APPENDIX E NOISE AND VIBRATION ASSESSMENT (RENZO TONIN & ASSOCIATES)

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GREEN SQUARE TO ASHMORE CONNECTOR ROAD - REVIEW OF ENVIRONMENTAL FACTORS

Noise and Vibration Assessment

27 September 2017

City of Sydney Council

TG980-02F02 GS2AC Acoustic Assessment (r1)

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1 Introduction

The City of Sydney ('City') is working on the delivery of the proposed Green Square to Ashmore Connector ('GS2AC') Road from Botany Road to Bowden Street in Alexandria to improve road and transport access to the Green Square Town Centre ('GSTC'), a planned major centre in the City of Sydney Local Government Area ('LGA'). The GS2AC has long been considered a viable road and transport outcome for the area and is consistent with *Sustainable Sydney 2030*.

Key elements of the 450 m long road include two vehicle travel lanes and tie-works in Bowden Street, two new signalised intersections and ancillary signal upgrades, bi-directional cycle lane, kerbside parking, landscaping and public domain treatments, lighting and signage as well as bus stops for future servicing requirements.

The project also provides an opportunity to undertake the sustainable renewal of the residue lands generated by the GS2AC which may include future affordable housing and mixed employment generating uses. The City is committed to providing two affordable housing developments on either side of the proposed road between Botany Road and O'Riordan Street.

The City proposes to commence construction of the GS2AC in 2019, with opening of the road to occur in 2020.

The project is being assessed under Part 5 of the NSW Environmental Planning and Assessment Act and a Review of Environmental Factors ('REF') has been prepared to assess key engineering, environmental and planning issues affecting the design, construction and operation of the road.

The City has engaged Renzo Tonin & Associates ('RT&A') to undertake a construction and operational noise and vibration assessment as a part of the preparation of the REF. This report presents an assessment of construction and operational noise and vibration on the nearest most potentially affected receivers to the project.

The assessment has been prepared on accordance with the various noise and vibration requirements of the following:

- NSW Environmental Protection Authority ('EPA') *Interim Construction Noise Guideline* ('ICNG'),
- Department of Environment and Conservation ('DEC') NSW *Assessing Vibration: A Technical Guideline*,
- DIN4150 *Structural vibration - Effects of vibration on structures*, and
- NSW *Road Noise Policy* ('RNP').

It is noted that DEC publications may be found in the Office of Environment & Heritage ('OEH').

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. APPENDIX A contains a glossary of acoustic terms used in this report.

2 Project overview

2.1 Project proposal

The City is working on the project delivery of the GS2AC which is a proposed new road that will improve access to the GSTC. The GS2AC is approximately 450 m long and 20 m wide, and will connect Botany Road to Bowden Street through O'Riordan Street, just south of the Green Square Railway Station ('GSRS'). Figure 1 and Figure 2 present the location of the GS2AC.

Figure 1: Location of GS2AC (Source: City of Sydney)

Figure 2: Location of GS2AC

2.2 Relevant policies and guidelines

The following policies and guidelines have been used in the assessment:

- ICNG,
- Assessing Vibration: A Technical Guideline,
- NSW RNP,
- State Environmental Planning Policy (Infrastructure) 2007 ('ISEPP'), and
- Development near Rail Corridors and Busy Road-Interim Guideline.

The above policies and guidelines have been addressed in this report as follows:

Policy or Guideline	Assessment outline	Report section
ICNG	Assessment of noise during the excavation and construction phase of the development and its potential impact on surrounding development	Section 5
Assessing Vibration: A Technical Guideline	The primary potential for vibration impact generated by the development is during the excavation and construction phase.	Section 5
RNP	Assessment of the operational road traffic noise generated by the development and its potential impact on surrounding development	Section 6
ISEPP	Discussion of implications for future noise sensitive development surrounding the GS2AC corridor	Section 6
Development Near Rail Corridors and Busy Road-Interim Guideline	Supporting guideline for the State Environmental Planning Policy – Infrastructure 2007	Section 6

2.3 Scope of assessment

The following sets out the primary acoustic consideration for the project along with the sections of this report in which they are discussed.

Acoustic consideration	Report section
Construction noise and vibration	Section 5
Operational road traffic noise assessment	Section 6

3 Nearest noise and vibration sensitive receivers

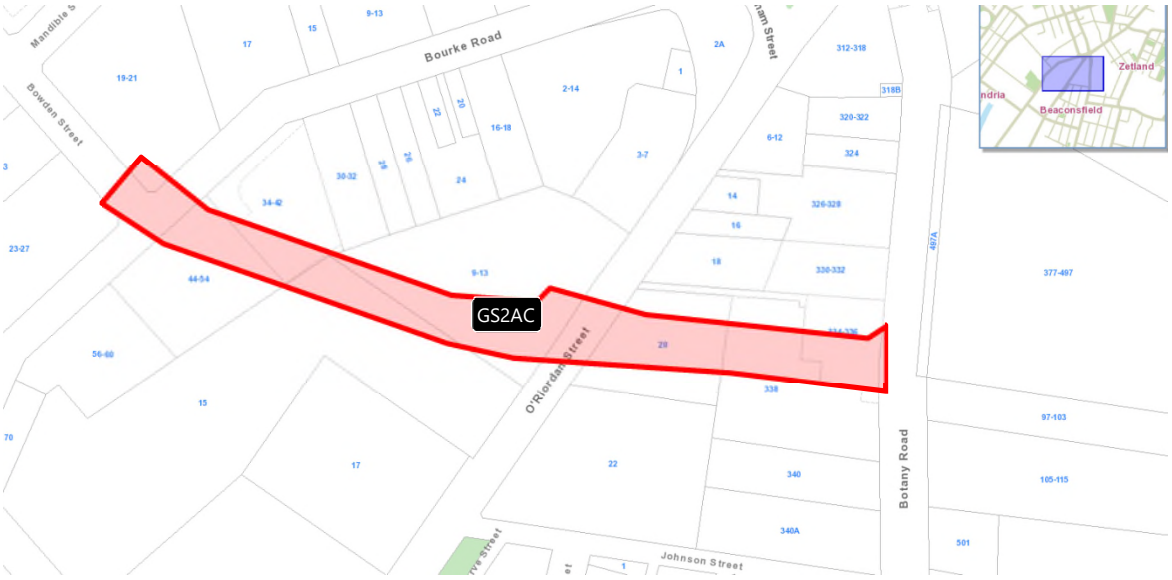
The nearest potentially affected receivers to construction and operational noise associated with the GS2AC development are presented in Table 1 and graphically in Figure 3. Figure 4 presents the cadastral areas and property addresses surrounding the GS2AC.

Table 1: Nearest receivers

Receiver Type	Receiver ID	Receiver location
Residential land uses	R1a	Victoria Street, Alexandria
	R1b	Queen Street, Alexandria
	R2	16 O'Riordan Street, Alexandria
Commercial premises	C1	9-13 O'Riordan Street, Alexandria
	C2	17 O'Riordan Street, Alexandria
	C3	18 O'Riordan Street, Alexandria
	C4	22 O'Riordan Street, Alexandria
	C5	34-42 Bourke Road, Alexandria
	C6	19-21 Bourke Road, Alexandria
	C7	23-37 Bourke Road, Alexandria
	C8	56-60 Bourke Road, Alexandria
Other sensitive development	O1	Airport rail tunnel

Figure 3: Nearest receiver locations

Figure 4: Cadastral areas and property addresses



Note is made that the nearest existing residences are located approximately 70m away along Queen Street to the south and the completed 7-storey ValueSuites Green Square at 16 O'Riordan Street to the north. Residences along Queen Street are shielded from the GS2AC by the commercial premises at 22 O'Riordan Street and assessment to these residences is not warranted due to the significant acoustic shielding provided by the intervening buildings.

Future affordable housing is proposed towards the eastern extents of the GS2AC and is permissible with consent in the proposed B7 Business Park Zone. In particular, the area encapsulated by 20-22 O'Riordan Street and 334-338 Botany Road is under consideration for affordable housing. It has been assumed in this assessment that, with the exception of one possible completed affordable housing development, future residences will be constructed following completion of the GS2AC.

Based on the above, this report has not included an assessment of excavation and construction noise upon future residential premises. However, for indicative noise levels, predictions made at commercial receiver C4 could be referred to. Predictions at future residential premises should be carried out for the detailed design and preparation of the Construction Noise and Vibration Management Plan ('CNVMP') for the project. With regard to operational noise upon future residential land uses, future development will need to be assessed in accordance with the ISEPP, however a brief assessment has been included to provide an indication of potential requirements on the built form.

4 Existing noise environment

Measurements of the existing noise environment have been referenced in the assessment of both construction and operational noise impacts. While the NSW ICNG sets fixed noise level targets for construction noise at commercial and industrial premises, noise impacts to internal areas of such development are typically more relevant. Internal noise levels within the nearest most potentially affected locations have also been referenced in the operational road traffic noise assessment.

Noise monitoring data outlined in the Green Square Storm Water Drain REF (Sydney Water, April 2014) have also been referenced.

This report was originally completed in the middle of 2015 and the project was deferred until the present time. The noise measurements undertaken in 2014 are considered still valid as there has not been a significant change in the receiving environment, hence there is no need to remeasure.

4.1 Noise measurement locations

The short-term measurement locations are outlined in Table 2 and presented in Figure 5.

Table 2: Noise monitoring locations

ID	Address	Description
Internal short-term noise monitoring		
S1	9-13 O'Riordan Street	The sound level meter was located within the south-east corner of 9-13 O'Riordan Street with roller doors open. The microphone was positioned 5m in from the eastern facade and 1.5m above ground level.
S2	9-13 O'Riordan Street	The sound level meter was located within the south-east corner of 9-13 O'Riordan Street with roller doors open. The microphone was positioned 25m in from the eastern facade and 1.5m above ground level.
S3	17 O'Riordan Street	The sound level meter was located within a small open office of 17 O'Riordan Street with windows and doors closed. The small office is located along the northern facade of the building, approximately 70m west of the O'Riordan Street curb. The microphone was positioned 1.5m above ground level.
S4	17 O'Riordan Street	The sound level meter was located within a delivery warehouse of 17 O'Riordan Street with roller doors open. The warehouse is located along the western facade of the building, approximately 95m from the O'Riordan Street curb. The microphone was positioned 1.5m above ground level.
S5	22 O'Riordan Street	The sound level meter was located within a car servicing warehouse of 22 O'Riordan Street with roller doors open. The warehouse is located approximately 25m from the O'Riordan Street curb. The microphone was positioned 1.5m above ground level.
S6	22 O'Riordan Street	The sound level meter was located within the reception area of 22 O'Riordan Street with windows and doors closed. The reception area is located approximately 12m from the O'Riordan Street curb. The microphone was positioned 1.5m above ground level.

