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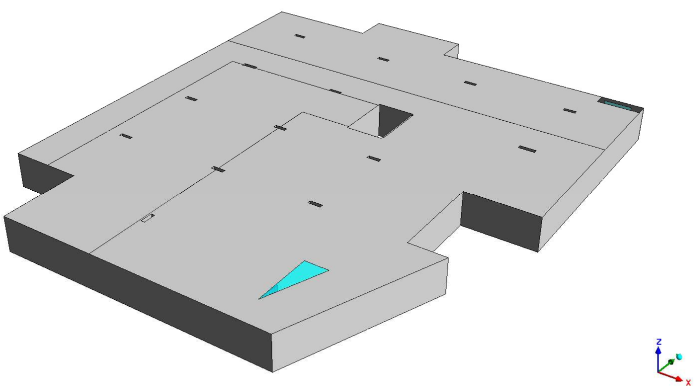

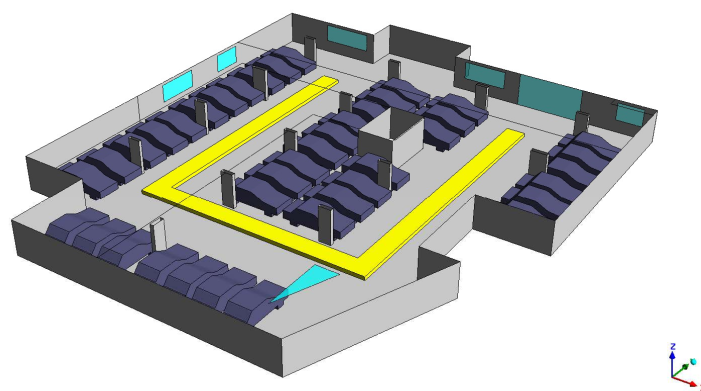

Carpark Ventilation and Air Quality – CFD Assessment Report

Levande Bulimba Stage 1

91 Lytton Road & 57 Andrew Street, Balmoral QLD 4171

Project No: Q126_001

Date: 15/05/2026

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1. INTRODUCTION

Levande Bulimba is a residential development and is located at 91 Lytton Rd and 57 Andrew St, Queensland. The development consists of four apartment buildings and carparks across a steeply sloped site. This study considers only the Stage 1 construction/design phase of the project.

The Building A carpark is mechanically ventilated with a dedicated carpark exhaust system for the L0 level; the Building B/C/D carparks are naturally ventilated with make-up air provided through the carpark entries and louvred openings, with small mechanical supply systems providing additional fresh air for Levels 1 and 2.

For the Building B/C/D carparks fresh air is distributed throughout via jet fans, and the contaminated air is extracted through wall louvres on the left side. The carpark is proposing to utilise a performance-based solution to deviate from the deemed to satisfy air flow rates clause, as well as jet fans operating in series, with the use of CFD analysis.

A development application (DA) for the proposed development is being assessed by Brisbane City Council (BCC), which requires an assessment of the level of air quality on the site due to the carpark exhaust discharge as per the Multiple Dwelling Code.

1.1 Purpose and Scope

The purpose of this document is to confirm if the proposed mechanical ventilation design is expected to meet the minimum performance requirements of Australian Standards as per the methodology for performance application to car park ventilation outlined in Appendix N, AS 1668.2-2012. This report is not considered mechanical services design and intends to provide supporting information to the mechanical consultant.

Furthermore, emissions from the carparks and mechanical exhaust discharge are assessed to determine if the air quality for the development will comply with the BCC City Plan 2014 and its Air Quality planning scheme policy.

1.2 Referenced Documents

NCC	National Construction Code
BCC City Plan 2014	Brisbane City Council City Plan 2014
AS 1668.2	Mechanical ventilation in buildings
AS 1668.4	Natural ventilation in buildings

1.3 Definitions and Acronyms

ABCB	Australian Building Codes Board
BCC	Brisbane City Council
CFD	Computational fluid dynamics
CO	Carbon Monoxide
DA	Development Application
DTS	Design-to-standard
PM	Particulate Matter
PPM	Parts per million
VOC	Volatile Organic Compounds

2. Methodology

2.1 Purpose

IGS propose a carpark ventilation design in relation to the exhaust air flow rates which deviates from the DTS requirement. The design supplements this by ensuring the volume of air distributing through the carpark is adequate to achieve compliance through the performance approach outlined in AS 1668.2-2012 and NCC.

2.2 Referenced Documents

The key technical documentation that forms the basis of the CFD modelling is outlined as follows.

Reference drawings and documents		
Drawing	Drawing Number	Revision & Date
2025073_DD-004_SITE_PLAN_(D2)	DD - 004	Rev D2 & 20.02.2026
B2 – General Arrangement Level 01	B-110	Rev D2 & 24.04.2026
B2 – General Arrangement Level 02	B-111	Rev D3 & 24.04.2026
B2 – General Arrangement Level 03	B-112	Rev D3 & 24.04.2026
B2 – General Arrangement Level 04	B-113	Rev D2 & 24.04.2026
B2 – General Arrangement Level 05	B-114	Rev D2 & 24.04.2026
B2 – General Arrangement Level 06	B-115	Rev D2 & 24.04.2026
B2 – General Arrangement Roof	B-116	Rev D2 & 24.04.2026
C2 – General Arrangement Level 01	B-120	Rev D2 & 24.04.2026
C2 – General Arrangement Level 02	B-121	Rev D2 & 24.04.2026
C2 – General Arrangement Level 03	B-122	Rev D2 & 24.04.2026
C2 – General Arrangement Level 04	B-123	Rev D2 & 24.04.2026
C2 – General Arrangement Level 05	B-124	Rev D2 & 24.04.2026
C2 – General Arrangement Level 06	B-125	Rev D2 & 24.04.2026
C2 – General Arrangement Level 07	B-126	Rev D2 & 24.04.2026
C2 – General Arrangement Roof	B-127	Rev D2 & 24.04.2026
D2 – General Arrangement Level 03	B-130	Rev D2 & 24.04.2026
D2 – General Arrangement Level 04	B-131	Rev D2 & 24.04.2026
D2 – General Arrangement Level 05	B-132	Rev D2 & 24.04.2026

Reference drawings and documents		
Drawing	Drawing Number	Revision & Date
D2 – General Arrangement Level 06	B-133	Rev D2 & 24.04.2026
D2 – General Arrangement Level 07	B-134	Rev D2 & 24.04.2026
D2 – General Arrangement Level 08	B-135	Rev D2 & 24.04.2026
D2 – General Arrangement Level 09	B-136	Rev D2 & 24.04.2026
D2 – General Arrangement Level 10	B-137	Rev D2 & 24.04.2026
D2 – General Arrangement Roof	B-138	Rev D2 & 24.04.2026
Port Cochere – General Arrangement	B-150	Rev D1 & 24.04.2026
Clubhouse Lobby & Courtyard – General Arrangement	B-151	Rev D1 & 24.04.2026
Q126_001 LEVANDE - MECH_30%DD	Q126_001	Rev D2 & 30.01.2026

