersection of Queen Victoria Street and River Lane. The closest and most affected points of reception for activities at 5C are residences in the vicinity

of the intersection.

Because of the above, this Noise Control Plan Report is split into two sections:

- Section 3 deals with noise control for Staging Areas 5A and 5B in Stanley Park, and,
- Section 4 deals with noise control for Staging Area 5C.

Section 2 describes Assessment Criteria and Noise Thresholds which are set in Specification Section 02482 and are common to all three Staging Areas.

Construction at Site 5 can be separated into two stages, Shaft Construction and Tunnelling

Shaft Construction occurs at 5A, 5B and 5C and consists of shaft excavation, using equipment such as excavators and hoe rams to create shafts which are approximately 16 m deep. The shafts will be reinforced where needed and lined with concrete. Shaft excavation is expected to commence in March 2017.

Tunneling and Muck Removal. Once the shafts are ready, then tunneling can commence. Between 5A and 5B, and, between 5B and 5C smaller tunnels will be dug using a micro tunneling machine which operates underground. The digging of the main east-west CSST tunnel, from 5A towards the downtown of Ottawa, will utilize a tunnel boring machine operating underground. The material excavated by the tunnel boring machine, called muck, will be moved underground by a rail car system, transported to the surface at 5A then taken away for disposal. The muck cars will be brought to the surface using a gantry crane, the muck emptied into stockpiles then loaded onto trucks and taken away for disposal. The detailed design of the muck removal processes and equipment at 5A is still under development. Muck removal from 5A is anticipated to commence approximately a year after the start of shaft construction.

This Noise Control Plan considers noise from shaft construction at 5A, 5B and 5C. It is anticipated that shaft construction, particularly hoe ramming and rock drilling, will create the greatest noise impacts at nearby residences compared to noise generated during the subsequent tunneling and muck removal operation. Noise control for the muck removal operation at Staging Area 5A is being developed along with the detailed design of the muck removal operation and will be the subject of a separate Noise Control Plan.

Noise levels will be monitored at 5A, 5B and 5C throughout the whole of the construction process. The details of construction activities cannot be fully anticipated because operations will vary due to local conditions, circumstances and events. This document presents a noise control plan, however, it is anticipated that noise mitigation measures will likely evolve, guided by the noise monitoring, as the project proceeds in order to ensure that the noise thresholds are met.

2.0 Assessment Criteria & Sound Level Thresholds

The City of Ottawa *Combined Sewage Storage Tunnel Specification, Section 02482*[1] specifies noise thresholds for on-site operations for various periods of operation and types of noise. The limits are summarized in Table 1 below.

It is noted that the noise thresholds have been set in terms of Lmax, the maximum sound level occurring over a period of time. (See the Terminology section of this report for explanations of acoustical terminology.) The assessment in this report is in terms of Lmax, and, the monitoring which is to take place during construction will also be in terms of Lmax.

Table 1: Noise Thresholds

Day	Time	Noise Threshold (Lmax)
Monday – Friday	07:00 – 19:00	130 dBA*
Monday – Friday	19:00 – 22:00	70 dBA
Monday – Friday	22:00 – 07:00	65 dBA
Saturday - Sunday	08:00 – 17:00	70 dBA
Saturday – Sunday	17:00 – 22:00	70 dBA
Saturday - Sunday	22:00 – 08:00	65 dBA

*When operating within 30 m of a classroom or a childcare facility additional conditions apply. Site reconnaissance determined no classrooms or childcare facilities are in close proximity to Site 5.

3.0 Noise Control for Shaft Construction 5A and 5B

This report is concerned with noise from shaft construction. A separate noise control report will be prepared for the primary muck removal operation to be located at 5A.

3.1 Staging Areas 5A and 5B and Surrounding Area Summary

Staging Areas 5A and 5B are shown in Figure 2 along with nearby points of reception which have been chosen to be representative on noise sensitive locations most affected by noise in various directions. The selected points of reception (POR's) are listed in Table A1 along with distances to the primary excavation locations at sites 5A, 5B and 5C. From Figures 1 and 2, and the distances in Table 1A, it can be seen that the Stanley Avenue Receptors and the South and West Receptors, POR1 to POR15, represent the closest receptors in various directions form excavation sites 5A and 5B.

Apart from residences located near busy roads, such as King Edward Avenue, most residences are subject to background noise from more distant traffic.

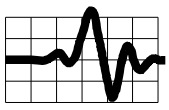
3.2 Activity and Noise Source Summary for 5A and 5B

The main shaft at 5A will be a main access shaft for the East-West tunnel of CSST. A second smaller shaft, known as the IOS shaft will also be constructed at 5A. Once the access shafts are complete and underground tunneling is underway, most of the muck from the East-West Tunnel will be brought to the surface at 5A where it will be hauled away in haulage trucks using the Haul Route shown in Figure 3.

A second access shaft is to be constructed at 5B.

The equipment to be used for excavating and constructing shafts at 5A and 5B include the following.

- Hoe rams
- Rock drills
- Excavators, equipped with a shovel or clam
- Loaders
- Skid steers
- Concrete Trucks
- Concrete Pumps
- Water pumps, for removing ground water from shafts and tunnels during construction.
- Diesel generators, to power pumps and ancillary equipment, if hydro power is not available.



The equipment used to haul away the muck from 5A or 5B shaft construction will be as follows.

- Wheeled loader to load the trucks
- Haulage Trucks, arriving and leaving via the Haul Route.

Not all of the above equipment will be on the 5A/5B site all the time, and there will be times when only a few pieces of equipment are on site.

The typical levels of noise from various construction equipment at various distances are shown in Table A2 in terms of Lmax. It can be seen that hoe ramming and rock drilling are the noisiest operations, with noise from an excavator or loader being approximately 10 dBA less noisy. Noise from a slow moving truck, such as a haulage truck moving along the Haul Route, tends to make approximately 9 dBA less noise than loaders and excavators.

The project noise criteria is in terms of Lmax, maximum noise level which occurs over very brief periods of time, fractions of a second, for most equipment. When several items of equipment are operating simultaneously, it is unlikely that sound maxima will occur simultaneously, especially for percussive equipment such as a hoe ram or hydraulic rock drill. This implies that Lmax is generally not cumulative when several items of equipment are working simultaneously. For noise estimation purposes, worst cases for the various types of construction operation have been taken as follows.

- Excavation: Approximately the first 3.5 m of excavation for a shaft will be loose material which will be removed using an excavator. Hoe ramming or rock drilling will commence once solid rock occurs. Hoe Ram noise will be considered the worst case noise for the excavation process and has similar noise levels to rock drilling.

- Removal of Muck: Wheeled loader noise, loading trucks, will be the worst case noise source at 5A. Similar noise levels are expected for general site works at either 5A or 5B.

- Slow Truck Movements: Trucks arriving and departing along the haul route will pass relatively close to the rear of houses on Stanley Avenue. This has been considered as a worst case for slow truck movements.

Lmax noise levels for the above scenarios have been calculated using an acoustic model described in the next section.

3.3 Calculation of Lmax Levels and Discussion

Noise calculations were carried out using standard methods which are acceptable to the City of Ottawa and the Ministry of Environment and Climate Change. The method is based on an International Standards Organization standard for outdoor sound propagation[2], which is implemented in a software package called CadnaA. The method takes into account the strengths of the noise sources (sound powers) including the following factors.

