omnii
Consulting Fire Engineers

Project

Snack Brands Australia

Lot 9, Distribution Drive, Orchard Hills New South Wales

Principal

Snack Brands Australia

Building Certifier

McKenzie Group Consulting (NSW) Pty Ltd

Fire Safety Strategy Report

August 2021

Project Number 9198100

Revision P3

omnii
Consulting Fire Engineers

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P1	29th June 2021	**Preliminary**	Alexandra Ceccato	Andrew Martin Walther Groenewald
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P2	20th July 2021	**Preliminary**	Vikrant Gorasia	Andrew Martin
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Authorisation of Final Document

Fire Safety Engineer:

Name	Signature	Registration No.

Table of Contents

1. Introduction

This document prepared for Snack Brands Australia (Principal) is the Fire Safety Strategy Report [FSSR] for the proposed development located at Snack Brands Australia, Lot 9, Distribution Drive, Orchard Hills New South Wales.

The purpose of this document is to identify the likely fire engineering outcomes (or proposed Performance Solution) required to address the expected departures from the Deemed To Satisfy [DTS] provisions of the National Construction Code – Volume 2019, Amendment 1, Building Code of Australia One (NCC).

The content of this document is preliminary and is subject to acceptance of the Fire Engineering Brief [FEB] and the Fire Engineering Report [FER] by the Authority Having Jurisdiction (AJH) and other relevant Regulatory Authorities.

1.1 Sources of Information

This document is based on the following sources of information:

a. BCA Report prepared by McKenzie Group Consulting (NSW) Pty Ltd dated 25th June 2021, refer Annexure A.

b. Correspondence from McKenzie Group Consulting (NSW) Pty Ltd dated 6th July 2021, refer Annexure D.

c. Existing Fire Engineering Report prepared by Scientific Fire Services dated 22 May 2019, refer Annexure B.

d. HLA Architects architectural plans uploaded to Procore, refer to Table 1.1.

Note: Although the plans indicate three levels, Omnii has been advised that the number of levels will be reduced to two (refer Annexure D). The report is provided on this basis.

Table 1.1 – Architectural Plans

Drawing No.	Revision	Drawing No.	Revision
A001	P13	A102	P4
A002	P9	A110	P6
A010	P4	A200	P7
A101	P4	A210	P8

1.2 Building Description

The Snack Brands Australia project consists of modifications to the existing Distribution Centre warehouse (Stage 1) and the construction of a new extension industrial building adjoining the warehouse. The existing Distribution Centre warehouse shall be referred to as the 'existing facility', and the new extension industrial building shall be referred to as the 'new extension' herein.

The existing facility and new extension shall form a single united building which extends over two separate allotments for ownership purposes. An agreement between the building owners shall be included in the Fire Engineering Report (FER), which details:

- The united building is permitted to be located over the two site allotments.
- The entity who will take responsibility of the maintenance and testing of the shared fire safety systems listed on the AFSS.
- If the site allotment ownership changes, then the fire engineering strategy must be re-assessed.
- Should the building, building use or fitout be changed, then the fire engineering strategy must be re-assessed.

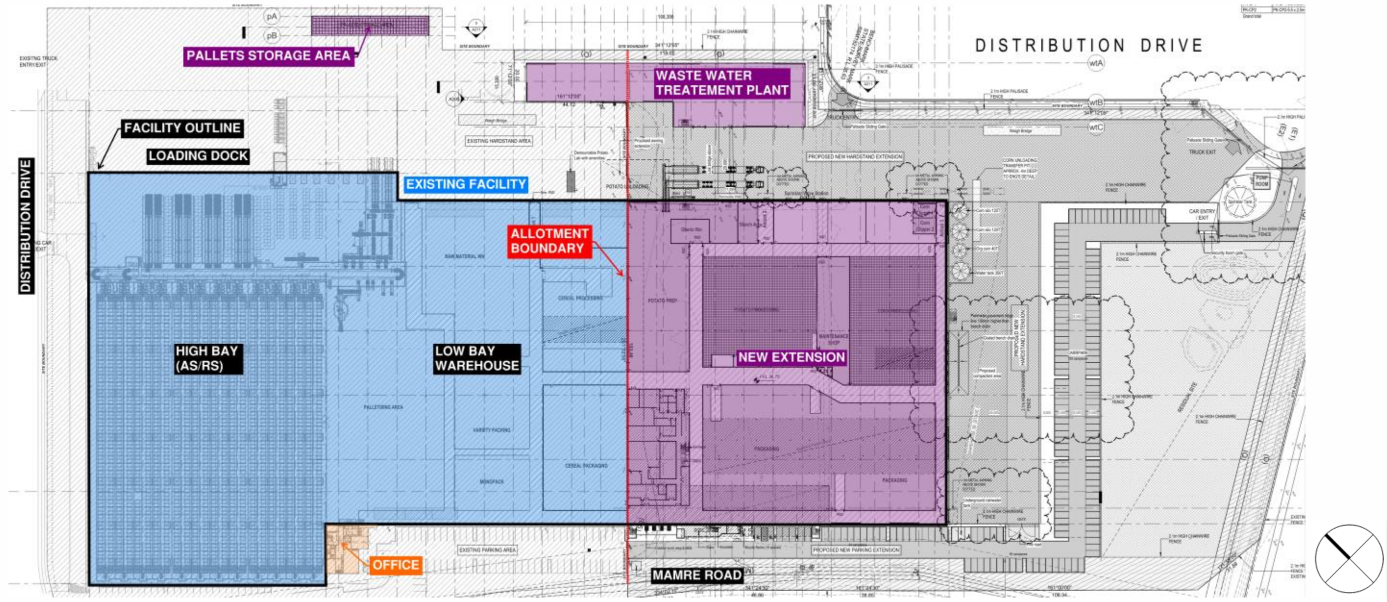

Figure 1.1 – Site Plan

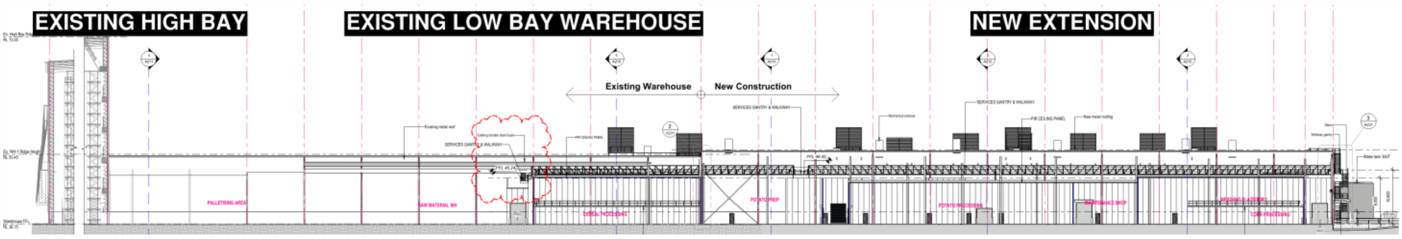

Figure 1.2 – Longitudinal Section

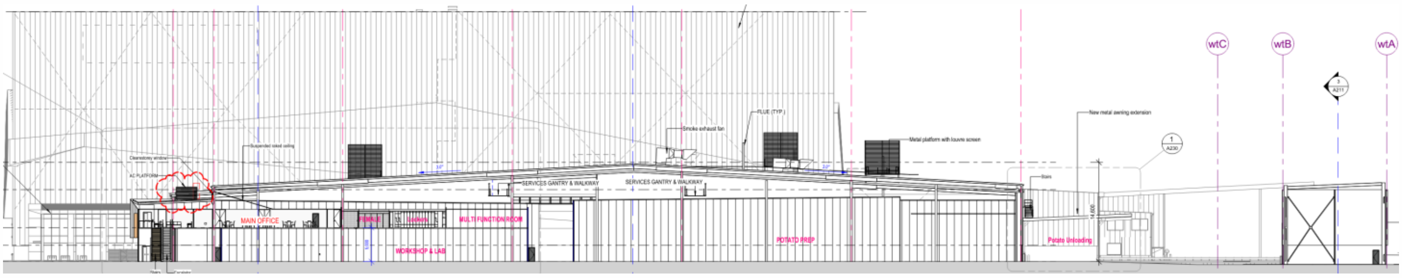

Figure 1.3 – Cross Section 1 (North to South)

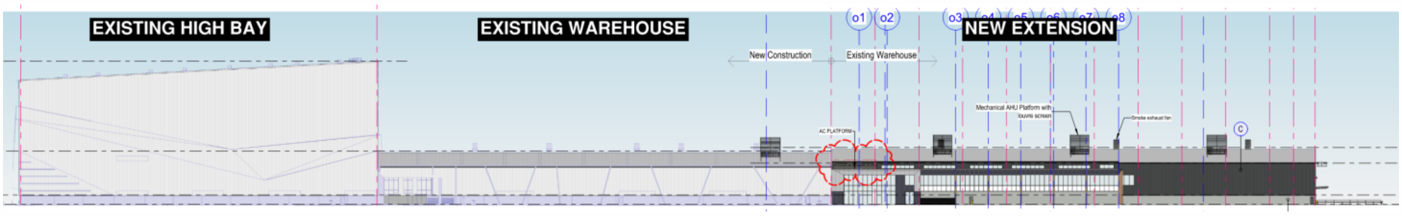

Figure 1.4 – Eastern Elevation (View from Mamre Road)

1.2.1 Building Characteristics

Table 1.2 details the general subject building characteristics in terms of the existing facility and the proposed extension that are relevant to the NCC, based on the information received in Section 1.1.

Table 1.2 – General Building Characteristics – Building Parts

Characteristic	Existing Facility	Proposed Extension
Ridge Height	36.8m (High Bay) 13.7m (Low Bay)	14.7m
Effective height	<12m	<12m
Rise in storeys	2 (office) 1 (Low and High Bay Warehouse)	2
Storeys contained	2 (office) 1 (Low and High Bay Warehouse)	2
Classifications	Class 5 (office) Class 7b (storage) Class 8 (manufacturing) – proposed within the low-bay warehouse	Class 8 (manufacturing)
Type of construction	C	C
Relevant Code	NCC 2016 Volume One, Amendment One	NCC 2019 Volume One, Amendment One
Building Type	Large-Isolated Building (LIB)	Large-Isolated Building (LIB)
Floor Areas*	11,023m² – High Bay 18,630m² – Low Bay 500m² – Main Office 100m² – Dock Office **Total = 30,255m² excl. awnings** **Total = 32,920m² incl. awnings**	15,858 m² – Ground Floor 700 m² – Mezzanine 1 2,400 m² – Office Level 1 **Total = 18,958m² excl. awnings** **Total = 19,385m² incl. awnings**

Table 1.3 summarises the general building characteristics applicable to the facility when evaluated as a united building that is relevant to the NCC, based on the information received in Section 1.1.

Table 1.3 – General Building Characteristics – United Building

Characteristic	United Building
Effective height	<12m
Rise in storeys	2
Storeys contained	2
Classifications	Class 5 (office) Class 7b (storage) Class 8 (manufacturing)
Type of construction	C
Building Type	Large-Isolated Building (LIB)
Floor Area	46,455m² excl. awnings 49,547m² incl. awnings
Volume	766,104m³

1.2.2 Building Structure

The facility will be of steel portal frame construction with additional internal steel columns. The external walls of the facility are of tilt-up panel construction approximately 2.4m high with steel sheeting above and steel sheet roof. The facility extension is required to be of Type C construction.

1.2.3 Fire Services

The united building is a Class 5-9 Large Isolated Building (LIB) with an area in excess of 18,000 m^2 and a volume in excess of 108,000 m^3. As such, the building must be provided with:

- Perimeter Vehicular Access (PVA) in accordance with NCC Clause C2.3
- Sprinkler system
- Smoke exhaust

  Note: An existing Performance Solution (Annexure B) removes smoke exhaust from the existing facility
- Fire detection and alarm system
- Hydrant system including ring main around the building
- System monitoring
- Fire control centre
- Emergency lighting and exit signage
- Fire hose reels
- Portable fire extinguishers.

1.2.4 Existing Facility

The existing facility includes a high bay storage area (Class 7b) has a ridge height of ~36.8 m and low bay warehouse (Class 7b) to the east which has a ridge height of ~13.7 m. A two (2) storey office (Class 5) serving the facility is located to on the south-east corner of the high bay racking area as shown in Figure 1.1.

The following key factors relating to the existing facility are:

- The existing facility was design in accordance with NCC 2016 Volume One, Amendment One, the NCC version applicable at the time of construction.
- The existing facility is classified as Class 7b warehouse and a Class 5 site office. All warehouse areas are single storey and the site office is two (2) storeys. The existing facility is a large-isolated Building construction in accordance with Type C construction.
- An existing Fire Engineering Report address the NCC DTS non-conformances for the existing facility (refer to Annexure B).
- The high bay racking area contains an Automated Storage and Retrieval Systems (ASRS) and is therefore not accessible by occupants.