ID	Address	Description
S7	34-42 Bourke Road	The sound level meter was located within the office area/tea room of 34-42 Bourke Road with windows and doors closed. The area is located approximately 10m from the Bourke Road curb. The microphone was positioned 1.5m above ground level.
S8	34-42 Bourke Road	The sound level meter was located within the south-west corner of the warehouse storage area of 34-42 Bourke Road with roller doors open. The western facade of the storage area is located approximately 26m from the Bourke Road curb. The microphone was positioned 1.5m above ground level.
S9	19-21 Bourke Road	The sound level meter was located in the centre of the ground floor commercial tenancy within 19-21 Bourke Road. The eastern facade of the commercial tenancy is located approximately 10m from Bourke Road. The microphone was positioned 1.5m above ground level.
External short-term noise monitoring		
S10	34-42 Bourke Road	The sound level meter was located on the drive way entrance to 34-42 Bourke Road, approximately 1m from the Bourke Road curb and 1.5m above ground level.
S11	9-13 O'Riordan Street	The sound level meter was located approximately 40m north of the northern facade of 17 O'Riordan Street and 1m from the O'Riordan Street curb. The microphone was positioned 1.5m above ground level.
S12	3 Queen Street	The sound level meter was located approximately 2m from the Johnston Street curb and 1.5m from the Queen Street curb. The microphone was positioned 1.5m above ground level.
Long-term noise monitoring - Green Square Stormwater Drain REF		
L1	1 Queen Street, Alexandria	Detail description of logger location is not available.

Figure 5: Noise monitoring locations

4.2 Short-term noise measurement results

Short-term noise measurements were undertaken during the daytime of Thursday, 6 November 2014, to determine the existing internal and external noise environment at the locations presented in Table 2 above. A summary of the short-term measurement results is presented in Table 3.

Table 3: Short-term noise monitoring results

Location / Time	Measured noise level, dB(A)		Comments on measured noise levels
	L_{Aeq}	L_{A90}	
Internal			
S1 - 9-13 O'Riordan Street 08:36-08:51	59	56	The background L_{A90} and the ambient L_{Aeq} noise level was determined by vehicle pass-bys on O'Riordan Street.
S2 - 9-13 O'Riordan Street 08:52-09:07	59	56	The background L_{A90} and the ambient L_{Aeq} noise level was determined by vehicle pass-bys on O'Riordan Street.
S3 - 17 O'Riordan Street 09:23-09:38	60	50	The background L_{A90} and the ambient L_{Aeq} noise level was determined by the use of a radio, telephone conversation and general office activities.
S4 - 17 O'Riordan Street 09:42-09:48	62	57	The background L_{A90} and the ambient L_{Aeq} noise level was determined by delivery warehouse activities, including unloading of delivery van.
S5 - 22 O'Riordan Street 10:12-10:27	71	65	The background L_{A90} and the ambient L_{Aeq} noise level was determined by car servicing activities, including car detailing, buffering, sprays and cleaning.
S6 - 22 O'Riordan Street 10:33-10:48	52	43	The background L_{A90} and the ambient L_{Aeq} noise level was determined by general reception activities, including telephone conversation and air-conditioning noise.
S7 - 34-42 Bourke Road 11:32-11:47	48	36	Note is made that the office area/tea room area was unoccupied during the measurement. The background L_{A90} and the ambient L_{Aeq} noise level was determined by distant murmur of warehouse activities.
S8 - 34-42 Bourke Road 11:49-12:04	60	44	The background L_{A90} and the ambient L_{Aeq} noise level was determined by warehouse activities, including loading/unloading of pallets, warehouse conversation and the occasional use of a forklift.
S9 - 19-21 Bourke Road 11:04-11:19	59	52	The background L_{A90} and the ambient L_{Aeq} noise level was determined by customers browsing and being assisted by a sales clerk.
External			
S10 - 34-42 Bourke Road 12:07-12:22	71	59	The background L_{A90} and the ambient L_{Aeq} noise level was determined by vehicle pass-bys on Bourke Road.
S11 - 9-13 O'Riordan Street 12:29-12:44	73	63	The background L_{A90} and the ambient L_{Aeq} noise level was determined by vehicle pass-bys on O'Riordan Street.
S12 - 3 Queen Street 12:47-01:02	63	54	The background L_{A90} and the ambient L_{Aeq} noise level was predominantly determined by vehicle passbys on O'Riordan Street, with occasional pass-bys along Johnson and Queen Streets.
L1 - 1 Queen Street	-	46	-

Location / Time	Measured noise level, dB(A)		Comments on measured noise levels
	L_{Aeq}	L_{A90}	

Note: The equipment used for noise measurements was a Brüel & Kjær Type 2250 precision sound level analyser which is a Class 1 instrument having accuracy suitable for field and laboratory use. The instrument was calibrated prior and subsequent to measurements using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification).

It is noted that the long-term noise monitoring results at 1 Queen Street reveal significantly lower background noise levels compared with the short-term measurements at 3 Queen Street. As the exact location of the 1 Queen Street logger has not been confirmed, it is possible that the noise monitor was located in the rear yard of the property and therefore acoustically shielded. The lower background noise monitoring results have nonetheless been utilised for the assessment.

The background noise levels at the completed ValueSuites Green Square are also expected to be higher than the measured noise levels at 1 Queen Street; however, due to the on-going construction work in the area, it will be nearly impossible to monitor the real background noise levels. Based on the measured results at S11 and S12, the long-term background noise level at 16 O'Riordan Street is estimated to be 55dB(A).

5 Construction noise and vibration assessment

5.1 Construction noise and vibration objectives

5.1.1 Construction noise objectives

The ICNG provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.

  NSW noise policies, including the INP, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- Application of reasonable and feasible noise mitigation measures.
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the scale of the construction works proposed for the GS2AC, a quantitative assessment is carried out herein, consistent with the ICNG requirements. For the nearest sensitive receivers to the GS2AC project, refer to Table 1 and Figure 3 of this report.

Table 4, reproduced from the ICNG, sets out the noise management levels which are primarily based on the Rating Background Level ('RBL'), and procedures for residential receivers.

Table 4: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB(A)	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2 of the ICNG.

Construction noise management levels can be determined using the ICNG. Table 5 sets out the noise management levels for various noise-sensitive land use developments, including commercial premises.

Table 5: Noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

Note: Noise management levels apply when receiver areas are in use only.

While initial screening of potential impacts at commercial and industrial premises has been carried out in accordance with the ICNG criteria, where noise impacts are revealed, consideration is given to the internal noise amenity, based on prevailing internal noise levels and the building envelope construction.

5.1.2 Construction vibration objectives

5.1.2.1 Disturbance to building occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECCs '*Assessing Vibration; a technical guideline*'. In accordance with the guideline, assessment against the human exposure criteria is typically reserved for long-term vibration impacts such as that associated with operational phases of development rather than construction works. While provided for reference, assessment of construction vibration is expected to be limited to potential structural damage.

The guideline provides criteria which are based on the British Standard BS 6472-1992. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 6 provides definitions and examples of each type of vibration.

Table 6: Types of vibration

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, eg. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude.	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

Source: Assessing Vibration; a technical guideline

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred'.*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, ie. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed.

The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced in Table 7.

Table 7: Preferred and maximum levels for human comfort

Location	Assessment period [1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (Weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas [2]	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night time	0.020	0.014	0.040	0.028
Workshops	Day- or nighttime	0.04	0.029	0.080	0.058
Impulsive vibration (Weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas [2]	Day or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92
Intermittent vibration (Vibration Dose Values, VDV, $m/s^{1.75}$, 1-80Hz)					
Critical areas[2]	Day or night-time	0.10		0.20	
Residences	Daytime	0.20		0.40	
	Night-time	0.13		0.26	
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40		1.60	
Workshops	Day or night-time	0.80		1.60	

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (eg. relevant standards) should be referred to.

5.1.2.2 Structural damage to buildings

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components*" (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage. " (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, set out below, the DIN standard deals with cosmetic issues than major structural failures.

The differences in levels of damage are more defined in British Standard 7385 Part 1 1990 (p.10):

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are also for the protection against cosmetic damage. Guidance on limits for minor or major damage is provided in Section 7.4.2 of the Standard (p.5):

> *7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values.*

British Standard

British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. Table 8 sets out the BS7385 criteria for cosmetic, minor and major damage.

The buildings surrounding the GS2AC would fall under Group 1 of BS 7385.

Table 8: BS 7385 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	**Reinforced or framed structures Industrial and heavy commercial buildings**	**Cosmetic**	**50**		
		Minor	**100**		
		Major	**200**		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor	30 to 40	40 to 100	100
		Major	60 to 80	80 to 200	200

Notes: Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure*' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure.

The vibration limits increase as the frequency content of the vibration increases. The criteria are presented in Table 9. The buildings surrounding the GS2AC would fall under Group 1 of DIN 4150-3.

Table 9: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies
1	**Buildings used for commercial purposes, industrial buildings and buildings of similar design**	**20**	**20 to 40**	**40 to 50**	**40**
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg. buildings under a preservation order)	3	3 to 8	8 to 10	8

With regard to potential impacts on the airport rail tunnel, consultation with Transport for NSW ('TfNSW') and/or Sydney trains should be undertaken. It would not be expected for criteria to be more stringent than for Group 1 structures.

5.2 Construction noise and vibration assessment

5.2.1 Proposal

5.2.1.1 Projected program and schedule

The project schedule is proposed to be conducted within two sections, being the eastern section and the western section. The eastern section is for works conducted between Botany Road and O'Riordan Street. The western section is for works conducted between O'Riordan Street and Bourke Road. Table 10 presents the indicative development program for construction works. This is subject to change upon awarding of construction contract.

Table 10: Indicative construction program

Section	Detailed breakdown	Time period	Vehicle trip estimates for duration
GS2AC East	Taxi building demolition (if required)	3 December 2018 to 3 June 2019	
	Remediation and excavation works and in-ground services other than trunk	3 December 2018 to 21 August 2019	750
	Retaining walls/batters	7 September 2019 to 1 December 2019	450
	Sub-grade	2 December 2019 to 30 Jan 2020	600
	Kerb & gutter	31 Jan 2020 to 26 March 2020	400

Section	Detailed breakdown	Time period	Vehicle trip estimates for duration
	Footpaths & trees	29 March 2020 to 6 May 2020	700
	Pavement lanes surfacing	9 May 2020 to 4 June 2020	600
GS2AC West	Remediation and excavation	7 September 2019 to 2 January 2020	700
	Retaining walls/batters	3 January 2020 to 26 March 2020	450
	Sub-grade	29 March 2020 to 20 May 2020	600
	Kerb & gutter	23 May 2020 to 18 July 2020	400
	Footpaths & trees	19 July 2020 to 9 September 2020	700
	Pavement lanes surfacing	10 September 2020 to 6 October 2020	600

5.2.1.2 Construction hours

The hours of excavation and construction works are likely to be in line with those outlined in the ICNG, being:

- Monday to Friday: 7:00am to 6:00pm
- Saturday: 7:00am to 1:00pm
- Sunday/Public holiday: No work

Given the offset of existing residences from the GS2AC, consideration could be given to out of hour's works. Due to the importance of maintaining through traffic on Botany Road, O'Riordan Street and Bourke Road particularly during peak hours, some out of hours work would be required to minimise disruptions to motorists and protect the safety of workers and the travelling public. Work outside of standard construction hours and extended construction hours would be undertaken in accordance with approvals and notification requirements of any Environment Protection Licence ('EPL') for construction of the proposal.

5.2.1.3 Construction traffic

With regard to the eastern section, the intersection of Geddes Avenue and Botany Road will be signalised approximately 12 months prior to the commencement of construction. Due to traffic volumes on Botany Road (2,600 vehicles am peak hour), this intersection shall be utilised to provide safe and controlled access from the road network to the eastern section of the site.

The western section of the GS2AC will be accessed via Bourke Road with a full suite of turning movements as this road has the lowest traffic volumes (1,070 vehicles am peak hour). Access at O'Riordan Street (2,865 vehicles am peak hour) would be limited to left in left out.