- Distance attenuation is based on spherical spreading.
- Atmospheric attenuation.
- Ground attenuations, as appropriate.
- Barrier attenuation, buildings for example, as appropriate.
- Heights of points of reception and noise sources.

Using the operational scenarios discussed the previous section, Lmax sound levels were calculated at all points of reception, see Table A3. A summary of the greatest impacts is presented in Table 2. Plots of noise contours for hoe ram operations at 5A and 5B are contained in Figures 5 and 6.

Table 2: Summary of Calculated Lmax Sound Levels for Various Operations at 5A and 5B, and Operational Implications

Operational Scenario	Calculated Highest Lmax Sound Levels at Stanley Ave and South & West Points of Reception*	Operational Implications to meet Project Noise Thresholds (Table 1)
Hoe Ram or Rock Drill at 5A	70 dBA at nearest POR's	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday
Loader, Skid steer or similar at 5A	66 dBA at nearest POR's	Operations limited to: 7 a.m. to 10 p.m. Monday to Friday 7 a.m. to 10 p.m. Saturday and Sunday
Truck & Loader at 5A	76 dBA at nearest POR to haul route	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday
Hoe Ram or Rock Drill at 5B	79 dBA at nearest POR	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday
Loader at 5A	75 dBA at nearest POR's	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday

* See Table A3 for a full list of calculated impacts at all Points of Reception (POR's)

The noise levels in Table 2 assume that no mitigation measures, such as local noise barriers are present. A local barrier shielding a particular operation will typically provide 5 to 10 dBA reduction in noise levels at receivers, depending on barrier height and location.

It may be possible to extend the allowable operating time for operation of a Hoe Ram or Rock Drilling at 5A using a local barrier.

Hoe ramming or rock drilling will start once the shaft is approximately 3.5 m deep. The initial hoe ramming, approximately 3.5 m below grade, will produce the worst case noise impacts. As the shaft deepens, the walls of the shaft become more effective noise barriers and the level of noise impact at surrounding points of reception decreases significantly. Once the shaft is 10 or more m deep, the walls of the shaft provide very significant noise mitigation for hoe ramming, rock drilling or any operation down the shaft.

It is recommended that monitoring data be reviewed during operations to see if the above time restrictions are still appropriate.

3.4 Noise Control for Operations at 5A and 5B

The following noise control measures are recommended for CSST operations at Staging Areas 5A and 5B.

3.4.1 Excavation of Shafts at 5A and 5B

- For initial operations, excavation using a hoe ram or rock drill is to be limited to Monday to Friday, 7 a.m. to 7 p.m.

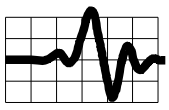
- Based on noise monitoring, the times of excavation operations using a hoe ram or rock drill may be increased provided that the project noise thresholds, Table 1, are met.

- Based on monitoring and the use of local barriers or changes in the type of excavation operation, the times for excavation may be increased provided that the project noise thresholds, Table 1, are met.

3.4.2 Loading and Hauling Muck from 5A Shaft Excavation

- Initial loading and hauling operations are to be limited to Monday to Friday, 7 a.m. to 7 p.m.

- Based on noise monitoring, the times for loading and hauling may be



increased provided that the project noise thresholds, Table 1, are met.

- Haulage trucks shall not exceed a speed of 20 km/hour while on the Haul Route, and, haulage trucks shall not use compression brakes (Jake Brakes) on the Haul Route or on residential streets.

3.4.3 General Construction Operations at 5A and 5B

- General construction operations means operations using mechanized equipment such as loaders, skid steers and similar equipment at 5A or 5B, but not including hoe rams or rock drills.

- General Construction Operations are to be limited to:
  - Monday to Friday, 7 a.m. to 10 p.m., and,
  - Saturday and Sunday, 8 a.m. to 10 p.m.

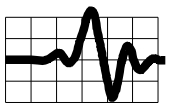
- Based on noise monitoring for specific types of General Construction Operations, the times of operations for specific types of General Construction Operations may be increased provided that the project noise thresholds, Table 1, are met.

3.4.4 Main East-West Tunneling Operation

The main east-west tunneling operation utilizes a tunnel boring machine operating underground which is not in itself expected to result in any significant noise at the surface. Muck from the east-west tunneling operation will be brought to the surface at Site 5A which will generate some surface noise, along with other surface equipment such as fans associated with tunneling.

This tunneling operation is planned to be a 24-hour operation, however, the plan is to remove muck by trucks from Site 5A only during the day, 7 a.m. to 7 p.m., with muck being stockpiled during the night.

A separate study of noise at 5A from this main east-west tunneling operation will be prepared as soon as the details of the operations are available. Noise mitigation will be planned as needed to ensure that noise from the process will meet the project noise thresholds. In addition, noise monitoring will occur throughout the tunneling period to ensure that noises thresholds are met.



4.0 Noise Control for Staging Area 5C

4.1 Staging Area 5C and Surrounding Area Summary

Staging Area 5C is located at the intersection of Queen Victoria Street and River Lane. Figure 4 shows Staging Area 5C and the surrounding areas. The selected points of reception (POR's) are listed in Table A1 along with distances to the excavation sites 5A, 5B and 5C. It can be seen that the distances between the operation and shaft at 5C and nearby POR's is small compared to the distance between operations and POR's for 5A and 5B.

The residences near 5C are located in a relatively quiet area, away from any major or busy roads. Background sound levels are likely to be typical of a quiet urban area.

4.2 Activity and Noise Source Summary for 5C

It is understood that an access shaft is to be constructed at 5C

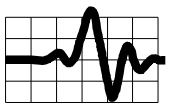
The equipment to be used for excavating and constructing shaft at 5C may include the following.

- Hoe rams
- Rock drills
- Excavator, equipped with a shovel
- Loaders
- Skid steers
- Concrete Trucks
- Concrete Pumps

Not all of the above equipment will be on site all the time, and there will be times when only a few pieces of equipment are on site.

The typical levels of noise from various construction equipment at various distances are shown in Table A2 in terms of Lmax. It can be seen that rock drilling and hoe ramming are the noisiest operations, with noise from an excavator or loader being approximately 10 dBA less noisy.

The project noise criteria is in terms of Lmax, maximum noise level which occurs over very brief periods of time, fractions of a second, for most equipment. When several items of equipment are operating simultaneously, it is unlikely that sound maxima will occur simultaneously, especially for percussive equipment such as a hoe ram or hydraulic rock drill. This implies that Lmax is generally not cumulative when several items of equipment are



working simultaneously. For noise estimation purposes, worst cases for the various types of construction operation would be as follows.

- Excavation: Hoe Ram noise will be considered the worst case noise for the excavation process and has similar noise levels to rock drilling.

- General Construction Operations: Operation of loaders, skid steers and similar equipment, but not including hoe rams or rock drills.

Lmax noise levels for the above scenarios have been calculated using an acoustic model described in the next section.

4.3 Calculation of Lmax Levels and Discussion

Noise calculations were carried out using standard methods which are acceptable to the City of Ottawa and the Ministry of Environment and Climate Change. The method is based on an International Standards Organization standard for outdoor sound propagation[2], which is implemented in a software package called CadnaA. The method takes into account the strengths of the noise sources (sound powers) including the following factors.

- Distance attenuation is based on spherical spreading.
- Atmospheric attenuation.
- Ground attenuations, as appropriate.
- Barrier attenuation, buildings for example, as appropriate.
- Heights of points of reception and noise sources.

