Noise Affected Space	

DRAWING NOTES

1. A noise affected space is classified as a space in which occupants cannot rely on opening the windows in the space to achieve the natural ventilation requirements of the NCC and simultaneously meet the acoustic requirements internal to the space.

2. Where the space is classified as Class 2 (residential apartments), an alternative means of natural ventilation shall be provided to the noise affected space such that when open, meets both the acoustic requirements and the requirements of the City of Sydney's "Draft Alternative natural ventilation of apartments in noisy environments - Performance pathway guideline".

3. Where the space is classified as Class 3, an alternative means of natural or mechanical ventilation shall be provided to the noise affected space such that when open, meets both the acoustic requirements and the requirements of the NCC.

4. Consideration should be given to the requirements for each Class 2 space to achieve the "purge" requirements of the ADG when calculated in accordance with the City of Sydney's methods (each space must be served by a minimum effective open area of 5% of the floor area of the space). This does not need to be achieved simultaneously with the acoustic requirements.

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004	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
003	Milestone Package 3	MIS	BN	10/07/20
002	Milestone Package 2	MIS	BN	22/05/20
001	Milestone Package 1	MIS	BN	1/04/20

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TITLE: NOISE AFFECTED LOCATIONS - BUILDING 4, LEVEL 08

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMQ-BLD4-WGE-AC-SK-AC7873	4

Noise Affected Space	

DRAWING NOTES

1. A noise affected space is classified as a space in which occupants cannot rely on opening the windows in the space to achieve the natural ventilation requirements of the NCC and simultaneously meet the acoustic requirements internal to the space.

2. Where the space is classified as Class 2 (residential apartments), an alternative means of natural ventilation shall be provided to the noise affected space such that when open, meets both the acoustic requirements and the requirements of the City of Sydney's "Draft Alternative natural ventilation of apartments in noisy environments - Performance pathway guideline".

3. Where the space is classified as Class 3, an alternative means of natural or mechanical ventilation shall be provided to the noise affected space such that when open, meets both the acoustic requirements and the requirements of the NCC.

4. Consideration should be given to the requirements for each Class 2 space to achieve the "purge" requirements of the ADG when calculated in accordance with the City of Sydney's methods (each space must be served by a minimum effective open area of 5% of the floor area of the space). This does not need to be achieved simultaneously with the acoustic requirements.

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004	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
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001	Milestone Package 1	MIS	BN	1/04/20

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMQ-BLD4-WGE-AC-SK-AC7874	4

15.5 Appendix 5 – Locations of Acoustic Ventilators

LEGEND

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

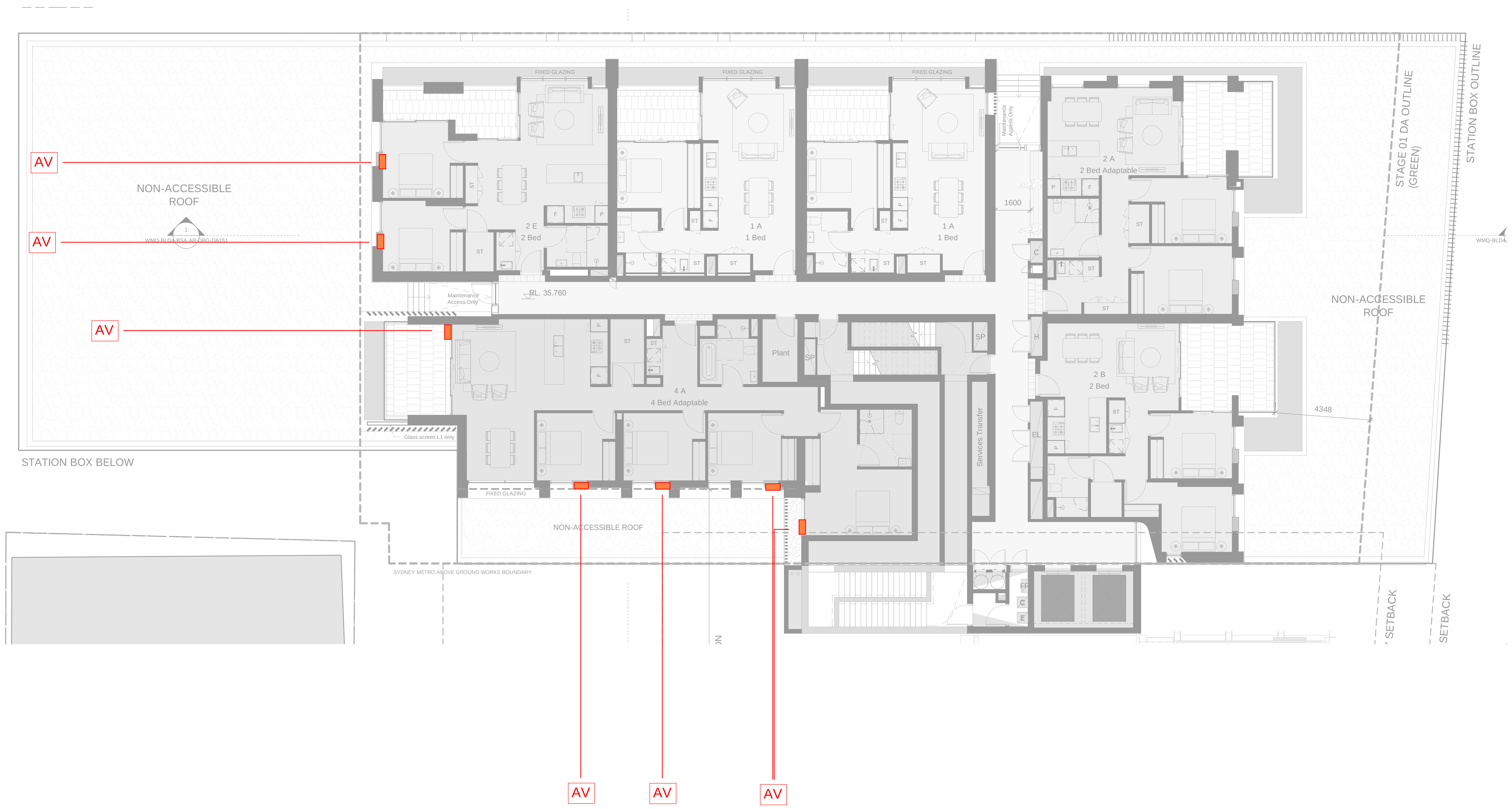
DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.



REV	DESCRIPTION	DRAWN	APP'D	DATE
004	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
003	Milestone Package 3	MIS	BN	10/07/20
002	Milestone Package 2	BN	BN	22/05/20
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TITLE: ACOUSTIC VENTILATOR LOCATIONS - BUILDING 4, LEVEL 01

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7836	4

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.

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1:100	46198	WMG-BLD4-WGE-AC-SK-AC7837	4

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.

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003	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
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001	Milestone Package 1	BN	BN	22/05/20

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TITLE: ACOUSTIC VENTILATION LOCATIONS - BUILDING 4, LEVEL 03

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7838	3

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.

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003	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
002	Milestone Package 3	MIS	BN	10/07/20
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TITLE: ACOUSTIC VENTILATOR LOCATIONS - BUILDING 4, LEVEL 04

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7839	3

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.

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003	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
002	Milestone Package 3	MIS	BN	10/07/20
001	Milestone Package 2	BN	BN	22/05/20

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TITLE: ACOUSTIC VENTILATOR LOCATIONS - BUILDING 4, LEVEL 05

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7840	3

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.

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003	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
002	Milestone Package 3	MIS	BN	10/07/20
001	Milestone Package 1	BN	BN	22/05/20

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TITLE: ACOUSTIC VENTIATOR LOCATIONS - BUILDING 4, LEVEL 06

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7841	3

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

4. Further analysis will be conducted to confirm if the acoustic ventilators are required to various spaces adjoining a balcony. The effect of alternative acoustic treatment to the balcony is under investigation.

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003	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
002	Milestone Package 3	MIS	BN	10/07/20
001	Milestone Package 1	BN	BN	22/05/20

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PROJECT	TITLE
WATERLOO METRO QUARTER DEVELOPMENT	ACOUSTIC VENTILATOR LOCATIONS - BUILDING 4, LEVEL 07

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7842	3

LEGEND

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

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004	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
003	Milestone Package 3	MIS	BN	10/07/20
002	Milestone Package 2	BN	BN	22/05/20
001	Milestone Package 1	BN	BN	1/04/20

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PROJECT: WATERLOO METRO QUARTER DEVELOPMENT

TITLE: ACOUSTIC VENTILATOR LOCATIONS - BUILDING 4, LEVEL 08

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:100	46198	WMG-BLD4-WGE-AC-SK-AC7843	4

LEGEND

Acoustic Ventilator Location

AV Acoustic Ventilator Identification

DRAWING NOTES

1. Dimensions of the acoustic ventilator's footprint are approximately 700mm x 330mm. Detailed dimensions are provided in drawing BLDA-AC-NV-D1.

2. Refer to drawing BLDA-AC-NV-D1 for a detailed horizontal section through the acoustic ventilator.

3. The locations of these acoustic ventilators are preliminary and will require coordination with the architect, structural engineer, building services and engineers and the facade engineer.

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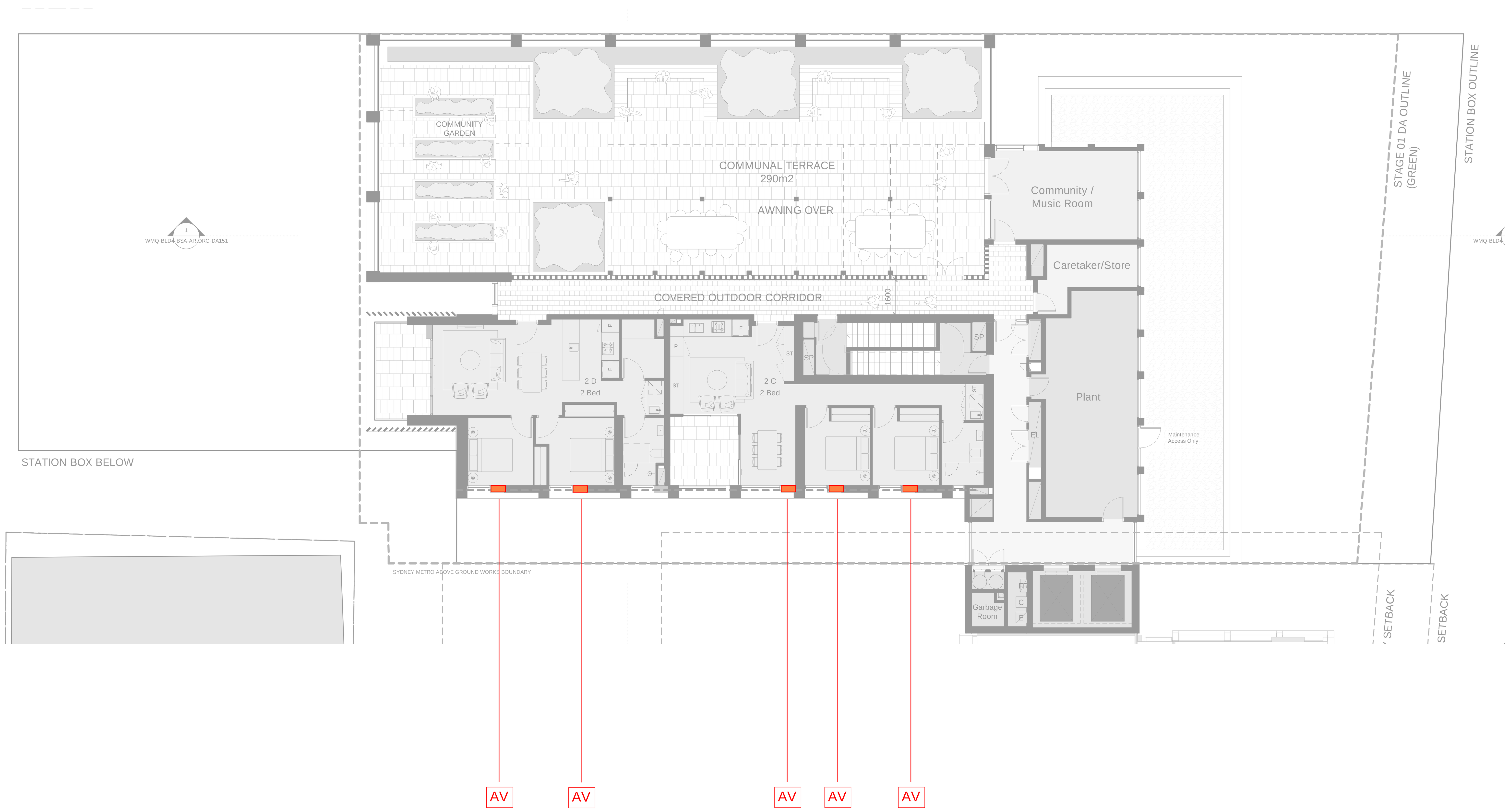

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004	SSDA ISSUE - FOR LANDOWNER'S CONSENT	MIS	BN	29/07/20
003	Milestone Package 3	MIS	BN	10/07/20
002	Milestone Package 2	BN	BN	22/05/20
001	Milestone Package 1	BN	BN	1/04/20

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1:100	46198	WMG-BLD4-WGE-AC-SK-AC7844	4

15.6 Appendix 6 – Acoustic Ventilator Design

Acoustic Ventilator Design - Typical Plan Arrangement

DRAWING NOTES

1. Product selections for the external louvre, operable damper, flyscreen and internal bargrille will be provided as the design progresses towards the submission of the Development Application.