Vehicle movements associated with each phase of construction are presented in Table 10 above. By comparison to existing traffic flows, the construction traffic will result in negligible noise impact on surrounding land uses.

5.2.1.4 Excavation and construction equipment

Noise generated from excavation and construction will vary depending on the specific type of activity carried out, as well the number of items of plant equipment operating at any one time. At this early stage of the development, the full details of excavation and construction are unknown. However, an indication of plant and equipment to be used during the works is provided in Table 11.

Table 11: Major construction equipment and sound power levels, dB(A)

Equipment type	Indicative size	L_w Sound power level
Excavation		
Tracked excavator	10t	99
Tracked excavator	15t	101
Tracked excavator	30t	103
Air compressor	-	111
Tipper truck	-	112
Concrete saw	-	113
Crushing / screening plant	-	117
Jack hammer	-	121
TOTAL	-	124
Construction		
Concrete Pump	6 t	103
Air compressor	-	111
Tipper truck	-	112
Vibratory roller	7t	120
Jack hammer	-	121
TOTAL	-	124

5.2.2 Noise assessment

Excavation and construction works are to take place at various locations across the development site. While equipment is likely to be distributed across various locations of the site, phases of work have been conservatively assessed by assuming all associated equipment is located in a specific zone. The site has been divided into four work zones extending from Botany Road to Bowden Street and noise emission from works within each of the zones has been assessed at the nearest receiver locations. The work zones are presented in Figure 6.

Figure 6: Work zones and nearest receiver locations

Based on the excavation and construction procedures and proximity of the nearest receivers, it is expected that the target levels may be exceeded during the peak excavation and construction activities. Noise prediction calculations have been carried out to determine worst case scenario noise levels of excavation and construction works at the subject site. Noise predictions have been assessed on the basis of the following:

- All plant and equipment for each stage operating concurrently for a conservative assessment,
- All plant and equipment distributed across each work zone.

Table 12 presents the predicted L_{Aeq} noise levels for peak activities during each stage of development.

Table 12: Predicted noise levels at nearest affected receivers

Receiver location	Work zone	Predicted L_{Aeq}, dB(A)		'Noise affected' targets	Comments
		Excavation	Construction		
R1 - Victoria Street and Queen Street, Alexandria	1	56	56	56	Work in all zones predicted to comply with the highly affected target of 75dB(A). Operations in Zones 2-4 predicted to exceed the noise affected target based upon the long-term noise monitoring results. By reference to the short-term measurements, only Zone 4 would exceed.
	2	**59**	**59**		
	3	**62**	**62**		
	4	**74**	**74**		
R2 - 16 O'Riordan Street, Alexandria	1	68	66	65	Work carried out in Zones 3 and 4 are predicted to exceed the highly affected target of 75dB(A). Operations in all zones were predicted to exceed the noise affected target based upon the
	2	73	69		
	3	78	72		

Receiver location	Work zone	Predicted L_{Aeq}, dB(A)		'Noise affected' targets	Comments
		Excavation	Construction		
	4	78	74		estimated long-term noise levels. However, the background noise levels are expected to be higher than estimated. Assessment of potential impacts during construction activities should be carried out to an internal location as noise levels from existing road traffic will require windows/doors to be closed for compliance against the RNP.
C1 - 9-13 O'Riordan Street	1	**79**	**80**	70	Work carried out in all zones predicted to exceed the external noise targets. For the reconfiguration of the site post partial site acquisition, it is recommended that driveway openings are removed from the site boundary and doors closed during intrusive construction activities, in order to protect internal amenity. Assessment of potential impacts during construction activities should be carried out to an internal location so that such measures can be considered.
	2	**96**	**96**		
	3	**79**	**79**		
	4	**73**	**73**		
C2 - 17 O'Riordan Street	1	**78**	**79**	70	Work carried out in all zones predicted to exceed the external noise targets, however only marginally for Zones 3 and 4. As the offices are constructed with fixed glazing and mechanically ventilated, assessment of potential impacts during construction activities should be carried out to an internal location. Based on site observations, 5mm fixed pane aluminium frame glazing was installed. Adopting a conservative internal noise criteria of background + 10dB and noise reduction from outside to inside of 20dB, all works zones are expected to result in reasonable internal amenity for the Red Cross building.
	2	**81**	**81**		
	3	**74**	**75**		
	4	70	**71**		
C3 - 18 O'Riordan Street	1	69	69	70	Work carried out in zones 2-4 are predicted to exceed the external noise targets. However, assessment to internal locations, given the solid southern façade of the building, is expected to result in reasonable internal amenity for occupants of the building.
	2	**74**	**75**		
	3	**79**	**80**		
	4	**79**	**79**		
C4 - 22 O'Riordan Street	1	70	70	70	Work carried out in Zones 2-4 are predicted to exceed the external noise targets, with most sensitive work zone being Zone 3. The impacts to inside the building will be dependent on the reconfiguration of the site post acquisition. It is recommended that the development be constructed and configured to minimise noise intrusion to internal areas for occupants. Consideration of construction noise mitigation measures is however warranted for those works in Zone 3.
	2	**76**	**76**		
	3	**96**	**96**		
	4	**83**	**83**		
C5 - 34-42 Bourke Road	1	**90**	**90**	70	Work carried out in Zones 1 and 2 is predicted to exceed the external noise targets. Assessment of potential impacts during construction activities should however be carried out to an internal location. Consideration of construction noise mitigation measures is however warranted, particularly for works in Zone 1.
	2	**79**	**80**		
	3	70	70		
	4	67	68		
C6 - 19-21 Bourke Road	1	**80**	**81**	70	Work carried out in Zones 1 and 2 is predicted to exceed the external noise targets, but only
	2	**72**	**72**		

Receiver location	Work zone	Predicted L_{Aeq}, dB(A)		'Noise affected' targets	Comments
		Excavation	Construction		
	3	66	67		marginally for Zone 2. Assessment of potential impacts during construction activities should however be carried out to an internal location. Adopting a conservative internal noise criteria of background + 10dB and noise reduction from outside to inside of 20dB with windows and doors closed, all works zones are expected to result in reasonable internal amenity.
	4	64	65		
C7 - 23-37 Bourke Road	1	**79**	**79**	70	Work carried out in Zones 1 and 2 is predicted to exceed the external noise targets, but only marginally for Zone 2. Assessment of potential impacts during construction activities should however be carried out to an internal location. Based on external inspection of the building, reasonable internal amenity is expected for all works zones.
	2	70	**71**		
	3	66	66		
	4	64	64		
C8 - 56-60 Bourke Road	1	**83**	**83**	70	Work carried out in Zones 1 and 2 is predicted to exceed the external noise targets, but only marginally for Zone 2. Assessment of potential impacts during construction activities should however be carried out to an internal location. Based on external inspection of the building, reasonable internal amenity is expected for all works zones.
	2	**74**	**74**		
	3	67	68		
	4	65	66		

5.2.3 Vibration assessment

5.2.3.1 Vibration sensitive receivers

Table 13 presents the nearest vibration sensitive receivers as well as the approximate distance to the nearest work zone.

Table 13: Nearest vibration receivers

Location ID	Receiver description	Nearest work zone	Approximate distance to nearest work zone
R1	Queen St, Alexandria	4	100m
R2	ValueSuites Green Square	3	50m
C1	Taxis combined services	2	10m
C2	Australian Red Cross	2	13m
C3	Autohaus One	3	40m
C4	Perfect Auto Body	3	5m
C5	Grace Records Management	2	5m
C6	Kelly Country	1	20m
C7	Danoz Direct	1	30m
C8	Quantum Energy Technologies	1	15m
O1	Airport line	1	Tunnel depth to be confirmed by TfNSW or Sydney Trains.

5.2.3.2 Vibration sources

The vibration generated from excavation and construction works will vary depending on the level and type of activity carried out at each site during each activity. Typical plant and equipment in use have been identified in Table 11.

Table 14 below identifies the dominant vibration generating plant and equipment. Potential vibration generated to receivers is dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver structure. Typical levels of ground vibration from these sources are shown in Table 14.

Table 14: Construction plant vibration levels

Plant equipment	Indicative size	PPV Vibration (mm/s) at distance from plant					
		5m	10m	15m	20m	30m	40m
Excavator & Breaker	Heavy	10.5	2.5	-	-	-	-
Excavator (travelling)	Heavy	8.0	3.4	1.6	-	-	-
Piling - Rotary bored cast in-situ	-	11.4	6.4	-	5.6	-	-
Roller - Vibratory (pad foot)	12t	15.1	10.3	3.2	-	-	-
Truck & Trailer	≤45t net	14.5	10.3	3.4	-	-	-

5.2.3.3 Indicative minimum working distances for vibration intensive equipment

As a guide, indicative minimum working distances for typical items of vibration intensive plant and equipment are provided in Table 15. The minimum working distances are quoted for:

- cosmetic damage, based on the British Standard 7385 (Group 2); and
- human comfort, based on the DECC's '*Assessing Vibration; a technical guideline*'.

Table 15: Recommended minimum working distances for vibration intensive equipment

Plant Item	Rating/ Description	Minimum Working Distance, m	
		Cosmetic Damage (BS 7385)	Human Response (DECC Guideline)
Vibratory Roller[2]	<50 kN (Typically 1-2 tonnes)	5	15 - 20
	<100 kN (Typically 2-4 tonnes)	6	20
	<200 kN (Typically 4-6 tonnes)	12	40
	<300 kN (Typically 7-13 tonnes)	15	100
	>300 kN (Typically 13-18 tonnes)	20	100
	>300 kN (Typically >18 tonnes)	25	100
Compactor[1]	852G	10	20
Dozer[1]	(D810) with ripper	2 (nominal)	10
Excavator[1]	<=30 Tonne (travelling/ digging)	10	15
Grader[1]	<= 20 tonne	2 (nominal)	10
Small Hydraulic Hammer[2]	300kg (5-12 tonne excavator)	2	7

Plant Item	Rating/ Description	Minimum Working Distance, m	
		Cosmetic Damage (BS 7385)	Human Response (DECC Guideline)
Medium Hydraulic Hammer[2]	900kg (12-18 tonne excavator)	7	23
Large Hydraulic Hammer[2]	1600kg (18-34 tonne excavator)	22	73
Pile Boring[2]	≤ 800 mm	2 (nominal)	N/A
Jackhammer[2]	Hand held	1 m (nominal)	Avoid contact with structure
Truck Movements[1]	-	-	10m

Notes:
1. More stringent conditions may apply to heritage or other sensitive structures
2. The minimum working distances are indicative and will vary depending on the specific equipment and geotechnical conditions.
3. They apply to cosmetic damage of buildings and have been derived from measured vibration data from a range of projects available in our database under varying geotechnical conditions. Vibration monitoring should be undertaken to confirm the safe working distances at specific sites where considered necessary.

The buildings nearest to works are C1 and C4 which require partial demolition and reconstruction to accommodate the GS2AC. The proximity of future structures will require a review when detailed information is available. With regard to human response, given the proximity of works, some adverse vibration may be experienced however the operations of both premises are not considered vibration sensitive. Cosmetic or structural damage is not expected based on the scope of work, however as stated, a review of future built should be carried out when specific machinery and equipment items to be utilised by the contractor has been finalised.