Using the operational scenarios discussed the previous section, Lmax sound levels were calculated at all points of reception, see Table A4. A summary of the greatest impacts is presented in Table 3. A plot of noise contours for hoe ram operations at 5C is contained in Figure 7.

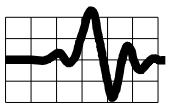


Table 3: Summary of Calculated Lmax Sound Levels for Various Operations at 5C, and Operational Implications

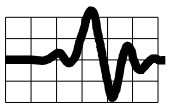
Operational Scenario	Calculated Highest Lmax Sound Levels at Queen Victoria Points of Reception*	Operational Implications to meet Project Noise Thresholds (Table 1)
Hoe Ram or Rock Drill at 5C No Barrier	98 dBA at nearest POR	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday
Hoe Ram or Rock Drill at 5C With Barrier	83 dBA at nearest POR	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday
Loader, Skid steer or similar at C No Barrier	92 dBA at nearest POR	Operations limited to: 7 a.m. to 10 p.m. Monday to Friday
Loader, Skid steer or similar at C With Barrier	80 dBA at nearest POR	Operations limited to: 7 a.m. to 7 p.m. Monday to Friday

* See Table A4 for a full list of calculated impacts at all Points of Reception (POR's)

Noise levels in Table 3 are calculated with and without a local noise barrier. In this case the local noise barrier is assumed to be located at the boundary fence for Staging Area 5C, built to a height of 5 m. This height of barrier will shield passing pedestrians and the main floors of adjacent residences and provide significant noise reduction on the second floors of the residences.

Hoe ramming or rock drilling will start once the shaft is approximately 3.5 m deep. The initial hoe ramming, approximately 3.5 m below grade, will produce the worst case noise impacts. As the shaft deepens, the walls of the shaft become more effective noise barriers and the level of noise impact at surrounding points of reception decreases significantly. Once the shaft is 10 or more m deep, the walls of the shaft provide very significant noise mitigation for hoe ramming, rock drilling or any operation down the shaft.

Although the above calculated sound levels are below the Project Monday to Friday daytime limit of 130 dBA, it is noted that the calculated Lmax sound level during excavation without a barrier is 98 dBA, significantly higher than the maximum calculated Lmax for operations at 5A or 5B. A 5 m high noise barrier located at the 5C Staging Area boundary is recommended to provide residences and passing pedestrians an approximate 15 dBA reduction in noise levels.



Extending operating hours beyond Monday to Friday, 7 a.m. to 7 p.m. is not recommended at this location due to the close proximity of the POR's.

Ground Borne Vibration and Noise from Hoe Rams or Rock Drills

The estimated sound Tables 3 and A3 are based on airborne noise from construction equipment, that is, noise emitted by the construction equipment which transmits through the air to the points of reception. For buildings close to the operation of excavation equipment such as a hoe ram or rock drill, ground borne noise also occurs, that is, vibrations from the operation transmit through the ground to the foundations of the building where they become noise within the building. The extent and level of ground borne noise within a building in this situation cannot be predicted as it depends on many unknown factors such as ground conditions and building construction, but, it is more likely to be significant when buildings or houses are as close to an excavation site as is the case at 5C. Generally there is no way to mitigate ground borne noise of this type, other than to change to a method of excavation which generates less ground vibrations.

The possibility of ground borne noise from excavation operations is raised in this report as it is anticipated that some noise complaints may be the result of ground borne noise.

4.4 Noise Control for Operations at 5C

4.4.1 Excavation of the Shaft at 5C

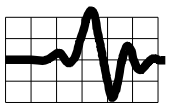
- Initial excavation of the shaft at 5C using a hoe ram or rock drill is to be limited to Monday to Friday, 7 a.m. to 7 p.m.

- Based on noise monitoring, the times for excavation may be extended up to 10 p.m. provided that the project noise thresholds, Table 1, are met.

- It is recommended that the boundary fence of Staging Area 5C be a 5 m high noise barrier. The noise barrier shall have no gaps and be constructed of a material with a minimum surface density of 20 kg/m^2, alternatively a commercial noise barrier material shall be used which has a minimum sound transmission loss rating of STC 30.

4.4.2 General Construction Operations at 5C

- General construction operations means operations using mechanized equipment such as loaders, skid steers and similar equipment at 5C, but not including hoe rams or rock drills.



- Initially, general construction operations are to be limited to Monday to Friday, 7 a.m. to 7 p.m.

- Based on noise monitoring, the times for general construction operations may be extended up to 10 p.m. provided that the project noise thresholds, Table 1, are met.

5.0 Summary

An analysis of noise form shaft construction operations at Site 5 Staging Areas 5A, 5B and 5C has been carried out to determine noise impacts at nearby noise sensitive locations, and, to determine what noise control measures may be required.

The conclusions of the analysis are that there is a need for restrictions in times of operations in order to satisfy the project noise thresholds as set out in Section 04282 of the CSST Contract. The use of a noise barrier around Staging Area 5C is recommended due to the close proximity of residences to this location.

Details of the recommended noise control measures are set out in the following sections of this report.

- Section 3.4 Noise Control for Operations at 5A and 5B

- Section 4.4 Noise Control for Operations at 5C

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References

1. City of Ottawa, *Combined Sewage Storage Tunnel, Contract No.ISD14-2036, Section 02482 Noise and Vibration,* 2015.

2. International Standards Organization, *Acoustics - Attenuation of Sound during Propagation Outdoors, Part 2: General Method of Calculation*, ISO 9613-2: 1996(E).

Acoustical Terminology

Decibels, dB: Sound levels are expressed in units of decibels, dB. Sound level is 10 times the Logarithm of the squared ratio of the sound pressure over a reference pressure, 20×10^{-6} Pascals.

A-weighting: A-weighting is an internationally standardized frequency weighting which is applied to sound measurements and approximates the variation in sensitivity of human hearing with frequency (pitch).

A-weighted decibels, dBA: For sound levels where A-weighting has been applied, the decibel units are written as dBA. IN this report, all reported sound levels have been A-weighted and hence have units of dBA.

Maximum sound level, Lmax: The maximum sound level occurring over a period of time.

Equivalent sound level, Leq: The Logarithmic Energy Equivalent Continuous Sound Level is the constant sound level over the time period in question, that results in the same total sound energy as the actual time varying sound. Leq must be associated with a time period. Leq is a measure of the total sound energy dose over a specified time period. Essentially, Leq is an energy based average sound level over the period of time.

Noise is unwanted sound.

Noise Barrier / Acoustic Barrier: Means a wall, berm wall/berm combination or similar structure, used as a noise control measure, and high enough to break the line-of-sight between the source and the receptor. Noise barriers must a minimum transmission loss attenuation to be effective.