2.3 Computational Fluid Dynamics (CFD)

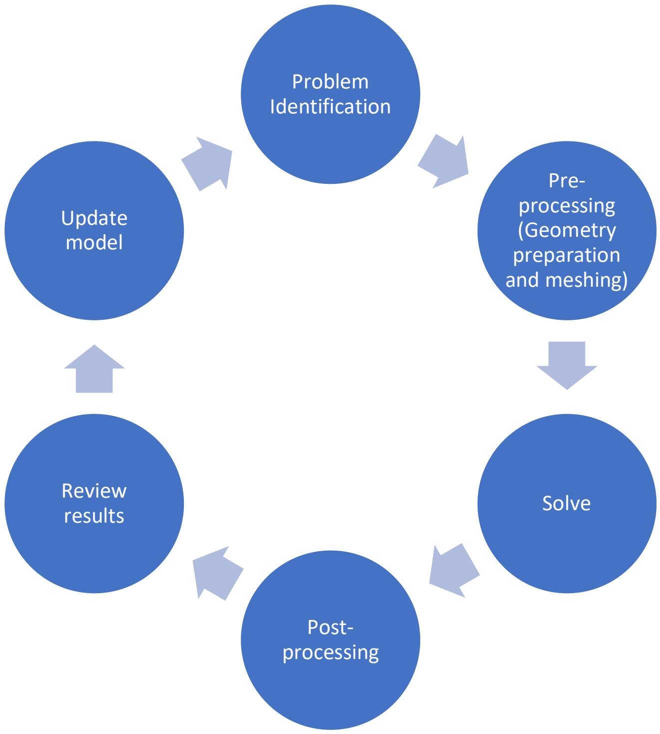
Computational Fluid Dynamics (CFD) is a powerful tool used to model the real-life behaviour of fluids. It allows the optimisation of design parameters without the need for the costly testing of multiple prototypes.

CFD is also a powerful graphical tool for visualising flow patterns that can give insight into flow physics that otherwise would be very difficult and costly to discover experimentally, if possible, at all.

Governing equations exist to model fluid behaviour, but it is not always possible to apply them to many of the complex flow patterns we see in the real world directly as there would be too many unknown variables. However, CFD involves creating a computational mesh to divide up real world continuous fluids into more manageable discrete sections. The governing equations for fluid flow can then be applied to each section individually, but as the properties of each section are inevitably linked to its neighbouring sections, all the sections can be solved simultaneously until a full solution for the entire flow field can be found. This method requires a huge amount of computational power.

2.3.1 CFD Process

The modelling process consists of first taking the real-world fluid geometry and replicating this in the virtual environment. From here, a mesh can be created to divide the fluid up into discrete sections. Boundary conditions must then be entered into the model to designate parameters such as the type of fluids to be modelled or the details of any solid edges or flow inlets/outlets. The simulation is then ready to be run and when a converged solution is found, it must be carefully analysed to establish whether the mesh is appropriately modelling the flow conditions. Generally, some form of mesh refinement will be necessary to put in further detail around the areas of interest.



2.3.2 Formula Derivation

The formula provided in AS1668.2- 2012 dictates the contamination generation rate of CO produced based on the carpark's properties and is used to estimate the rate of expected pollution at peak traffic. This should be analysed against the appropriate traffic reports to determine the representation of car usage for each carpark.

$$Contaminant\ generation\ rate$$
$$= n_1 * \left[0.5min@\ 25\frac{g}{min} + 0.5 * (25 - 16)\right] + n_1 d_1 * 0.01\frac{min}{m} * 16\frac{g}{min} + n_2 d_2 * 0.01\frac{min}{m} * 16\frac{g}{min}$$
$$= 17n_1 + 0.16n_1 d_1 + 0.16n_2 d_2$$

(Referenced: AS 1668.2 – 2012 Appendix J; Equation 4.4.4.1)

2.4 Compliance Criteria

Section 4 of AS 1668.2-2012 outlines the ventilation design criteria for carparks and other enclosures used by internal combustion engine vehicles.

IGS are proposing to deviate from the following clauses outlines in section 4 of AS 1668.2-2012.

- Clause 4.4.4.2 – Airflow rate

The need to comply with this clause is replaced with Appendix N, AS 1668.2-2012.

To achieve compliance, the mechanically ventilated carpark is modelled using CFD to achieve less than the following CO levels which are referenced in Appendix N, AS 1668.2 Performance application to car park ventilation.

- 60 ppm for a 1h maximum average.
- 100 ppm for a 30-minute maximum average; and
- 30 ppm (TWA) 8h.

2.5 Compliance Method

This report demonstrates that the proposed design will limit CO concentration to the levels set out in Section N4 of Appendix N of AS 1668.2-2012. To do this we have used excerpts from AS 1668.2-2012 to establish a 'worst-case scenario' of CO generation in the car park and used CFD analysis to model the proposed ventilation system and find the peak and average levels of carbon monoxide expected. Appendix J of AS 1668.2-2012 outlines the basis for the CO generation rate equation used in the design requirements in Clause 4.4.4. The formula aims for a 1-hour average CO concentration of 60 ppm assuming the ambient level of CO is 9 ppm (i.e., 51 ppm rise). We have used the formulae given in Appendix J to calculate the CO generation rate in kg/s and assumed this to be the worst-case scenario. Appendix J of AS 1668.2-2012 is attached to this report in the methodology section. The car park has been modelled in Autodesk Fusion & Ansys Spaceclaim and processed in Ansys Fluent. The car park was modelled with the proposed supply and exhaust systems working at maximum speed and CO generation rate spread cross the driving areas of the floor plate in front of the car parking bays. CO concentration in ppm was injected into the fluid domain at a height of 300mm above each carpark floor level.

2.6 Modelling assumptions

The CO introduced into the model is calculated from the equations given in AS1668.2-2012 Appendix J. The exhaust gas is introduced along the floor plate as detailed in the previous section.

The CFD verification was completed based on the drawings detailed in Section 2.2. The mechanical designer is to ensure any changes to the architectural layout is reflected with CFD verification or the scope to capture this intent by the contractor should the project undertake a D&C mechanical procurement method.

2.7 Background air quality

For carparks, the primary pollutants of concern are those generated by vehicles as products of combustion. These typically include (in order of significance):

- Carbon monoxide;
- Nitrogen dioxide (NO_2);
- Particulate matter as PM_{10} and $PM_{2.5}$; and
- Volatile organic compounds (VOCs).

As stated in Clause 4.12.1 in AS1668.2, although NO_2 is produced by some combustion engines (typically diesel engines), monitoring results indicate that CO levels exceed the relevant exposure standard before NO_2 levels – CO is therefore considered in this study to characterise the air quality on the site.

As per the Schedule 6 Air Quality planning scheme policy in the BCC City Plan 2014, background concentrations of the pollutants of concern have been determined for the five most recent years (2020-2024 inclusive) from the Queensland Government website.

Ambient CO concentrations were obtained from the Woolloongabba Air Quality monitoring station operated by the Queensland Government. The location of this site is the closest available to the development site, and is primarily influenced by traffic emissions which is consistent with the development site location. The background data from this station is included below for the impact assessment of the carpark ventilation emissions.