1.2.5 New Works

As shown in Figure 1.1, the new extension is located east of the existing facility and is proposed to be to be used for the manufacture potato and corn chips (i.e. Class 8). It is understood that the proposed new works include the:

- Conversion of part of the existing low-bay warehouse (Class 7b) into manufacturing (Class 8) as highlighted in green in Figure 1.5.
- Construction of a new wastewater treatment plant and a pallet storage area (external from the facility). A link bridge is proposed to connect the waste water treatment plant and the new extension at gantry/walkway level as shown in Figure 1.8.
- Construction of manufacturing rooms with walls and ceilings of different type of construction. Refer to Section 1.2.5.2 for more information.
- Construction of new two (2) storey office with offices and laboratory areas located ground floor, offices and staff amenities on Level 1 (office) as shown in Figure 1.7.

The proposed new extension will be designed in accordance with NCC 2019 Volume One, Amendment One, the current applicable NCC. As discussed in Section 1.2.5.1, the extension is proposed to contain two mezzanine levels. Therefore, the extension will contain two storeys and is required to be constructed with Type C construction.

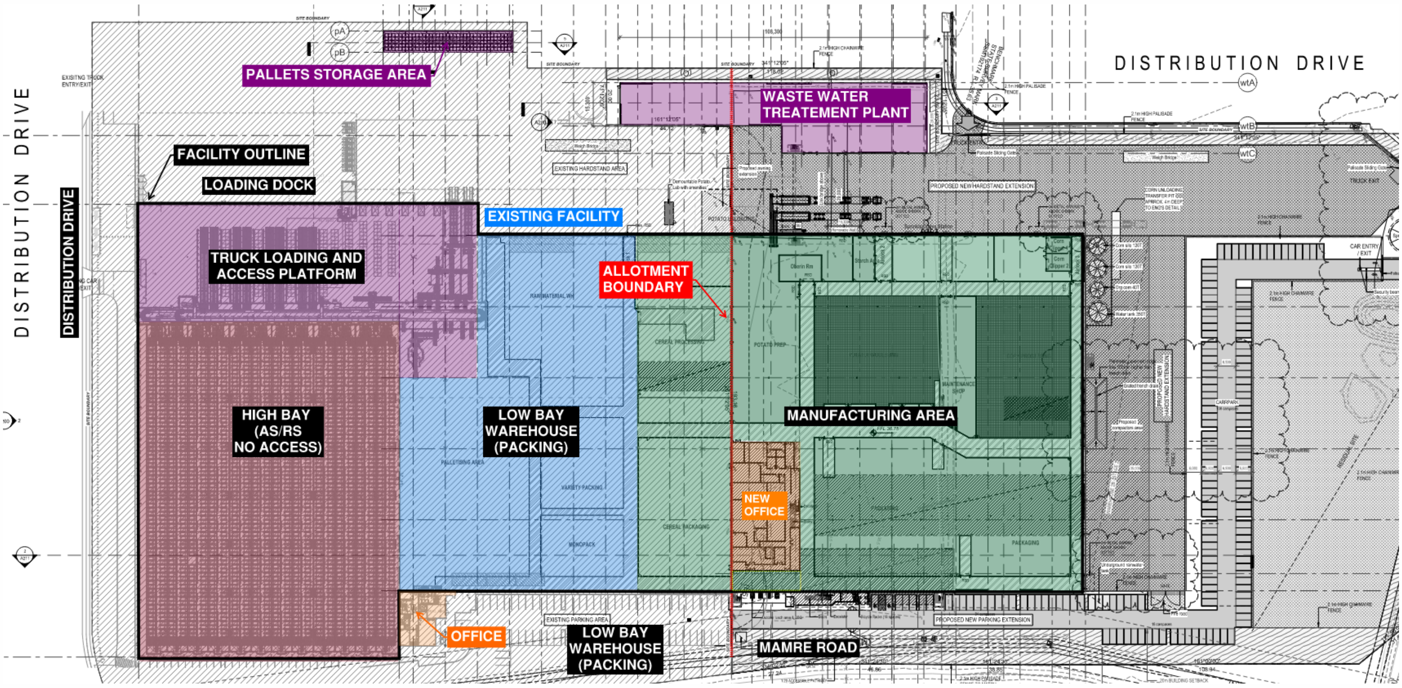

Figure 1.5 – Proposed Manufacturing Area – Site Plan

1.2.5.1 Intermediate Floors

The proposed manufacturing layout includes additional intermediate floors to meet the Client's operational requirements as a food manufacturing business:

- Two (2) mezzanine floors are proposed within the manufacturing area as shown in Figure 1.6 and Figure 1.7. Mezzanine 1 includes a platform which serves the cereal processing area and switch rooms and weighing platform which serve the potato and corn processing areas. Mezzanine 2 serves the potato and corn processing areas and is proposed to contain equipment utilised for seasoning cooked chips.
- Service walkways and gantries are proposed approximately 9.5m above ground floor to provide maintenance access above the manufacturing rooms (TBC) as shown in Figure 1.8.

  Note: The travel distance to the nearest exit on the gantries is recommended not to exceed 75 m, subject to Fire Engineering modelling.

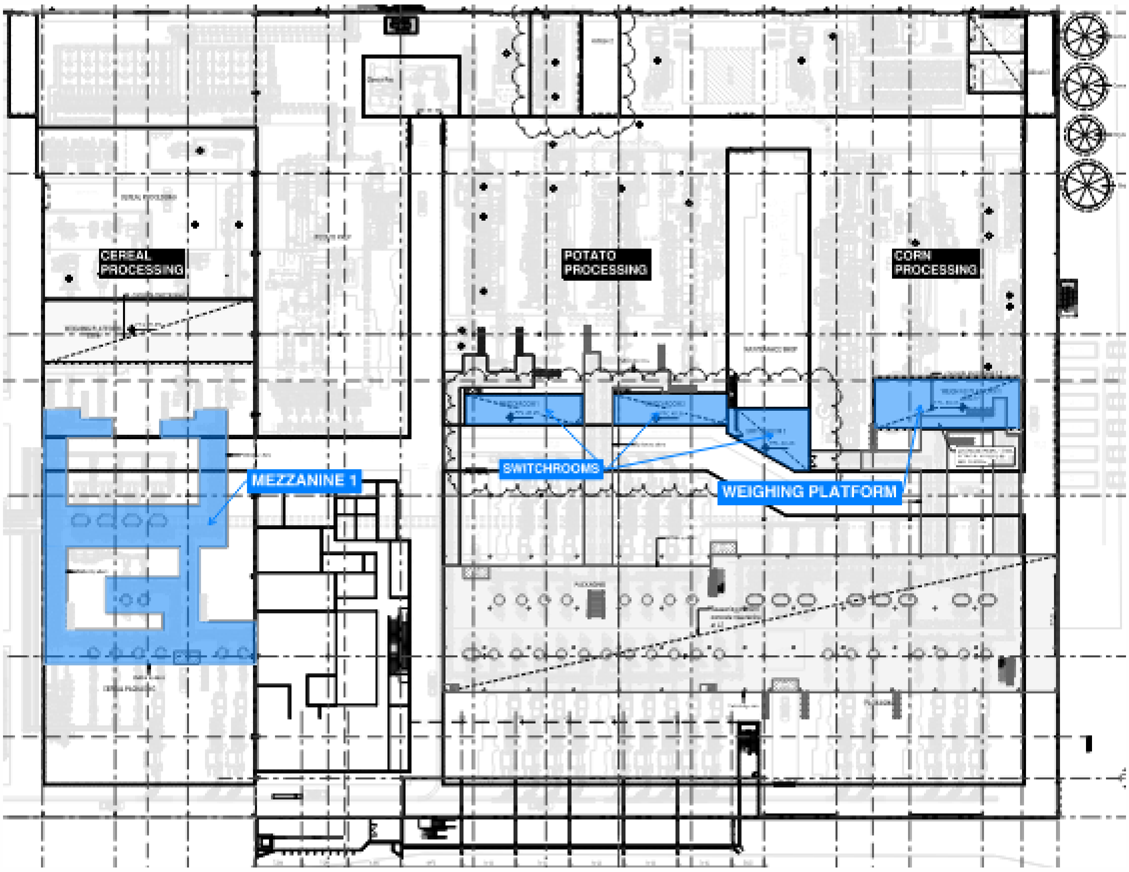

Figure 1.6 – Mezzanine 1 Plan

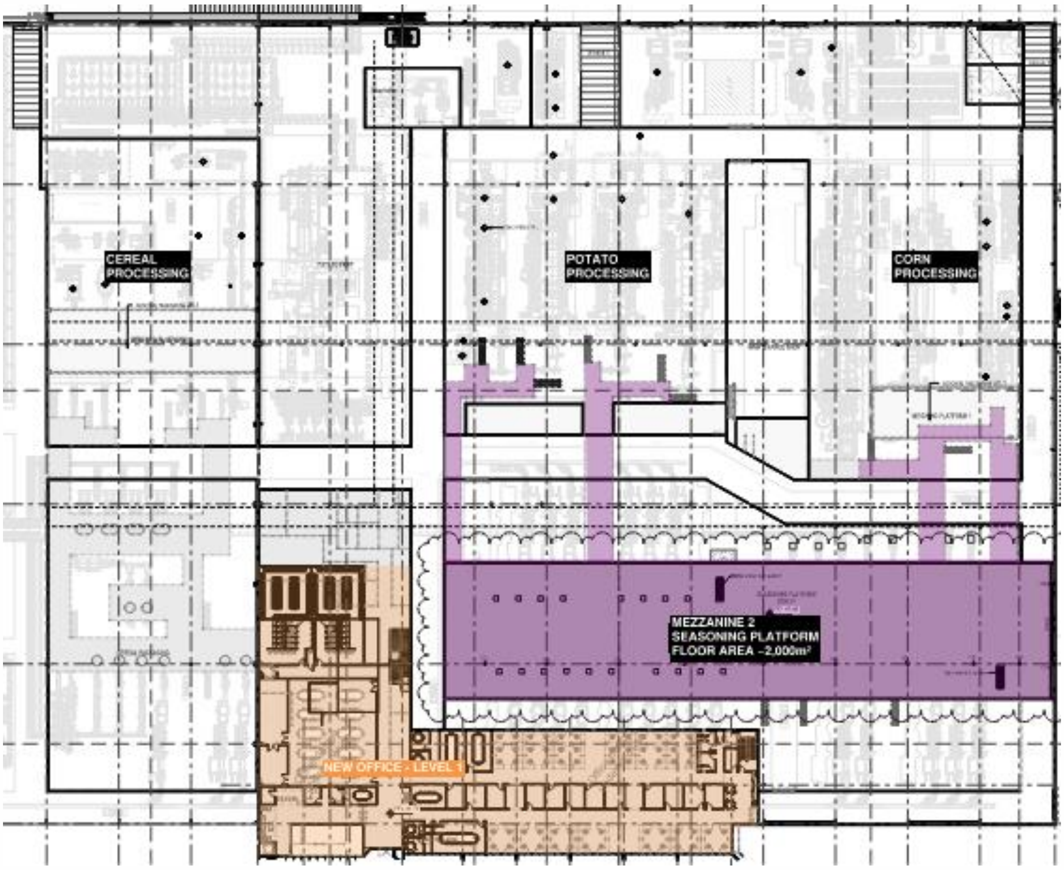

Figure 1.7 – Mezzanine 2 Plan – Seasoning Platform and New Office Plan

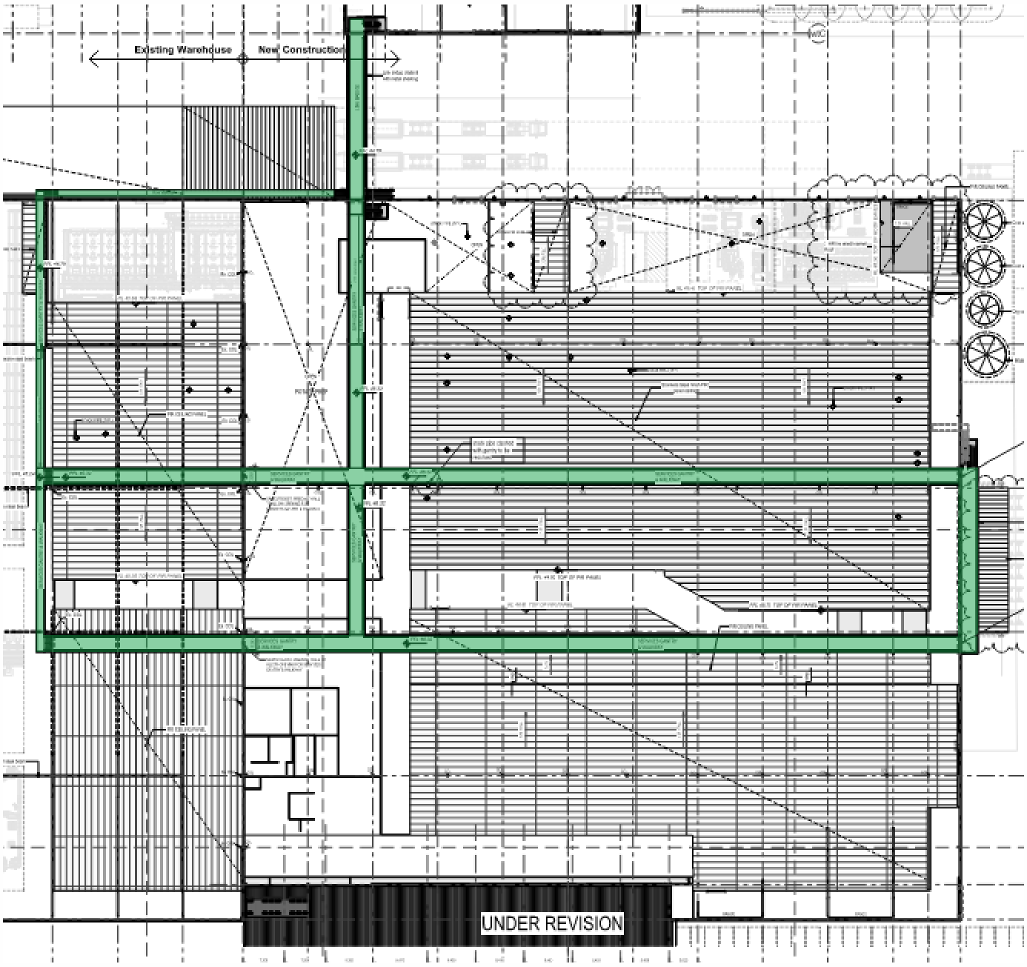

Figure 1.8 – Service Gantries – High Level Service Gantry

1.2.5.2 Manufacturing Room Construction

FM Global recommends that one (1) hour fire-rated construction be provided between oil cooker areas and heat transfer fluid systems. Thereby, it is proposed to provide the following as illustrated in Figure 1.5:

- 60/60/60 FRL construction is proposed to the processing rooms which contain heat transfer systems
- Non-combustible wall construction to the manufacturing rooms which contain oil cookers.