With regard to the nearest residential receivers, no adverse vibration impacts are expected as a result of the project works.

5.2.4 Recommendations

It is recommended that a site specific Construction Noise and Vibration Management Plan ('CNVMP') to be prepared prior to the issue of Construction Certificate ('CC') which should include noise modelling of construction activities after the exact selection of equipment to be used on-site becomes available.

5.2.4.1 Noise control measures

The following at-source control and management measures should be considered for the management of noise from excavation and construction works to reduce potential noise impacts. Noise reductions of between 3-8dB(A) for individual plant items could be expected where alternative process or localised noise barriers are practical. In other area, the management measures are focused on minimising unnecessary noise generation from the site and the extent and duration of peak noise levels.

Table 16: Construction noise control measures

Measure	Detail
Source controls	
Noise barriers	Construction of solid site hoarding along the corridor is unlikely to be practical or feasible. Noise barriers would provide some noise reduction to ground level receptors only. Where possible, localised barriers could be constructed for stationary equipment.
Equipment selection	Use the quietest and least vibration emitting construction methods where feasible and reasonable, eg. use of eccentric rippers rather than rock hammers.
Limit equipment in use	Only the equipment necessary for the upgrade works will be used at any time. Avoid any unnecessary noise when carrying out manual operations and when operating plant. Simultaneous operation of noisy plant and equipment within discernible range of a sensitive receiver should be avoided/ limited where possible.
Limit activity duration	Any equipment not in use for extended periods shall be switched off. For example, heavy vehicles should switch engines off whilst being unloaded.
Reversing alarms	Alternatives reverse alarm, such as 'quackers' should be installed where feasible and reasonable.
Management measures	
Implement community consultation measures	Inform community of construction activity and potential impacts.
Develop good relations	Good relations with building occupants should be established at the beginning of the works and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints seriously and dealing with them expeditiously is critical. The person selected to liaise with the building occupants should be adequately trained and experienced in such matters.
Work staging	Where practical, stage works so that that intrusive works are carried out at least noise sensitive periods.
Site inductions	All employees, contractors and subcontractors are to receive a Project induction. The environmental component may be covered in toolboxes and must include: • all relevant project specific and standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise and vibration generating activities • location of nearest sensitive receivers • environmental incident procedures
Complaints management procedure	A management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
Noise monitoring	A monitoring schedule is recommended to be developed and implemented during high noise and vibration generating activities where required. Noise and vibration monitoring would be carried out for any identified sensitive works, where monitoring could be used to proactively identify noisy works that may be otherwise managed and mitigated.

5.2.4.2 Vibration control measures

Based on available data from a database containing vibration measurements from past projects and from library information, Table 17 below presents the recommended minimum working distances for high vibration generating plant.

Table 17: Vibration minimum working distances

Plant item	Rating / description	Minimum. working distance, m	
		Cosmetic damage[2]	Human response[3]
Bobcat	Travelling	1 (nominal)	Avoid contact with structure
Jackhammer	Hand held	1 (nominal)	Avoid contact with structure
Large Hydraulic Hammer	1600 kg	5	73
Excavator	<=30 Tonne (travelling/ digging)	5	15
Truck Movements[1]	Travelling loaded	5	10
Vibratory Rollers	20t	10	100

Notes:
1. Renzo Tonin & Associates project files, databases & library
2. Based on DIN4150.3 Group 1 Buildings
3. For residential receivers. Provided for reference only. Management measures isolated to structural damage for construction works.

Site specific buffer distances shall be determined where vibration significant plant items, in particular large rock hammers/breakers and vibratory rollers, operate within Cosmetic Damage minimum working distances detailed in Table 17. Where this occurs, minimum buffer distances to affected receivers shall be determined by site measurements prior to the commencement of the regular use of the vibration significant plant on site. The site-specific minimum working distance shall be maintained in order to comply with relevant vibration limits.

6 Operational noise assessment

6.1 Operational traffic noise criteria

This report assesses road traffic noise impact in accordance with the NSW RNP. The GS2AC is classed as a local road as it only provides vehicular access to surrounding streets.

According to the RNP, this project is a new road as it is proposed on a corridor that has not previously been a road and therefore the project is classed as a 'new road'.

6.1.1 Residential land uses

The RNP is used to assess the potential traffic noise impact from the new road. The 'new road' criteria for residential receivers are presented in Table 18 below. These criteria are for noise levels assessed in front of a building facade. In accordance with Section 3.4.1 of the RNP, the criteria in Table 18 are based on the traffic noise level contribution from just the GS2AC.

Table 18: Road traffic noise assessment criteria for residential land uses

Road category	Type of project/land use	Assessment Criteria, dB(A)	
		Day 7:00am-10:00pm	Night 10:00pm-7:00am
Local roads	Existing residences affected by noise from new local road corridors	$L_{Aeq,(1\ hour)}$ 55 (external)	$L_{Aeq,(1\ hour)}$ 50 (external)

Note: Land use developers must meet internal noise goals in the Infrastructure SEPP (Department of Planning NSW 2007) for residences near busy roads (see RNP Appendix C10).

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria.

6.1.1.1 Increase in traffic on surrounding road network

The GS2AC will affect traffic on the surrounding road network, and has the potential to either increase or decrease traffic. For receivers located on surrounding roads that are not directly influenced by traffic noise from the GS2AC but may experience an increase in traffic noise due to the project, assessment against the RNP 2dB increase allowance has been undertaken. In accordance with the RNP when assessing feasible and reasonable mitigation measures, an increase of up to 2dB represents a minor impact that is considered barely perceptible to the average person.

6.1.2 Non-residential land use developments

The RNP also sets criteria for the assessment of traffic noise on non-residential land uses such as schools, hospitals, places of worship and recreation areas. With the exception of commercial receivers, no potentially non-residential affected sensitive receivers have been identified in the study area.

6.1.3 Commercial developments

While the RNP does not outline specific criteria for commercial premises, the RNP does reference the internal noise levels contained in Australian Standard 2107:2000 (Standards Australia 2000). For this project, commercial developments have been assessed against Australian Standard 2107:2000.

For commercial receivers, external to internal noise level reductions have been estimated based on each receiver type's building construction, and these reductions range from 20 to 25dB(A). Where estimation has not been possible, a conservative 20dB(A) reduction from external to internal noise levels has been adopted to allow an external assessment.

6.2 Relative increase criteria

Traffic noise impacts from the proposed 'new road' would need to also comply with the 'Relative Increase Criteria' as discussed in Section 2.4 of the RNP. The relative increase criteria are to be applied to the external areas of existing residential and sensitive land uses impacted upon by the redeveloped road.

The relative increase criteria as set out in the RNP applicable to this project are reproduced below.

Table 19: Relative increase criteria

Type of development	Total traffic noise level increase, dB(A)
New road corridor	Existing traffic $L_{Aeq(period)}$ + 12 dB (external)

Note: 'Existing traffic' refers to the traffic noise levels for the relevant 'no build' option.

Residential receivers alongside Johnson Street are already exposed to high level of traffic noise from Botany Road, O'Riordan Street and Johnson Street, and since this project is located more than 100 metres from these receivers, there is no location where the project will cause an increase of more than 12dB over the existing noise levels. The project therefore complies with the relative increase criteria.

6.3 Maximum noise level goal

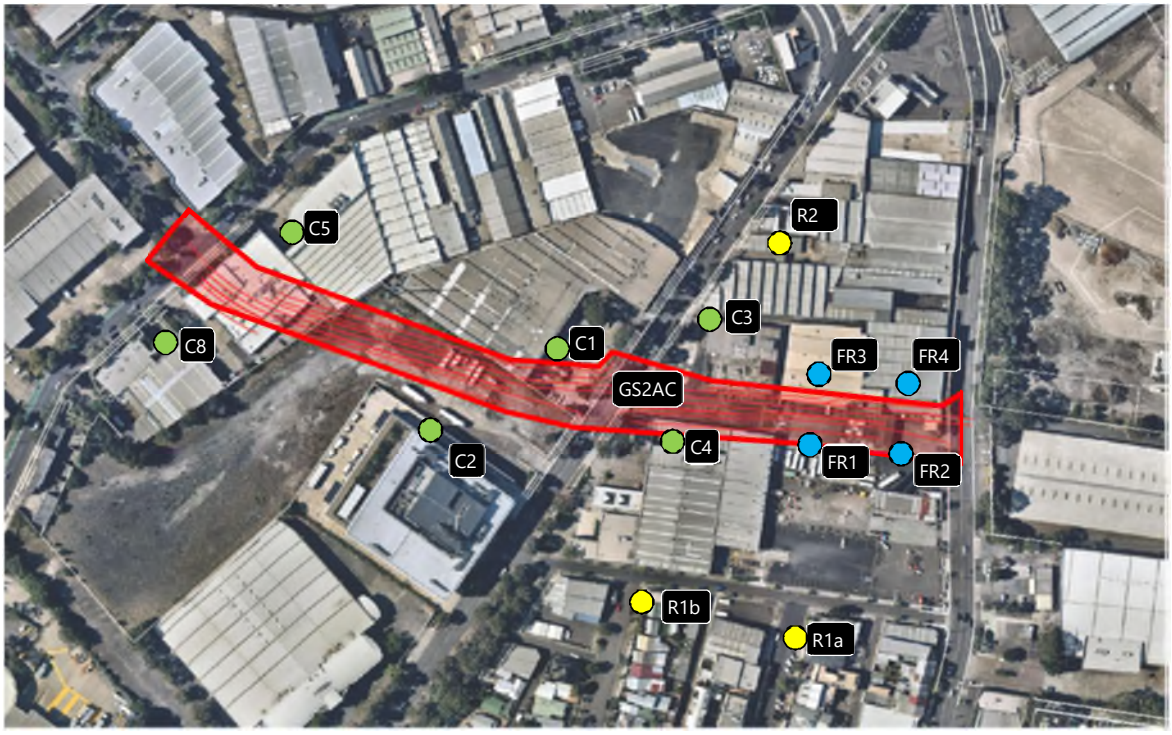
Maximum noise levels generated by road traffic noise have the potential to cause disturbance to sleep. The RNP does not specify a night-time L_{Max} noise limit or noise goal. Research conducted to date in this field has not been definitive and the relationship between maximum noise levels, sleep disturbance and subsequent health effects is not currently well defined. Research on sleep disturbance is however reviewed in the RNP and it is concluded that that the range of results is sufficiently diverse that it is not reasonable to issue new noise criteria for sleep disturbance.

According to the policy however, the likely maximum or peak noise levels are to be broadly assessed and reported for the night-time period, which is considered by the NSW EPA as being 10pm to 7am.

6.4 Assessment locations

The nearest potentially affected receivers to operational noise associated with the GS2AC development are presented in Figure 3 of this report. Based on site observations of the construction of commercial buildings, the operational traffic noise assessment locations (pertaining to the nearest potentially affected facade) are presented in Figure 7. Also shown in Figure 7 are the assessment locations related to potential future residential use, which is discussed in Section 6.7.2.

Figure 7: Operational traffic noise assessment locations



6.5 Traffic flow and composition summary

Traffic data (1-hour peak hour traffic volumes) have been provided by AECOM for the future years 2021 (Year of Opening) and 2031 (Design Year) are provided in Table 20.

In addition, RMS Strategic Model traffic data (2-hour peak hour traffic volumes) provided by RMS for 2021 and 2031 have also been utilised for this assessment and are shown in APPENDIX B. The RMS data has been utilised to assess the influence of the GS2AC project as the modelling included scenarios with and without the GS2AC.