The adopted background criteria (shown in bold) are derived in accordance with the guidance provided in the Air Quality planning scheme policy, and compared to the air quality criteria to be complied with in the BCC City Plan 2014 guidelines. It should be noted that the air quality criterion of 9 ppm is the 8-hour time-weighted average value, which is much longer than the 1-hour peak period of car park usage considered in the analysis.

Pollutant	**Air quality planning criteria (BCC City Plan 2014)**	**2020-2024 Concentration (1-hour average data, highest 70th percentile)**
CO	9 ppm	0.2 ppm

2.8 Multiple Dwelling Code

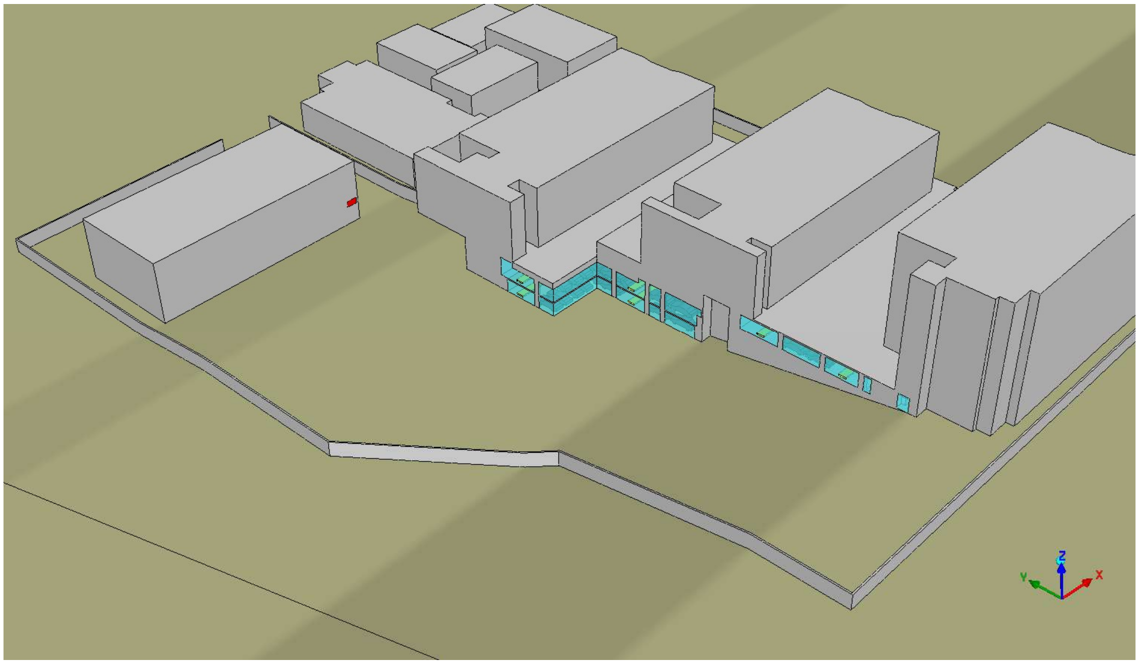
Table 9.3.14.3.A of the Multiple Dwelling Code specifies the performance outcomes and acceptable outcomes; the criteria relevant to this assessment are as per the following table.

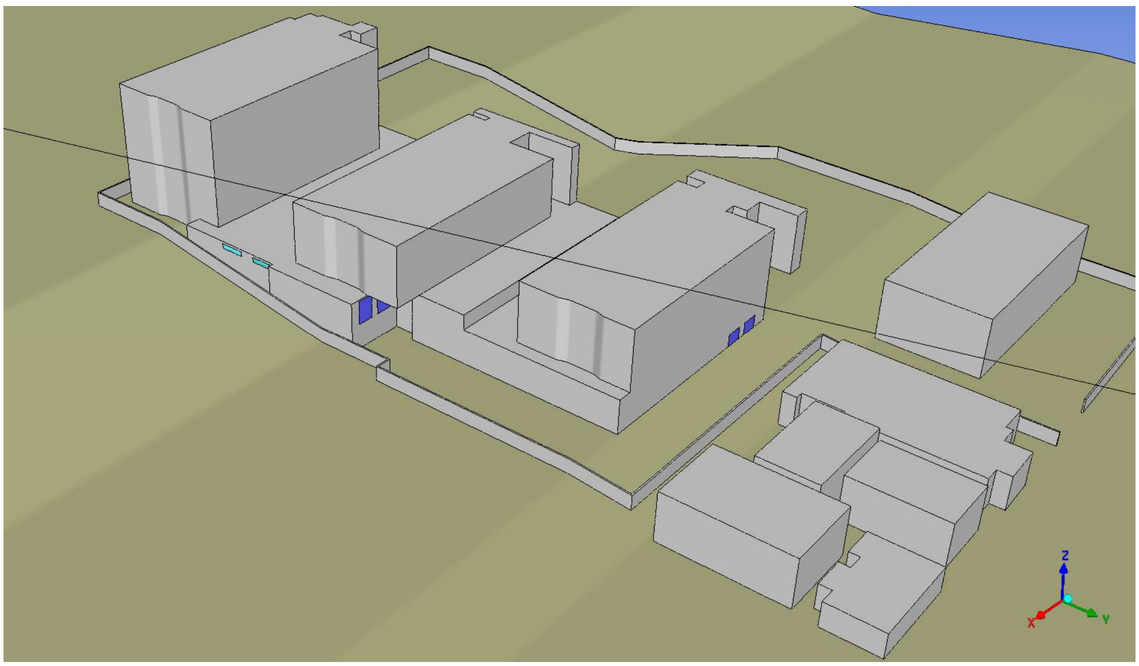
Performance outcomes	Acceptable outcomes
P020	A020.1
Development is located, designed and constructed to achieve the: (a) Air quality (planning) criteria in Table 9.3.14.3.G; (b) Odour criteria in Table 9.3.14.3.H Note – An air quality impact report prepared in accordance with the Air quality planning scheme policy can assist in demonstrating achievement of this performance outcome.	Development in a zone in the centre zones category or the Mixed use zone, including any outdoor air intakes for the development, is separated from: (a) Exhaust vent outlets of premises where food or cooking odour is released, by a minimum of 6m; (b) Exhaust vent outlets from car parks or bus stations, by a minimum of 15m.