The remainder of the manufacturing rooms are proposed to be constructed of polyisocyanurate (PIR) sandwich panels.

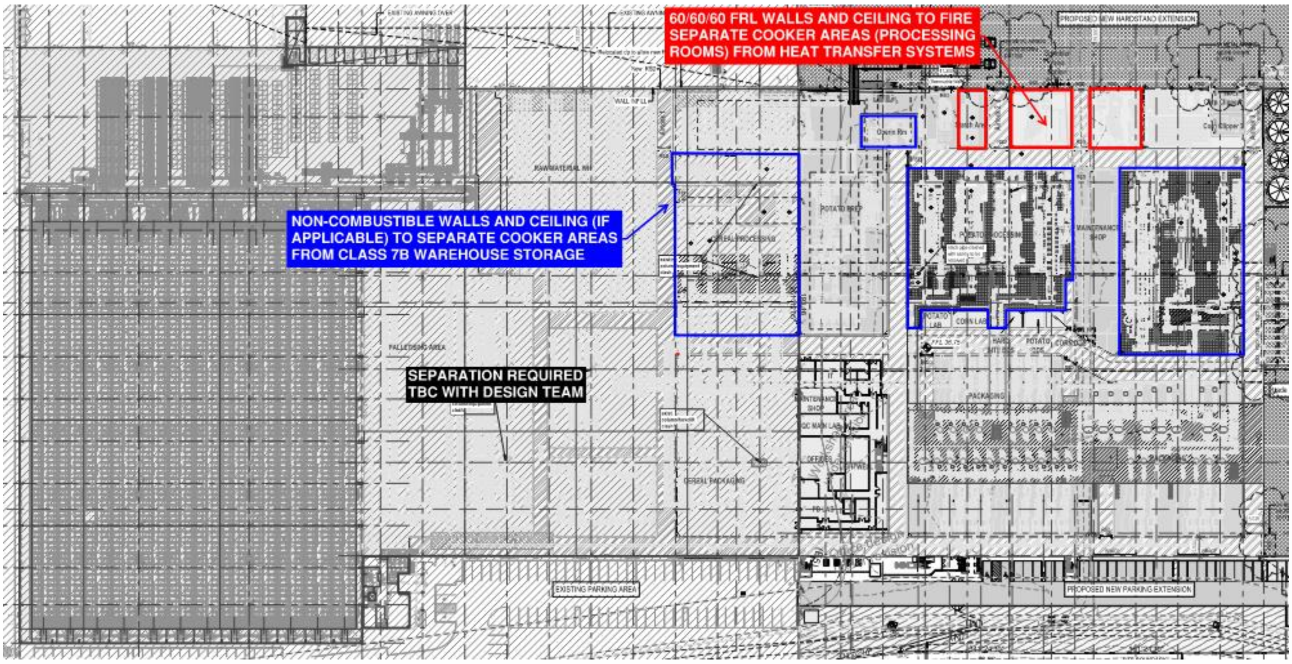

Figure 1.9 – Proposed Manufacturing Room Construction – Site Plan

1.2.6 Fire Separation

The united building (existing facility and extension) is proposed to form a single fire and smoke compartment. The eastern wall of the existing facility located on the site allotment boundary is proposed to be modified, with large openings created to allow the reticulation of manufacturing equipment and conveyors through the wall as shown in Figure 1.10 in red. Due to the number and substantial size of the openings, it is not considered feasible to fire separate the existing facility and new building. As a result, the existing facility is considered to be directly connected to the new building parts without fire separation, forming one compartment.

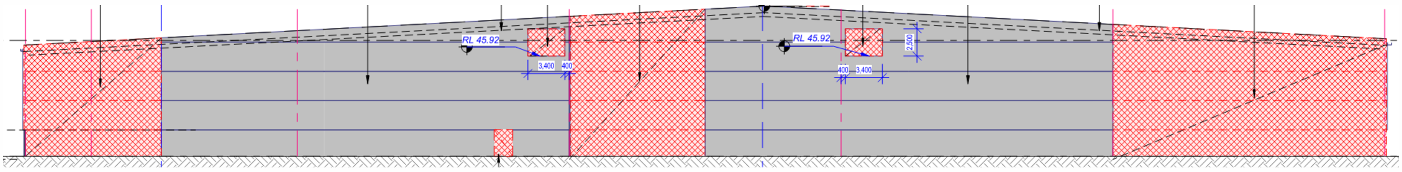

Figure 1.10 – Proposed Demolition – Existing Facility Fire Wall on Site Boundary

2. Impact Assessment of Existing Fire Engineered Solutions

Table 3.1 summarises the potential impact on the existing fire engineered solutions due to the proposed works. It is proposed to retain the existing Fire Engineering Report (Annexure B) and address any existing solutions which may potentially be impacted in the Omnii Fire Engineering Report (refer to Table 3.1). Where the existing solutions are considered not to be impacted, no further assessment is required. However, existing solutions which are considered to be impacted will be addressed in the forthcoming Fire Engineering Report.

Table 2.1 – Impact Assessment of Existing Fire Engineered Solutions

#	NCC/BCA Departures	Discussion	Further Assessment Required
1	**Open Space and Vehicular Access** The following compliance issues have been identified with respect to the proposed perimeter vehicular access serving the warehouse: • The far side of the perimeter vehicle access along the eastern boundary of the site is up to 26m from the external wall of the building in lieu of 18m; and • The access provided to the north of the site is proposed to be on the adjacent allotment which is intended to be acquired by Snack brands at a future date.	The extension to the facility will modify the vehicular access path and therefore impact upon the existing assessment. However, the existing non-conformances whereby the access path is up to 26m from the external wall and the vehicular path extends over two allotments is still applicable.	Yes
2	**Exit Travel Distance and Smoke Hazard Management** It has been identified that the exit travel distances within the warehouse portion exceed the maximum travel distances as permitted by the prescriptive provisions from Volume One of the NCC. In this instance, it is proposed to permit exit travel distances as per the following: • The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and • The distance between alternative exits exceeds 60m (i.e.: up to 172m). Furthermore, it is proposed to rationalise the provision for an automatic smoke exhaust system within the building. In this instance, it is proposed to permit a manually operated smoke clearance system having a smoke clearance capacity of 1 air change per hour.	The low-bay warehouse is to undergo fit-out changes to contain plant equipment rooms. In addition, the connection to the proposed extension containing manufacturing equipment and layout may impact the travel distances previously assessed. Since the extension to the facility increases the size of the fire and smoke compartment, the smoke hazard management strategy will need to be reviewed.	Yes
3	**Fire Hose Reels** The fire hose reel system shall be design and installed in accordance with AS 2441.1:2005 with the exception of the following: • To permit the fire hose reel coverage shortfalls throughout the high bay area.	Access to the high bay area will not be changed and therefore the existing assessment is not expected to be impacted by the new works.	No

<table>
<tr><th>#</th><th>NCC/BCA Departures</th><th>Discussion</th><th>Further Assessment Required</th></tr>
<tr><td>4</td><td>Fire Hydrants
The fire hydrant system shall comply with AS 2419.1 2005 with the exception of the following:
• Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and
• It is proposed to permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only.</td><td>Existing fire hydrants are not proposed to be modified. Additional fire hydrants will be provided to achieve coverage to the plant areas. The new works are therefore not expected to impact upon the existing Fire Engineered Solution.</td><td>No</td></tr>
<tr><td>5</td><td>Exit Signs (Excluding High Bay Area)
Directional and non-directional exit signs are to be installed throughout the warehouse portion in accordance with Part E4 from Volume One of the NCC and AS 2293.1:2005 with the exception that the mounting heights of exit signage within the warehouse storage portions (excluding the high bay area). In this instance, it is proposed to permit the top of the exit signs to be mounted no greater than 6m above the finished floor level within the warehouse portion only in lieu of 2.7m as required by the prescriptive provisions from Volume One of the NCC.</td><td>Access to the high bay area will not be changed and therefore the existing assessment is not expected to be impacted by the new works.</td><td>No</td></tr>
<tr><td>6</td><td>Exit Signs and Emergency Lighting (High Bay Area)
It is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable.
Note: As confirmed by Modcol Pty Ltd (refer to Appendix Q), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area.</td><td>Access to the high bay area will not be changed and therefore the existing assessment is not expected to be impacted by the new works.</td><td>No</td></tr>
<tr><td>7</td><td>Fire Indicator Panel Location
The FIP is located within the main office of the warehouse, which is not located within the main entrance (vehicular access) of the site.</td><td>The FIP will be retained and not moved. The proposed extension is located remote from the vehicular access point to the site and therefore shall not impact the existing assessment which relies upon existing directional signage. Therefore, the existing assessment is not expected to be impacted by the new works.</td><td>No</td></tr>
</table>

3. Expected Performance Solutions

Table 3.1 summarises the NCC DTS departures, associated NCC DTS Clauses and Performance Solutions.

Table 3.1 – NCC DTS Non-Compliances (Identified New Non-Compliances)

Item 1 – Fire Wall at Allotment Boundary	
NCC DTS Clause	C1.1, Specification C1.1, Clause 5.1 and Table 5
Performance Solution It is proposed to construct the extension of the building on the adjacent allotment without providing a fire wall at the allotment boundary between the two site allotments.	
Item 2 – Protection of Openings at Allotment Boundary	
NCC DTS Clause	C3.2
Performance Solution It is proposed not to protect any openings within 3m of the allotment boundary between the two site allotments.	
Item 3 – Perimeter Vehicular Access	
NCC DTS Clause	C2.4(b)
Performance Solution Perimeter vehicular access to be: a. up to 26m from the united building in lieu of 18m; and b. the access path is proposed to be provided over two site allotments (modified existing Performance Solution).	
Item 4 – Extended Travel Distances – Warehouse and Manufacturing	
NCC DTS Clause	D1.4 and D1.5
The travel distance from any point within the warehouse and manufacturing areas is permitted as follows: The exit travel distance from any point on a floor: a. to a point at which travel in different directions where two (2) exits are available is not more than: i. 42m within seasoning platform on Mezzanine 2 (TBC, platform appears to be provided with third exit) in lieu of 20m; and b. to the nearest exit, where two (2) exits are available, is not more than: i. 60m throughout the warehouse and manufacturing areas on ground floor ii. 60m within seasoning platform on Mezzanine 2 in lieu of 40m Distance between alternative exits within the building are to be located not more than: c. 90m within the warehouse and manufacturing areas on ground floor d. 65m within seasoning platform on Mezzanine 2 in lieu of 60m.	
Item 5 – Extended Travel Distances – New Office	
NCC DTS Clause	D1.4 and D1.5
The travel distance from any point within the warehouse and manufacturing areas is permitted as follows: The exit travel distance from any point on a floor: a. to a point at which travel in different directions where two (2) exits are available is not more than: i. 30m within staff offices on ground floor ii. 33m within staff amenities on Office Level 1 (TBC, review required to reduce travel to 30m) in lieu of 20m; and Distance between alternative exits within the building are to be located not more than: b. 65m within the office on ground floor in lieu of 60m.	