Table 20: 2021 and 2031 AM and PM 1-hour peak intersection traffic volumes (with development)

Intersection	Approach	2021 AM	2021 PM	2031 AM	2031 PM
Botany Road / Geddes Avenue	Botany (N)	1008	1219	1123	1163
	Geddes (E)	279	279	486	336
	Botany (S)	1027	876	1201	929
	GS2AC (W)	144	225	474	665
O'Riordan Street / GS2AC	O'Riordan (N)	1142	1006	1154	1002
	GS2AC (E)	227	269	380	259
	O'Riordan (S)	1124	1118	1049	1216
	GS2AC (W)	125	161	403	448
Bourke Road / GS2AC	Bourke (N)	471	340	399	274
	GS2AC (E)	180	241	194	207
	Bourke (S)	423	456	486	535
	Bowden (W)	300	340	436	331
Botany Road / Bourke Road / Bourke Street	Botany (N)	877	1083	917	930
	Bourke (E)	585	649	481	554
	Botany (S)	1000	848	1155	957
	Bourke (W)	1032	1089	1025	1224
Wyndham Street / O'Riordan Street	Wyndham (N)	658	581	763	574
	Bourke (E)	369	439	309	400
	O'Riordan (S)	1065	1045	1033	1233
	Bourke (W)	370	460	409	494

Note: 2021 AM and PM data for Botany Road / Geddes Avenue, O'Riordan Street / GS2AC and Bourke Road / GS2AC intersections are based on Draft Green Square to Ashmore Connector Route Strategy prepared by AECOM Australia Pty Ltd and dated 3 April 2017.

Based on consultation with AECOM the 1-hour peak volumes were multiplied by a conversion factor of 10 in order to estimate the 'Annual Average Daily Traffic' (AADT). With regard to the RMS Strategic Model 2-hour peak data, a 6.5 multiplier was used to estimate the AADT. Both AADT estimates were found to be comparable. To determine the 15-hour day and 9-hour night splits, the following assumption, in consultation with AECOM, has been utilised:

- Daytime (7am to 10pm) = 85% of AADT;
- Night (10pm to7am) = 15% of AADT.

6.6 Road traffic noise prediction modelling

Noise predictions are based on a method developed by the United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1988)" known as the CoRTN (1988) method. This method has been adapted to Australian conditions and extensively tested by the Australian Road Research Board and as a result it is recognised and accepted by the NSW Environment Protection Authority. The model predicts noise levels for steady flowing traffic and noise from high truck exhausts is also taken into account.

The CoRTN algorithms are contained within the 'CadnaA' noise modelling software which has been used to calculate traffic noise levels at receivers. The noise prediction model takes into account the following inputs.

Input parameters	Data acquired from
Traffic volumes and mix	Based on forecast data from AECOM and RMS $L_{Aeq,1hr}$ volumes based on the average AECOM peak hourly volumes
Vehicle speed	Posted Traffic Speed: 50km/h
Source height	0.5 metre for car exhaust, 1.5 metres for car and truck engines and 3.6 metres for truck exhaust and detailed within CORTN88
Ground topography at receiver and road	2m Ground Contours obtained from NSW Land & Property Information (LPI)
Angles of view from receiver	Contained within model
Reflections from existing barriers, structures and cuttings on opposite side of road	Calculated in CadnaA through CoRTN algorithm
Ground absorption factor	0.5
Receiver Heights	Residences: 1.5 metre above ground level for ground floor and 4.5 metre above ground level for 1st floor Commercial: estimated (range from 1.5m to 6.5m)
Facade correction	+2.5dB(A)
Correction for Australian conditions	-1.7 dB(A) for 'at facade' conditions from Australian Road Research Board ('ARRB') Transport Research (Saunders et al 1983)
Acoustic properties of road surfaces	Dense graded asphalt - no corrections applied
Noise mitigation measures	Existing significant fences included in noise model

6.7 Noise model prediction results

In accordance with Section 3.4.1 of the RNP, the traffic noise level contributions from the GS2AC have been predicted to the assessment locations in Figure 7. Predictions have been undertaken for the worst-case scenario, 'Design Year' day period, and results are presented in Table 21.

Table 21: Design Year (2031) Daytime Operational noise level predictions from GS2AC

Receiver location	External $L_{Aeq,1hr}$ dB(A) daytime noise level[1]	Inside to outside noise reduction dB(A)[2]	Internal $L_{Aeq,15hr}$ dB(A) daytime noise level[1]	RNP criteria or AS 2107:200 recommended Satisfactory noise level	Consideration for noise mitigation
R1a - Victoria Street, Alexandria	48	-	-	55[3]	No
R1b - Queen Street, Alexandria	42	-	-	55[3]	No
R2 - 16 O'Riordan Street	46	-	-	55[3]	No
C1 - 9-13 O'Riordan Street	63	25	38	40[4]	No
C2 - 17 O'Riordan Street	62	25	37	40[4]	No
C3 - 18 O'Riordan Street	60	20	40	40[4]	No
C4 - 22 O'Riordan Street	58	25	33	40[4]	No

Receiver location	External $L_{Aeq,1hr}$ dB(A) daytime noise level[1]	Inside to outside noise reduction dB(A)[2]	Internal $L_{Aeq,15hr}$ dB(A) daytime noise level[1]	RNP criteria or AS 2107:200 recommended Satisfactory noise level	Consideration for noise mitigation
C5 - 34-42 Bourke Road	57	25	32	40[4]	No
C8 - 56-60 Bourke Road	54	25	29	40[4]	No

Notes:
1. At facade noise prediction (ARRB correction applied)
2. Estimated inside to outside noise level reduction based on receiver type's building construction
3. RNP criteria for 'new' sub-arterial road
4. Internal noise level for general office areas

As shown in Table 21, noise compliance is achieved at all assessment locations.

6.7.1 Receivers on surrounding roads

Based on the RMS Strategic Model traffic data, analysis has been undertaken to determine potential traffic noise level increases/decreases along existing surrounding roads (ie. Botany Road, O'Riordan Street, Bourke Road and Bowden Street) due to the GS2AC project. A summary of the analysis is presented in Table 22.

Table 22: Noise level difference dB(A) on surrounding roads due to the GS2AC project

Road	2021		2031	
	AM 2Hr Peak	PM 2Hr Peak	AM 2Hr Peak	PM 2Hr Peak
Botany Road	0.2	0.1	0.7	-0.4
O'Riordan Street	-0.2	-0.3	0.1	-0.9
Bourke Road (North of GS2AC)	0.3	0.2	-0.3	0.0
Bourke Road (South of GS2AC)	0.7	0.9	0.1	-0.2
Bowden Street	1.1	1.4	1.9	0.7

Table 22 shows that the project will not cause traffic noise levels along existing surrounding roads (ie. Botany Road, O'Riordan Street, Bourke Road and Bowden Street) to increase by 2dB(A). In accordance with the RNP, when assessing feasible and reasonable mitigation measures this is considered a minor impact that is considered barely perceptible to the average person.

6.7.2 Future residences

An existing residence is best interpreted as applying from DA approved development onwards. That is, residential subdivided or zoned land would not ordinarily be affected by the RNP, as there is an opportunity for addressing noise through good placement, layout and building design of residences.

The area encapsulated by 20-22 O'Riordan Street, and 334-338 Botany Road is under consideration for future affordable housing. Even though GS2AC, O'Riordan Street, and Botany Road would not be presently classed as a 'busy road' (ie. <40,000 ADT) within the Infrastructure SEPP (Department of Planning NSW 2007), the ISEPP provides the most applicable guidance for this development.

Table 24 summarises the ISEPP criteria for new residential development, including an equivalent external noise goal.

Table 23: ISEPP noise criteria for new residential development

Room	Location	$L_{Aeq,\ 15hr}$ Day 7am – 10pm	$L_{Aeq\ 9hr}$ Night 10pm – 7am
Living rooms*	Internal, windows closed	40	40
	Internal, windows open	50	50
	External free-field (allowing windows to remain open)^	60	60
	External 1m from façade level (allowing windows to remain open)^	62.5	62.5
Bedrooms*	Internal, windows closed	40	35
	Internal, windows open	50	45
	External free-field (allowing windows to remain open)^	60	55
	External 1m from façade level (allowing windows to remain open)^	62.5	57.5

Notes: * Requisite for 40,000AADT Roads only under ISEPP 2007.

^ ISEPP Guideline states that where internal noise criteria are exceeded by more than 10dB(A) with windows open mechanical ventilation is required. External goals have been calculated on the basis of nominal 10dB(A) reduction through an open window to a free-field position. Windows open to 5% of floor area in accordance with the BCA 2011 requirements.

A preliminary assessment has been undertaken for an indicative future residential housing on the corner of GS2AC and Botany Road. An indicative residential building has been included in the noise model and predictions have been undertaken and summarised in Table 24. Assessment locations are shown in Figure 7 and setback distances from GS2AC and Botany Road are shown in Table 24.

Table 24: Design Year (2031) daytime operational noise level predictions at future residences

Receiver location	Kerb setback distance in metres [3]	External $L_{Aeq,15hr}$ dB(A) daytime noise level contribution from GS2AC[1]	External $L_{Aeq,15hr}$ dB(A) daytime noise level contribution from Botany Rd[1]	External $L_{Aeq,15hr}$ dB(A) daytime total noise level[1,2]
FR1	5 (GS2AC) & 70 (Botany Road)	66	58	67
FR2	5 (GS2AC) & 20 (Botany Road)	65	66	68
FR3	5 (GS2AC) & 70 (Botany Road)	52	72	72
FR4	5 (GS2AC) & 20 (Botany Road)	44	72	72

Notes:
1. At facade noise prediction (ARRB correction applied)
2. Total noise includes traffic noise from GS2AC and Botany Road
3. Distances are from the kerb of the road

Predictions within Table 24 show that at location FR1, GS2AC is the dominant traffic noise source, at FR2, they are equally contributing and at FR3 and FR4, Botany Road is slightly dominating. Therefore, any at-road noise mitigation would only be beneficial to assessment location FR1 and FR2. The extent of noise reduction provided by the mitigation would be limited by the existing traffic noise contribution from Botany Road.

The predicted noise levels indicate that noise mitigation treatment to the building facade will be required for future noise sensitive development along the GS2AC. The extent of treatment will be dependant of the types of uses, setback from the road and orientation. Design advice for future noise sensitive development is not within the scope of the GS2AC REF.

6.8 Maximum noise level assessment

The nearest residential receivers are located greater than 100m away from the proposed GS2AC, near Johnson Street. Given this distance and the proximity of surrounding existing roads, sleep disturbance from GS2AC is unlikely. It is also expected that the number of L_{Amax} events could decrease along Johnson Street, as the GS2AC could be utilised as an alternative to Johnson Street. Furthermore, the development of land between the GS2AC and existing residential premises will provide additional acoustic shielding.

6.9 Road traffic noise mitigation options

While the assessment reveals compliance at all existing receptors and that future development may require noise mitigation to the building design, consideration has been given to potential noise reduction measures for the road design.

The advice provided here is in respect of acoustics only. Supplementary professional advice may need to be sought in respect of fire ratings, structural design, buildability, fitness for purpose and the like.