Figures

Contents:

Figure 1: Area Plan, showing Points of Reception (POR's)

Site North

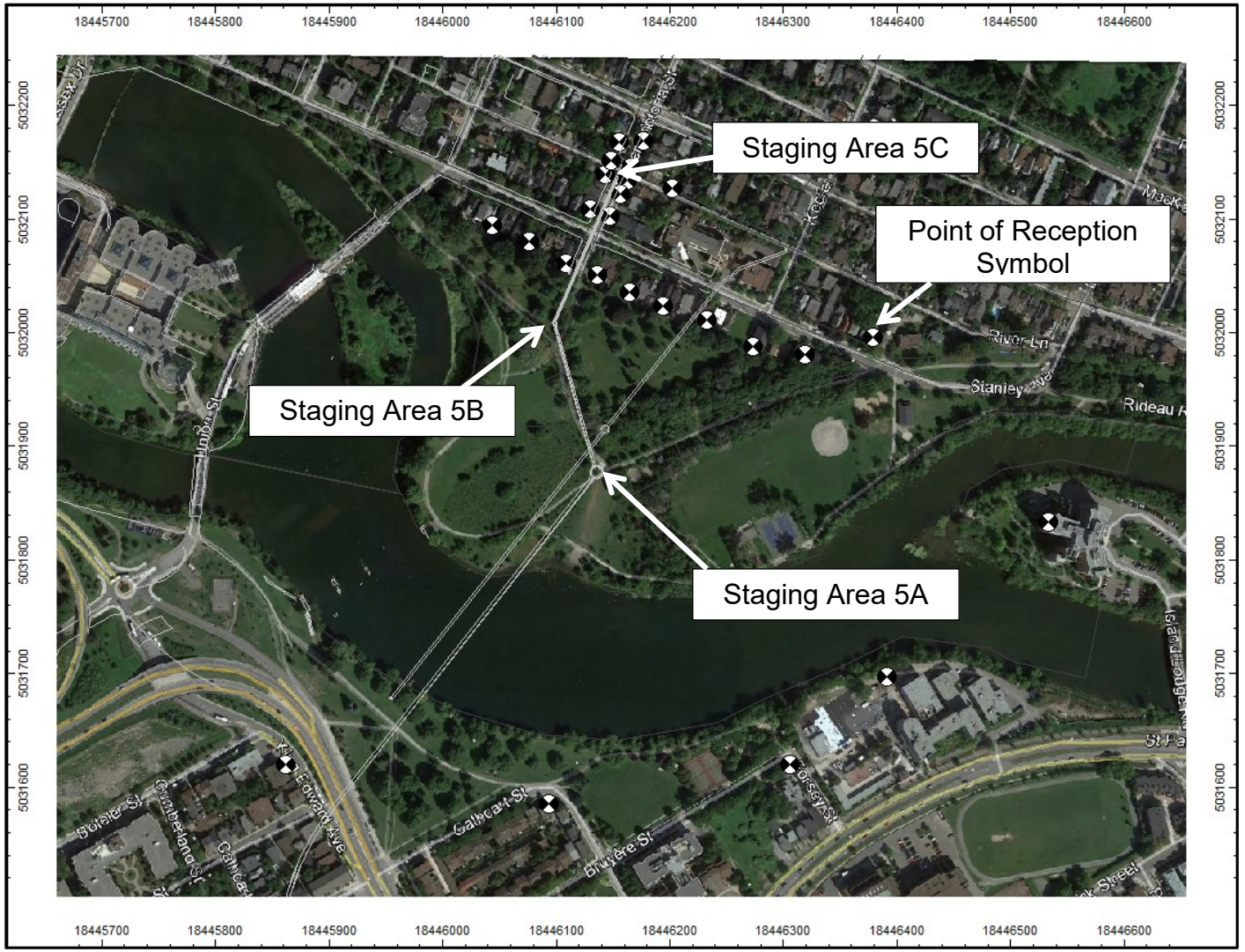


Figure 2: Area Plan for Staging Areas 5A and 5B, showing Points of Reception (POR's)

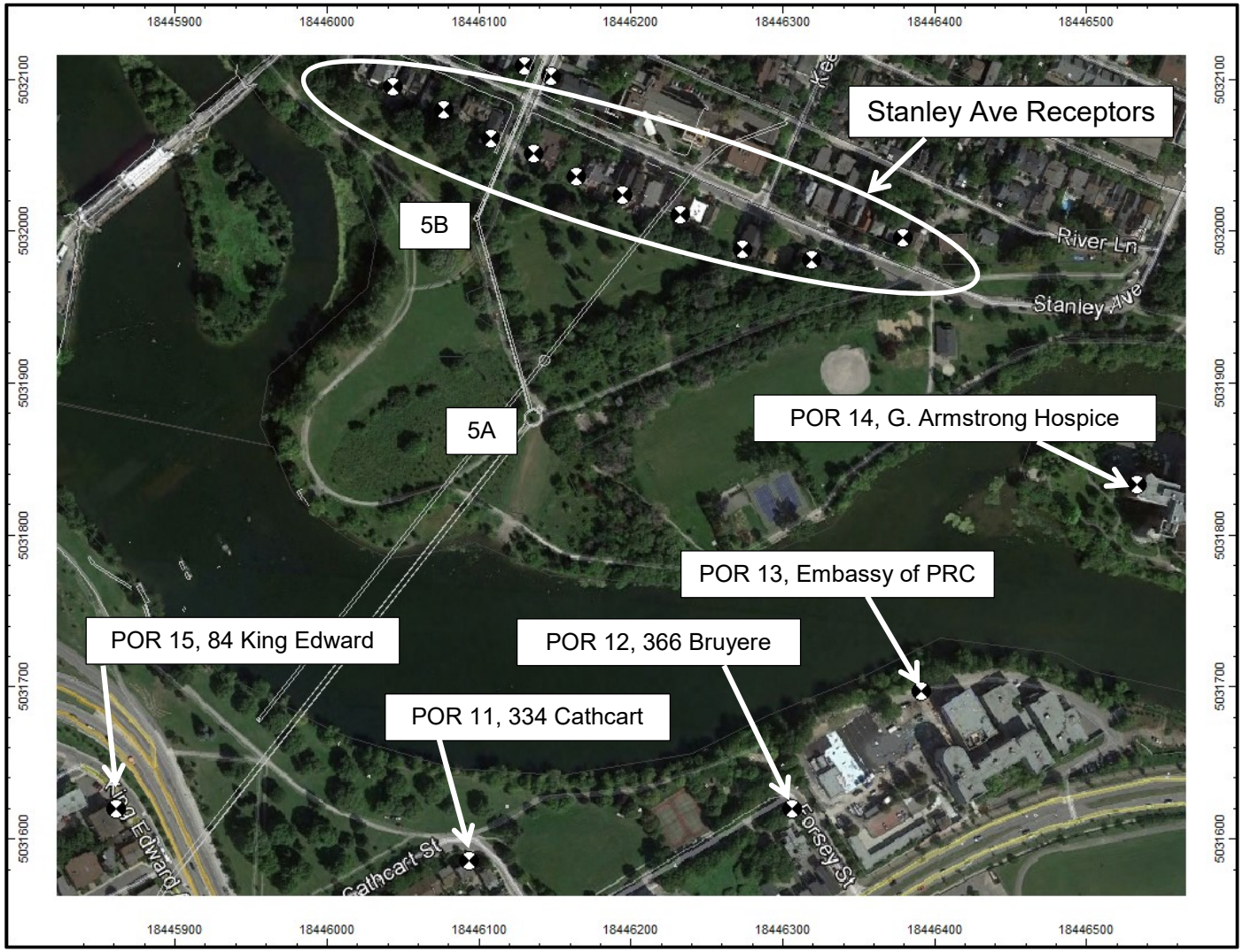


Figure 3: Staging Areas 5A and 5B, Showing Points of Reception (POR's)