Item 6 – Extended Travel Distances –Service Gantries at High Level	
NCC DTS Clause	D1.4 and D1.5
Performance Solution a. The exit travel distance to the nearest exit, where two (2) exits are available, is not more than 60m in lieu of 40m b. Distance between alternative exits within the building is permitted to be up to 100m in lieu of 60m	

Item 7 – Fire Hose Reel Coverage	
NCC DTS Clause	E1.4
Performance Solution Fire Hose Reel coverage is proposed to be omitted from inaccessible manufacturing areas and manufacturing rooms which are fire-separated.	

Item 8 – Fire Sprinkler System Design Requirements	
NCC DTS Clause	E1.5 inter alia AS 2118.1:2017
Performance Solution Fire sprinkler system is to be provided in accordance with a combination of AS 2118.1:2017 and FM Global design requirements, in lieu of being provided solely in accordance with AS 2118.1:2017.	

Item 9 – Fire Services	
NCC DTS Clause	E1.3 and E1.5 inter alia AS 2419.1:2005 and AS 2118:2017
Performance Solution It is proposed to permit the united building extending over two allotments under separate ownership to be provided with a shared fire water supply infrastructure, in lieu of being provided with separate hydrant and sprinkler systems for each allotment.	

Item 10 – Smoke Hazard Management	
NCC DTS Clause	E2.2, Table E2.2b, Spec E2.2b
Performance Solution Smoke hazard management to be provided throughout the united building in accordance with NCC DTS Specification E2.2b with the following modifications: ‣ Rationalised smoke exhaust quantities. ‣ The warehouse is to be treated as a single smoke reservoir (i.e. smoke baffles are not provided). ‣ Smoke and heat vents provided to the equipment rooms which vent into the overall building volume (TBC)>	

Item 11 – Exit Signage Mount Heights	
NCC DTS Clause	E4.6, E4.8 inter alia AS 2293.1 Clause 6.8
Performance Solution Directional exit signs within the building to be installed between 2.7m and 5.0m above the finished floor level, in lieu of 2.7m maximum.	

The BCA Report (Annexure A), lists a Performance Solution under NCC DTS Provision C3.3 and Provision C3.4. Since the united building forms a single fire compartment, separation of external walls and associated openings in different fire compartments is not considered relevant. Therefore, NCC DTS Provision C3.3 is not proposed to be addressed by the Performance Solution.

4. Proposed Fire Engineering Outcomes

The proposed Fire Engineering Outcomes (also known as the proposed Performance Solution) are required to address departures from the NCC DTS provisions and is intended to achieve a level of fire and life safety.

All other items of fire and life safety, where not specifically addressed or reviewed as part of this document are to be in accordance with NCC DTS provisions and the existing FER (Annexure B) or as accepted by the Authority Having Jurisdiction (AHJ) and other Regulatory Authorities.

The following items relate solely to the new works, which include the construction of a new facility extension and fit-out changes to the existing warehouse.

Fire and Smoke Resistance

a. The extension to the building is permitted to be constructed in accordance with NCC DTS requirements for Type C construction

b. The allotment boundary is not to be considered as a fire source feature with the united building extending across the site allotment boundary (refer to Figure 4.1), subject to receiving a copy of the agreement between the building owners, which details:

   – The united building is permitted to be located over the two site allotments.

   – The entity that will take responsibility for the maintenance and testing of the shared fire safety systems listed on the AFSS.

   – If the site allotment ownership changes, then the fire engineering strategy must be re-assessed.

   – Should the building, building use or Fitout be changed, then the fire engineering strategy must be re-assessed.

ii. Fire wall separation between the existing facility and new extension on different building allotments is permitted not to be provided in accordance with NCC DTS Provision C2.7 when the united building extends across the site allotment boundary.

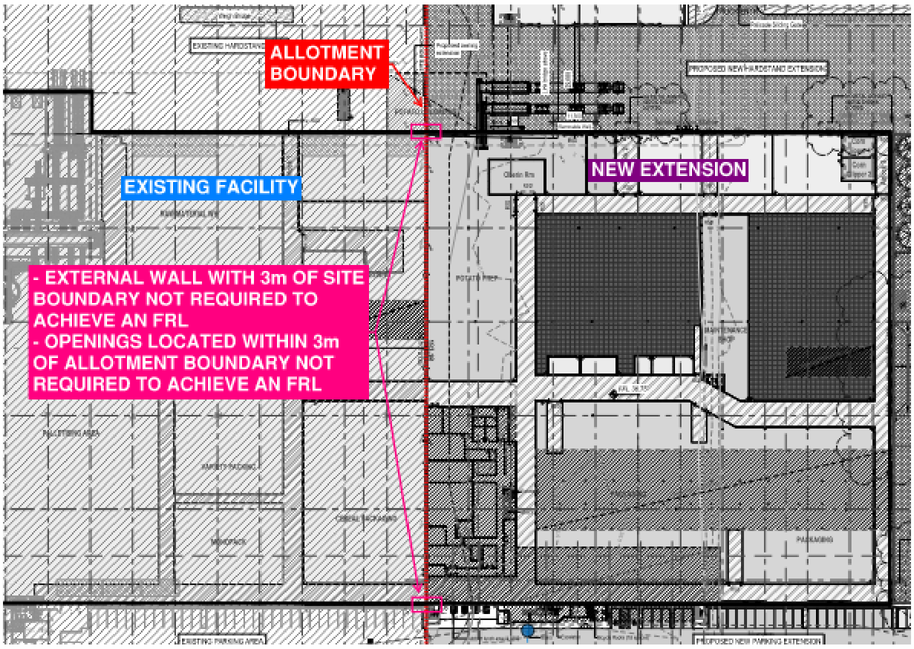

Figure 4.1 – External Wall Within 3m of Allotment Boundary

c. Fire rated construction achieving an FRL of not less than 60/60/60 must be provided between heat transfer fluid systems from the cooker areas, as per the requirements of FM Global Data Sheet 7-20 (2018) as shown in Figure 1.9.

   i. In addition, containment and emergency draingage for all oil cooker areas must be provided in accordance with FM Global Data Sheet 7-20 (2018).

d. Manufacturing rooms containuing oil cookers must be constructed of non-combustible materials, as per the requirements of FM Global Data Sheet 7-20 (2018) as shown in Figure 1.9.

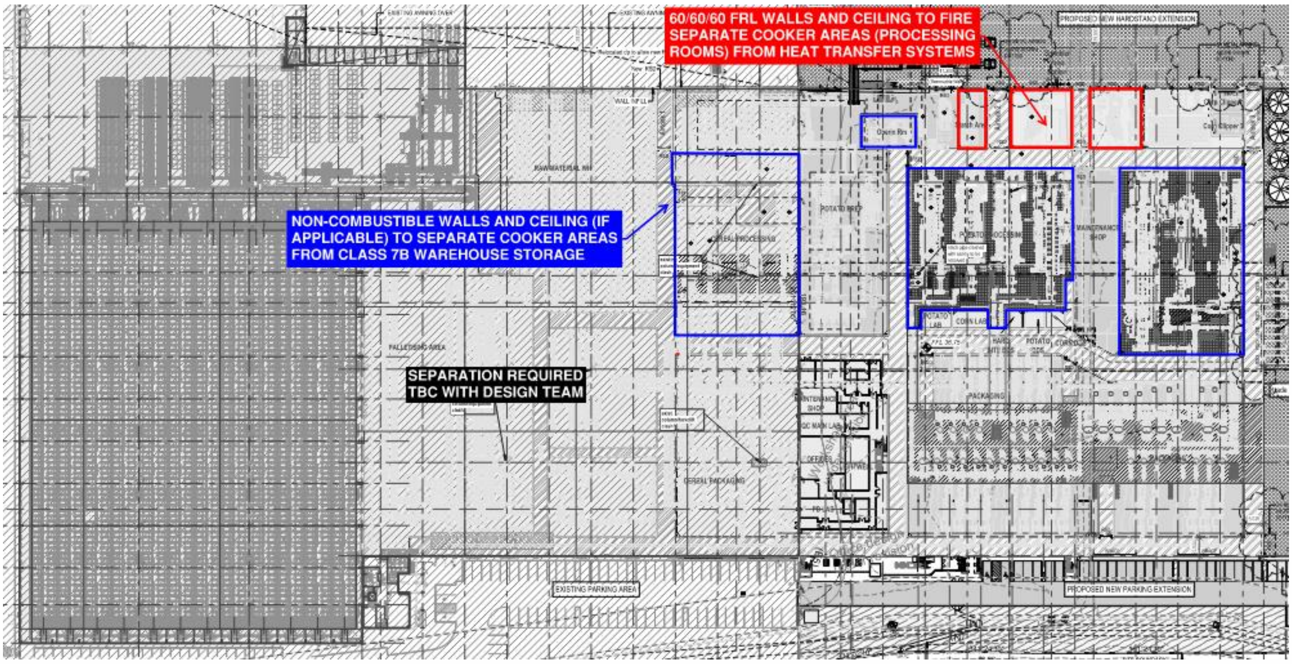

Figure 4.2 – Proposed Manufacturing Room Construction – Site Plan

Compartmentation and Separation

e. Where PIR (Polyisocyanurate) Rigid Insulative Panel is used, the product must meet the following requirements:

   i. Not be installed within external walls.

   ii. The panel product must meet the requirements of the Insulated Panel Council of Australasia Ltd (IPCA) Code of Practice (CoP) (i.e. achieve a Class 1 rating in accordance with FM Global Approval Standard 4880).

   iii. The panels must be installed in accordance with the requirements of the IPCA CoP.

      – Certification of the installation must be provided from an accredited installer with IPCA CoP or the Principal Certifying Authority.

   iv. The use of the PIR panel must be identified in accordance with the requirements of the CoP by way of signage placement on all doors leading into the building.

   v. A key diagram indicating the location of the PIR panels must be provided at the FIP.

   vi. The use of combustible ISPs must be reviewed by the facility Insurer to obtain in principle agreement.

Perimeter Vehicular Access

f. Perimeter vehicular access must be in accordance with NCC DTS requirements and FRNSW Guideline (Annexure C), except that, as shown in Figure 4.3, the perimeter vehicular access:

   i. Is permitted to be located so that no part of its furthest boundary is more than 26m from the united building.

   ii. The access path is proposed to be provided over two (2) site allotments.

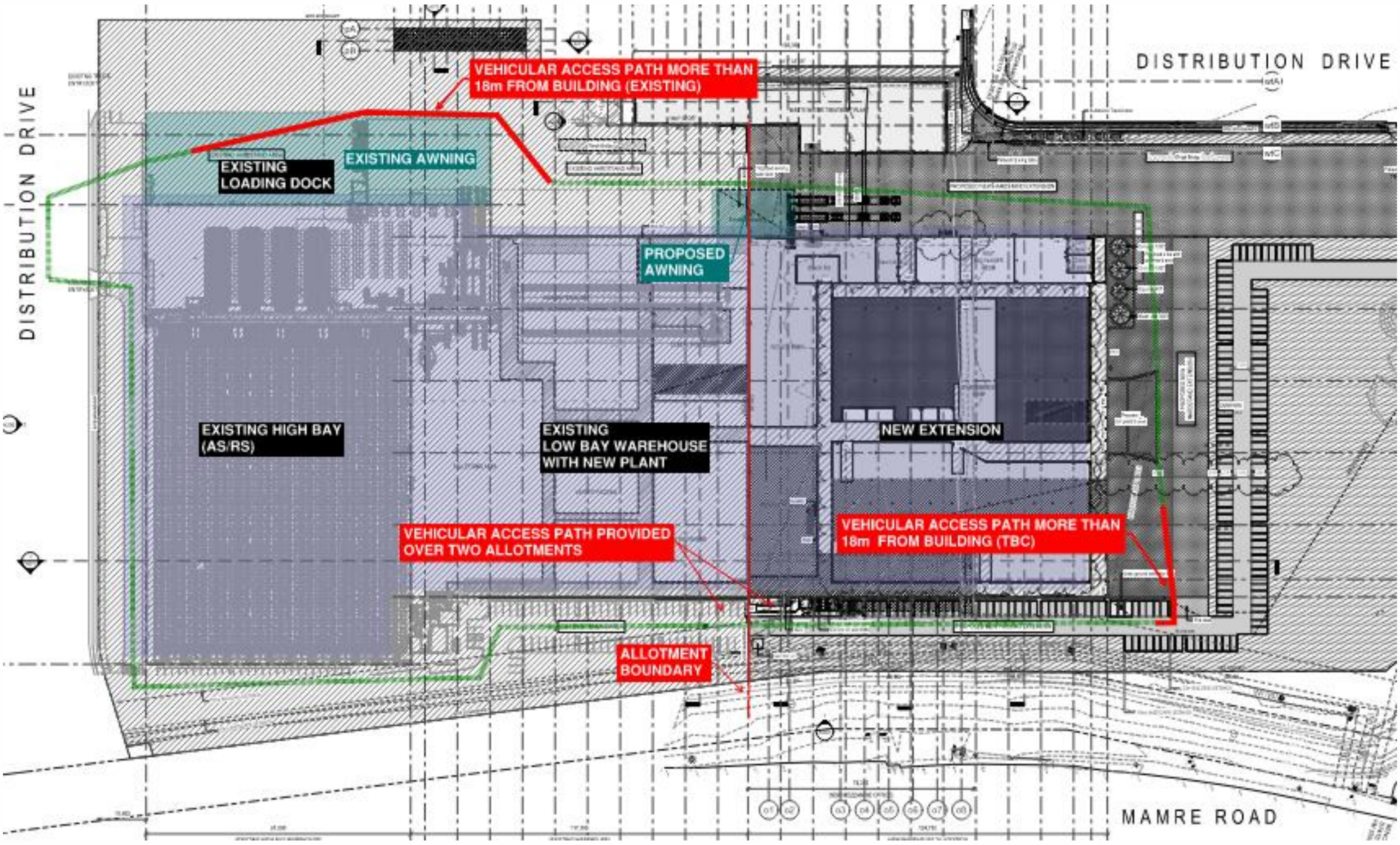

Figure 4.3 – Perimeter Vehicular Access

Protection of Openings

g. Openings in the external wall of the building must be protected in accordance with NCC DTS provisions, noting that the site allotment is not to be considered a fire source feature with the united building extending across the site allotment boundary (refer to Figure 4.1).