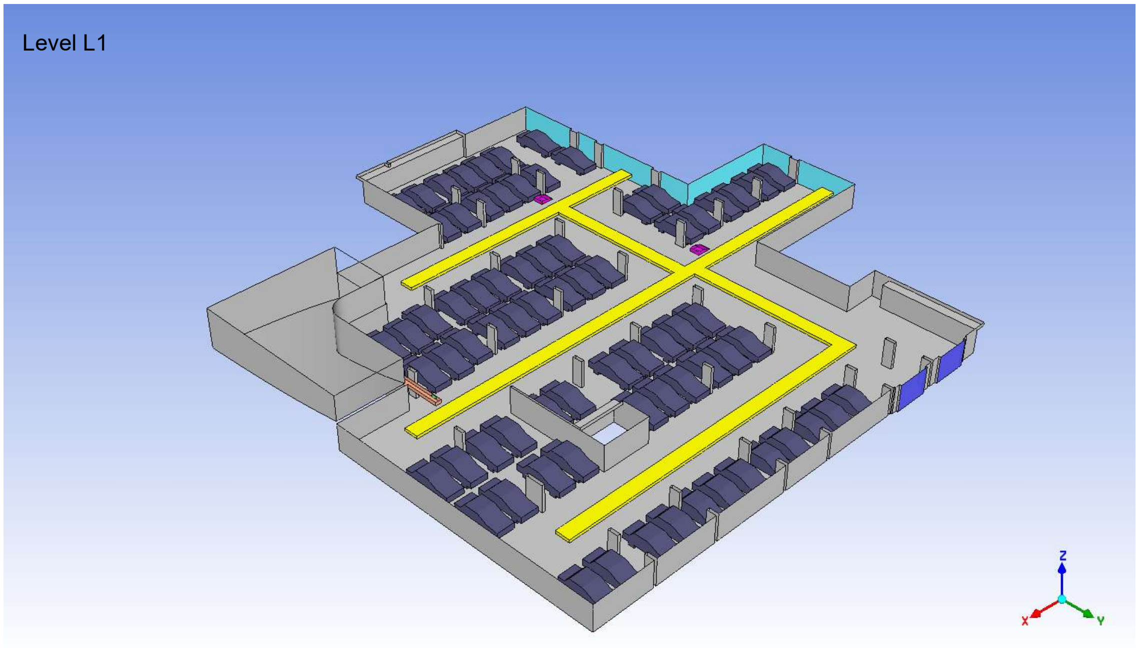
3. Model

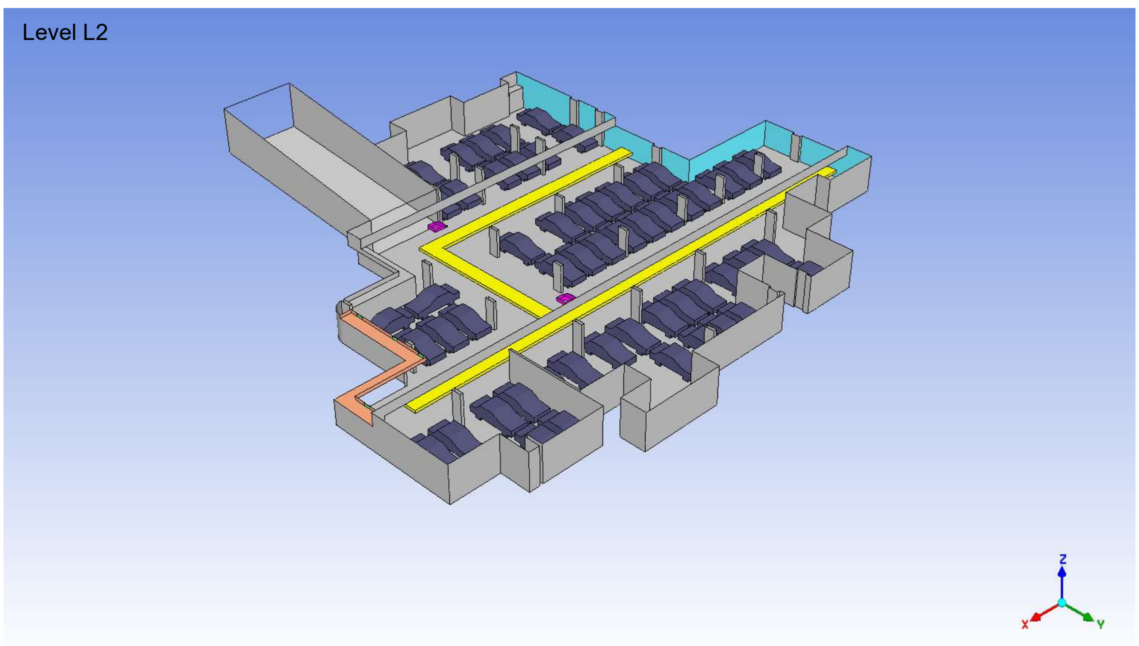
Refer to Appendix A for calculation results.

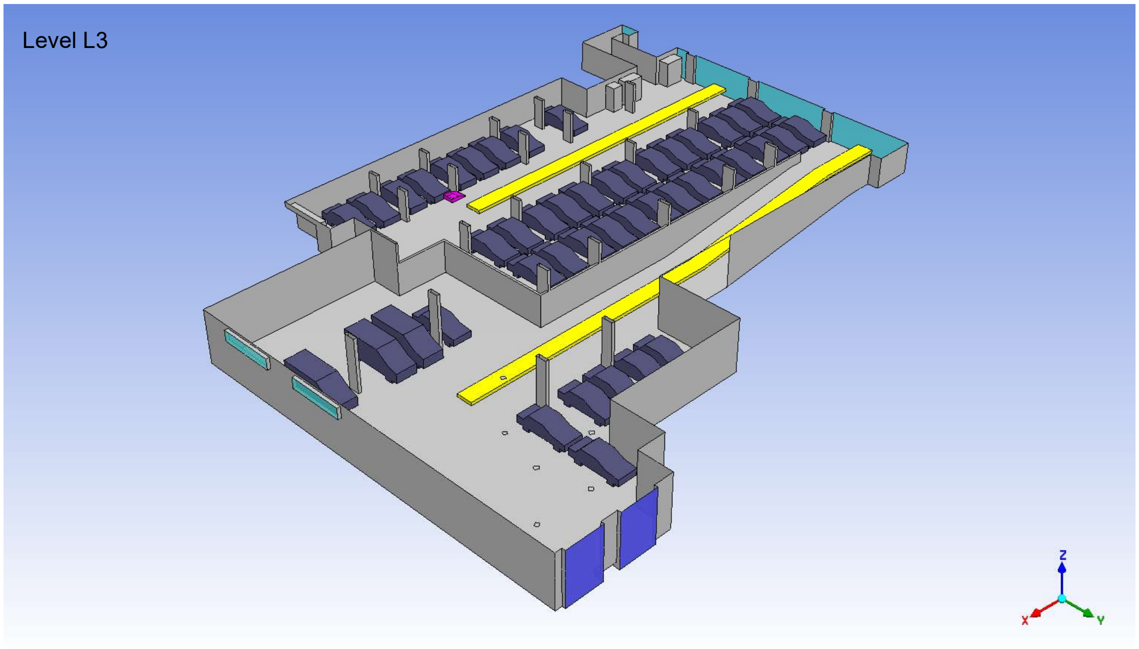
3.1 Fluid Region






Level L1
Z
X
Y


Level L2
Z
X
Y



3.2 Supply & Exhaust Allocation

Level L1 to Level L2 consists of various Exhaust Air grilles, originally sized for the DtS approach. These have been resized to represent proportionate reductions in airflow, whilst maintaining adequate input velocities. As the simulation represents the worst-case scenario, the input velocities have been chosen to demonstrate the system responding to the higher CO concentration levels generated at peak traffic hour.