The RNP sets out that priority should first be given to reducing noise during road design and traffic management where there may be greater opportunity to provide cost effective integrated outcomes with better urban design. Following traffic management and road design, Section 3.4.1 of the RNP indicates the following priority order for noise mitigation:

i. Quieter pavement surfaces
ii. In-corridor noise barriers/mounds
iii. at-property treatments or localised barriers/mounds

All reasonable and feasible traffic management and road design opportunities to reduce road traffic noise have been considered within the concept design. Therefore, the following sections assess the feasible and reasonableness of the remaining mitigation options in accordance with the order of priority stated above.

6.9.1 Quieter pavements

The RNP sets out that quieter pavement surface is the preferred form of noise mitigation as it reduces source noise levels and provides protection to both external and internal noise levels and also has the least visual impact.

Application of a quiet pavement is not recommended for this proposal for the following reasons:

- The posted speed limit for the GS2AC is to be 50 km/h, and the noise reductions achieved from this mitigation measure would be negligible.
- There are multiple intersections along the GS2AC, which is not ideal for quiet pavements and can cause increased wear and maintenance.

Dense graded asphalt is therefore considered the most appropriate road surface for both noise and other design considerations.

6.9.2 Noise barriers

Not only are noise barriers considered impractical for the project, but future residential development will be multi-storey and therefore noise barriers will provide no noise reduction benefit.

7 Conclusion

Renzo Tonin & Associates have completed a noise and vibration assessment for the Green Square to Ashmore Connector (GS2AC) REF, located at Green Square, Sydney, NSW. Noise and vibration associated with the project construction activities, along with noise from operation of the project road has been assessed.

The findings of this study are:

Construction noise and vibration assessment

- Construction noise is likely to exceed the construction noise goals for the majority of receivers along the construction route. Impacts will be greatest for residential receivers when construction is taking place towards the eastern end of the works. All reasonable and feasible noise mitigation should be applied during the construction phase. Possible noise mitigation measures and their effectiveness have been discussed.
- The risk of structural damage during construction is generally assessed as being low, although this should be confirmed for the detailed design. There is low risk of adverse comment from the nearest receivers for tactile vibration. Vibration mitigation measures and indicative buffer distances have been provided.
- Dilapidation surveys are recommended prior to the commencement of construction at properties that do not comply with the nominated indicative buffer distances.
- Vibration monitoring is recommended during the construction phase to determine site specific buffer distances.

Traffic noise assessment

- Traffic noise levels along existing surrounding roads (ie. Botany Road, O'Riordan Street, Bourke Road and Bowden Street) are not predicted to increase by more than 2dB(A) as a result of the GS2AC. Therefore the impact associated with increased noise from the project along existing roads is considered minor and does not warrant any noise mitigation measures.
- Noise compliance is achieved at all existing assessment locations.
- Possible at-road mitigation options for future residential housing is limited, as set out in Section 6.9. The need for any noise mitigation treatment for future residential housing should be assessed for each proposed development along the GS2AC corridor, and where required, noise mitigation treatment applied to the building.

APPENDIX A Glossary of terminology

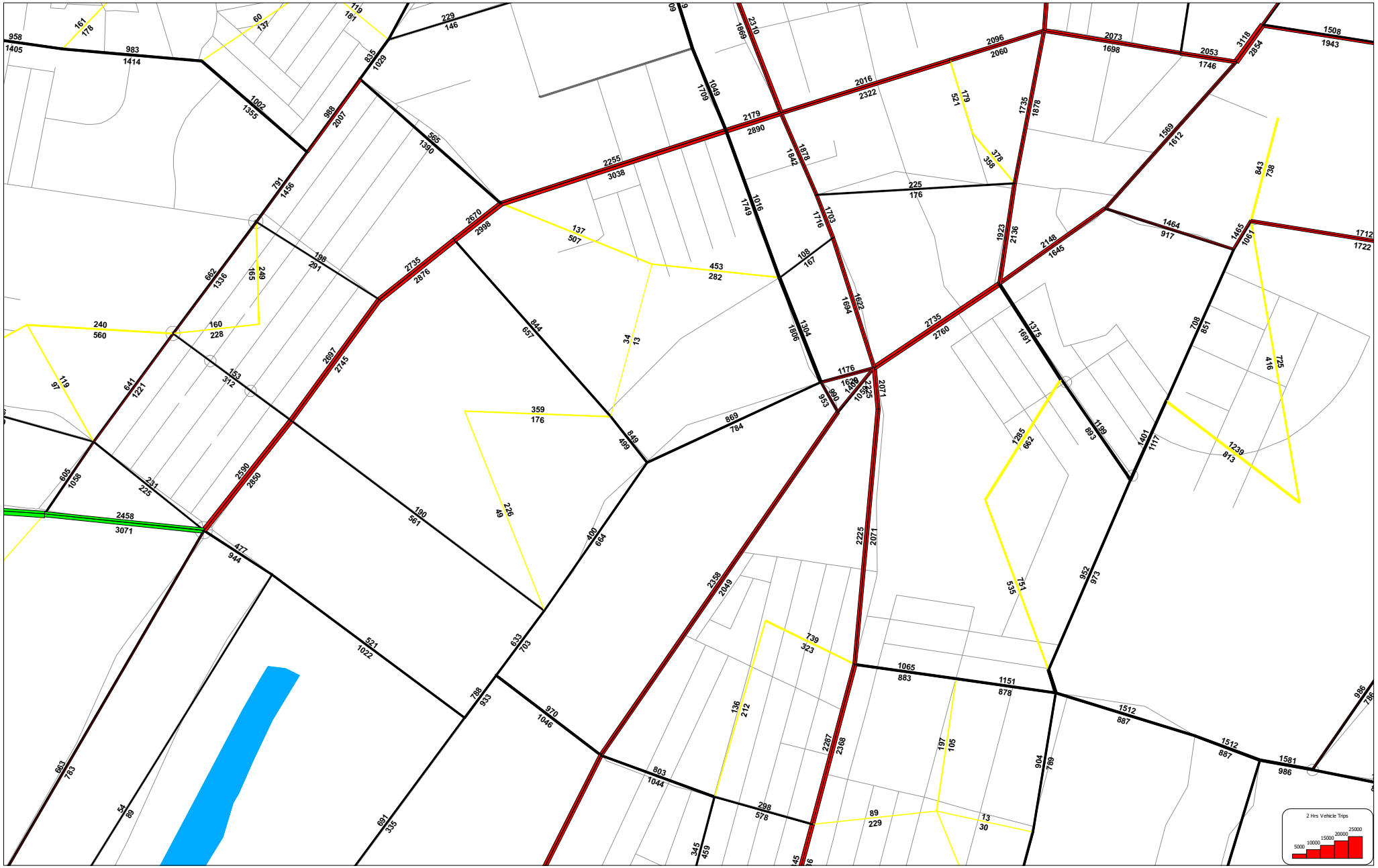
The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L_{90} noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dBThe sound of a rock band 115dBLimit of sound permitted in industry 120dBDeafening
dB(A)	A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A-filter.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain L_{eq} sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B RMS Strategic Model Traffic Data

TRAFFIC VOLUMES__



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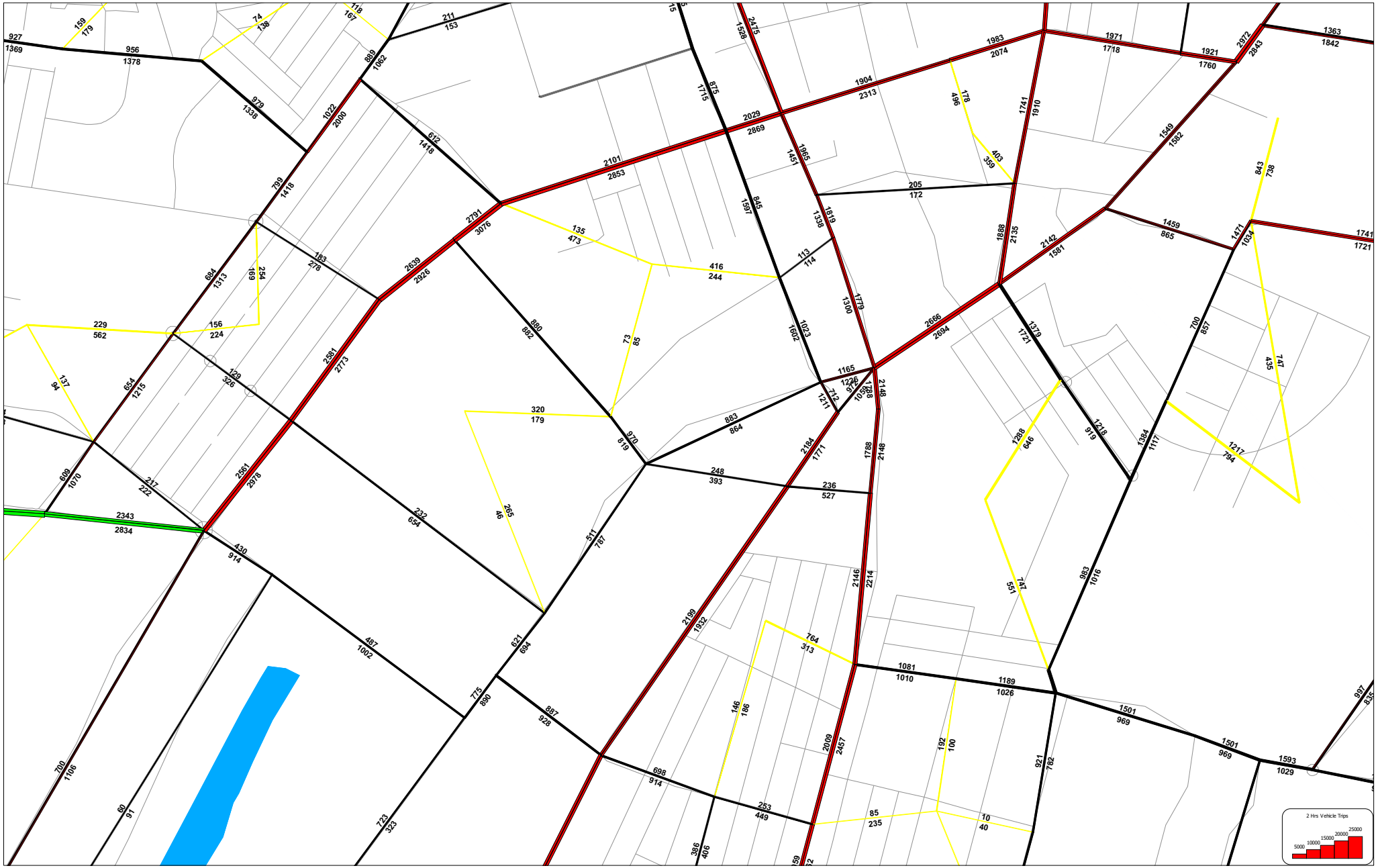
TRAFFIC VOLUMES__