Doorsets and the Like

h. Personnel access swing doors must be provided as the final exit door from the service gantries at high level, as shown in Figure 4.4.

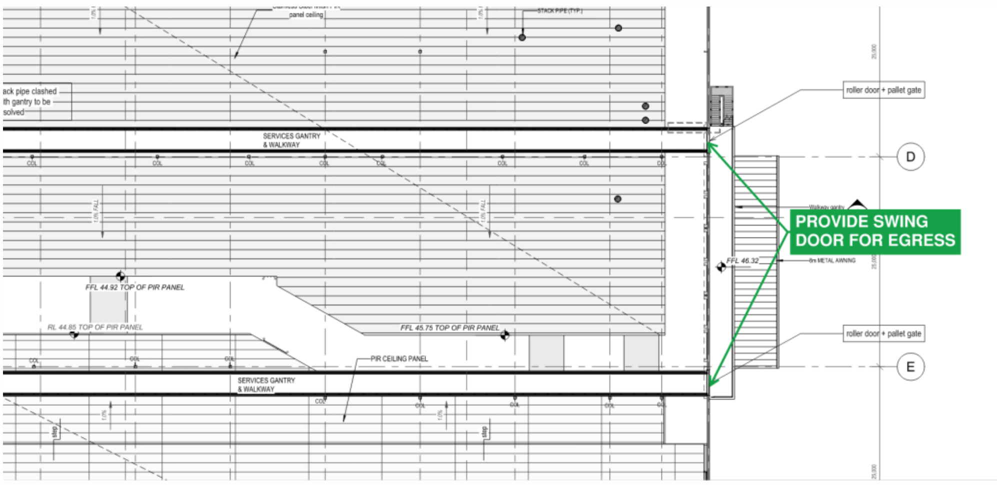

Figure 4.4 – Final Exit Swing Doors – High Level Service Gantries

Provisions for Escape

i. The exit travel distances must comply with NCC DTS Clause D1.4, except that the distance of travel:
   i. To a point at which travel in different directions where two (2) exits are available is not more than:
      – 42m within seasoning platform on Mezzanine 2 (TBC)
      – 30m within staff offices on ground floor
      – 33m within staff office amenities on Office Level 1 (TBC)
   ii. To the nearest exit, where two (2) exits are available is permitted to be not more than:
      – 60m throughout the warehouse and manufacturing areas on ground floor
      – 60m within seasoning platform on Mezzanine 2
      – 60m on the service gantries at high level*

   as shown in Figure 4.5 – Figure 4.7.

j. Distance between alternative exits must comply with NCC DTS Clause D1.5, except that the distance between alternative exits is permitted to be not be more than:
   i. 90m within warehouse and manufacturing areas on ground floor.
   ii. 65m within seasoning platform on Mezzanine 2.
   iii. 100m on the service gantries at high level*

   as shown in Figure 4.5 - Figure 4.7.

   *NOTE: Although the BCA Report does not consider the service gantries to be a storey, occupants may be present on the service gantries during a fire occurrence. Thereby, safe evacuation from the service gantries is proposed to be considered.

   In addition, as shown in Figure 4.8, an additional exit stair is recommended to be provided to reduce travel distances along the service gantries at high level.

k. Evacuation routes are to be maintained in an efficient condition and kept readily accessible, functional and clear of obstruction in accordance with the Work Health and Safety Act 2011 (NSW).

Figure 4.5 – Extended Travel Distances in Warehouse and Manufacturing – Ground Floor

Figure 4.6 – Extended Travel Distances in New Office – Ground Floor

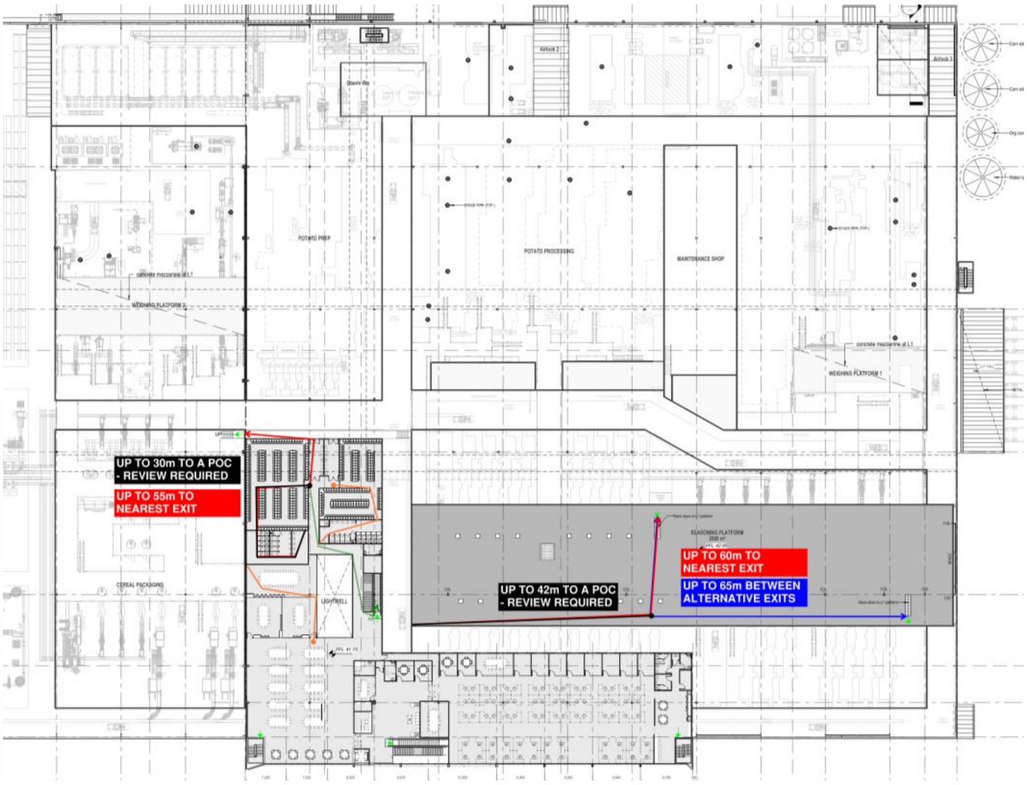

Figure 4.7 – Extended Travel Distances – Office Level 1 / Mezzanine 2

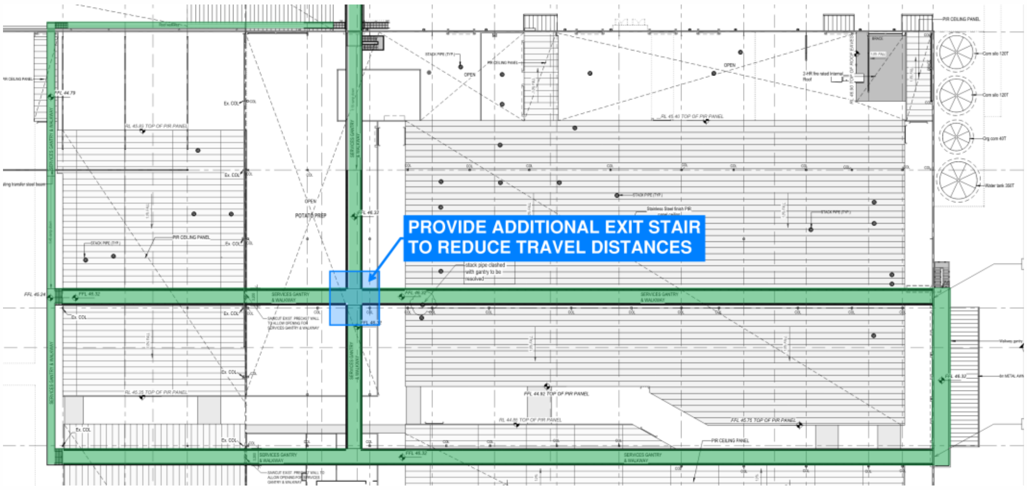

Figure 4.8 – Additional Egress Stair Required – High Level Service Gantry

Fire Hydrants, Hose Reels and Extinguishers

l. Fire hose reels must be provided in accordance with the NCC DTS requirements and the following:

   i. Fire hose reels coverage is permitted to be omitted from inaccessible manufacturing areas and manufacturing rooms which are fire-separated, contingent on Item 'm.i.' being provided.

m. Portable fire extinguishers must be provided in accordance with the NCC DTS requirements, and the following:

   i. Where fire hose reel provisions are varied in Item 'l.i.', additional fire extinguisher/s must be provided to the shortfall areas in accordance with AS 2444:2001 Section 4.

n. Fire hydrants must be provided in accordance with the NCC DTS requirements and/or Fire Brigade requirements, and the following:

   i. The fire hydrant system is permitted to share infrastructure with the existing fire hydrant system afforded to the existing facility, contingent on the agreement between the site allotment owner's being provided as per Item 'a.b'.

   ii. All new hydrants must be fitted with Storz couplings. The Storz fittings must be manufactured to DIN 14303, aluminium alloy delivery couplings, in accordance with Appendix A of AS 2419.2-1994. Blank caps must be provided in accordance with Clause 2.8 of AS 2419.2-1994

Fire Sprinkler Systems

o. Fire sprinkler system must be provided throughout the building accordance with AS 2118.1:2017 and the appropriate FM Global Data Sheets, and the following:

   i. Where there is a discrepancy between Australian Standards and FM Global Data Sheets, the more stringent requirements must be followed.

   ii. Shared water supply and infrastructure for the sprinkler system is permitted to be serve the new extension and thereby the united building, contingent on the agreement between the site allotment owner's being provided as per Item 'a.b'.

   iii. Fire sprinkler heads throughout the development must be fitted with fast response type heads (i.e. RTI <$50m^{½}s^{½}$).

      – This includes directly under ceiling openings within the Class 7b and Class 8 warehouse/manufacturing areas (eg. smoke exhaust fans) in accordance with AS 2118.1-2018 Clause 11.5.1.13 requirements.

   iv. Extended coverage sprinkler heads must not be used.

   v. Activation of the fire sprinkler system must initiate the smoke exhaust throughout the entire facility.

   vi. Activation of the fire sprinkler system must initiate the Building Occupant Warning System (BOWS) as per 'Item y'.

vii. Be connected to a fire alarm monitoring system as per 'Item z'.

Fire Control Centres/Rooms

p. A new Fire Detection Control and Indicating Equipment (FDCIE) panel is to be provided at the main entrance of the building, which will network with the existing main FDCIE at fire control centre.

Smoke Detection System

q. A Smoke Detection System must be provided in accordance with NCC DTS provisions and located in accordance with AS 1670.1:2018 Clause 5.

r. Manufacturing areas and other areas where access to smoke detectors for annual testing would be problematic must be provided with aspirating smoke detection systems or optical beam smoke detectors.

s. Challenging areas containing smoke or dust particulates in the air must be provided with aspirating smoke detection systems.

t. Heat detectors may be used in lieu of smoke detectors in rooms where nuisance alarms could occur, contingent on confirmation from the Fire Safety Engineer.

u. Activation of a detector in any room not provided with sprinklers must automatically activate the smoke exhaust fans serving the building and the relevant make-up air provisions to open (where applicable).

v. Activation of any detector in the building must automatically initiate the Building Occupant Warning System (BOWS) as per 'Item.y'.

w. The smoke detection system is permitted not to be connected to a fire alarm monitoring system as required by the NCC DTS Provisions.

Smoke Exhaust System

x. A smoke exhaust system must be provided throughout the united building in accordance with the NCC DTS requirements, except as follows:

   i. The united building (i.e. existing facility and extension) are permitted to be treated a single (1) smoke reservoir.

   ii. The smoke exhaust fans provided to the roof of the united building must achieve an exhaust rate not less than 80m^3/s.

   NOTE: Confirmation of the required smoke exhaust rate is subject to fire modelling. The aforementioned value is indicative only.