2. Noise attenuation of the acoustic ventilator will be provided in the Noise & Vibration Impact Assessment prepared as part of the Development Application.

3. The size (dimensions) of the perforated sheet metal exterior facing on elevation will be refined as the design develops. The size shown at this stage is slightly larger than what may possibly be required, and may be reduced following preliminary ventilation modelling.

REV	DESCRIPTION	DRAWN	APP'D	DATE
003	Draft DA Issue	BN	BN	29/06/20
002	Milestone Package 2	BN	BN	22/05/20
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PROJECT: WATERLOO OVER STATION DEVELOPMENT
TITLE: ACOUSTIC NATURAL VENTILATION DESIGN - DETAIL SHEET 1

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:1	46198	BLD2-AC-NV-D1	003

15.7 Appendix 7 – Natural Ventilation Study

15.7.1 Executive Summary

Stantec have been engaged to undertake a ventilation assessment of the acoustic ventilators for the Central Precinct over station development (OSD) at the Waterloo Metro Quarter site to the requirements of the City of Sydney's Draft Alternative Natural Ventilation of Apartments in Noise Environments – Performance Pathway Guideline.

Dynamic simulation software IESVE (Integrated Environmental Solutions Virtual Environment) has been used to determine the percentage of the year in which minimum performance requirements are met for apartments and habitable rooms provided with alternative means of natural ventilation due to internal noise level conditions. The proposed acoustic ventilator design has been evaluated using computational fluid dynamic simulation to determine the effective openable area of the device.

Applicable apartments have been evaluated to demonstrate the following performance requirements are achieved for at least 90% of all hours of the year:

- If the apartment area is less than the threshold area: 10 litres/second/person for each apartment, where the number of people equals the number of bedrooms plus 1, OR
- If the apartment area is more than or equal to the threshold area: 0.3 litres/second/m2 for each apartment.

Each habitable room provided with alternative means of natural ventilation has also been assessed for adequate ventilation of 10 litres/second.

A tabulated summary of results is presented below. The results demonstrate that the assessed apartments and habitable rooms meet the minimum performance requirements for greater than 90% of the all hours of the year. As such, the minimum level of ventilation has been met and adequate natural ventilation is achieved via the alternative ventilation proposal.

Apartment Number	Apartment Area (m^2)	Number of Bedrooms	Number of Persons	Required Volume Flow Rate (L/s)	Percentage of Year Criteria Achieved (%)
101	77	2	3	30	99.8%
102	70	2	3	30	99.8%
103	134	4	5	50	100.0%
104	72	2	3	30	99.9%
203	71	2	3	30	100.0%
204	73	2	3	30	100.0%
205	90	3	4	40	100.0%
301	76	2	3	30	99.9%
302	71	2	3	30	99.8%
803	71	2	3	30	100.0%
804	73	2	3	30	100.0%
805	90	3	4	40	100.0%

Table 65: Apartment Natural Ventilation Results

Habitable Room Number	Required Volume Flow Rate (L/s)	Percentage of Year Criteria Achieved (%)
101 Bed 1	10.0	94.5%
101 Bed 2	10.0	95.0%
102 Bed 1	10.0	94.6%
102 Bed 2	10.0	97.1%
103 Bed 1	10.0	92.7%
103 Bed 2	10.0	92.6%
103 Bed 3	10.0	92.3%
104 Bed 1	10.0	97.6%
104 Bed 2	10.0	96.0%
203 Bed 1	10.0	93.0%
203 Bed 2	10.0	92.0%

204 Bed 1	10.0	90.1%
204 Bed 2	10.0	90.3%
205 Bed 1	10.0	97.4%
205 Bed 2	10.0	97.1%
301 Bed 1	10.0	94.4%
301 Bed 2	10.0	95.0%
302 Bed 1	10.0	94.5%
302 Bed 2	10.0	97.1%
803 Bed 1	10.0	93.3%
803 Bed 2	10.0	91.9%
804 Bed 1	10.0	90.3%
804 Bed 2	10.0	90.7%
805 Bed 1	10.0	95.6%
805 Bed 2	10.0	97.1%

Table 66: Habitable Room Natural Ventilation Results

15.7.2 Reference Documents

The following documents have been used for the purposes of this study:

- Architectural plans, sections and elevations issued by Bates Smart dated 15 June 2020.
- City of Sydney's Draft Alternative Natural Ventilation of Apartments in Noise Environments – Performance Pathway Guideline
- MacroFlo Calculation Methods for IESVE
- AccuRate and the Chenath Engine for Residential House Energy Rating, September 2016

15.7.3 Ventilation Performance Requirements

As per the City of Sydney's Draft Alternative Natural Ventilation of Apartments in Noise Environments – Performance Pathway Guideline, the natural ventilation system for each apartment must provide an average hourly volume flow rate of:

- Criteria 1: If the apartment area is less than the threshold area, 10 litres/second/person for each apartment, where the number of people equals the number of bedrooms plus 1, OR

- Criteria 2: If the apartment area is more than or equal to the threshold area, 0.3 litres/second/m2 for each apartment.

This must be demonstrated across 90% of all hours in the year.

Each habitable room must also be provided with effective natural ventilation at a rate of 10 litres/second for 90% of all hours in the year.

The criteria selected for minimum performance requirements is determined by the threshold apartment areas:

Number of Bedrooms	Threshold Apartment Area (m^2)
1	67
2	100
3	133

Table 67: Threshold Apartment Areas from City of Sydney's Draft Alternative Natural Ventilation of Apartments in Noise Environments – Performance Pathway Guideline

Based on the above, the following table outlines the natural ventilation performance requirements for each noise affected apartment:

Apartment Number	Apartment Area (m^2)	Number of Bedrooms	Number of Persons	Apartment Over Threshold Area?	Criteria 1 or 2?	Required Volume flow Rate (L/s)
101	77	2	3	NO	Criteria 1	30
102	70	2	3	NO	Criteria 1	30
103	134	4	5	NO	Criteria 1	50
104	72	2	3	NO	Criteria 1	30
201	71	2	3	NO	Criteria 1	30
202	73	2	3	NO	Criteria 1	30
203	90	3	4	NO	Criteria 1	40
701	76	2	3	NO	Criteria 1	30
702	71	2	3	NO	Criteria 1	30
801	71	2	3	NO	Criteria 1	30
802	73	2	3	NO	Criteria 1	30
803	90	3	4	NO	Criteria 1	40

Table 68: Natural Ventilation Performance Requirements for Apartments

In addition to the criteria for overall apartment flow rates, each habitable room provided with an alternative means of natural ventilation must demonstrate adequate natural ventilation to 10 litres/second per room across 90% of all hours of the year is provided.

15.7.4 Modelling Parameters

Software

The natural ventilation simulations in this study are performed using the IES Virtual Environment version 2017.4.0.0 modelling software.

To assess the building's natural ventilation, the modules used for simulation include ModelIT, MacroFlo and ApacheSim:

- The ModelIT module provides the facility for developing the three-dimensional model of the building design including the specifications of the construction types, inputs of site location and ambient weather data.
- MacroFlo is a module specifically developed for use with naturally ventilated and mixed-mode buildings. It simulates the flow of air through openings in the building envelope. Openings are associated with windows, doors and holes created in the geometry model. Opening Types are defined within the MacroFlo module, including the degree and timing of window openings.
- ApacheSim is a dynamic thermal simulation program based on first principles mathematical modelling of the heat transfer processes occurring within and around a building. Within ApacheSim, conduction, convection and radiation heat transfer processes for each element of the building fabric are individually modelled and integrated with models of room heat gains, air exchanges and HVAC plant. The simulation is driven by simulated weather data. The time-evolution of the building's thermal conditions is traced at intervals as small as a minute. ApacheSim uses a stirred tank model of the air in a room. This means that the calculations are based on the concepts of bulk air temperature and humidity, which are assumed to be uniform within the room.

Weather File

The Sydney Observatory Hill design weather data and 17_SydneyRO_NSW_CZ0512_12_TMYA climate file has been used for the purposes of this simulation. It was determined that this weather file was most appropriate given the project's location.

Although the Guidelines instruct the use of the 94767 Mascot 1987 TRY weather file, analysis of this file revealed that for approximately 40% of the year, wind speeds were zero. As such, it is impossible to demonstrate the natural ventilation performance requirements for 90% of all hours of the year.

In consultation with the software provider, Integrated Environmental Solutions, the Typical Meteorological Year (TMY) file for Sydney has been chosen as it provides a more realistic view of typical conditions at the site.

Terrain Type

In accordance with the Guidelines, a 'City' terrain type has been selected within the model. The terrain type defines how the wind speed varies with height, dependent upon the local terrain and is based on ASHRAE 2001 wind speed profiles.

Assessed Apartments

The apartments assessed as part of this analysis are presented in the table below. Arrangement and features of apartments have been modelled in the simulation. The locations of acoustic ventilators are shown in Appendix 5 – Locations of Acoustic Ventilators.

In accordance with the Guidelines, each unique apartment design and apartments with a similar plan but difference in height of more than 6 storeys have been modelled.

Assessed Apartment	Assessed Apartment Representative Of
101	201
102	202
103	N/A
104	N/A
203	303, 403, 503, 603, 703
204	304, 404, 504, 604, 704
205	305, 405, 505, 605, 705
301	401, 501, 601, 701, 801
302	402, 502, 602, 702, 802
803	901
804	902
805	N/A

Table 69: Assessed and Representative Apartments

As no apartment numbers are shown on plans, the following images outline the apartment numbering used in the analysis:

Figure 13 - Level 1 Apartment Numbering Used

Figure 14 - Level 2 Apartment Numbering Used

Figure 15 - Level 3-7 Apartment Numbering Used

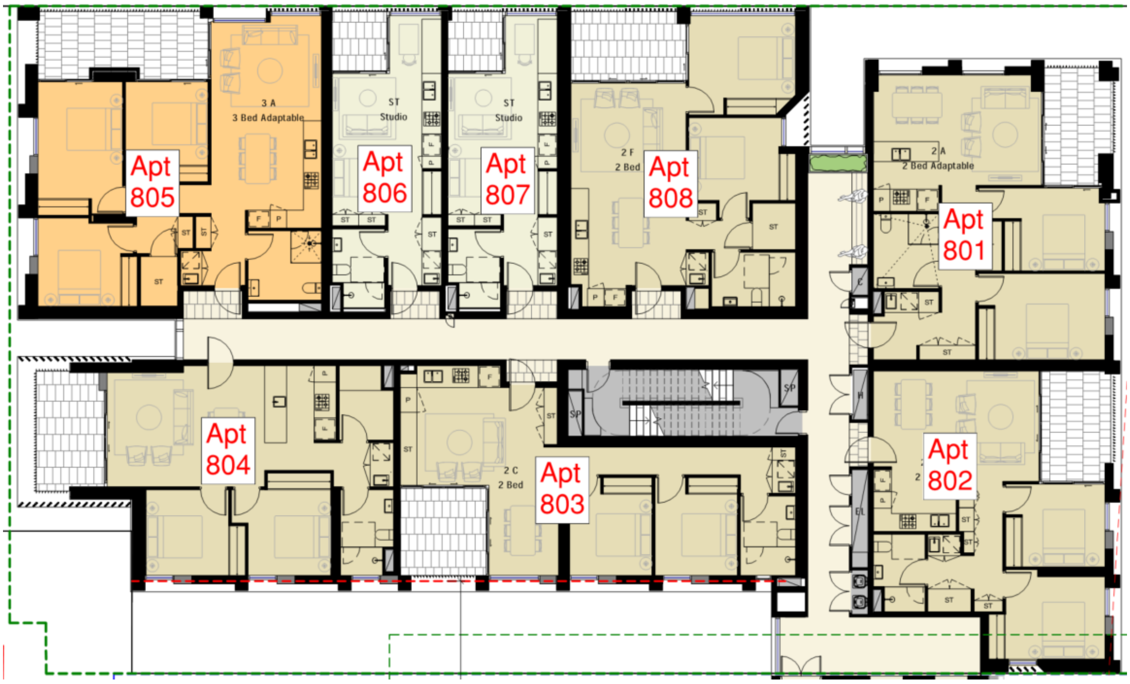


Figure 16 - Level 8 Apartment Numbering Used

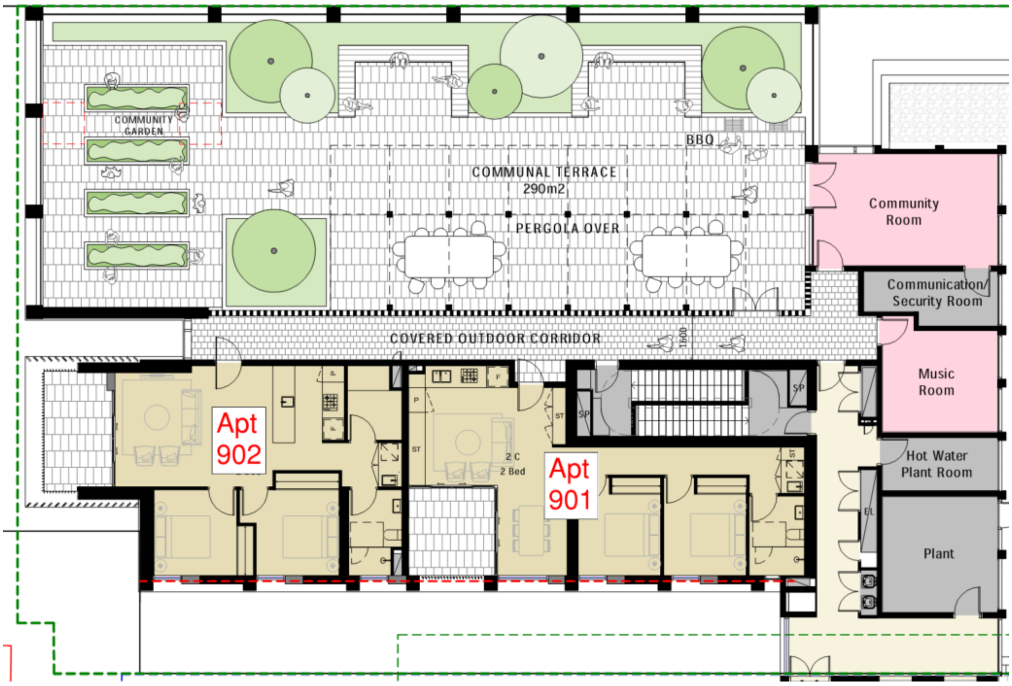


Figure 17 - Level 9 Apartment Numbering Used

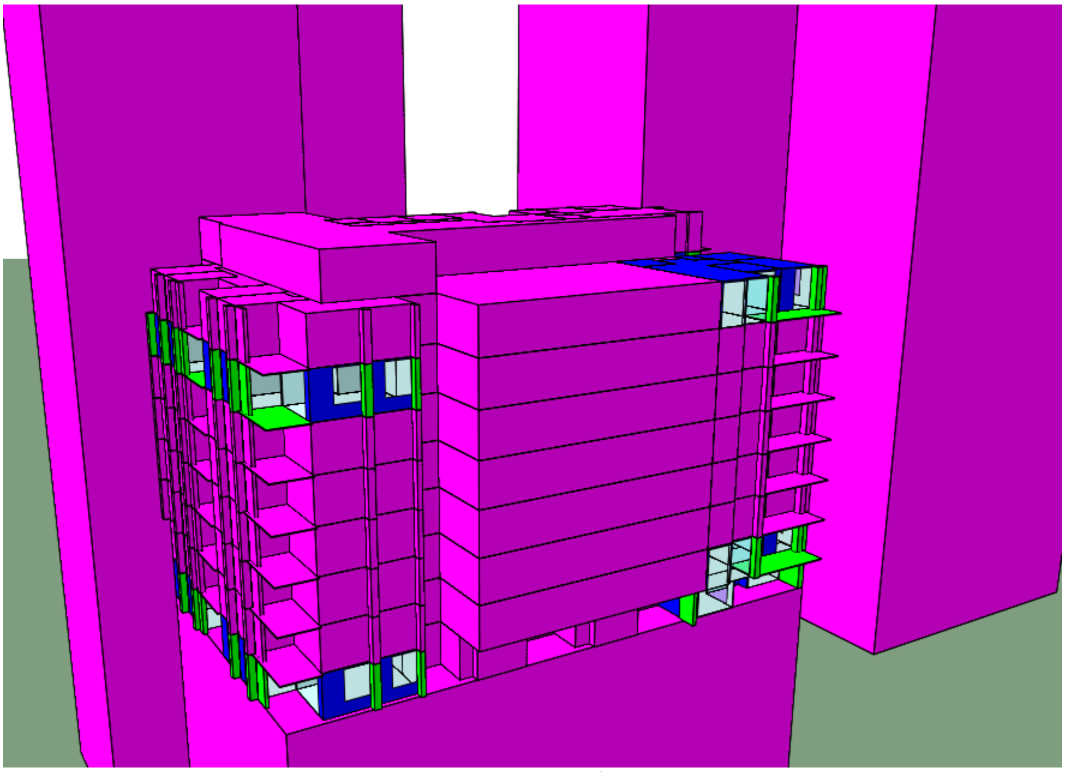


Figure 18 - 3 dimensional IES model

Surrounding Buildings & Pressure Coefficient Correction

Surrounding buildings have been modelled at the same height as the subject building as per the Guidelines.

Exposure types for each opening type in MacroFlo have been modelled as 'high-rise sheltered wall' to account for the degree of sheltering. 'Sheltered' is used when the surrounding obstructions are of similar height to the building. The IES 'MacroFlo Calculation Methods' guidance documents notes that the term "high-rise" is applicable to building of more than 3 storeys. As this development is 22 storeys in height, "high-rise" coefficients have been used.

Wind pressure coefficients are set further according to the height of the assessed floor in relation to the height of the building (h/H):

Level	Floor Height (RL)	h/H	Exposure Type Used
1	35.76	0.558	58. High-rise sheltered wall h/H=0.6
2	38.86	0.607	58. High-rise sheltered wall h/H=0.6
3	41.96	0.655	58. High-rise sheltered wall h/H=0.6
8	57.46	0.897	59. High-rise sheltered wall h/H=0.8

Table 70: Exposure Types Set Within IES MacroFlo Module

Heating and Cooling Setpoints

Natural ventilation modelled within MacroFlo is a mixture of both wind pressure and buoyancy pressures. In order to more accurately estimate the buoyancy pressures experienced by the apartments and its effect on natural ventilation, apartments have been modelled to be conditioned to within the same thermostat settings used for Nationwide House Energy Rating Scheme (NatHERS) analysis. The NatHERS tools utilise the Chenath engine to determine the annual heating and cooling energy use to maintain a certain range of thermal comfort.

In line with the Chenath Engine thermostat settings for NatHERS Climate Zone 56, the following setpoints have been used for this analysis:

- Bedrooms: Cooling = 24.5°C, Heating = 18°C
- Living spaces: Cooling = 24.5°C, Heating = 20°C

Ventilation Openings

To simulate the correct natural ventilation openings in IES, it is first necessary to obtain amount of air that can pass through the acoustic ventilators from the outside to the room. The effective openable area of ventilation openings has been modelled using Computational Fluid Dynamics (CFD) and modelled in IES as follows:

- Acoustic Ventilator: $(k_o/k)^{0.5} = (2.6/205.3)^{0.5} = 0.11253 = 11.25\%$
- Other façade openings modelled to 5% of the floor area being served

Acoustic ventilator openings have been modelled in the IES software as 575mm wide x 2700mm high in accordance with the CFD modelling, and an openable area of 11.25% has been applied to opening to represent the effective openable area of the device. Figure 19 below demonstrates how the acoustic ventilators have been modelled within the IES software.

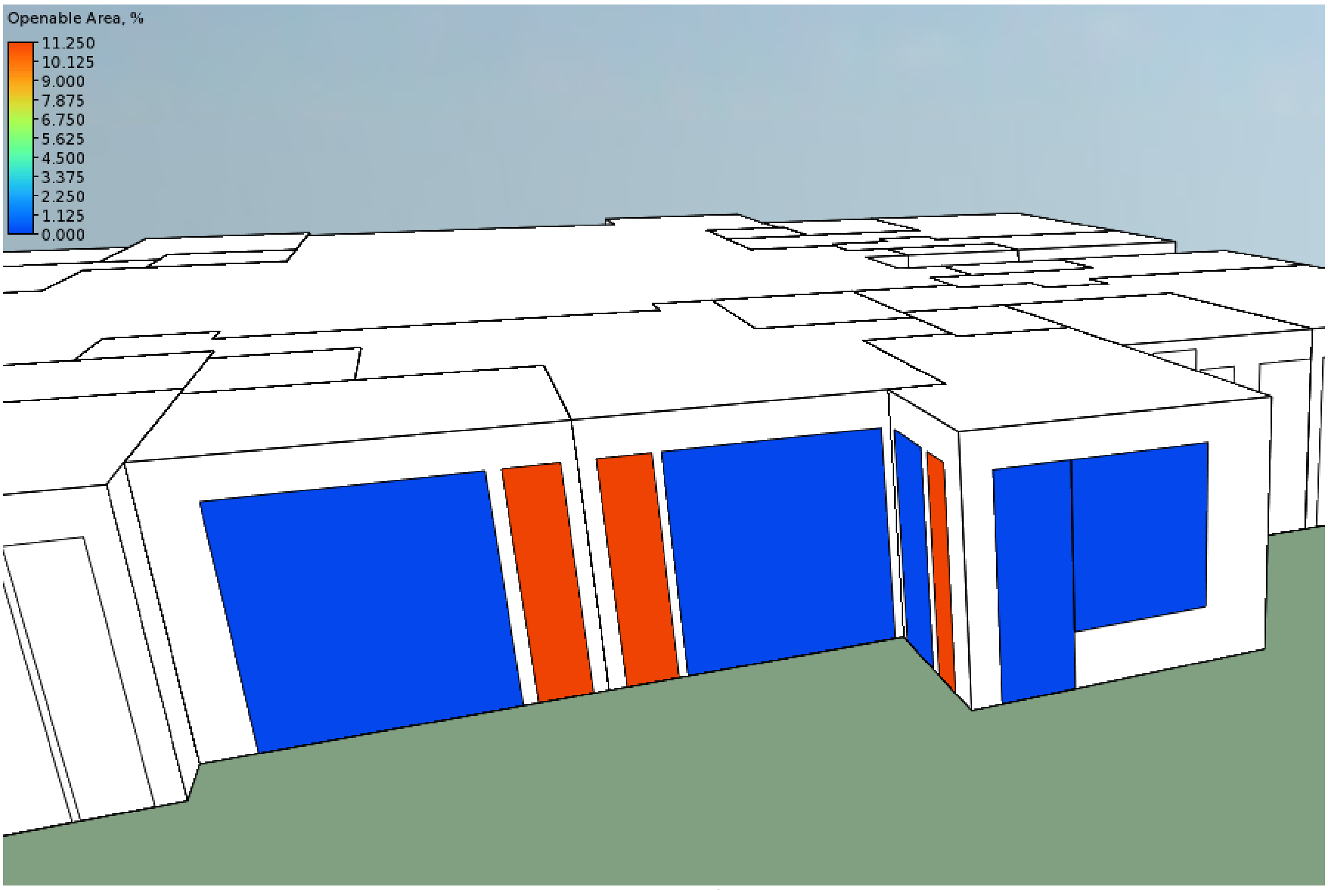


Figure 19 - Acoustic Ventilators Openable Area Modelling

All ventilation openings have been modelled to satisfy the acoustic requirements for each apartment. i.e. where a room is provided with both operable windows and acoustic ventilators, only acoustic ventilators have been modelled to demonstrate the natural ventilation criteria is achieved whilst also satisfying acoustic criteria.

To simulate natural ventilation exchange and pressure differences between internal rooms, internal doors have been modelled between bedrooms and living spaces. Doors have been modelled as open for 100% of the time.

Disclaimer

This study provides an estimate of the developments predicted natural ventilation performance. This estimate is based on a necessarily simplified and idealised version of the building that does not and cannot fully represent all of the intricacies of the building and its operation. As a result, the modelled results only represent an interpretation of the potential performance of the building. No guarantee or warranty of building performance in practice can be based on modelling results alone.

The results generated from this analysis are based on specific criteria outlined in the report and are not considered to be a true representation of the actual operation of the building. Actual performance will depend on local weather, ventilation openings, construction quality, internal loads and numerous other elements outside the control of the investigation.

15.7.5 Acoustic Ventilator Computational Fluid Dynamics Modelling

Governing Equations

To simulate the correct natural ventilation openings in IES, it is first necessary to obtain the pressure coefficient of the two acoustic plenums. This is done through the use of CFD modelling.

The pressure coefficient (k) takes into account an effective area loss due to resistance inducing components within the system, including but not limited to: weatherproof louvres, operable dampers and grilles. The pressure coefficient was evaluated using CFD analysis to be 205.3 for the plenum.