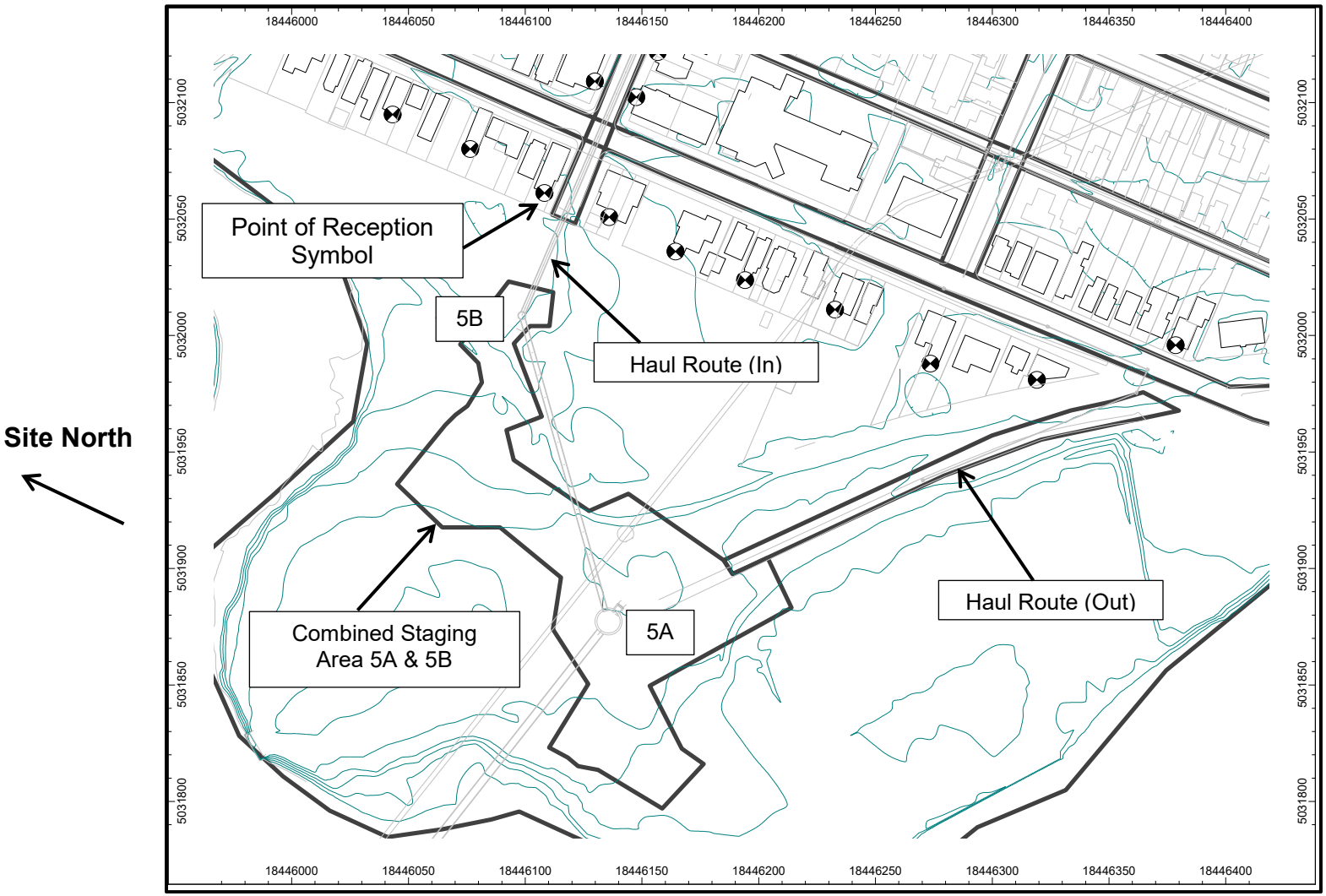


Figure 4: Staging Area 5C, Showing Points of Reception (POR's)