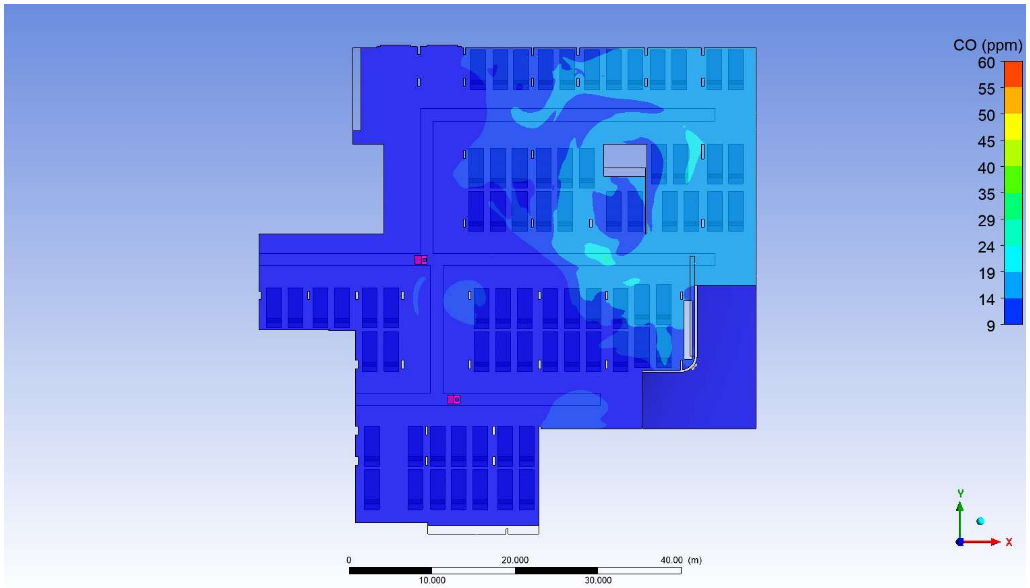
Name	Description	Value
L1 Supply	3 off 1300mm x 450mm grilles	3,900 L/s total
L2 Supply	4 off 900mm x 400mm grilles	3,200 L/s total
Jet Fans	5 off Pac Vent JF JVC 25	30N thrust

For the air quality assessment, the DTS flowrate for the Building A (Level 0) carpark exhaust discharge is 4,100 L/s with an average CO concentration in the discharge of 19 ppm. The exhaust is discharged through a 2600mm x 1300mm louvre at high level on the Level 1 façade of Building A.

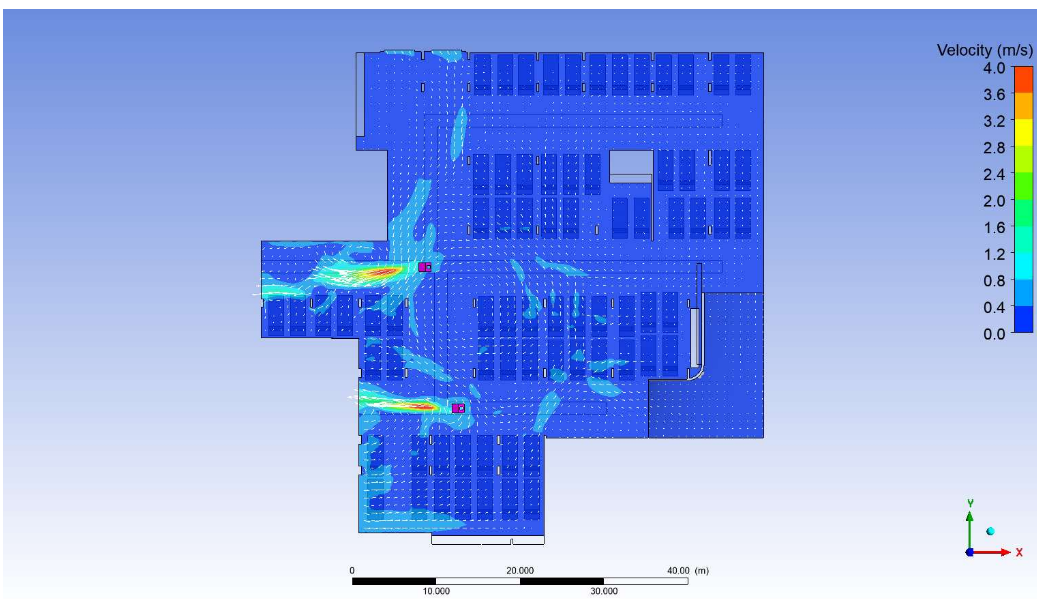
4. Outcomes

Based on the proportionate reductions from DtS airflows, this is the anticipated CO concentrations and velocity magnitudes for each level.

4.1 Level L1



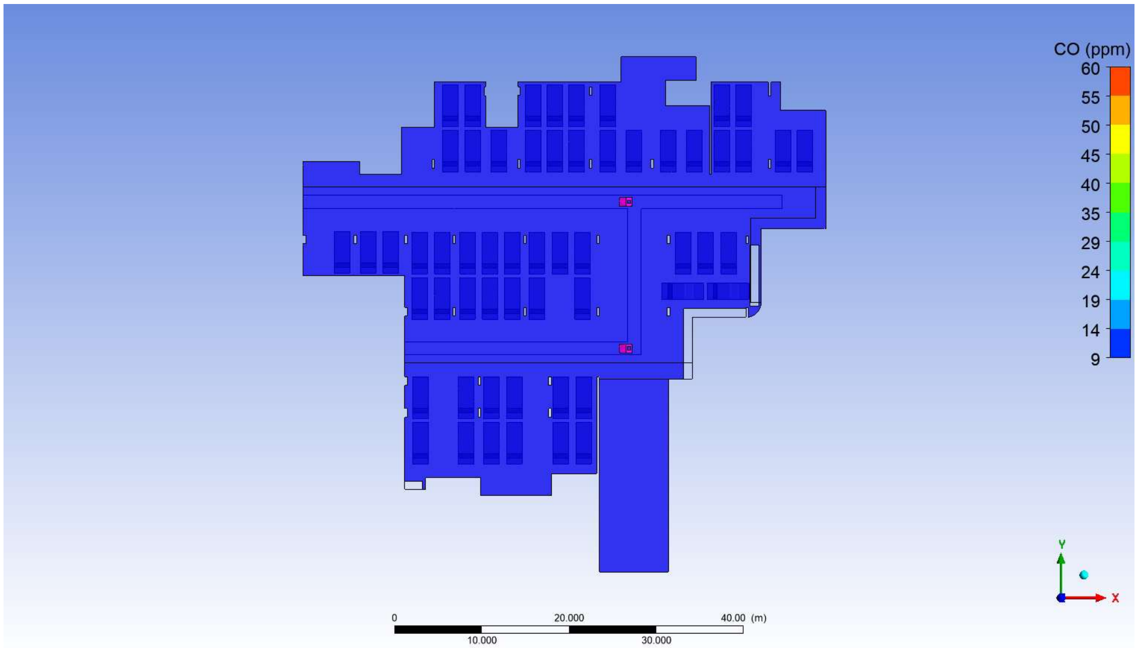
Level L1 Carbon Monoxide Concentration Colour Map (ppm)