IES considers the CFD modelled pressure coefficient through the following equations:

$$\boldsymbol{\Delta P = k \times \frac{1}{2}\rho u^2} \tag{1}$$

$$\therefore k = \frac{2 \times \Delta P}{\rho u^2} \tag{2}$$

Where:

ΔP = the pressure difference across the system

k = the pressure coefficient

ρ = the air density

u = the mean air speed at a specified cross section of the flow

The pressure/flow relationship for the MacroFlo openings is given by equation (3), below:

$$\boldsymbol{\Delta P = k_o \times \frac{1}{2}\rho u_o{}^2} \tag{3}$$

Where:

ΔP = the pressure difference across the opening

k_o $=\left(\frac{1}{0.62}\right)^2 \approx 2.6$. This is known to be the pressure coefficient for openings which are small compared to their adjacent spaces

u_o = the mean air speed through the opening

The conservation of mass equation states:

$$\boldsymbol{\rho_o u_o A_o = \rho_d u A_d = constant} \tag{4}$$

Assuming incompressible flow (density is constant), we obtain the following:

$$\boldsymbol{A_o = \frac{u}{u_o} \times A_d \qquad NB.\ \frac{u}{u_o} = \left(\frac{k_o}{k}\right)^{0.5} per\ equ^n\ (1)\ and\ equ^n\ (3)} \tag{5}$$

$$\therefore A_o = \left(\frac{\mathrm{k_o}}{\mathrm{k}}\right)^{0.5} \times \mathrm{A_d} \tag{6}$$

The value of $(k_o/k)^{0.5}$ provides the required percentage openable area of the acoustic plenums and is utilised in forming the inputs for the IES model. In the CFD simulation, the following $(k_o/k)^{0.5}$ ratio was calculated for the acoustic plenum:

$$\left(\frac{\mathrm{k_o}}{\mathrm{k}}\right)^{0.5} = \left(\frac{2.6}{205.3}\right)^{0.5} = 0.1125 = \mathbf{11.25\%} \tag{7}$$

CFD Modelling

The commercial software ANSYS CFX 2019 R2 was used for all CFD simulations. CFX is a general unstructured flow solver that employs a cell-centred control volume solution technique whereby the partial differential equations of fluid flow are discretised and numerically integrated using a fully implicit finite volume formulation.

Description of CFD Model

The following model was built to represent part of the CFD model represents the air that passes through the plenum from the outside to the room. The modelling is restricted to the internal dimensions of the plenum and accounts for the reduction in the volume of air from obstructions including an external weatherproof louvre, duct, operable damper, fly screen, bar grille and internal acoustic lining. The dimensions considered in the CFD model are representative of the worst case of several plenum types found within the development at the Waterloo Metro Quarter Development.
The plenum geometry as considered within the CFD modelling is shown in Figure 20, below.

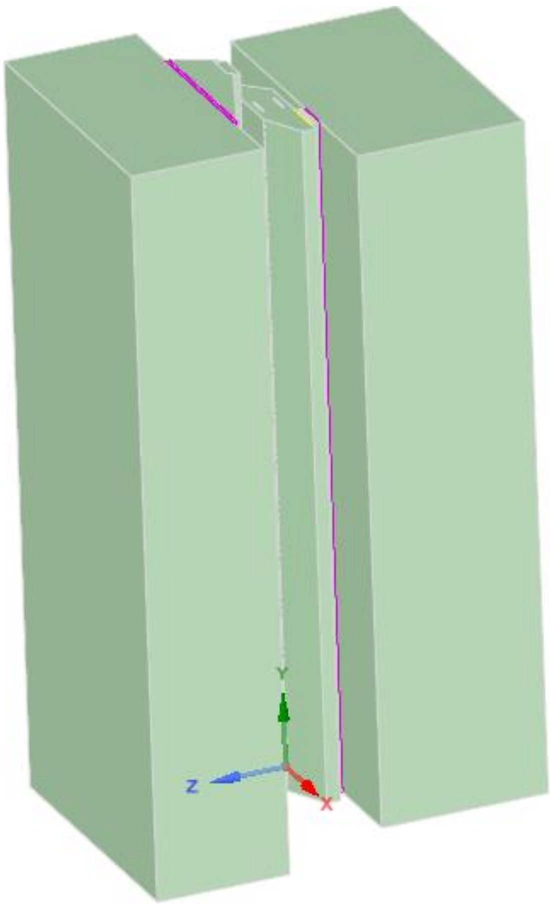


Figure 20 - Plenum geometry

15.7.6 CFD Modelling Inputs

Mesh

The meshing applied to both plenums have local refinement applied where finer detail is required. The global mesh size is 50 mm with local mesh refinement ranging from 1 mm up to 7.5 mm, the resulting mesh is shown in Figure 21. The local refined mesh is applied to capture the fine details of the internal components. The larger global mesh size is applied to regions where there is less interaction between the air flow and solid components.

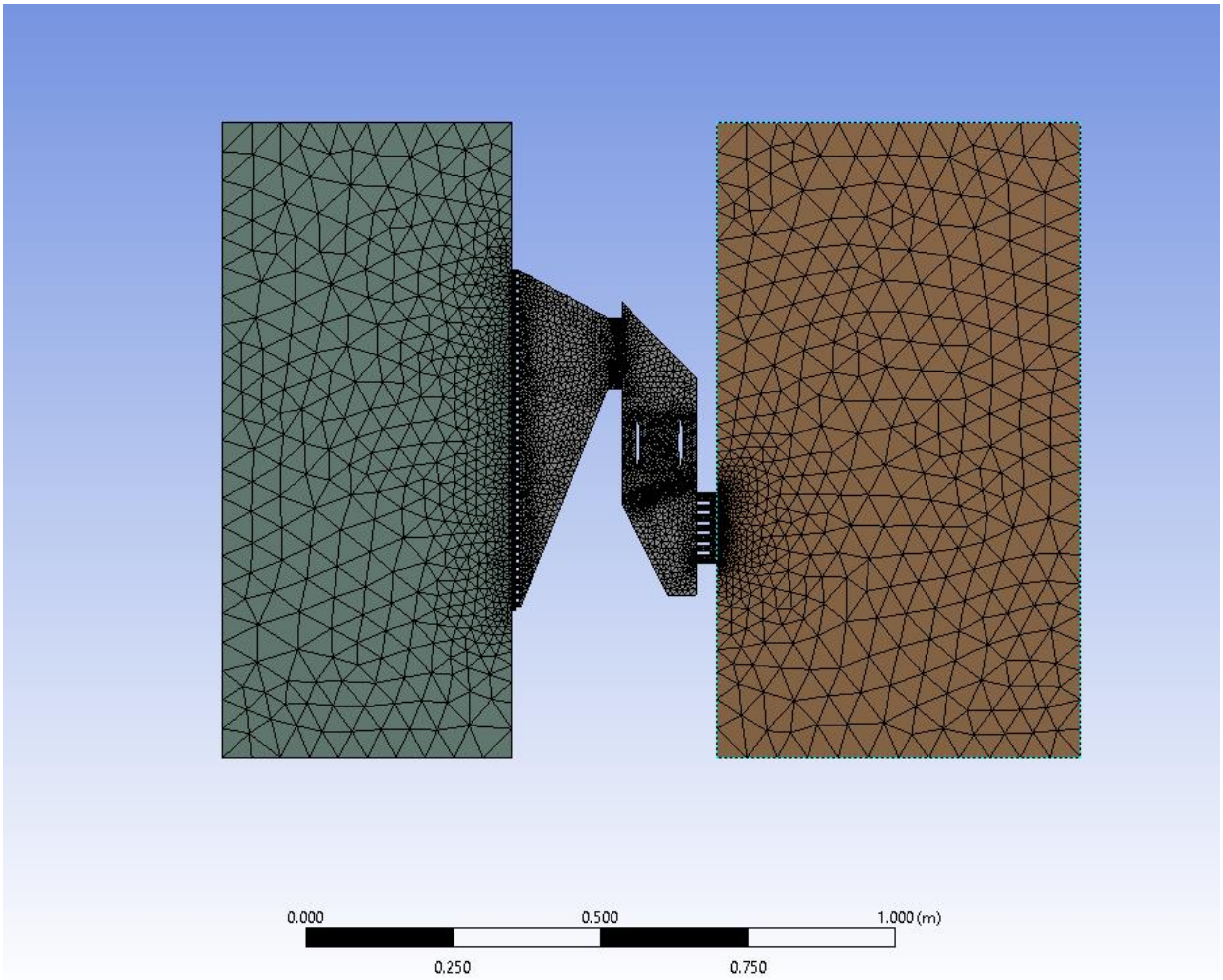


Figure 21 - Meshing applied to the model geometry

Boundary Conditions

The boundary conditions applied to the model are shown in Figure 22. To assess the performance of the plenum, air is passed from the inlet to the outlet. All faces not shown in the figure below are subjected to a no slip wall.
Surface roughness is applied to the walls of the plenum to model the effects of the internal acoustic lining.

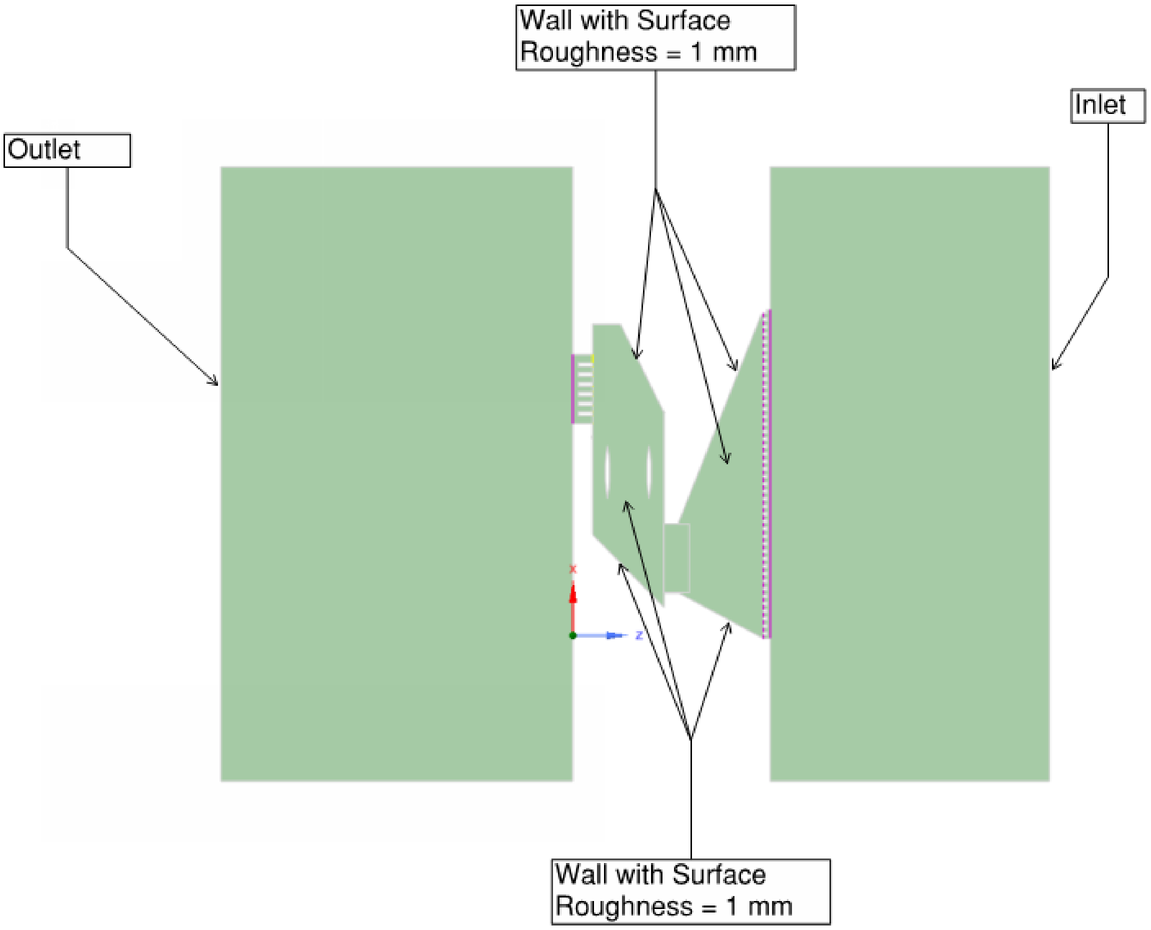


Figure 22 - Boundary Conditions

Solver

The solver utilized is to solver the Naiver - Stokes equation is the inbuilt ANSYS CFX solver. The simulation is treated as isothermal as there is no heat input being considered and an ambient fluid temperature of 25 °C. Buoyancy effects are not considered due the scale of the model and no heat input. Turbulence is modelled through the Shear Stress Transport model.