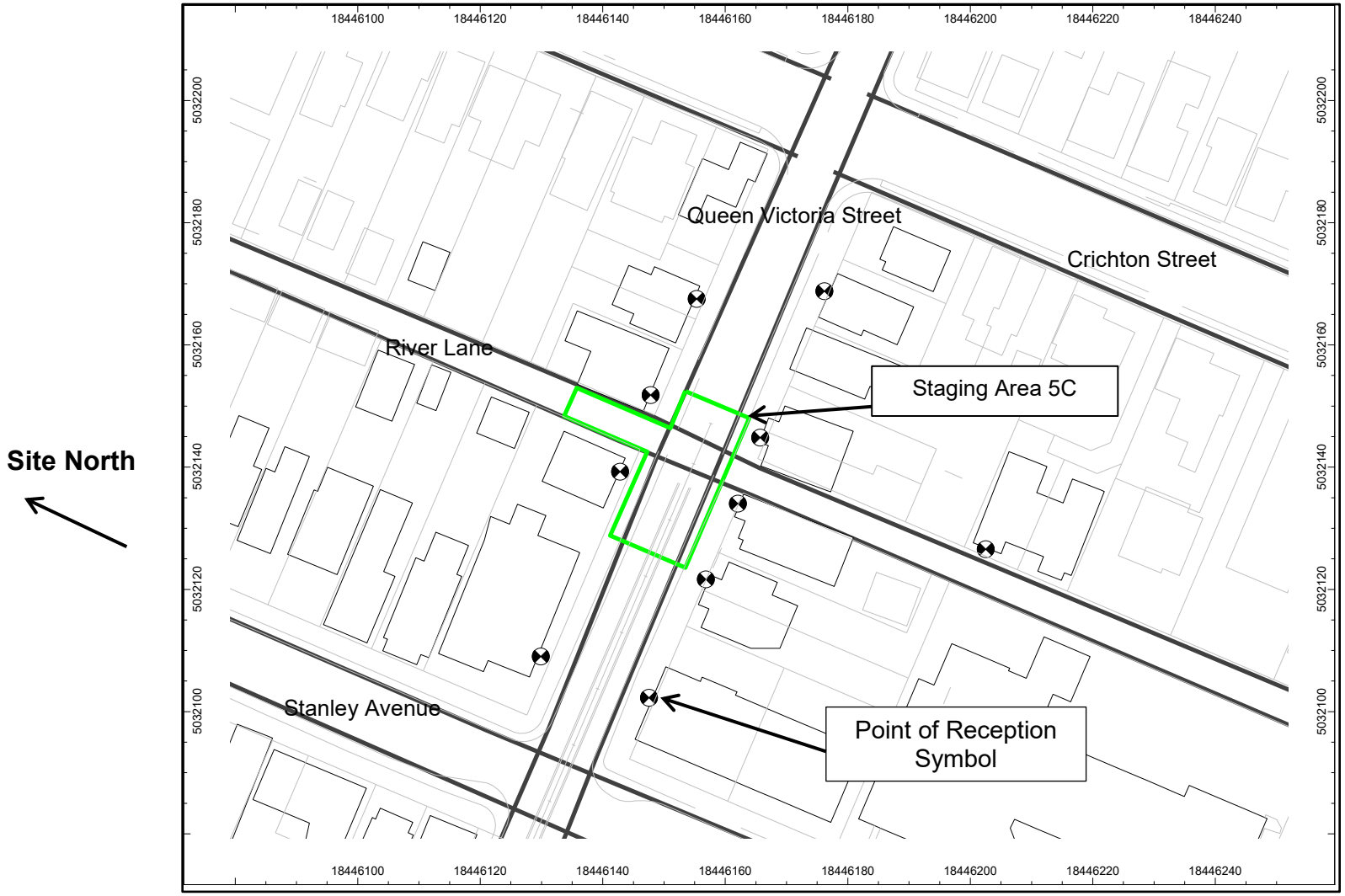
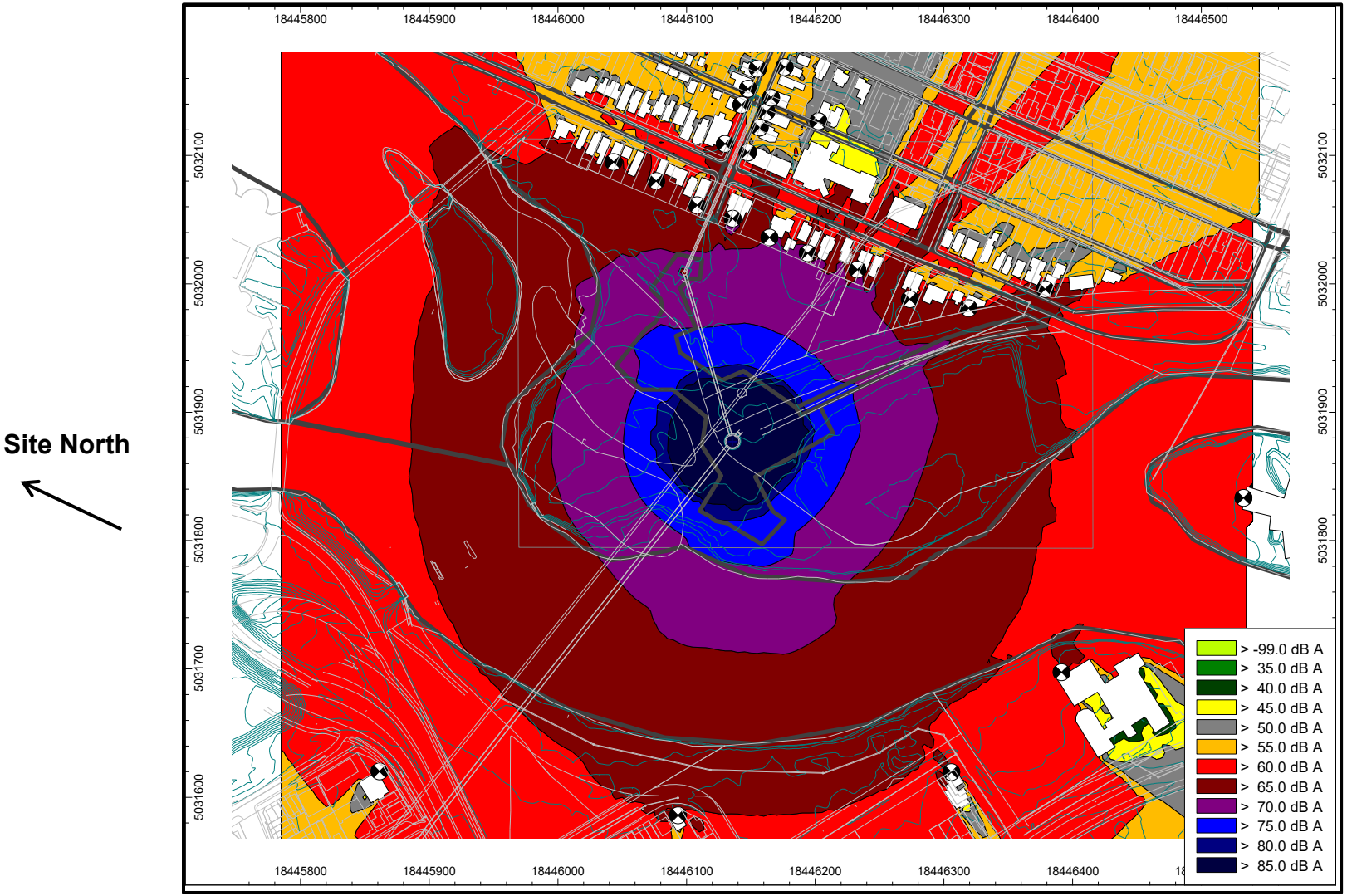
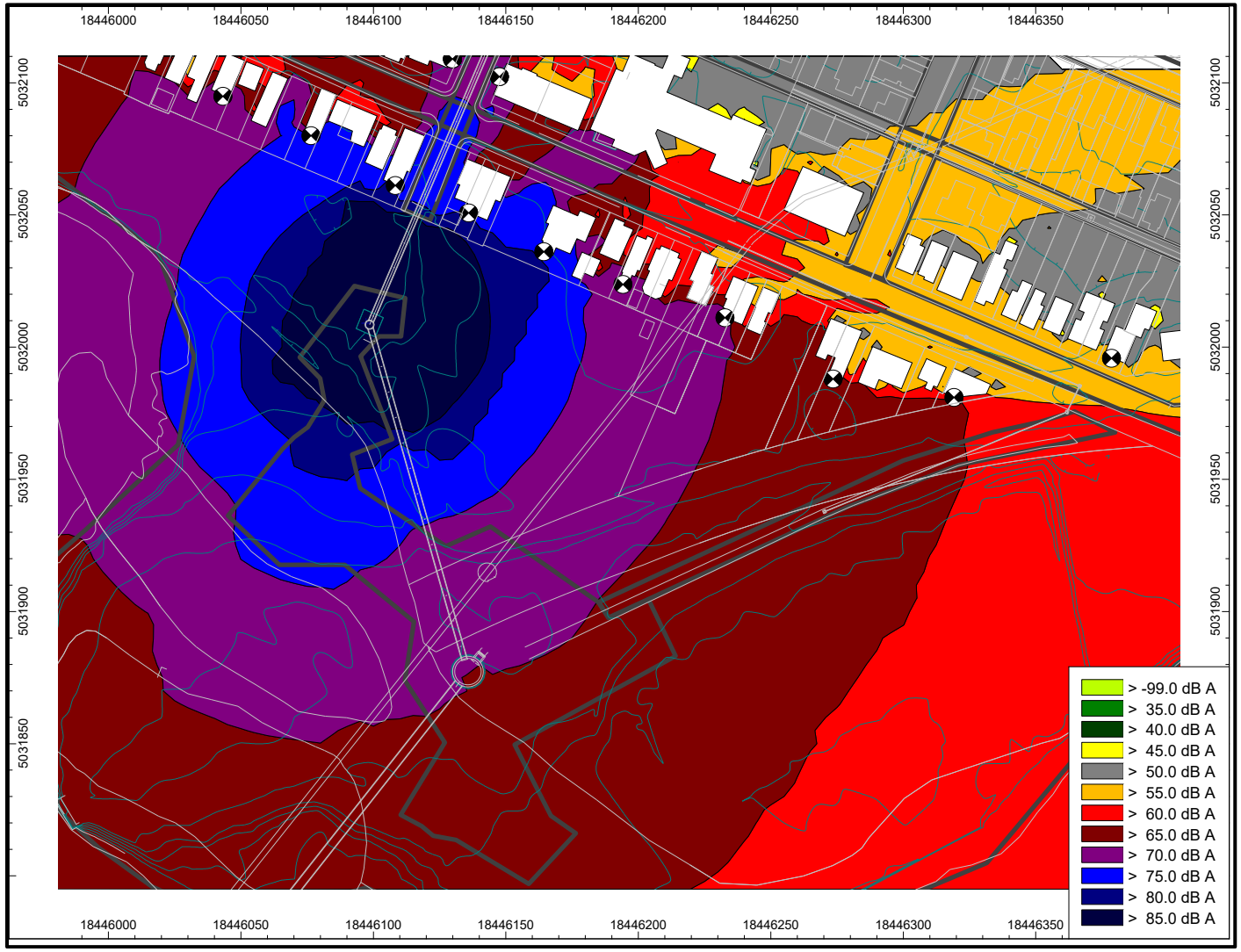