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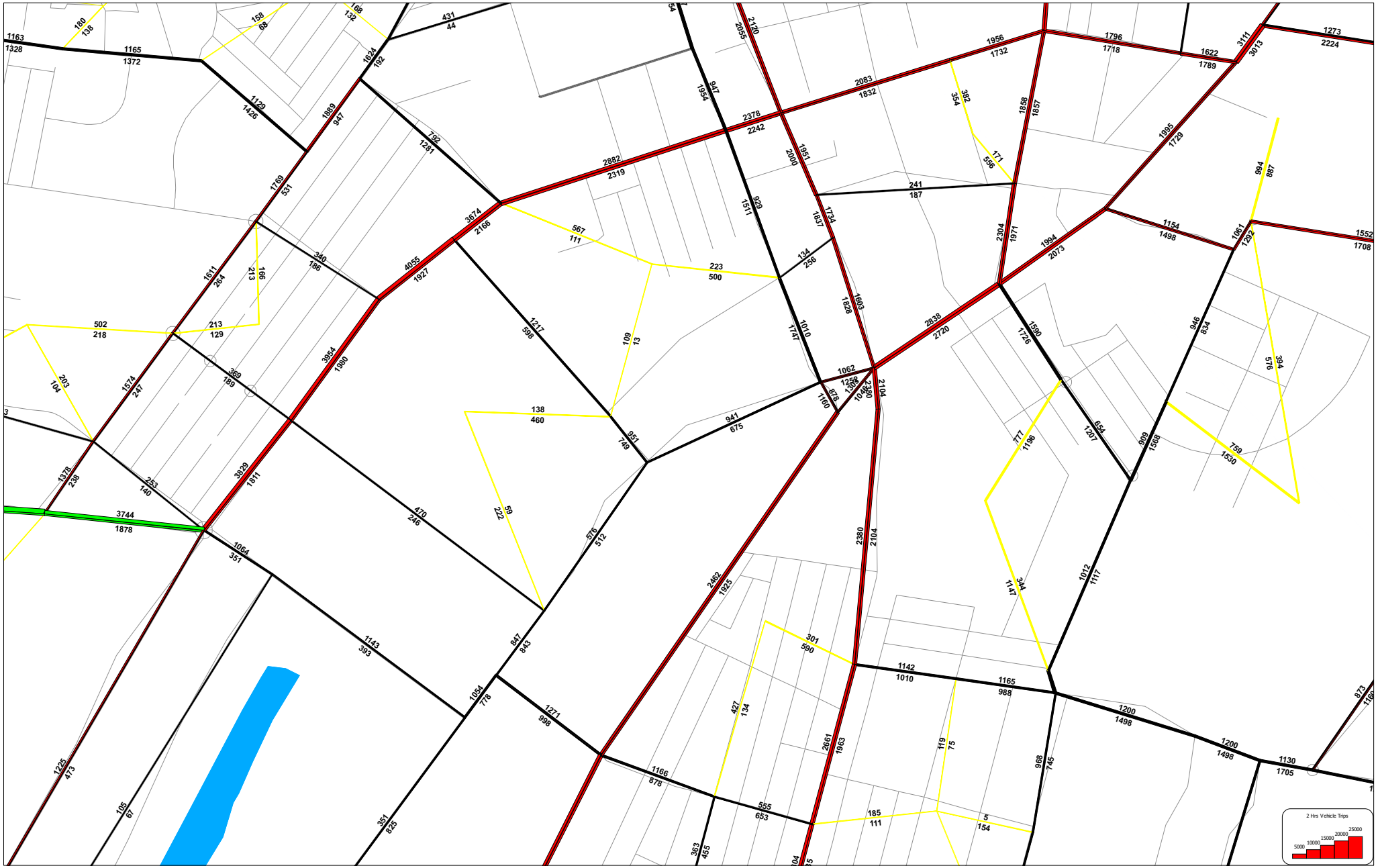
TRAFFIC VOLUMES__



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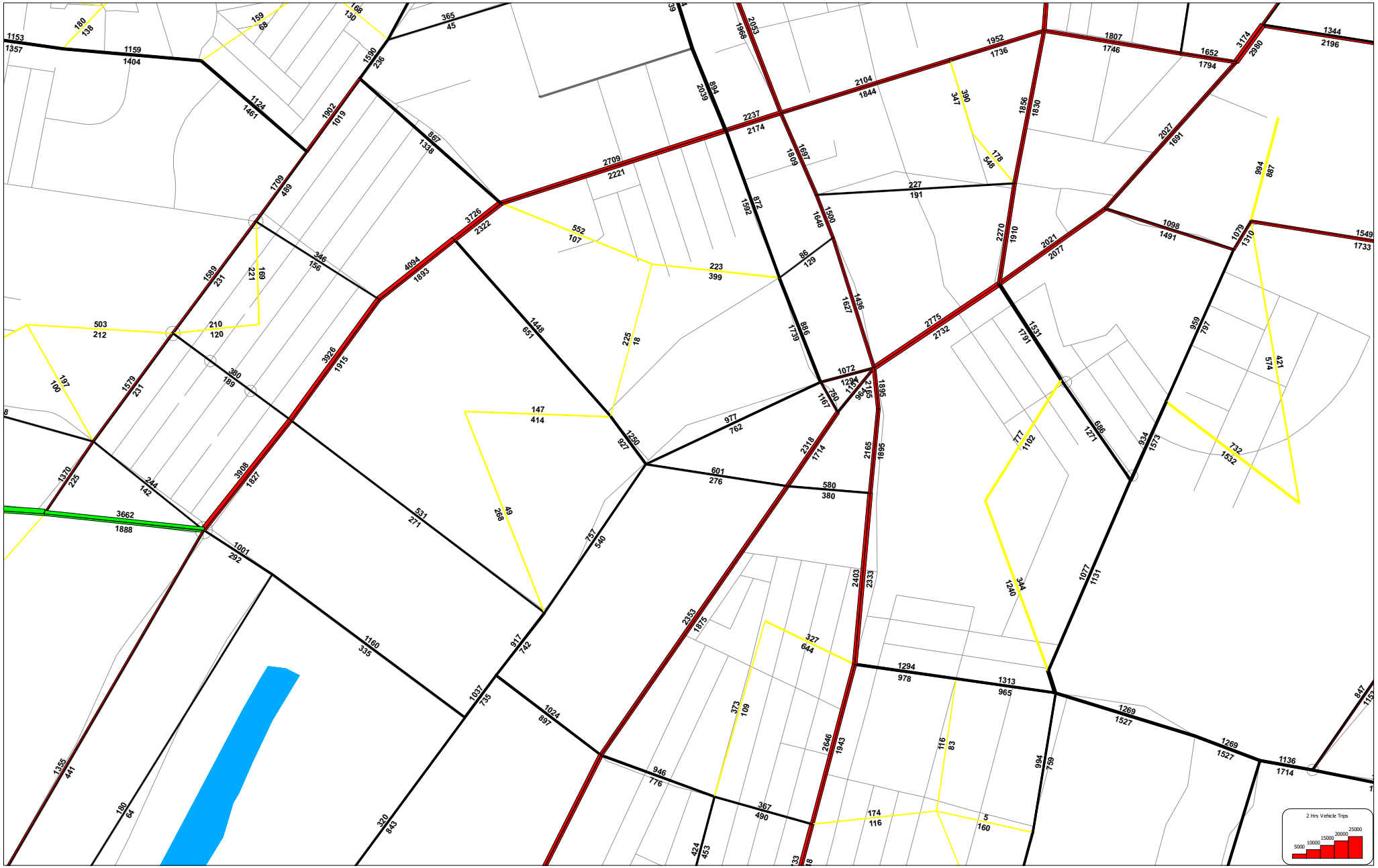
TRAFFIC VOLUMES__



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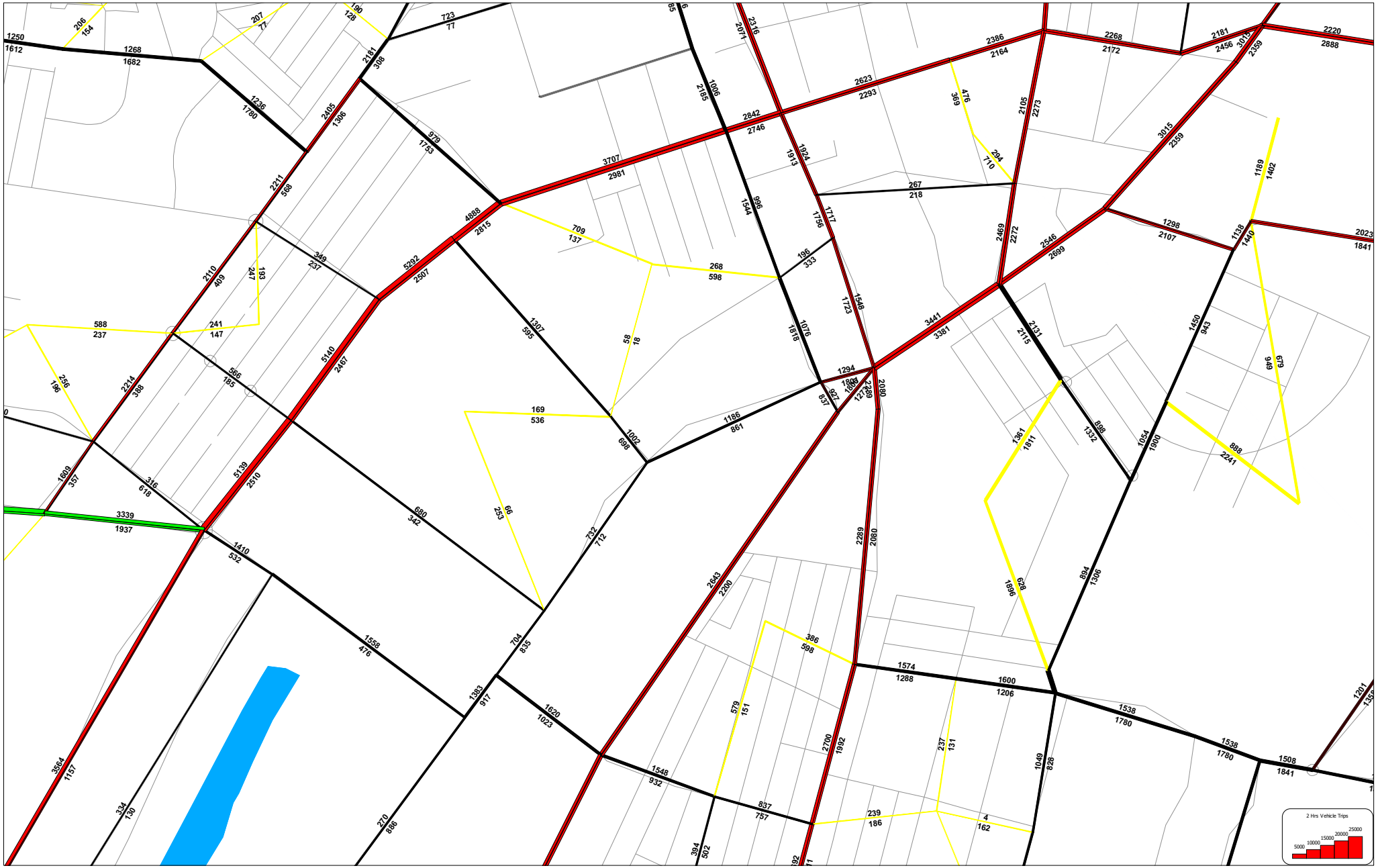
1
2
3
4
5