Residuals

The simulation utilizes an iterative approach to solve the flow field with a targeted error of 10^{-3}. The flow field will fluctuate throughout the simulation run until a time step at which the fluctuation stabilizes, and the graph of the flow field parameters converge to a final value with the targeted error. The results are presented at time step 300 which corresponds to the converged, steady state condition indicated by the flattening of selected flow field parameters with time step as shown in Figure 23.

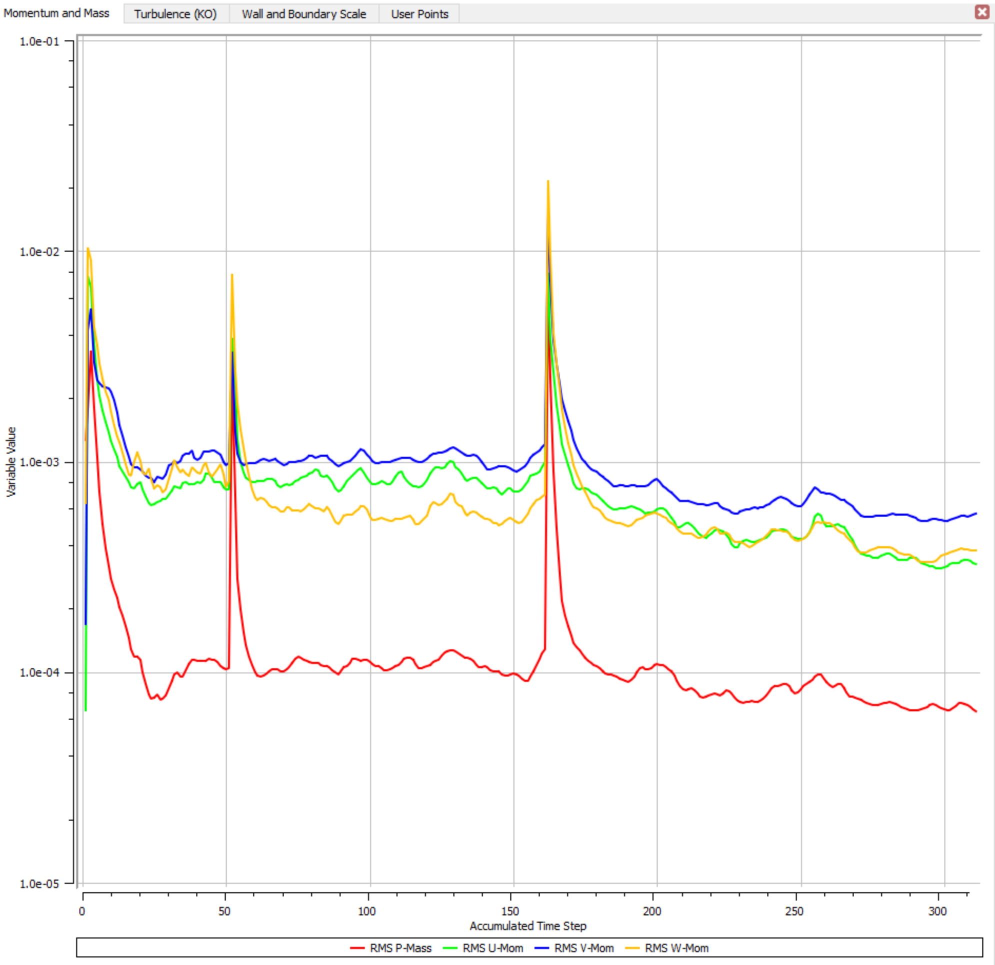


Figure 23 - Convergence plot

CFD Results

CFD was used to evaluate the pressure coefficient (defined as k in equation 2) in the system to be used as the input for the IES VE model.

The total pressure drop across the plenum is shown in Figure 24 and Figure 25 which shows a pressure difference of 3.33 Pa for the given condition and incident velocity of 0.158 m/s. This leads to a k value of 205.3.

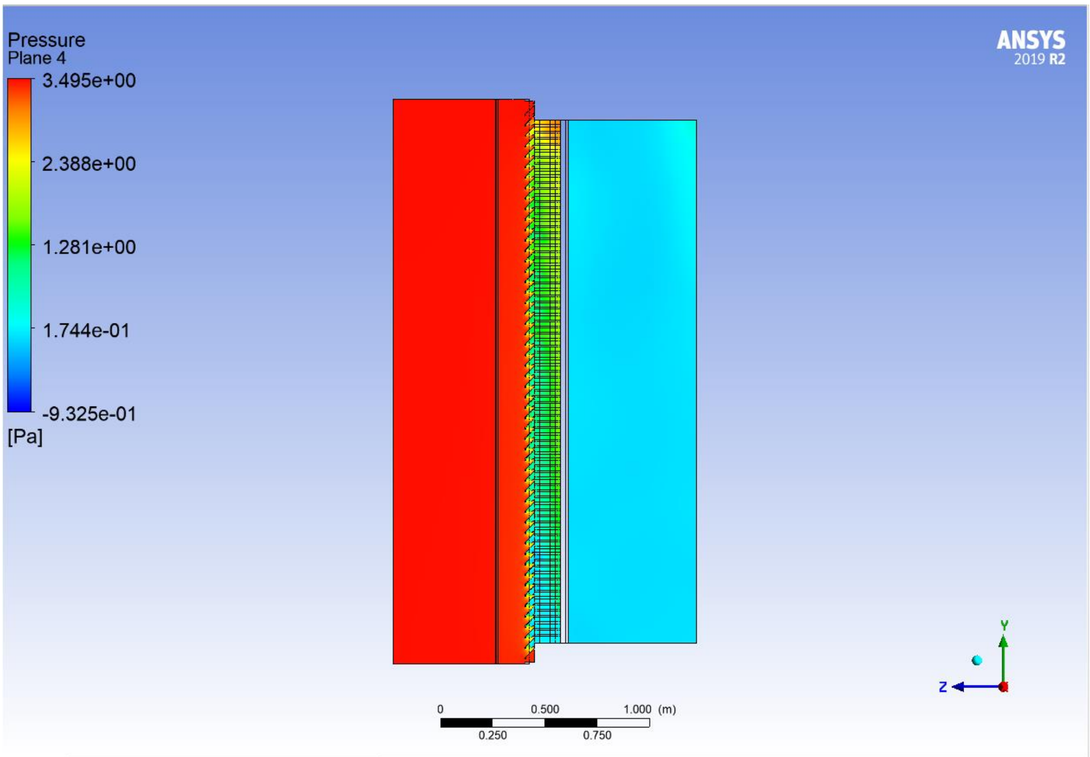


Figure 24 - Section depicting total pressure drop through the plenum (outside air passing through the external weatherproof louvre, duct, operable damper and fly screen and bar grille into the habitable room). Side View.

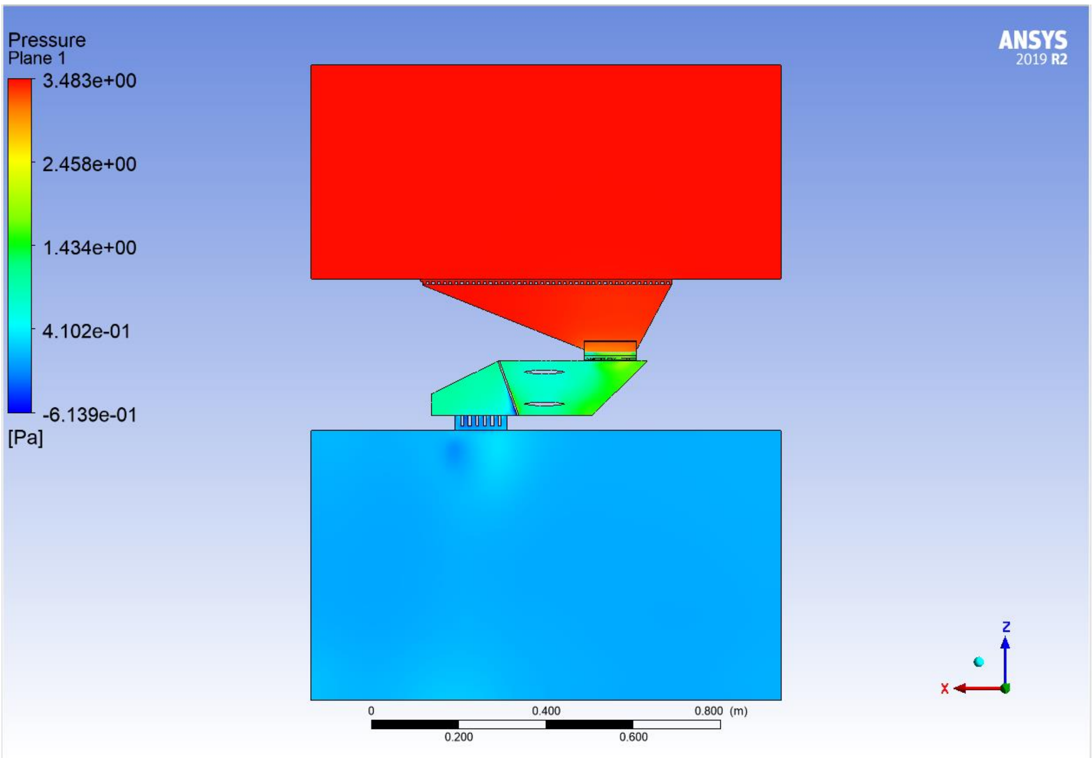


Figure 25: Section depicting total pressure drop through the plenum (outside air passing through the external weatherproof louvre, duct, operable damper and fly screen and bar grille into the habitable room). Top View.

15.7.7 Natural Ventilation Study Results

The ventilation rate for each apartment has been assessed for each hour of the year using a 2-minute simulation time step and reported at 60-minute intervals.

The ‘MacroFlo Ext Vent’ and ‘MacroFlo Int Vent’ variables have been assessed for each individual room within IESVE. The definitions of these variables are as follows:

- MacroFlo ext vent: The sum of MacroFlo-calculated air flows entering the room from the external environment.
- MacroFlo int vent: The sum of MacroFlo-calculated air flows entering the room from adjacent rooms.

As neither the ‘MacroFlo Ext Vent’ or ‘MacroFlo Int Vent’ variables can report negative airflows (air flowing out of the space into the external environment), the absolute difference between the two variables has been assessed. This allows the natural ventilation of each space under positive and negative pressures to be captured and provides a result in litres per second at each hour across the year for the room.

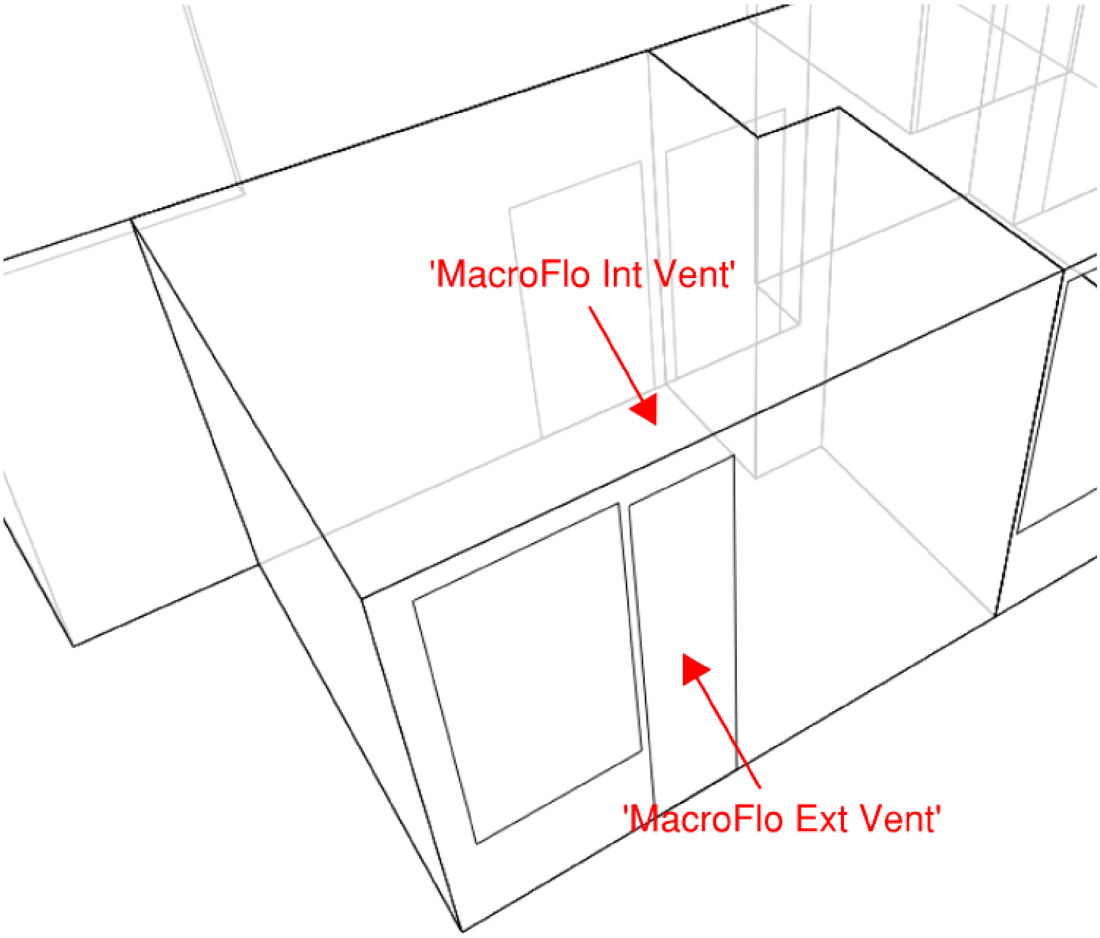


Figure 26: MacroFlo Parameters

In the example below, airflow into the room from the external environment through the acoustic ventilator (red line) at 8:30am is 161.95 l/s and airflow into the room from ventilation openings in the adjacent space (blue line) is 27.58 l/s. The ventilation rate for this room at this point in time is calculated as:

|External ventilation – Internal ventilation| = |161.95 l/s – 27.58 l/s| = 134.37 l/s