   - Not less than eight (8) smoke exhaust fans must be provided to the roof of the facility. The location of each exhaust fan must be confirmed by the mechanical engineer.
   - Smoke exhaust fans shall be designed to ramp from a stationary position to their maximum exhaust rate in not more than 20 seconds.
   - All smoke exhaust fans must be activated simultaneously by operation of the smoke detection system.
   - Make-up air must be permanently provided to the facility at low level (<4m AFFL) and distributed as evenly as possible on at least two (2) opposing faces to achieve a maximum velocity through the openings of 2.5m/s when the smoke exhaust is in operation.

   iii. Each manufacturing room over 1,000m² in floor area must be provided with smoke vents within the ceiling:

   - Smoke vents must be located in the ceiling of each manufacturing room, venting smoke into the roof space of the larger building.
   - Smoke vents for each manufacturing room must open upon activation of a detector in the room or upon activation of the sprinkler system .

   Note: The effective free area of the smoke vents and the make-up area is TBC for <u>each</u> of the manufacturing rooms.

Occupant Warning

y. A Building Occupant Warning System (BOWS) must be provided in accordance with NCC DTS provisions.

System Monitoring

z. The fire detection and sprinkler systems serving the united building must be monitored by a fire station dispatch centre in accordance with AS 1670.3:2018.

Emergency Lighting and Exit Signs

aa. Exit signage must be provided in accordance with the NCC DTS requirements, except that:

  i. Exit signs above exit doors from the warehouse and manufacturing areas must be mounted at a height not more than 2.7m Above Finished Floor Level (AFFL); and

  ii. Directional signage in the warehouse and manufacturing areas are permitted to be mounted at a height of not more than 5.0m Above Finished Floor Level (AFFL).

Commissioning

bb. All fire safety equipment or equipment associated with fire safety must be correctly commissioned including integrated testing.

Maintenance

cc. Maintenance of the Fire Safety Installations must be undertaken by an independent, suitably qualified and/or competent representative licensed maintenance company or Building Manager's representative – not by the Building Owner.

dd. Up to date logbooks must be provided on site.

Other Provisions

ee. A copy of the approved Fire Engineering Report must be provided at building handover and be located at one of the following:

  i. Next to the FIP; or

  ii. In the Annual Fire Safety Schedule (AFSS); or

  iii. Management In Use Plan manual.

ff. No changes to the fire safety strategy without the express written consent of Omnii (NSW) Pty Ltd.

Annexure A BCA Report

Building Code of Australia Assessment Report

Proposed Manufacturing Facility Additions for Snack Brands Australia

685-649 Mamre Road, Orchard Hills

Prepared for:	**Snack Brands Australia**
	C/- TMX Insight
Date:	**25st June 2021**
Revision:	**02**

Table of Contents

Date	Rev No	No. of Pages	Issue or Description of Amendment	Assessed By	Approved By	Date Approved
01.06.2021	01	21	DRAFT	Vanessa Hinge	Geoff Pearce	01.06.2021
25.06.2021	02	21	FINAL	Vanessa Hinge	Geoff Pearce	25.06.2021

1. Executive Summary

Development Overview

The proposed development involves the construction of an additional an existing warehouse / manufacturing facility with associated office and carparking areas. A waste treatment facility is also proposed as part of the application. This extension is proposed to be completed over 2 stages.

Compliance Summary

As Certifying Authority we have reviewed the architectural design documents prepared by HLA Architects (refer appendix A) for compliance with the current building assessment provisions, i.e. the Building Code of Australia 2019 (BCA).

The report is intended as an overview of the relevant provisions of the BCA for assistance only. Detailed drawings and associated review will be required as the final design is developed.

Performance Solutions – Existing Development

The existing warehouse is subject to a Fire Engineering Report prepared by Scientific Fire Services dated 27th February 2020. The existing building is of Type C Construction with a rise in storeys of 2 and subject to a number of performance solutions, including:

1. Perimeter vehicular access
2. Travel distances
3. Hose reel coverage
4. Hydrant coverage
5. Sprinkler omission to the server room
6. Design of the in-rack sprinklers
7. Exit signage
8. Emergency lighting
9. Location of the FIP

The development of an additional Fire Engineering Strategy for the new additions is to consider the existing Fire engineering Report for the development and verify whether the consistency is retained with the existing solutions and/or these need to be reconsidered as part of the new development works.

Performance Solutions – The Proposed Development

The assessment of the design documentation has revealed that the following areas are required to be assessed against the relevant performance requirements of the BCA, as they deviate from the deemed-to-satisfy provisions of the BCA

No.	Performance Solution Description	DTS Clause	Performance Requirements
Fire Safety Items			
1	**Exposure to Fire Source Feature - Fire Resistance Levels** The fire rated construction of the “external wall”, including column therein, due to proximity to the boundary line requires FRL of 90/90/90. The manner of construction if this fire wall including it’s interface with the roof line, and/or any rationalisation of FRL is to be further reviewed.	C1.1, C3.3	CP1, CP2
2	**Perimeter Vehicular access**	C2.3	CP9

No.	Performance Solution Description	DTS Clause	Performance Requirements
	The location of access road for FRNSW vehicles is located greater than 18m from the building.		
3	**Protection of Openings in External Wall and Adjacent Fire Compartment.** Openings within 6m of the adjacent building / boundary require protection under DtS provisions. Any rationalisation or omission of protection will be required to be assessed by the Fire Engineer as a performance solution.	C3.2, C3.4	CP2
4	**Separation of Buildings of Multiple Classifications** The proposed extension of the existing building will have a Rise in Storey's of 3, increasing the Type of construction required to the building to be Type B. The construction of the Fire Separating wall between the two types of classifications is to be verified by the Fire Engineer for compliance with the performance requirement of the BCA in lieu of construction to BCA Clause C2.7.	C1.3, C2.7	CP1, CP2
5	**Travel distances** Travel distances within the development are in excess of DtS provisions.	D1.4, D1.5, D1.9	DP4, EP2.2
6	**Suppression System** The Fire Services Engineer has outlined that deviation from Compliance with AS2118.1 will be presented in the design in order to comply with FM Global requirements	E1.5 and AS2118.1	EP1.4
7	**Smoke Hazard Management** Rationalisation of smoke exhaust for the warehouse.	E2.2	EP2.2
8	**Location of Exits Signage and Emergency Exits** The location of Exit signs is proposed to be higher than 2.7.	E4.5, E4.2	EP4.1, EP4.2, EP2.2
Miscellaneous Items			
9	**Weatherproofing of External Walls** As there are no deemed to satisfy provisions relating to the weatherproofing of external walls, a performance solution is to be provided by the façade engineer/registered architect demonstrating that the external walls comply with the requirements of Performance Requirement FP1.4.	-	FP1.4

The fire engineered solution relating to insert relevant CP9, EP1.4, EP2.2 items will need to be approved after consultation with the NSW Fire Brigade as part of the Construction Certificate process.

Further Assessment

The assessment of the design documentation has also revealed that the following additional information is required in order to complete the assessment, and/or the following areas need to be further reviewed.

No.	Further Information / Review Required	Report Reference
1.	Fire compartmentation drawings	5.1
2.	Services design including services designers identifying an additional performance solution.	7.0

3.	Location of Exits and egress paths from the building.	6.0

Documentation to enable assessment and demonstrate compliance will be required to address the above items prior to approval.

The application for Construction Certificate shall be assessed under the relevant provisions of the Environmental Planning & Assessment Act 1979 (As Amended) and the Environmental Planning & Assessment Regulation 2000.

2. Introduction

The proposed development involves the construction of an additional an existing warehouse / manufacturing facility with associated office and carparking areas. A waste treatment facility is also proposed as part of the application. This extension is proposed to be completed over 2 stages.

This report is based upon the review of the design documentation listed in Appendix A of this Report

The report is intended as an overview of the relevant provisions of the Building Code of Australia for assistance only. Detailed drawings and associated review will still be required as the final design is developed.

The applicable legislation governing the design of buildings is the Environmental Planning and Assessment Act 1979. This Act requires that all new building works must be designed to comply with the BCA.

The version of the BCA applicable to the development, is version that in place at the time of the application to the Certifying authority for the Construction Certificate. For the purposes of this Report, BCA 2019 has been utilised as the version of the BCA applicable at the time of preparation this Report.

3. Preliminaries

3.1. Building Assessment Data

Summary of Construction Determination:

Part of Project	Existing Building	Proposed Extension
Classification	5, 7b	5, 8
Number of Storeys	2	3
Rise In Storeys	2	3
Type of Construction	C	B
Effective Height (m)	<12m	<12m

Note: The effective height of the project includes all stories included in the rise in stories of the project.

Summary of the floor areas and relevant populations where applicable: -

Proposed Extension	BCA Classification	Approx. Floor Area (m^2)	Approximate Volume (m^3)	Assumed Population
Warehouse – 2A addition	7b	15612	TBA	50*
Warehouse – 2B addition	8	2813	TBA	30*
Office	5	1800	TBA	180
Total		20225	TBA	260

Notes:

- The above populations for the office have been based on floor areas and calculations in accordance with Table D1.13 of the BCA.
- The populations noted with (*) are to be verified by the client.

4. Structure

4.1. Structural Provisions (BCA B1):

Any new structural works are to comply with the applicable requirements of BCA Part B1, including AS/NZS 1170.0-2002, AS/NZS 1170-1-2002, AS/NZS 1170.2-2011 and AS 1170.4-2007.

Depending on the importance level of the building as determined by AS/NZS 1170.0-2002, the non structural elements of the building, including partitions (and non-structural fire walls), ceilings, services and racking/shelving may be required to comply with the seismic restraint requirements of AS 1170.4-2007. Where this is required, certification will be required confirming that the design of the seismic restraints comply with AS 1170.4-2002. This may be provided by a specialist seismic consultant or by the architect and services design engineers.

It is noted that BCA 2019 introduced a new Verification Method, BV2, which is a pathway available to verify compliance with BCA Performance Requirement BP1.1(a)(iii).

Glazing is to comply with AS1288-2006, and AS2047-2014.

Concrete external walls that could collapse as complete panels (e.g. tilt-up and pre-cast concrete), in a building having a rise in storeys of not more than 2, must comply with Specification C1.11.

Prior to the issue of the Construction Certificate structural certification is required to be provided by a Professional Engineer registered on the National Engineering Register.

5. Fire Protection

5.1. Fire Compartmentation (BCA C1.1)

The BCA stipulates three levels of fire resistant construction, which is based upon the rise in storeys and classification of the building. Each of these types of construction has maximum floor area and volume limitations as per BCA Table C2.2.

Based upon the rise in storeys and use of the building, it is required to be constructed in accordance with the requirements of Type B Construction, in accordance with Table 4 Specification C1.1 of the Building Code of Australia 2019.

The proposed extension of the existing building will have a Rise in Storey's of 3, increasing the Type of construction required to the building to be Type B. The construction of the Fire Separating wall between the two types of classifications is to be verified by the Fire Engineer for compliance with the performance requirement of the BCA in lieu of construction to BCA Clause C2.7.

The existing building is considered a large isolated building and subject to BCA provisions of C2.3. as the proposed works / building is to be located within 6m of the existing, the building in combination are to comply with the provisions of BCA Clause C2.3. This includes:

- Automatic sprinkler protection to AS2118.1 and BCA Specification E1.5 throughout the development / smoke detection and alarm system in accordance with AS1670,
- Perimeter emergency vehicular access 6m wide located within 18m of the entire building perimeter in accordance with BCA Clause C2.4,

- Smoke exhaust or smoke and heat vents required throughout the development if the building exceeds 18,000m^2 or 108,000m^3 in volume
- Provision of a fire hydrant ring main

The building is considered to be united under the provisions of BCA clause A7.0. The existing building and the proposed extension will be connected and used as one building and together compliance with the requirements of the BCA.

Given the above, the united building will be location across two (2) allotments, the site boundary presenting a fire source feature to the proposed extension works. To this regard, a performance solution is proposed to address:-
- The exposure of the proposed extension to the boundary and the associated FRLs
- The protection of openings in the fire wall which is exposed to the boundary.

Fire source feature is defined as;

a) The far boundary of a road, river, lake or the like adjoining an allotment,
b) The side or rear boundary of the allotment,
c) The external wall of another building on the allotment which is not a class 10 building.

5.2. Fire Hazard Properties (BCA C1.10 and BCA C1.9)

The fire hazard properties of fixed surface linings and mechanical ductwork will also need to be addressed within the detailed documentation phase pursuant to Specification C1.10 of the Building Code of Australia.

5.3. Separation of equipment (C2.12)

Equipment listed below must be separated from the remainder of the building providing a FRL as required by Spec C1.1 but not less than 120/120/120 with a self-closing fire door with an FRL or not less than -/120/30. When separating a lift shaft and life motor room, an FRL of not less than 12/-/- is required.

a) Emergency generators used to sustain emergency equipment operating in the emergency mode; or
b) Central smoke control plant; or
c) Boilers; or
d) A battery system installed in that building that has total voltage of 12 volts or more and a storage capacity of 200kWh or more.