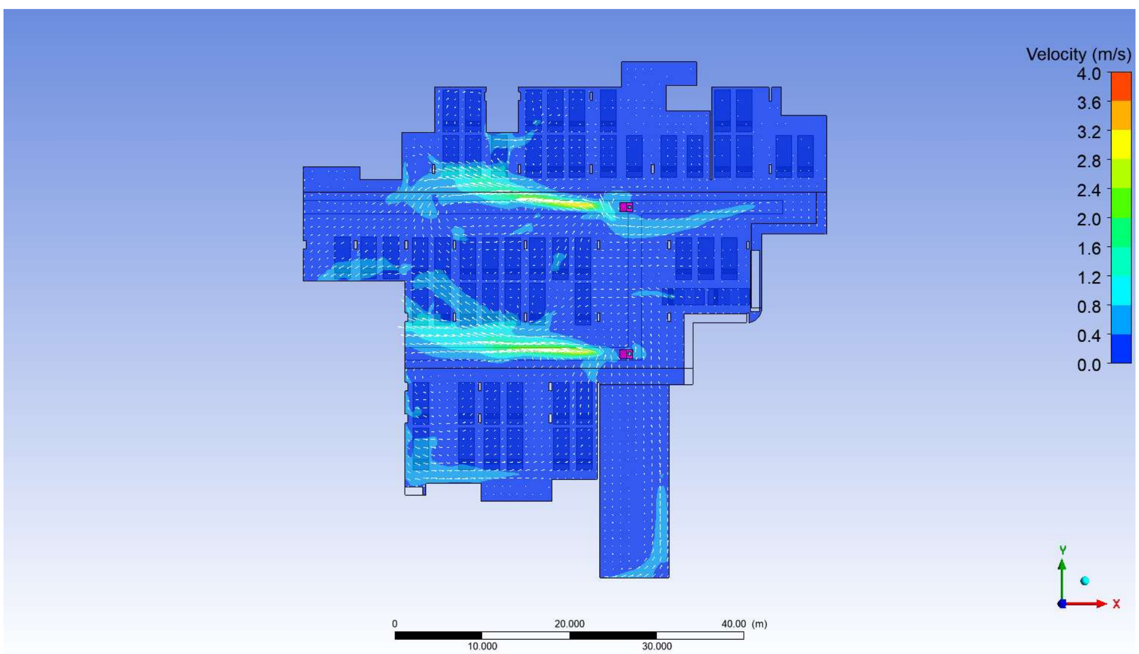
Level L1 Velocity Magnitude Colour Map (m/s)

4.2 Level L2

Plane cut (1600mm):



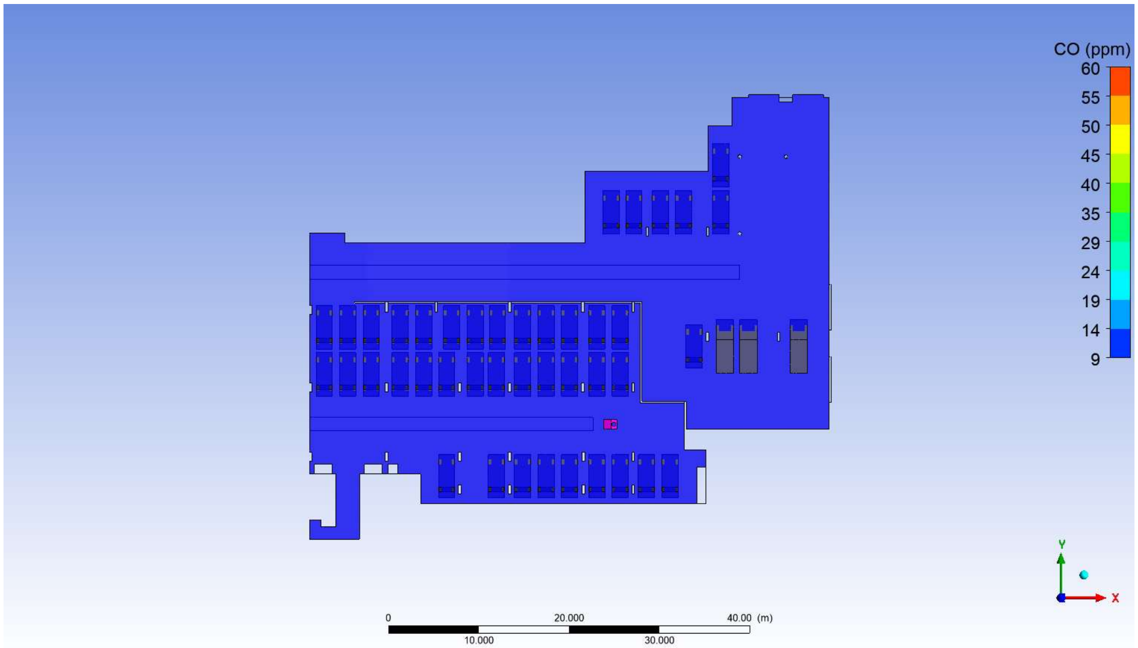
Level L2 Carbon Monoxide Concentration Colour Map (ppm)



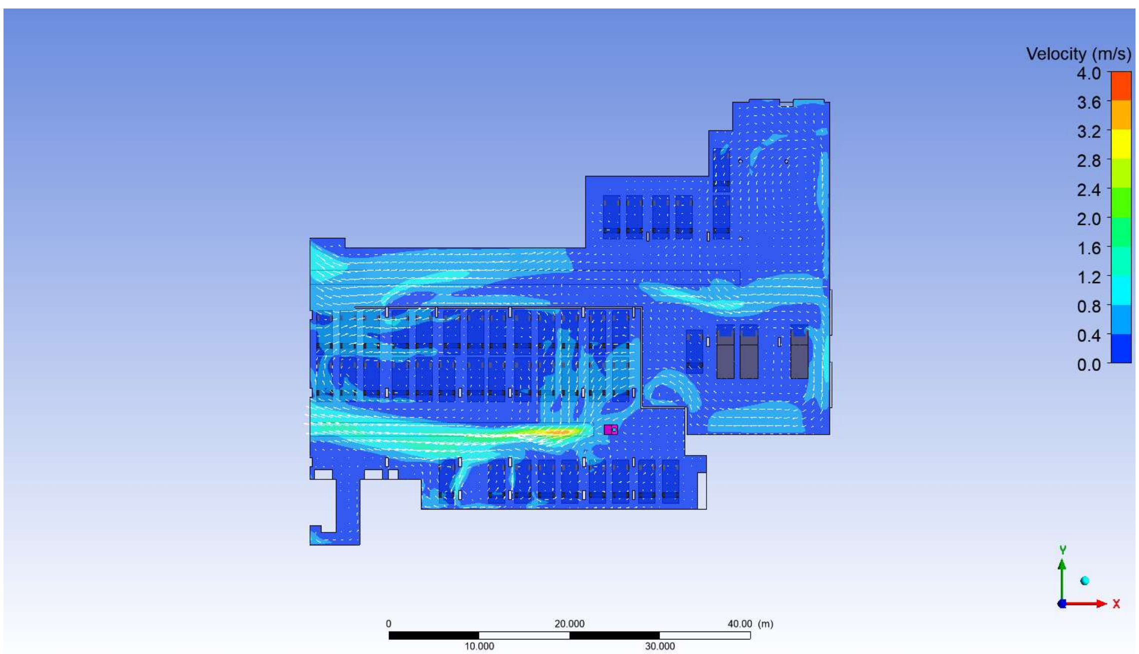
Level L2 Velocity Magnitude Colour Map (m/s)