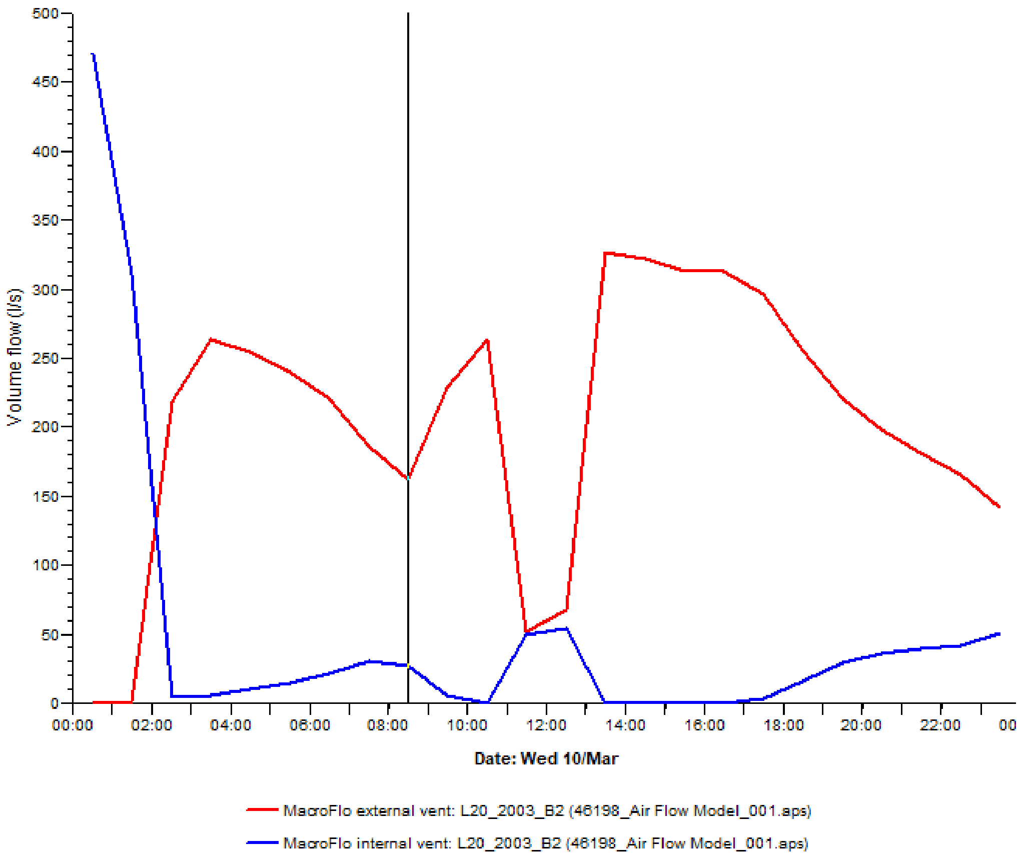


Chart Data

Chart Date/Time: Wed, 10/Mar 08:30.00

Variable Name	Line Colour	File Name	Location	Type	Value	Lock
MacroFlo external vent (l/s)		46198_Air Flow Model_001	L20_2003_B	Volume flow (l/s)	161.95	
MacroFlo internal vent (l/s)		46198_Air Flow Model_001	L20_2003_B	Volume flow (l/s)	27.58	

Figure 27: Example Result

The number of hours with flow rates exceeding the required flow rate is counted for each hour of the year, providing the overall results below.

Overall Apartment Ventilation

A summary of the percentage of annual hours that are predicted to meet or exceed the minimum performance requirements for each apartment is as follows:

Apartment Number	Apartment Area (m^2)	Number of Bedrooms	Number of Persons	Required Volume Flow Rate (L/s)	Percentage of Year Criteria Achieved (%)
101	77	2	3	30	99.8%
102	70	2	3	30	99.8%
103	134	4	5	50	100.0%
104	72	2	3	30	99.9%
203	71	2	3	30	100.0%
204	73	2	3	30	100.0%
205	90	3	4	40	100.0%
301	76	2	3	30	99.9%
302	71	2	3	30	99.8%
803	71	2	3	30	100.0%
804	73	2	3	30	100.0%
805	90	3	4	40	100.0%

Table 71: Apartment Natural Ventilation Results

The assessed apartments meet the minimum performance requirements for greater than 90% of the all hours of the year. Due to the wind and buoyancy pressures experienced at each of the ventilation openings, an adequate amount of natural ventilation is experienced in each apartment.

Habitable Room Ventilation

A summary of the percentage of annual hours that are predicted to meet or exceed the minimum performance requirements for each habitable room provided with alternative means of natural ventilation is as follows:

Habitable Room Number	Required Volume Flow Rate (L/s)	Percentage of Year Criteria Achieved (%)
101 Bed 1	10.0	94.5%
101 Bed 2	10.0	95.0%
102 Bed 1	10.0	94.6%
102 Bed 2	10.0	97.1%
103 Bed 1	10.0	92.7%
103 Bed 2	10.0	92.6%
103 Bed 3	10.0	92.3%
104 Bed 1	10.0	97.6%
104 Bed 2	10.0	96.0%
203 Bed 1	10.0	93.0%
203 Bed 2	10.0	92.0%
204 Bed 1	10.0	90.1%
204 Bed 2	10.0	90.3%
205 Bed 1	10.0	97.4%
205 Bed 2	10.0	97.1%
301 Bed 1	10.0	94.4%
301 Bed 2	10.0	95.0%
302 Bed 1	10.0	94.5%
302 Bed 2	10.0	97.1%
803 Bed 1	10.0	93.3%
803 Bed 2	10.0	91.9%
804 Bed 1	10.0	90.3%
804 Bed 2	10.0	90.7%
805 Bed 1	10.0	95.6%
805 Bed 2	10.0	97.1%

Table 72: Habitable Room Natural Ventilation Results

Each habitable room meets the minimum performance requirements for greater than 90% of the all hours of the year.

Example annual natural ventilation flow rate graphs for:

- 101 Bed 1
- 101 Bed 2
- 102 Bed 1

are shown below. This presents a representative sample of the ventilation profiles across the year for the lowest level assessed.