5.4. Protection of Openings in External Walls (BCA C3.2 / C3.3 / C3.4)

The prescriptive provisions of the BCA stipulate that any external opening within 3m of the boundary, within 6m of the far boundary of a road, river, lake or the like that adjoins the allotment, or within 6m of another building on the allotment requires protection by -/60/- fire rated construction, or externally located wall wetting sprinklers.

Where a building is separated into fire compartments, the distance between parts of external walls and openings within them must be not less than the table below unless those parts of each external wall has an FRL not less than 60/60/60 and openings are protected.

Angle Between Walls	Minimum Distance
0º (walls opposite)	6m
More than 0º to 45º	5m
More than 45º to 90º	4m
More than 90º to 135º	3m

Angle Between Walls	Minimum Distance
More than 135º to 180º	2m
More than 180º	Nil

Fire compartmentation plans will be further assessed as part of the application for a Construction Certificate.

As noted in section 5.1 of the report, the exposure to the site boundary is to be assessed as a performance solution.

5.5. Protection of Openings fire rated building elements (BCA C3.5 and BCA C3.10)

The prescriptive provisions of the BCA stipulate that openings within building elements required to have an FRL shall be protected as follows:

a) Any penetration through a wall or room required to have an FRL (e.g. substation, boiler room, apartment separating wall etc) is to be protected either by a tested prototype (e.g. fire collar, fire damper, etc) or be installed within a shaft achieving an FRL of 90/90/90 (or 120/120/120 where it is a room such as a substation);
b) Self-closing -/60/30 fire doors to the doors opening to the fire isolated stairs (note that this also includes the access doors to the condenser units on the plant platforms).

As the design develops, details will need to be included in relation to sealing of penetrations / construction of fire rated shafts.

6. Access and Egress

6.1. Provision for Escape (BCA D1)

The egress provisions for the proposed building are provided by the following:

- External perimeter doorways
- Required non-fire isolated stairways
- Non Fire isolated Stairs
- External Doors

Detailing issues that will need to be addressed as the design develops include:

- Door Hardware
- Exit Door Operation
- Stair Construction
- Handrail and Balustrade construction
- Door swings

6.2. Exit Travel Distances (BCA D1.4)

The locations of the proposed exits would appear to indicate that the deemed to satisfy requirements in terms of travel distances, distances between alternative exits and egress widths would be satisfied.

The travel distances to exits should not exceed:

Class 5 to 9

- no point on the floor must be more than 20m to a single exit or point of choice and where two exits are provided, a maximum of 40m to one of those exits; and
- exits shall be located to not be more than 60m apart and not closer than 9m

The extended travel distances and distance between the exit stairs will need to addressed as performance solutions by the Fire Safety Engineer using BCA Performance Requirements DP4 & EP2.2.

Travel distances measured within the development are as follows:

- 55m to an exit, in lieu of 40m;
- 100m between alternative exits, in lieu of 60m;
- 110m travel distance to an exit via a non-fire isolated stair; in lieu of 80m;
- 55m travel distance from a non-fire isolated stair to an exit.

Further details are to be provided on the architectural plan for assessment of exit locations and travel distances. Including details of available travel paths with consideration of plant and equipment.

6.3. Dimensions of Exits (BCA D1.6)

Minimum dimensions of 1000mm and 2000mm height to be provided within exits, with the paths of travel should provide a minimum width of 1000mm (note that all maintenance access, cat walks, etc may comply with AS1657-2018 in which case a 600mm clear width is required).

Doorways are permitted to contain a clear opening width of the required width of the exit minus 250mm, with a height of 1980mm as part of egress requirements. Access for persons with disabilities however requires a clear doorway opening width of 850mm (i.e. minimum 920 mm doors).

6.4. Balustrades and Handrails (BCA D2.16 / BCA D2.17 / D2.24)

Balustrading to a minimum height of 1000mm with a maximum opening of 124mm in any direction should be provided adjacent to balconies, landings, corridors etc where located adjacent to a change in level exceeding 1000mm, or where it is possible to fall through an openable window located more than 4m above the surface beneath.

Where it is possible to fall more than 4m to the surface below, the balustrade shall not contain any horizontal or near horizontal members that facilitate climbing between 150 – 760mm above the floor.

Handrails should generally be provided at a minimum height of 865mm alongside of all ramps and stairs.

The public stairs and ramps located along an accessible path of travel should be designed in accordance with the requirements of AS1428.1 for persons with disabilities. This requires a handrail on each side of the stair and ramp and for the handrail to extend approximately 550mm – 600mm past the last tread / end of ramp.

Class 8 Buildings

Balustrades in the fire isolated stairways and Class 7b or 8 parts of buildings are permitted to contain a 3 rail system, with a bottom rail situated at not more than 150mm above the nosings. The distance between the rails shall not exceed 460mm.

Handrails are required on both sides of all stairways except for fire isolated stairways used only for emergency egress purposes.

Note: in a required exit serving an area required to be accessible, handrails must be designed and constructed to comply with Clause 12 of AS1428.1-2009

6.5. Slip Resistance

The adoption of BCA 2014 introduced a requirement for slip resistance of stairway treads and ramp surfaces. The requirements are as follows:

Table D2.14 SLIP-RESISTANCE CLASSIFICATION

Application	Surface conditions	
	Dry	**Wet**
Ramp steeper than 1:14	P4 or R11	P5 or R12
Ramp steeper than 1:20 but not steeper than 1:14	P3 or R10	P4 or R11
Tread or landing surface	P3 or R10	P4 or R11
Nosing or landing edge strip	P3	P4

7. Services and Equipment

The following section of this report describes the essential fire safety measures and the minimum performance requirements of those measures. A draft essential fire safety schedule can be found in Appendix B.

7.1. Fire Hydrants (BCA E1.3)

A system of Fire Hydrants is required to be provided in accordance with BCA Clause E1.3 and AS2419.1-2005.

Pressure and flow information will be required to confirm the required pressures and flow to the system, depending on the type of hydrant to be utilized;

The building is required to be provided with a booster assembly as part of the fire hydrant requirements. The booster is required to be located attached to the building at the main entry. If remote from the building, the booster is to be located at the main vehicle entry or with sight of the main entry of the building within 20m of a hardstand area.

A fire ring main is required.

The fire pump location is to be further assessed which design becomes available.

7.2. Fire Hose Reels

A Fire Hose Reel System is required to BCA Clause E1.4 and AS2441-2005.

Fire hose reels are to be located within 4m of exits and provide coverage within the building based on a 36m hose length and 4m of water spray. Where required, additional fire hose reels shall be located internally as required to provide coverage. These hose reels are to be located adjacent to internal hydrants.

Fire hose reel cupboards must not contain any other services such as water meters, etc., and doors to fire hose reel cupboards are not to impede the path of egress unless an alternative solution is developed under BCA Performance Requirement EP1.1

7.3. Fire Extinguishers (BCA E1.6)

The provision of portable fire extinguishers is required to BCA Clause E1.6 and AS2444 - 2001 to provide coverage.

Table E.6 details when portable fire extinguishers are required:

Occupancy Class	Risk Class (as defined in AS 2444)
General provisions – Class 2 to 9 buildings (except within sole-occupancy units of a Class 9c building)	a) To cover Class AE or E fire risks associated with emergency services switchboards. (Note 1) b) To cover Class F fire risks involving cooking oils and fats in kitchens. c) To cover Class B fire risks in locations where flammable liquids in excess of 50 litres are stored or used (not excluding that held in fuel tanks of vehicles). d) To cover Class A fire risks in normally occupied fire compartments less than 500m^2 not provided with fire hose reels (excluding open deck carparks). e) To cover Class A fire risks in classrooms and associated schools not provided with fire hose reels. f) To cover Class A fire risks associated with Class 2 or 3 building or class 4 part of building.

7.4. Automatic Sprinkler Protection (BCA E1.5)

Automatic sprinkler protection is required to Specification E1.5 and AS2118.1-2017 throughout the building as it is considered a large isolated building under BCA Clause 2.3.

The sprinkler system shall be connected to and activate an occupant warning system complying with BCA Specification E2.2a.

Details of the proposed sprinkler system design will need to be reviewed as the design develops.

7.5. Smoke Hazard Management (BCA E2.2)

Smoke hazard management shall be provided throughout the building by means of the following systems:

- Automatic Shutdown of Mechanical Systems in accordance with the requirements of AS/NZS 1668.1-2015 Amendment 1;
- Automatic Smoke Exhaust System activated by Automatic Smoke Detection & Alarm System in accordance with the requirements of BCA Spec E2.2a and AS1670.1-2018

A fire indicator panel is required as part of the detection system. This panel is to be located within 4m of the main entry and should be incorporated within the fire control room. Any variation to the prescriptive provisions will require the consent of the fire brigade and should form part of the fire safety engineering report to verify the performance requirements of the BCA.

7.6. Lift Services (BCA E3.4 and BCA E3.6)

Due to size of the mezzanine level being over 200 sqm, a lift is to be provided to afford access to this level under BCa Part D3. The passenger lifts to be installed are to be:-

- Fitted with warning signs, fire service controls in accordance with Clauses E3.3, Figure E3.3, E3.7, E3.9 and E3.10 of the BCA.
- Be provided with the following in order to satisfy accessibility requirements:
  - A handrail in accordance with AS1735.12-1999,
  - Minimum internal floor dimensions of 1400 x 1600mm for lifts which travel more than 12m, or 1100 x 1400mm for lifts which travel not more than 12m,
  - Fitted with a series of door opening sensory devices which will detect a 75mm diameter or across the door opening between 50mm and 1550mm above floor level,

- Have a set of buttons for operating the lift located at heights above level complying with AS1735.12 - 1999
- For lifts serving more than 2 levels, automatic audible information within the lift car identifying the level each time the car stops, and audible and visual indication at each lift landing to indicate the arrival of a car

7.7. Exit Signs and Emergency Lighting (BCA E4.2 and BCA E4.5)

Emergency Lighting and Exit Signs indicating exit location paths of travel to exits to be provided in accordance with BCA Part E4 and AS/NZS 2293.1-2018, including the potential use of photo luminescent exit signs.

To avoid potential damage by forklifts in the warehousing areas, it is recommended the Fire Safety Engineer include an alternative solution in the FER to permit directional exit signage to be located above 2.7m. This is to be assessed to BCA Performance Requirement EP4.2.

Details are required to be provided for review.

7.8. Fire Control Centre (BCA E1.8)

As the Class 6, 7, 8 or 9 building contains a floor area of greater than 18,000m^2, a fire control centre is required in accordance with BCA Specification E1.8.

Further design of the Fire Control Centre are to be provided.

8. Health and Amenity

8.1. Sanitary Facilities (BCA F2.2 and BCA F2.3)

Further assessment of the provision of sanitary facilities will be need to be undertaken as the design develops including number, location, layout, dimensions, etc of the sanitary facilities.

Note: The Unisex facilities provided for people with disabilities may be counted once for each sex. These facilities are to be provided in accordance with AS1428.1-2009.

Bathroom Construction

Where bathrooms or rooms containing water closets have the WC within 1200mm of the doorway, the door shall be either sliding, open outwards, or be provided with removable hinges.

8.2. Light and Ventilation (BCA Part F4)

Natural Ventilation is required to be provided to rooms at a rate of 5% of the floor area in openings. Alternatively, mechanical ventilation is required in accordance with AS1668.2-2012

Artificial lighting complying with AS/NZS1680.0-2009 is to be incorporated with the final detailed design to be developed to confirm this.

8.3. Waterproofing (BCA FP1.4)

Performance Requirement FP1.4 which relates to the prevention of the penetration of water through external walls, must be complied with. It is noted that there are no Deemed-to-Satisfy Provisions for this Performance Requirement in respect of external walls.

As such, a performance solution is to be prepared by a suitably qualified professional that demonstrates that the external walls of the proposed building complies with Performance Requirement FP1.4 which reads as follows:

A roof and external wall (including openings around windows and doors) must prevent the penetration of water that could cause—

a) unhealthy or dangerous conditions, or loss of amenity for occupants; and
b) undue dampness or deterioration of building elements.

9. Energy Efficiency

9.1. SECTION J (JP1 Energy Use)

Efficient energy use must be achieved appropriate to the function and use of the building, level of human comfort, solar radiation, energy source of the services and sealing of the building envelope. To achieve this JV1, JV2, JV3 and JV4 verification methods have been introduced as options available to achieve compliance.

It is noted that a deemed to satisfy pathway is still available.

Access for maintenance is to be provided to the building in accordance with the requirements of BCA Part J8.

The proposed site will be located in a climate zone 5.

Due to special nature of the building some energy provisions may not be appropriate.

Certification from an appropriately qualified engineer should be provided for either option with a report / computations outlining how compliance is achieved.