Figure 5: Lmax Noise Contours, Hoe Ramming at 5A, 3.5 m down



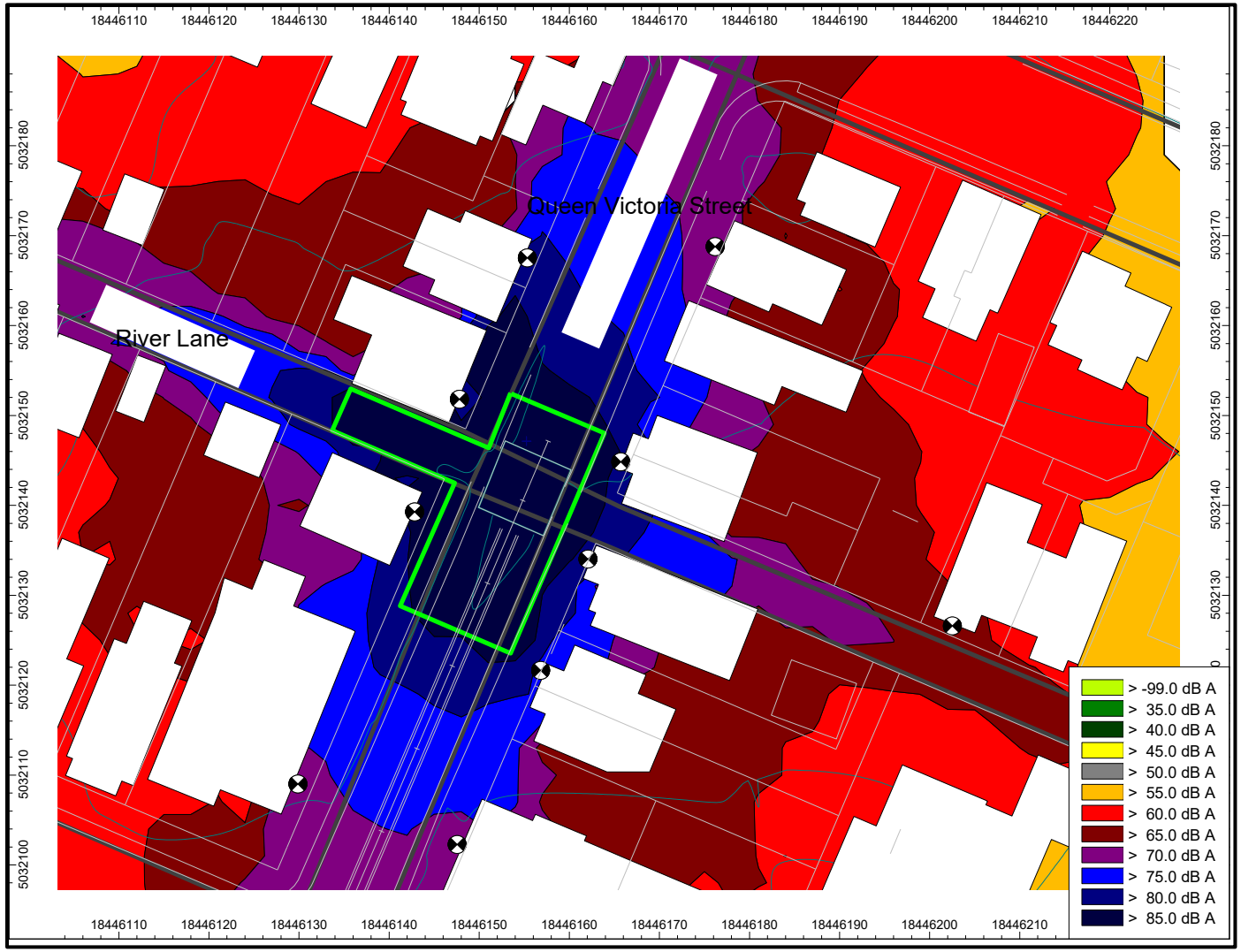
Site North

Figure 6: Lmax Noise Contours, Hoe Ramming at 5B, 3.5 m down



Site North

Figure 7: Lmax dBA Noise Contours, Hoe Ramming with Barrier at 5C, 3.5 m down



Site North

Appendix 1

Tables

Contents:

Table A1: Points of Reception and Distances

General Description	ID	Address	Distance from (metres)		
			5A	5B	5C
Stanley Ave Receptors	POR1_W	197 Stanley Ave	212	224	229
Stanley Ave Receptors	POR2_W	185 Stanley Ave	178	178	193
Stanley Ave Receptors	POR3_W	173 Stanley Ave	166	136	151
Stanley Ave Receptors	POR4_W	157 Stanley Ave	158	98	124
Stanley Ave Receptors	POR5_W	151 Stanley Ave	161	72	105
Stanley Ave Receptors	POR6_W	139 Stanley Ave	173	57	92
Stanley Ave Receptors	POR7_W	135 Stanley Ave	185	53	93
Stanley Ave Receptors	POR8_W	127 Stanley Ave	210	74	100
Stanley Ave Receptors	POR9_W	111 Stanley Ave	235	101	121
Stanley Ave Receptors	POR10_W	204 Stanley Ave	271	282	266
South and West Receptors	POR11_W	334 Cathcart St,	295	423	559
South and West Receptors	POR12_W	366 Bruyere St.	310	442	543
South and West Receptors	POR13_W	Embassy of PR China	314	429	503
South and West Receptors	POR14_W	E. Armstrong Hospital	401	470	487
South and West Receptors	POR15_W	84 King Edward	375	455	598
Q. Victoria Receptors	POR21_W	50 Queen Victoria	262	138	13
Q. Victoria Receptors	POR22_W	54 Queen Victoria	274	151	13
Q. Victoria Receptors	POR23_W	51 Queen Victoria	258	141	10
Q. Victoria Receptors	POR24_W	55 Queen Victoria	269	152	11
Q. Victoria Receptors	POR25_W	49 Queen Victoria	245	127	19
Q. Victoria Receptors	POR26_W	136 Stanley Ave	225	106	40
Q. Victoria Receptors	POR27_W	132 Stanley Ave	231	105	41
Q. Victoria Receptors	POR28_W	58 Queen Victoria	291	169	26
Q. Victoria Receptors	POR29_W	63 Queen Victoria	294	178	35
Q. Victoria Receptors	POR30_W	103A River Lane	258	158	49

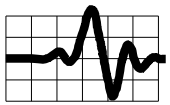


Table A2: Crude Estimates of Lmax from Various Construction Equipment at Various Distances

Lmax = Maximum Sound Level for standard 'fast' time weighting, A-weighted

Estimates assume the equipment is operating on the surface with no obstructions or absorptive ground between the noise source and the receiver.

Results below are based on field measurements by Hugh Williamson Associates for typical equipment of this type

Note: Noise levels may vary considerable depending on work being performed and local conditions.