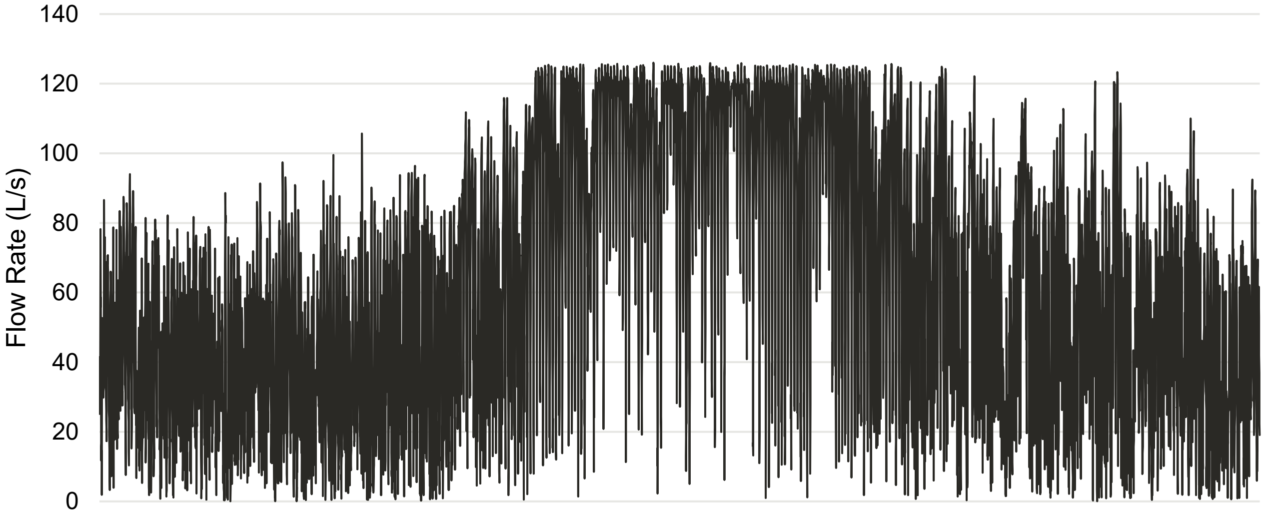


Figure 28: 101 Bed 1 Annual Ventilation Graph

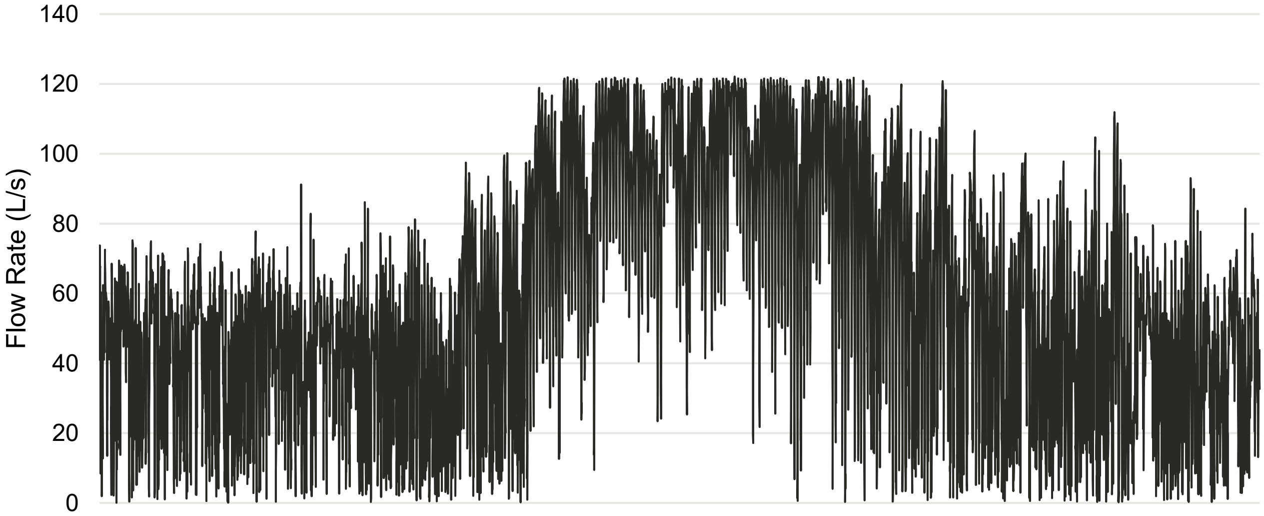


Figure 29 - 101 Bed 2 Annual Ventilation Graph

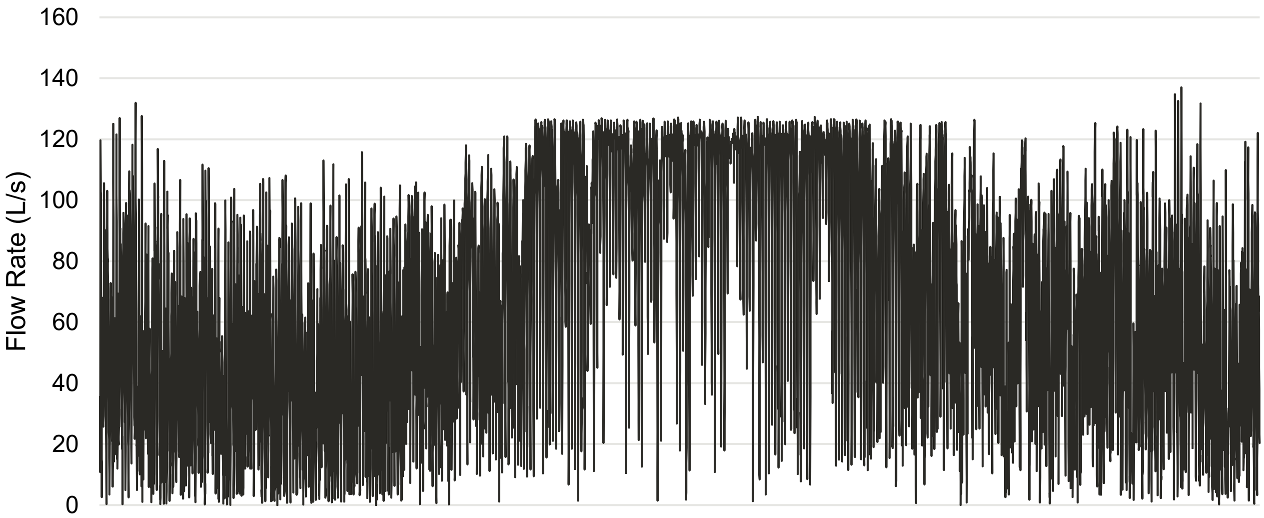
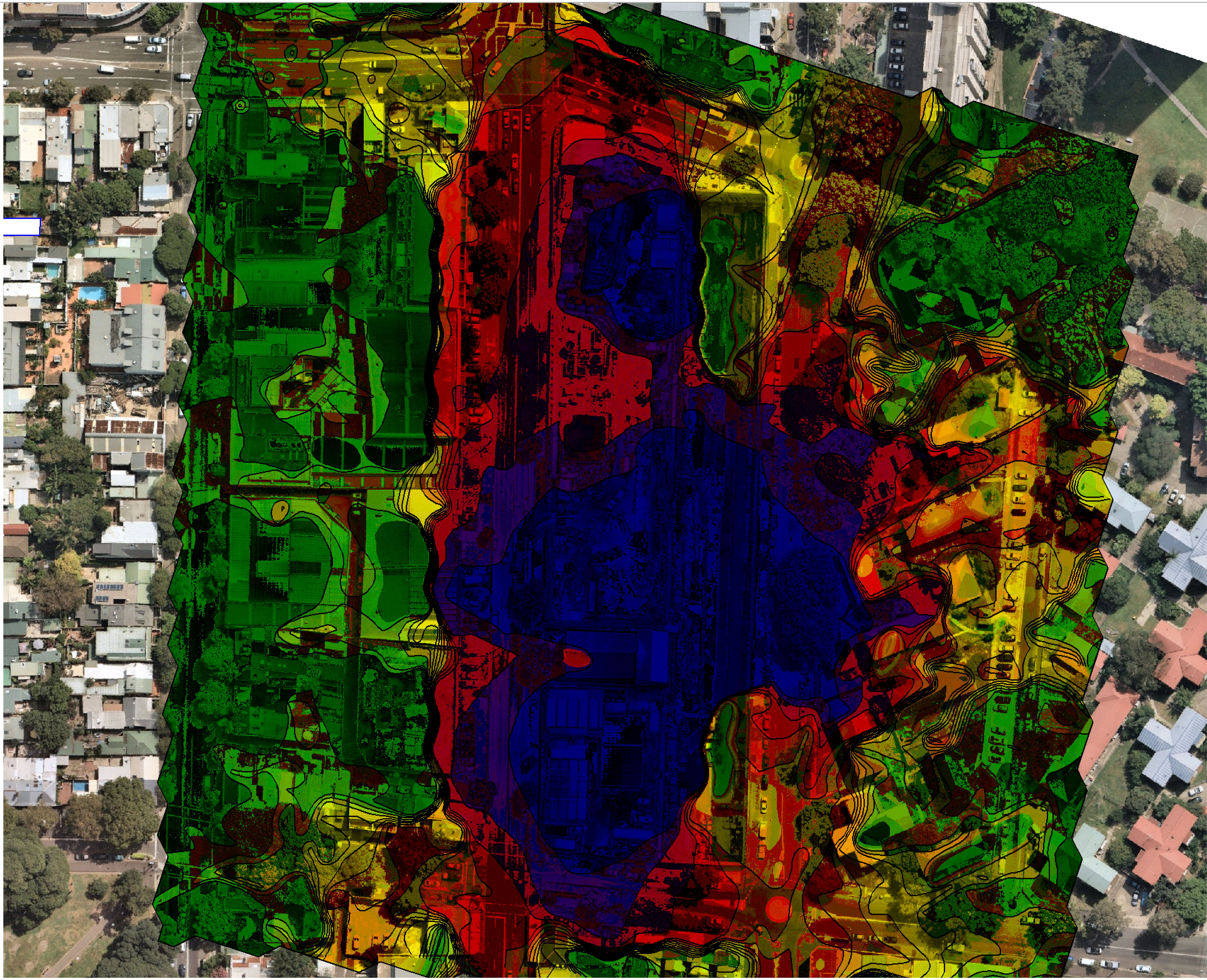


Figure 30 - 102 Bed 1 Annual Ventilation Graph

15.8 Appendix 8 – Construction Assessment Grid Noise Map

15.8.1 Cumulative Construction Noise Modelling Results



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BLACK & WHITE PRINTING MAY BE USED IF SPECIFIC BLACK & WHITE DOCUMENTS HAVE BEEN OBTAINED FROM WGE

REV	DESCRIPTION	DRAWN	APP'D	DATE
002	Development Application	MIS	BN	29/07/20
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

Waterloo Integrated Station Development
A Joint Venture Project
JOHN HOLLAND mirvac
ARCHITECT/CLIENT

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - CIVIL WORKS, NO MITIGATION

Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
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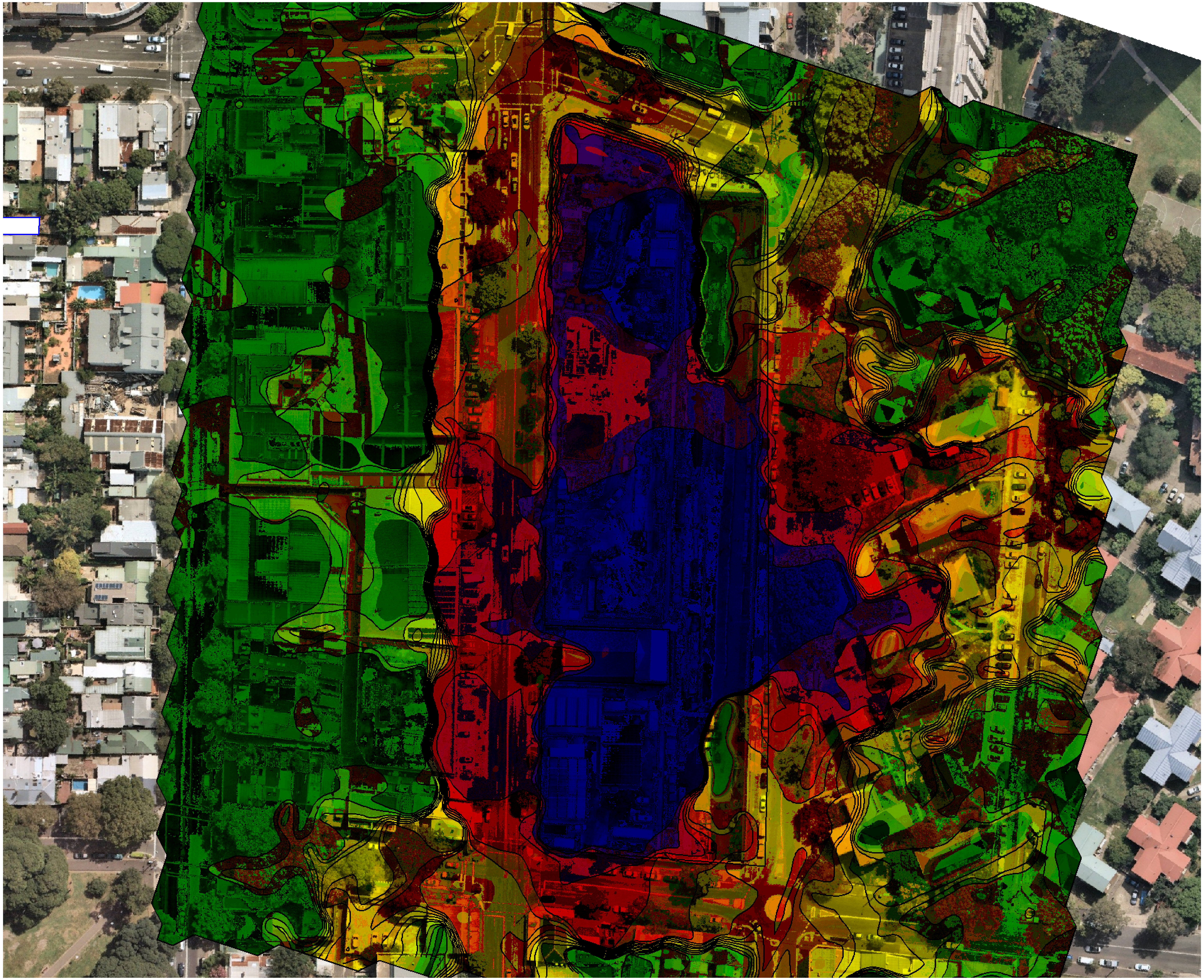

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REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

Waterloo Integrated Station Development
A Joint Venture Project
JOHN HOLLAND
mirvac

ARCHITECT/CLIENT

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - CIVIL WORKS, WITH MITIGATION

Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
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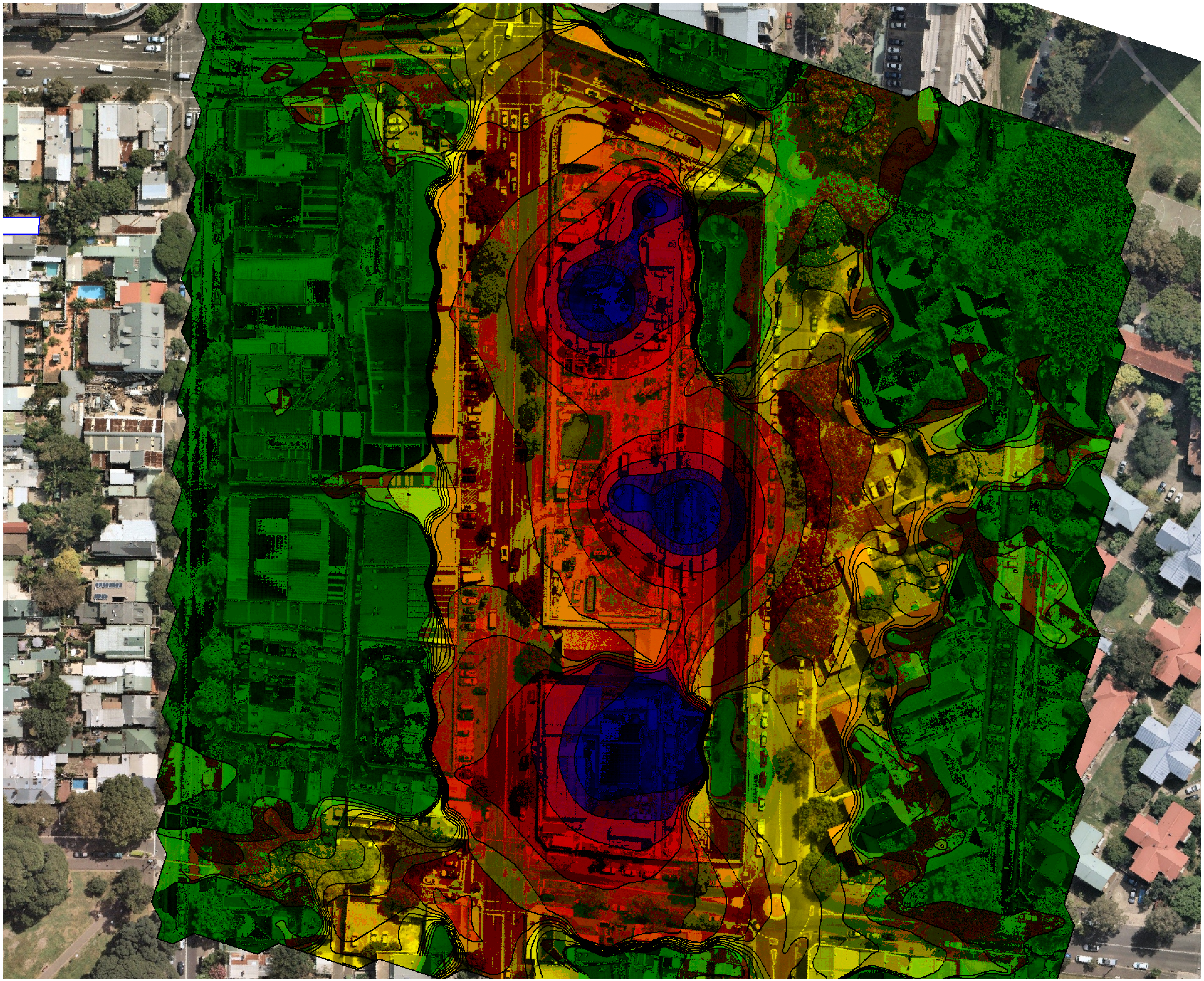