TRAFFIC VOLUMES__



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Scenario 31127: 2036 SYDNEY ROAD NETWORK (INTDELAY)-7-9AM(mf15)
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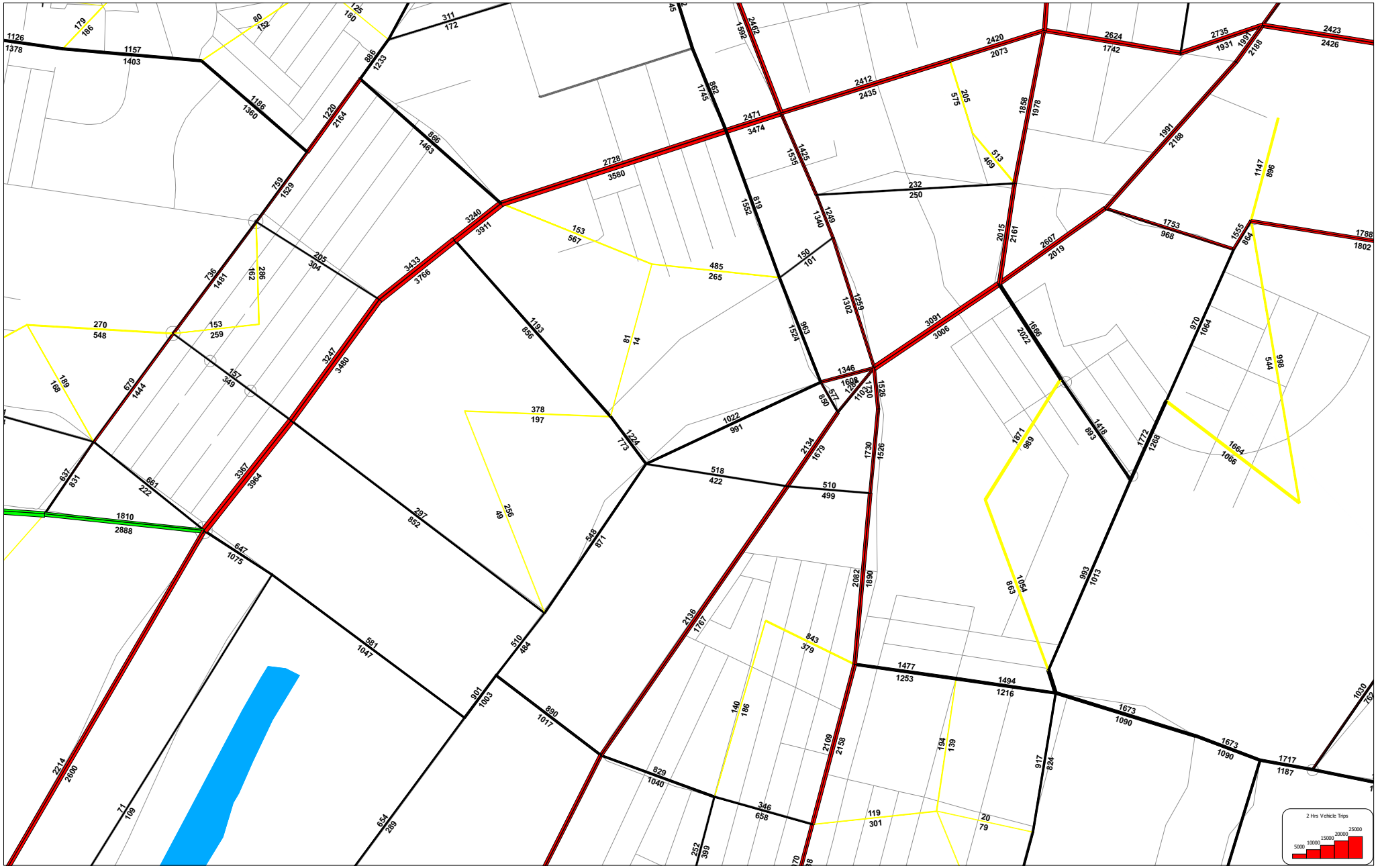
2
3
4
5

TRAFFIC VOLUMES__



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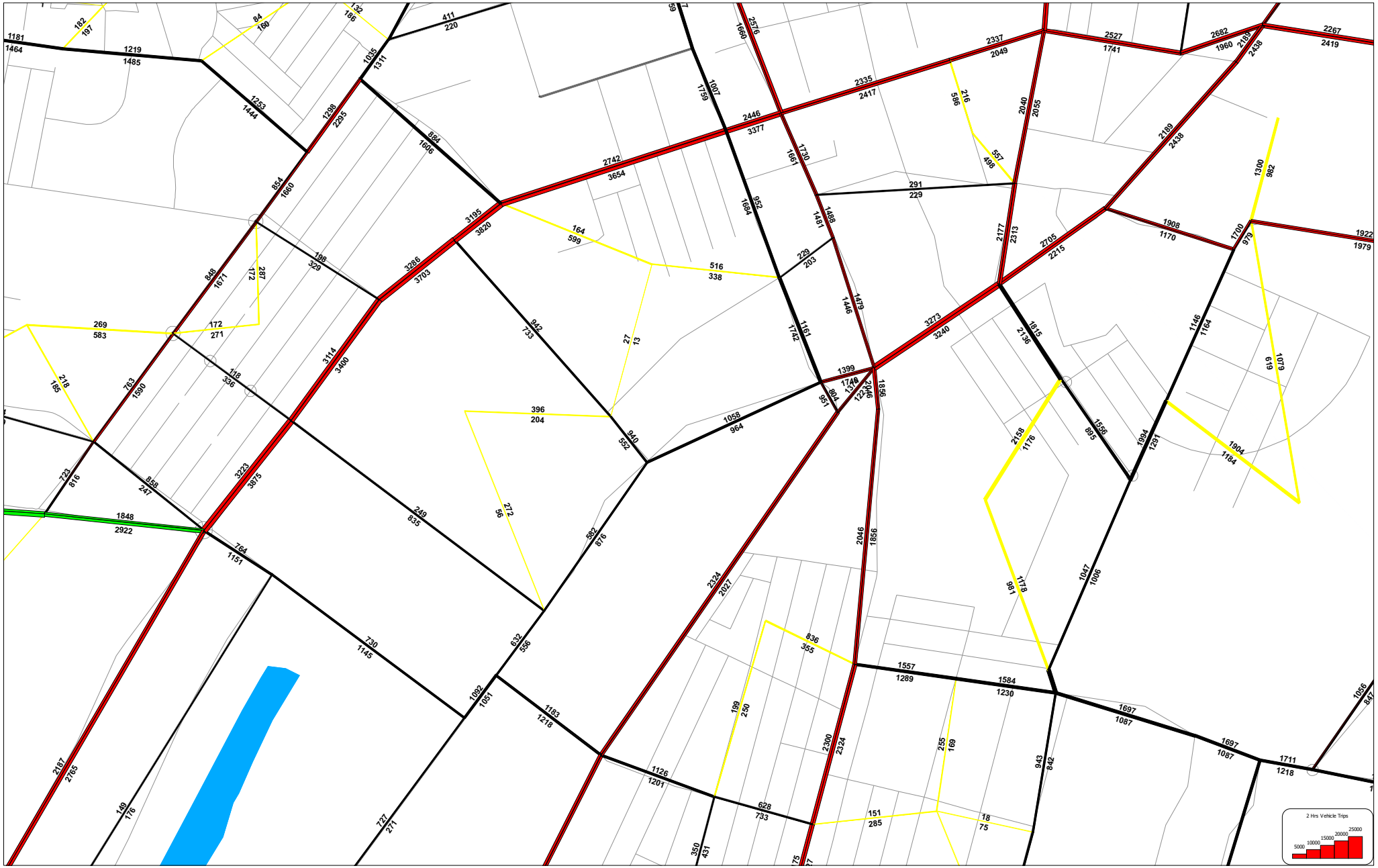

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4
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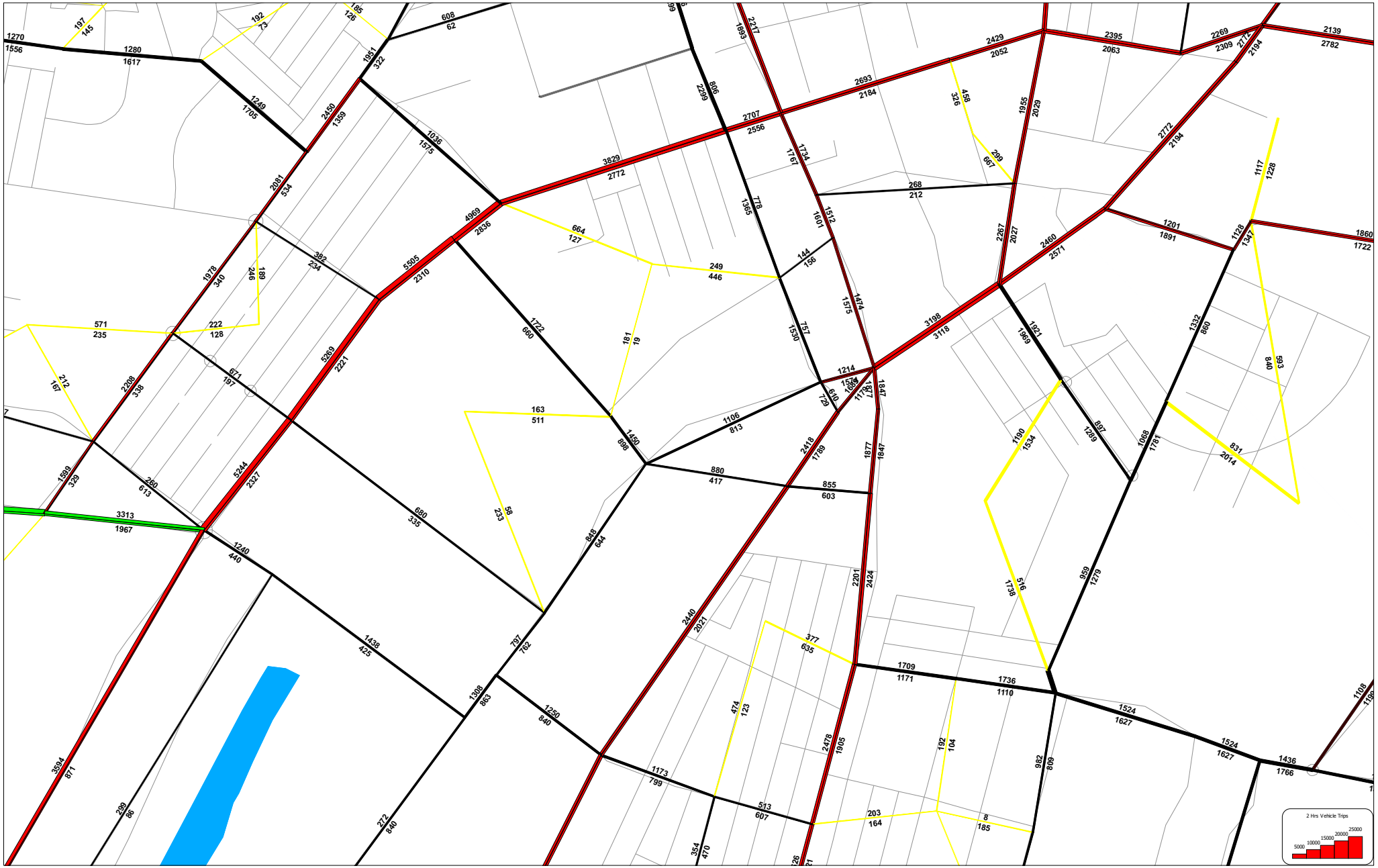
TRAFFIC VOLUMES__



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