4.3 Level L3

Plane cut (1600mm):



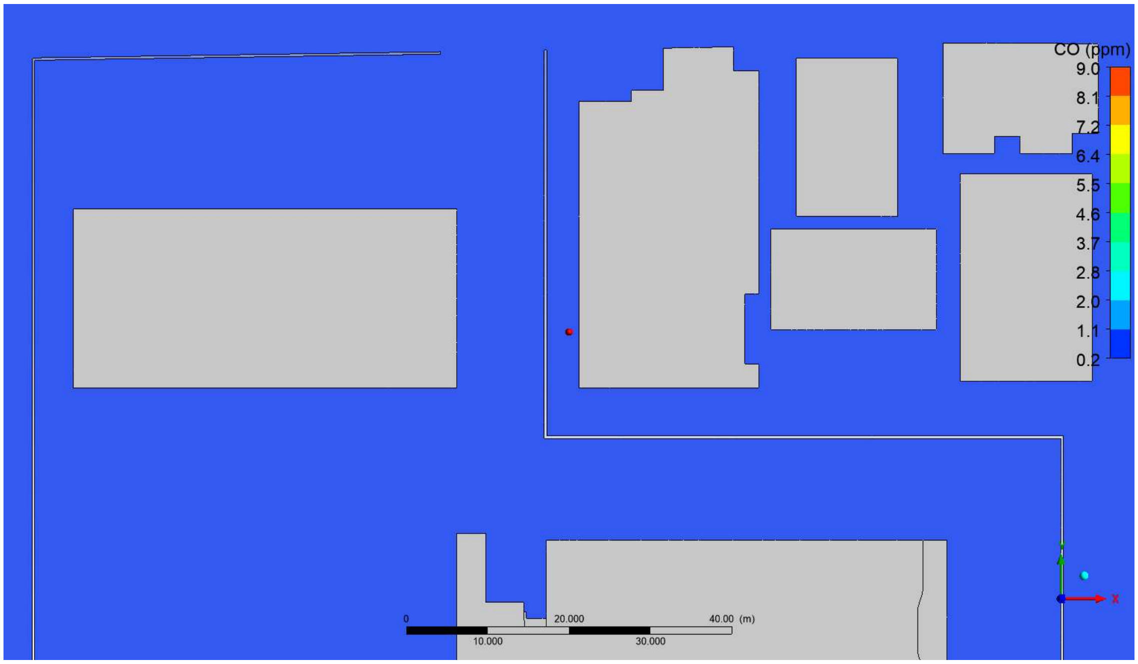
Level L3 Carbon Monoxide Concentration Colour Map (ppm)



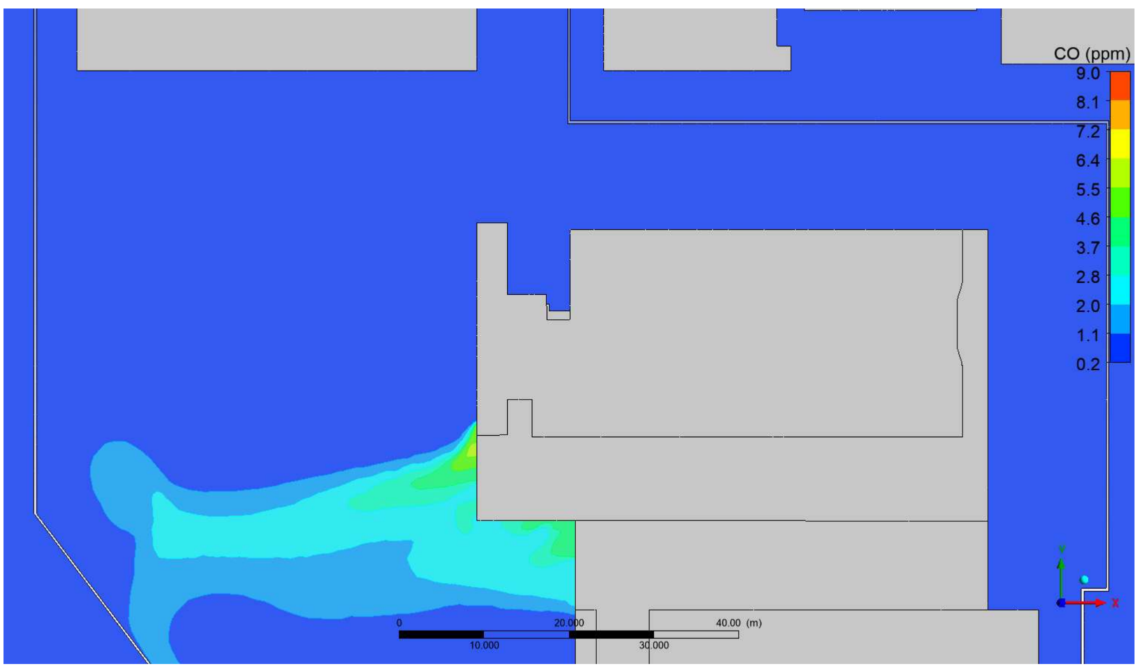
Level L3 Velocity Magnitude Colour Map (m/s

4.4 Air Quality Assessment

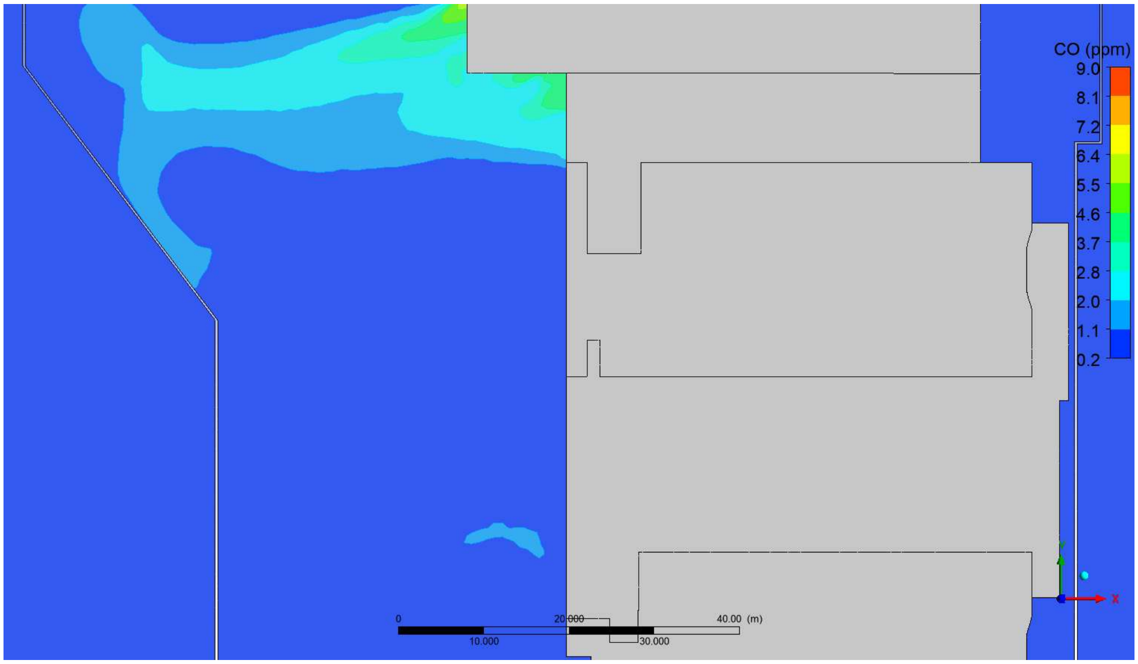
Plane cut (1600mm):