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REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

ARCHITECT/CLIENT: Waterloo Integrated Station Development
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JOHN HOLLAND
mirvac

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE GF TO L5, NO MITIGATION

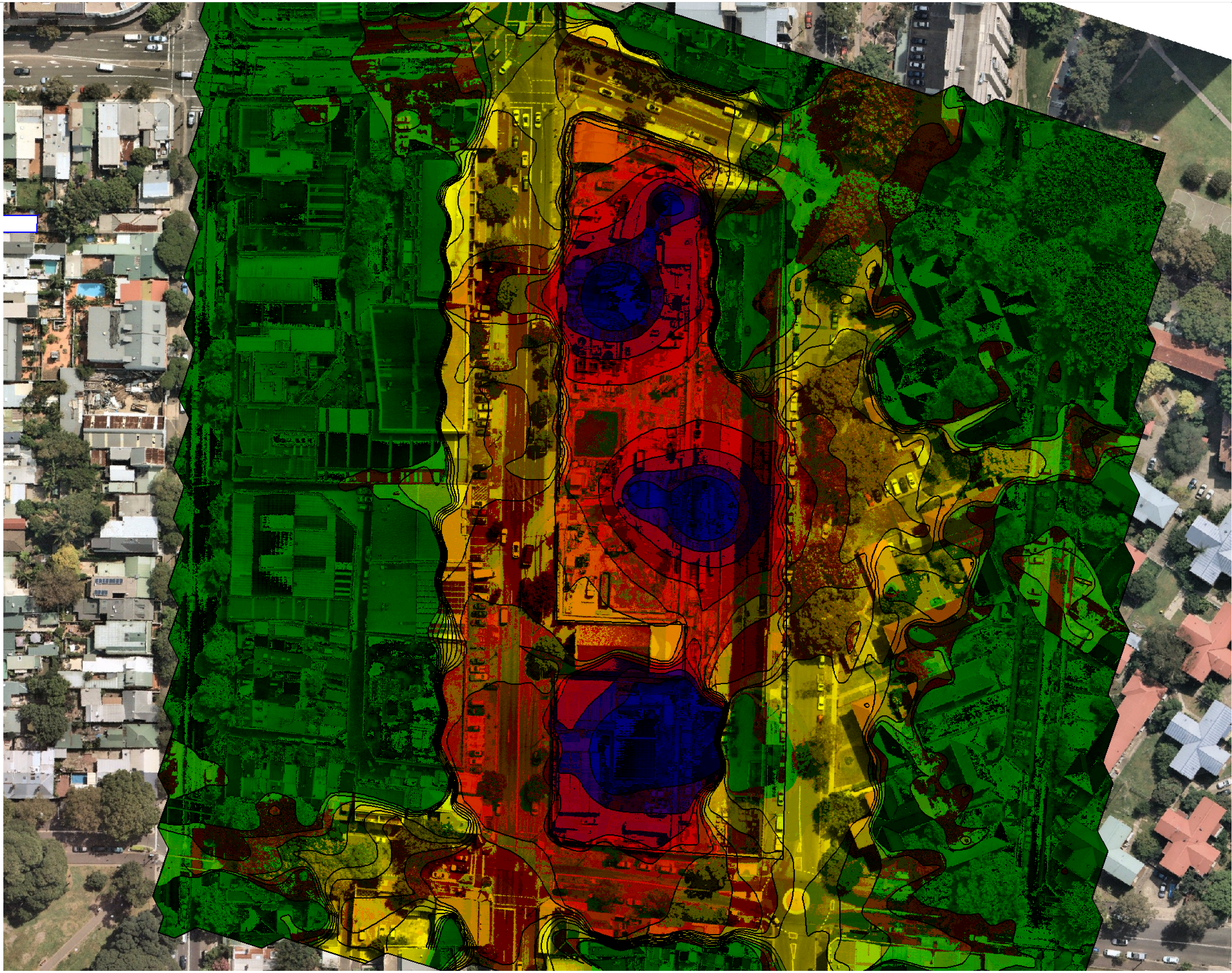
Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	ALL-AC-GRM	001



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REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

ARCHITECT/CLIENT: Waterloo Integrated Station Development — A Joint Venture Project — JOHN HOLLAND, mirvac

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE GF TO L5, WITH MITIGATION

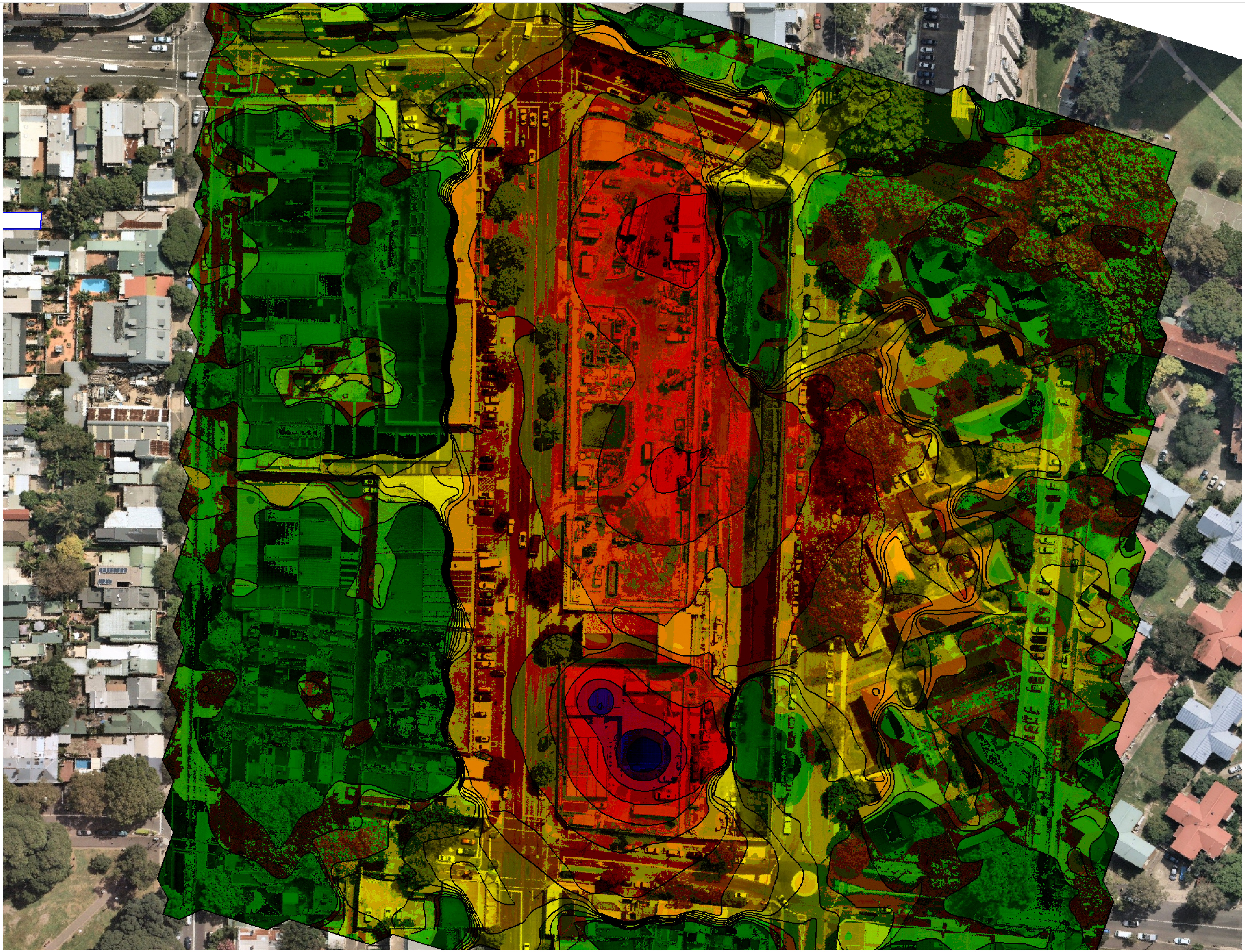
Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	ALL-AC-GRM	001



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REV	DESCRIPTION	DRAWN	APP'D	DATE
001	DA Package	MIS	BN	10/07/20

Noise Level Legend - $L_{Aeq,15min}$ in dB(A)

< 45	49-51	55-57	61-63	67-69
45-47	51-53	57-59	63-65	69-71
47-49	53-55	59-61	65-67	> 71

Waterloo Integrated Station Development
A joint Venture Project
JOHN HOLLAND
mirvac

ARCHITECT/CLIENT

PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE L6 TO L10, NO MITIGATION

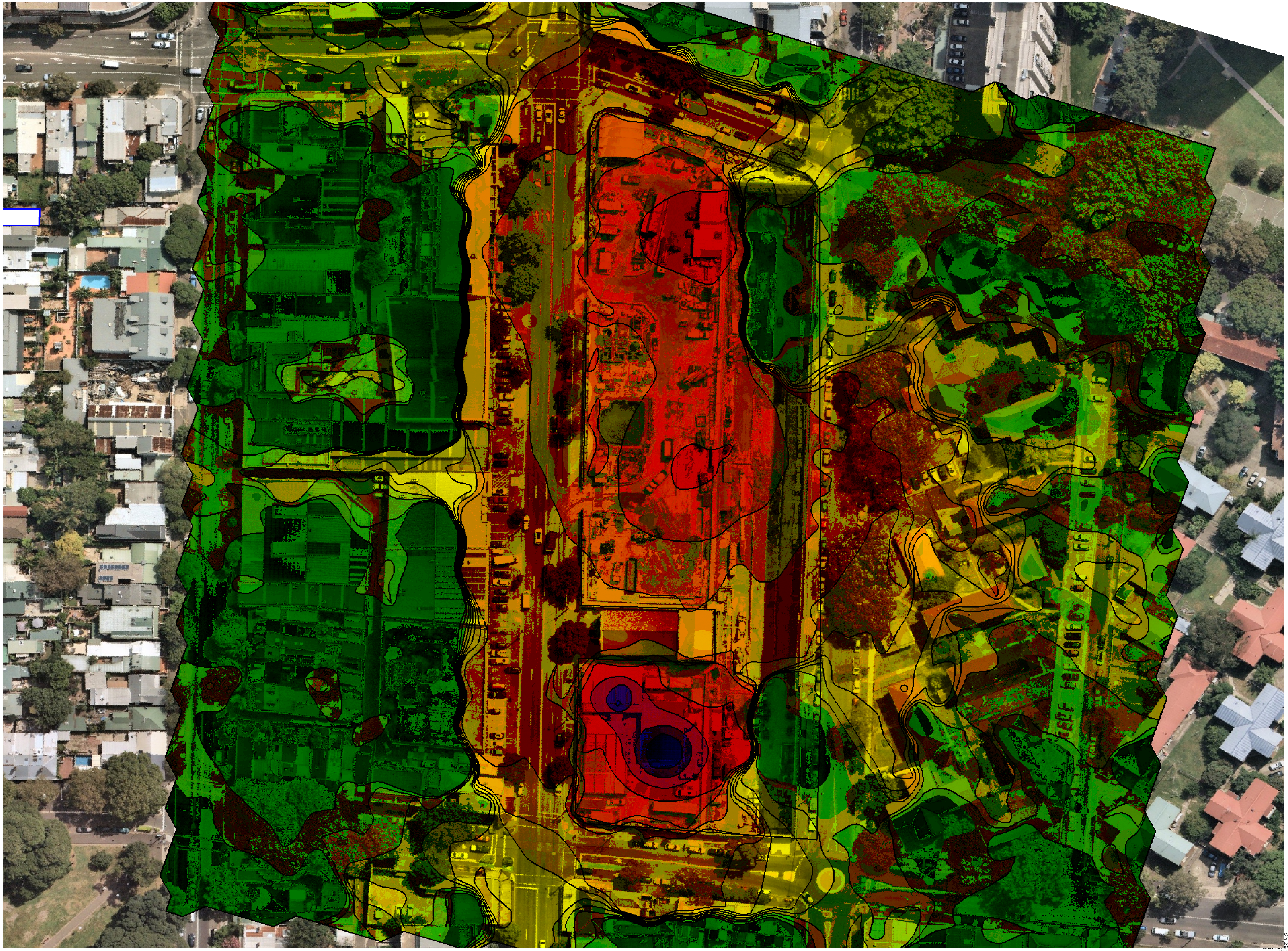
Stantec

Noise Model

Construction Noise Modelling Results

Noise & Vibration

SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	ALL-AC-GRM	001



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PROJECT: WATERLOO OVER-STATION DEVELOPMENT - CUMULATIVE ASSESSMENT

TITLE: CONSTRUCTION NOISE EMISSIONS - STRUCTURE L6 TO L10, WITH MITIGATION

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Noise Model

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SCALE @ A0	PROJECT No	DRAWING No	REV
1:200	46198	ALL-AC-GRM	001