	Lmax (in dBA)					
Equipment	**1 m**	**5 m**	**10 m**	**20 m**	**50 m**	**100 m**
Rock Drill	118.1	104.1	98.1	92.1	84.1	78.1
Hoe Ram (on excavator)	118.5	104.5	98.5	92.5	84.5	78.5
Excavator (with shovel)	107.4	93.4	87.4	81.4	73.4	67.4
Loader (Wheeled)	109.6	95.6	89.6	83.6	75.6	69.6
Skid Steer	109.2	95.2	89.2	83.2	75.2	69.2
Haulage Truck (slow moving)	100.6	86.6	80.6	74.6	66.6	60.6

Table A3: Calculated Sound Levels (Lmax in dBA) for Various Operations at 5A and 5B

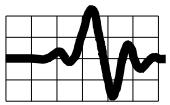
General Description	ID	Hoe Ram at 5A	Loader at 5A	Loader & Truck at 5A	Hoe Ram at 5B	Loader at 5B
Stanley Ave Receptors	POR1_W	67	64	**76**	65	60
Stanley Ave Receptors	POR2_W	68	65	68	67	64
Stanley Ave Receptors	POR3_W	69	**66**	66	70	67
Stanley Ave Receptors	POR4_W	**70**	**66**	67	73	70
Stanley Ave Receptors	POR5_W	69	**66**	66	76	72
Stanley Ave Receptors	POR6_W	68	65	65	78	**75**
Stanley Ave Receptors	POR7_W	68	64	64	**79**	**75**
Stanley Ave Receptors	POR8_W	67	63	63	76	72
Stanley Ave Receptors	POR9_W	66	63	63	72	70
Stanley Ave Receptors	POR10_W	66	63	67	58	55
South and West Receptors	POR11_W	65	62	62	60	58
South and West Receptors	POR12_W	64	60	61	60	57
South and West Receptors	POR13_W	65	62	63	62	58
South and West Receptors	POR14_W	61	58	59	58	55
South and West Receptors	POR15_W	61	58	58	60	57
Q. Victoria Receptors	POR21_W	61	57	57	70	67
Q. Victoria Receptors	POR22_W	59	56	56	69	67
Q. Victoria Receptors	POR23_W	50	43	44	71	67
Q. Victoria Receptors	POR24_W	49	42	42	70	67
Q. Victoria Receptors	POR25_W	52	45	45	71	68
Q. Victoria Receptors	POR26_W	52	45	46	73	70
Q. Victoria Receptors	POR27_W	65	59	59	73	66
Q. Victoria Receptors	POR28_W	59	56	56	69	65
Q. Victoria Receptors	POR29_W	52	47	47	69	65
Q. Victoria Receptors	POR30_W	51	44	44	60	55

Largest values of Lmax Bolded in each column

Table A4: Calculated Sound Levels (Lmax in dBA) for Various Operations and Conditions at 5C

General Description	ID	Hoe Ram at 5C No Barrier	Hoe Ram at 5C with Barrier	Loader at 5C No Barrier	Loader at 5A with Barrier
Stanley Ave Receptors	POR1_W	46	46	40	40
Stanley Ave Receptors	POR2_W	48	47	42	42
Stanley Ave Receptors	POR3_W	50	50	43	43
Stanley Ave Receptors	POR4_W	53	52	46	46
Stanley Ave Receptors	POR5_W	57	55	49	48
Stanley Ave Receptors	POR6_W	58	56	52	49
Stanley Ave Receptors	POR7_W	62	57	54	50
Stanley Ave Receptors	POR8_W	56	55	48	48
Stanley Ave Receptors	POR9_W	53	53	48	48
Stanley Ave Receptors	POR10_W	45	45	40	39
South and West Receptors	POR11_W	51	47	49	49
South and West Receptors	POR12_W	46	43	46	44
South and West Receptors	POR13_W	46	43	43	42
South and West Receptors	POR14_W	44	42	48	41
South and West Receptors	POR15_W	56	46	50	48
Q. Victoria Receptors	POR21_W	**97**	**83**	**88**	**78**
Q. Victoria Receptors	POR22_W	**98**	**83**	**92**	**80**
Q. Victoria Receptors	POR23_W	**98**	**83**	**89**	**78**
Q. Victoria Receptors	POR24_W	**98**	**83**	**91**	**80**
Q. Victoria Receptors	POR25_W	94	79	83	74
Q. Victoria Receptors	POR26_W	88	74	79	70
Q. Victoria Receptors	POR27_W	82	74	78	70
Q. Victoria Receptors	POR28_W	92	82	85	75
Q. Victoria Receptors	POR29_W	89	73	83	70
Q. Victoria Receptors	POR30_W	81	67	65	62

Largest values of Lmax Bolded in each column



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QUALIFICATIONS:

Ph.D. Mechanical Engineering, University of New South Wales, 1972

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Member, Canadian Acoustical Association

Member, American Society of Heating, Refrigeration and Air-conditioning Engineers

KEY COMPETENCIES:

- Architectural and building acoustics, acoustics of office spaces, meeting rooms, auditoriums and studios, noise and vibration control of building mechanical services.
- Design and testing for speech privacy and for speech secure spaces.
- Environmental noise and vibration assessments, Environmental Compliance Approval (ECA). Noise assessment for land use planning
- Noise impact assessments for development approvals.
- Transportation noise and vibration assessments.

PROFESSIONAL EXPERIENCE:

Hugh Williamson is a professional engineer with many years of experience in the measurement, analysis and control of noise and vibration. Hugh Williamson Associates was incorporated in 1997 and provides consulting services in architectural, building, industrial, transportation and environmental acoustics and vibration. Clients include architects, engineering firms, industrial firms and government departments. Prior to establishing Hugh Williamson Associates, his career included extensive periods in industry as well as university level research and teaching. He is a former Director of the Acoustics and Vibration Unit at the Australian Defence Force Academy. He has published over 50 engineering and scientific papers and has been an invited speaker on noise and vibration at national and international conferences. He has more than 20 years of experience as a consultant.

CLIENT LIST:

Hugh Williamson Associates provides consulting services to large and small clients including: National Research Council, National Capital Commission, Public Works Government Services Canada, J. L. Richards & Associates, HOK Urbana Architects, ASDG, Design Associates, Claridge Homes and Barry Padolsky Associates.

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- Architectural and building acoustics, acoustics of office spaces, meeting rooms, auditoriums and studios, noise and vibration control of building mechanical services.
- Industrial noise and vibration assessment and control.
- Transportation noise and vibration.
- Design services including sketch design, design development (development / permit applications), contract documents, tendering and contract administration.

PROFESSIONAL EXPERIENCE:

Michael Wells is a professional Architect registered in NSW with many years of experience in the Architectural and Construction industries. With key competencies in measurement, analysis and control of noise and vibration, Michael Wells joined Hugh Williamson Associates in 2012 and provides consulting services in architectural, building, industrial, transportation and environmental acoustics and vibration. Clients include architects, engineering firms, industrial firms and government departments. Prior to joining Hugh Williamson Associates, his career includes the founding of Michael Wells Architect in Sydney Australia which specialized in the design of institutional, commercial and residential projects. He is a Director of Architectural Workshops Australia and Vision Blue Pty Ltd. He has more than 10 years of experience as a consultant.

CLIENT LIST:

Hugh Williamson Associates provides consulting services to large and small clients including: National Research Council, National Capital Commission, J. L. Richards & Associates, Barry Padolsky Associates, HOK Urbana Architects, Genivar, Nasittuq Corporation, PWGSC, R. W. Tomlinson, Geo. Tackaberry Construction and Miller Paving.

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