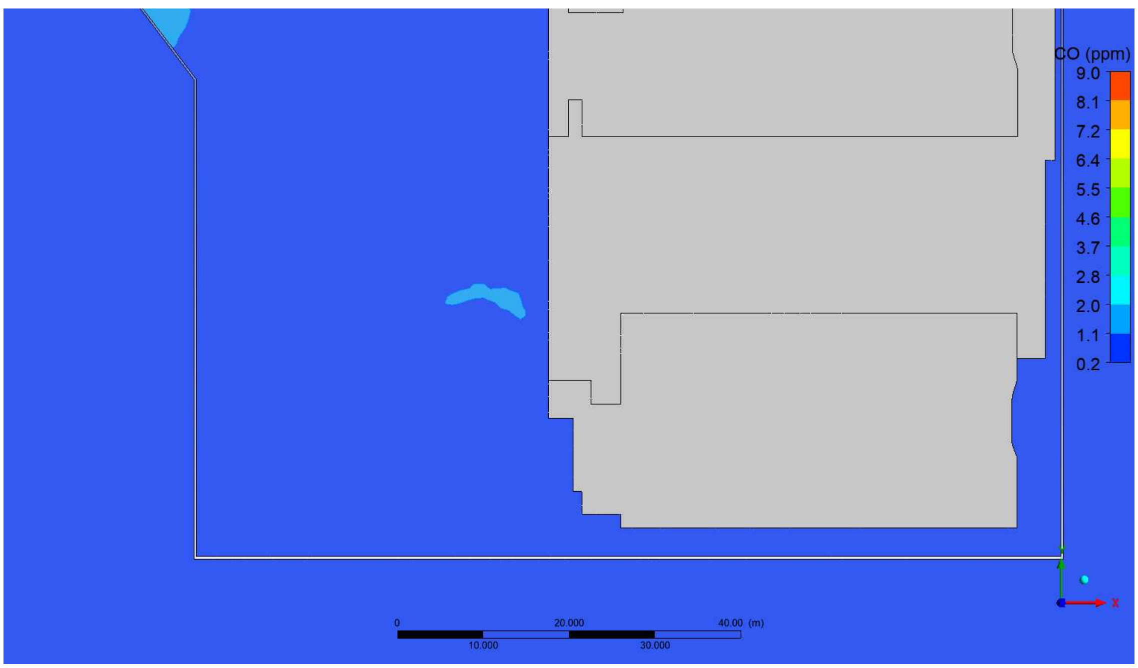
Building A Carbon Monoxide Concentration Colour Map (ppm)



Building B Carbon Monoxide Concentration Colour Map (ppm)



Building C Carbon Monoxide Concentration Colour Map (ppm)



Building D Carbon Monoxide Concentration Colour Map (ppm)

4.5 Fire Mode

4.6 Operation description

During normal operation mode the car park ventilation system will supply air through the dedicated mechanical ventilation ducts and will be controlled by the systems proposed by the mechanical engineer.

During fire mode the carpark ventilation system will continue to extract air at a predetermined, set airflow quantity, as per the latest fire engineering report.

The mechanical contractor shall ensure to have fully read and understood the fire engineering report and requirements. All controls and shutdowns shall comply to the project's Fire Engineering Report and Mechanical Design.

5. Disclaimer

This report is prepared using the information described above and inputs from other consultants. Whilst IGS has endeavoured to ensure the information used is accurate, no responsibility or liability to any third party is accepted for any loss or damage arising out of the use of this report by any third party. Any third party wishing to act upon any material contained in this report should first contact IGS for detailed advice which will consider that party's particular requirements.

Computer building simulation provides an estimate of building 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 once built. As a result, simulation 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 simulation results alone. IGS and its employees and agents shall not be liable for any loss arising because of, any person using or relying on the Report and whether caused by reason or error, negligent act, or omission in the Report.

This CFD analysis report should be read in conjunction with the relevant plans and specifications and any supplementary regulatory information.

6. Conclusion

The results from the simulation demonstrate that the proposed design complies with the requirements set out in AS 1668.2 – 2012 via a performance solution. The compliance criteria for this project were twofold, sample at a height between 750mm and 1800mm (1600mm nominated) above floor level & keep the CO concentration below:

1. 60 ppm average over one hour

The 1-hour average 60-ppm maximum is based on a 9-ppm ambient level of CO and therefore a 51-ppm rise. The model simulated the 1 hour of peak CO generation and peak car park exhaust extraction and found that the maximum CO levels throughout the car park are expected to be not greater than the 60 ppm limit.

Carpark Level	Compliant Maximum CO (ppm)	Simulated Maximum CO (ppm)
Level L1	60	27
Level L2	60	9
Level L3	60	5

Contaminated air from the carparks are discharged through the western façade louvres for Buildings B-D, and through the mechanical exhaust discharge grille for Building A. For the latter, the discharge is well above the local ground level and the air quality (in terms of CO concentration) around the building are essentially the ambient value of 0.2 ppm. This is aided by the fact that CO is lighter than air and therefore has a natural tendency to rise. For the other buildings, the local air quality remains well less than the 9 ppm criteria.

For the whole site, the air quality is acceptable and compliant with the BCC City Plan 2014 air quality planning criteria.

7. Appendix A

7.1 Car Park Exhaust Calculations

Car Park Level	P	n_1	d_1	n_2	d_2	Cars Per Hour	Total CO Emission Rate
L1	0.3	73	28	57	64	22	235
L2	0.3	57	30	0	0	17	137

Car Park Level	P	n_1	d_1	n_2	d_2	Cars Per Hour	Total CO Emission Rate
Level 3	0.3	45	40	0	0	14	122

Use of car park	Parking usage factor
Residential	0.3
Commercial	0.5
Retail/food and drink service	0.7
Entertainment/sports centre	1
Vehicle depots	2.4

Table 1

Time (mins)	CO Emission Rates (g/min)
0 - 1	10
1 - 2	4
2 - 3	1
3 - 4	1
4 - 5	1
5+	1

Table 2

Carpark Level	Supply Air (L/s)	Exhaust Air (L/s)
Level L1	3,900	n/a
Level L2	3,200	n/a
Level L3	n/a	n/a