Verification Methods

The Verification Methods available to demonstrate compliance with the BCA on a performance basis are as follows:

JV1 NABERS Energy for Offices

- To achieve compliance with JP1 a class 5 building must achieve a minimum of 5.5 NABERS Energy for Offices Base Building Commitment Agreement and comply with ANSI/ASHRAI Standard 140.
- To achieve the energy model for (JP1 (i)) solar radiation the base buildings greenhouse gas emissions are not more than 67% of the 5.5 star level when excluding:
  - Tenant supplementary heating; and
  - Cooling systems; and
  - External lighting; and
  - Car park services.
  - A thermal comfort level between predicted mean vote of -1 to +1 is achieve across not less than 95% of the floor area of all occupied zones for not less than 98% f annual hours of operation.
- The building also need to comply with additional requirements of Spec JVa.

JV2 Green Star

- To achieve compliance with JP1 for Class 3,4,5,6, 7, 8, 9 and common area of Class 2 buildings Green Star can be used as a verification method when the calculation method complies with ANSI/ASHRAE Standard, Specification JVb and when:
  - The building complies with simulation requirements and is registers for a Green Star – Design & As-Built rating; and
  - The annual greenhouse gas emissions of the proposed building are less than 90% of the annual greenhouse gas emissions of the reference building; and
  - In the proposed building, a thermal comfort level of between predicted mean vote of -1 to +1 is achieve across not less than 95% of the floor area of all occupied zones for not less than 98% of the annual hours of operation of the building; and
  - The building complies with the additional requirements of Specification JVa.

JV3 Verification Using a Reference Building

- To achieve compliance with JP1 for Class 3,4,5,6, 7, 8, 9 and common area of Class 2 buildings verification using a reference building can be used when the calculation method complies with ANSI/ASHRAE Standard, Specification JVb and when:
  - It is determined that the annual greenhouse gas emissions of the proposed building are not more than the annual greenhouse gas emissions of a reference building when the proposed building is modeled with the proposed services and the proposed building is modelled with the same services as the reference building. The proposed building thermal comfort level is to be between predicted mean vote of -1 to +1 across not less than 95% of the floor area of all occupied zones for not less than 98% of the annual hours of operation; and
  - The building achieves the additional requirements in Specification JVa; and
  - The greenhouse gas emissions of the proposed building may be offset by renewable energy generated and use on site and another process such as reclaimed energy used on site.

JV4 Building Envelope Sealing

- Compliance with sealing of the building against air leakage is verified when the envelope is sealed at an air permeability rate tested in accordance with Method 1 of AS/NZS ISO 9972, of not more than –
  - For a class 2 building or a class 4 part of a building, $10m^3hr.m^2$ at 50 Pa reference pressure; or
  - For a class 5, 6, 8, 9a or 9b building other than a ward area in climate zones 1, 7 and 8, 5 $m^3/hr.m^2$ at 50 Pa reference pressure; or
  - For class 3 or 9c building, or a class 9a ward area in climate zones 1, 3, 4, 6, 7 and 8 $5m^3/hr.m^2$ at 50 Pa reference pressure.
- Part J3 and performance solution that uses on of the other NCC assessment Methods which verifies that compliance with JP1 (e) will be achieve can also be used as verification methods.

10. Access for People with Disabilities

The development is required to comply with the accessibility provisions contained within:

- The Building Code of Australia 2019;
- Disability (Access to Premises – Buildings) Standards 2010;
- AS1428.1-2009 General Requirements for Access – New Building Work;
- AS1428.4.1 -2009 Tactile Ground Surface Indicators
- AS2890.6-2009 Car Parking for People with Disabilities

Note: With the introduction of the Commonwealth *Disability Discrimination Act (DDA)* in 1992 (enacted in 1993), all organisations have a responsibility to provide equitable and dignified access to goods, services and premises used by occupants. Organisations and individuals since its introduction, are required to work to the objects of the Act which are to eliminate, as far as possible, discrimination against persons on the ground of disability in the **areas of work, accommodation, education, access to premises, clubs and sports, and the provision of goods, facilities, services and land, existing laws and the administration of Commonwealth laws and programs.**

This report assesses against the requirements contained with the Building Code of Australia (and documents referred to therein) and is not considered to be a full assessment against the Disability Discrimination Act.

10.1. General Building Access Requirements (BCA D3.1)

Access for people with disabilities shall be provided to and within the building in accordance with the requirements of Clause D3.2, D3.3 and D3.4 of the BCA 2019 and AS 1428.1. Parts of the building required to be accessible shall comply with the requirements of:-

- AS1428.1-2009 General Requirements for Access – New Building Work;
- AS1428.4.1 -2009 Tactile Ground Surface Indicators
- AS2890.6-2009 Car Parking for People with Disabilities

Access for persons with a disability is to be provided as follows:

<u>Office/shops (Class 5/Class 6 buildings)</u>

To and within all areas normally used by the occupants

<u>Warehouse and production/Manufacturing facilities</u>

To and within all areas normally used by the occupants, but as the uses of these areas could be deemed inappropriate, confirmation is required as the appropriateness of the areas in question by the owners or tenant.

10.2. Provision for Access to Buildings

The BCA prescribes access to be provided to and within the building as follows:

- Via the principle pedestrian entry and at least 50% of all other entrances from the allotment boundary
- From designated car parking spaces for the use of occupants with a disability.
- From another accessible building connected by a pedestrian link.
- All areas used by the occupants.

In buildings over 500m^2 in floor area, a non-accessible entrance must not be located more than 50m from an accessible entrance.

Where a pedestrian entry contains multiple doors, the following is required;

- Entrance containing not more than 3 doors, at least one of the doorways must be accessible.
- Where an entrance contains more than 3 doors, not less than 50% of the doorways must be accessible.

A door is considered to be accessible if it is automatic (open and closing) or is more than 850mm in clear opening width and contains the required door circulation space.

10.3. Accessibility within Building (BCA D3.3)

A building required to be accessible is required to be equipped with either a AS 1428.1 compliant lift or AS 1428.1 compliant ramp, (but the maximum vertical rise of a ramp must not exceed 3.6m).

Within the building the following are required;

- Door circulation space as per AS1428.1 Clause 13.3;
- Doorways must have a clear opening of 850mm;
- Passing spaces (1.8m wide passages) must be provided at maximum of 20m intervals
- Within 2.0m of end access ways/corridors, turning areas spaces are required to be provided.
- Carpet pile height of not more than 11mm to an adjacent surface and backing <4mm
- Any glazing capable of being mistaken for a doorway or opening must be clearly marked (or contain chair rail, hand rail or transom as per AS 1288 requirements)

10.4. Car Parking (BCA D3.5)

Accessible car parking spaces are required to comply with AS 2890.6-2009 at the rate of 1 per every 100 spaces or part thereof.

The development is proposed to contain 35 car parking spaces which requires a minimum of 1 accessible spaces.

A ‘shared zone’ of minimum 5400mm x 2400mm is required adjacent to accessible car parking spaces, protected with a bollard.

10.5. Tactile Indicators (BCA D3.8)

Tactile indicators are required to be provided to warn occupants of all stairs (except Fire Isolated stairs) and ramps regardless of public nature or private environment and where an overhead obstruction occurs less than 2.0m above the finished floor level.

10.6. Stairs (BCA D3.3 inter Alia AS1428.1)

Stairs shall be constructed as follows:

a) Where the intersection is at the property boundary, the stair shall be set back by a minimum of 900mm so that the handrail and TGSIs do not protrude into the transverse path of travel.
b) Where the intersection is at an internal corridor, the stair shall be set back one tread width plus 300mm (nominally 700mm as per AS 1428.1-2009 Fig 26(b)), so the handrails do not protrude into transverse path of travel.
c) Stairs shall have opaque risers.
d) Stair nosing shall not project beyond the face of the riser and the riser may be vertical or have a splay backwards up to a maximum 25mm.
e) Stair nosing profiles shall;

- Have a sharp intersection;
- Be rounded up to 5mm radius; or
- Be chamfered up to 5mm x 5mm

f) All stairs, including fire isolated stairs shall, at the nosing of each tread have a strip not less than 50mm and not more than 75mm deep across the full width of the path of travel. The strip may be set back a maximum of 15mm from the front of the nosing. The strip shall have a minimum luminance contrast of 30% to the background. Where the luminous contrasting strip is affixed to the surface of the tread, any change in level shall not exceed a difference of 5mm.

10.7. Accessible Sanitary Facilities (BCA F2.4)

Unisex Accessible Sanitary Facilities

An accessible unisex sanitary facility must be located so that it can be entered without crossing an area reserved for one sex only and provided in accordance with AS 1428.1-2009 and must contain a closet pan, washbasin, shelf or bench top and adequate means of disposal of sanitary products and as per following.

Building Type	Minimum accessible unisex sanitary compartments to be provided
Office, industrial, assembly building	a) 1 on every storey containing sanitary compartments; and b) Where a storey has more than 1 bank of sanitary compartments containing male and female sanitary compartments, at not less than 50% of those banks.

Ambulant Facilities

At each bank of toilets where there is one or more toilets in addition to an accessible unisex sanitary compartment, a sanitary compartment suitable for a person with an ambulant disability in accordance with AS 1428.1-2009 must be provided for use by males and females.

Where male sanitary facilities are provided at a separate location to female sanitary facilities, accessible unisex sanitary facilities are only required at one of those locations.

An accessible unisex sanitary compartment or an accessible unisex shower need not be provided on a storey or level that is not provided with a passenger lift or ramp complying with AS 1428.1-2009

10.8. Signage (BCA D3.6)

As part of the detailed design package, specifications will need to be developed indicating:

- Sanitary Facility Identification Signs (note that they are to comply with BCA Specification D3.6 and include the use of Braille, Tactile, etc and be placed on the wall on the latch side of the facility);
- Directional / Way Finding signs to the Lifts, Sanitary Facilities, etc;
- Hearing Augmentation System;
- Identify each door required by BCA Clause E4.5 to be provided with an exit sign, stating 'EXIT' and 'Level" number
- Braille and tactile signs must be illuminated to ensure *luminance contrast* requirements are met at all times during which the sign is required to be read.

10.9. Lifts (BCA E3.6)

Lifts compliant to BCA E3.6 and BCA E3.7 must be provided, where required to be provided, with a minimum size of 1400 x 1600mm or 1100mm x 1400mm (whichever is appropriate) in size – with appropriate handrails and auditory commands.

11. Appendix A - Reference Documentation

The following documentation was used in the assessment and preparation of this report:

Drawing No.	Title	Issue	Date	Revision
HLA-AR-A001 -	Site Plan (Overall)	DA		P15
HLA-AR-A010 -	Existing Site and Proposed Demolition Plan	DA	9/06/2021	P4
HLA-AR-A100 -	Warehouse 2A Floor Plan	DA	31/05/2021	P2
HLA-AR-A101 -	L1 Mezzanine Plan	DA	23/06/2021	P5
HLA-AR-A102 -	L2 Mezzanine Plan	DA	23/06/2021	P5
HLA-AR-A103 -	Ceiling Level Plan	DA	23/06/2021	P9
HLA-AR-A110 -	Roof Plan	DA	18/06/2021	P7
HLA-AR-A120 -	Office Ground Floor Plan	DA	23/06/2021	P8
HLA-AR-A121 -	Office First Floor Plan	DA	18/06/2021	P7
HLA-AR-A200 -	Warehouse Elevations	DA	18/06/2021	P8
HLA-AR-A201 -	Office Elevations	DA		P5

12. Appendix B - Draft Fire Safety Schedule

	Essential Fire Safety Measures	Standard of Performance
1.	Automatic Fail Safe Devices	BCA Clause D2.19 & D2.21
2.	Automatic Smoke Detection and Alarm System	Clause 3 or 4 or 5 BCA Spec. E2.2a, AS 1670.1 – 2018, AS/NZS 1668.1 – 2015,
3.	Automatic Fire Suppression System	BCA Spec. E1.5 & AS 2118.1 – 2017 Amdt 1,
4.	Building Occupant Warning System activated by the Sprinkler System	BCA Spec. E1.5 & Specification E2.2a Clause 7
5.	Emergency Lighting	BCA Clause E4.2, E4.4 & AS/NZS 2293.1 – 2018
6.	Emergency Evacuation Plan	AS 3745 – 2002
7.	Exit Signs	BCA Clauses E4.5, E4.6 & E4.8 and AS/NZS 2293.1 – 2018
8.	Fire Control Centres and Rooms	BCA Spec. E1.8
9.	Fire Dampers	BCA Clause C2.12, C3.15, Spec C2.5, D1.7, E2.2, E2.3, F4.12, Spec E2.2, E2.3, Spec E2.2b, Spec G3.8 & AS 1668.1 – 2015
10.	Fire Doors	BCA Clause C3.2, C3.4, C3.5, C3.6, C3.7 & C3.8 and AS 1905.1 – 2015
11.	Fire Hose Reels	BCA Clause E1.4 & AS 2441 – 2005 Amdt 1
12.	Fire Hydrant System	Clause C2.12, E1.3, Spec E1.5a, H3.9 & AS 2419.1 – 2005 Amdt 1
13.	Fire Seals	BCA Clause C3.15, C3.16, Spec C3.15, Spec D1.12, & AS 1530.4 –2014
14.	Mechanical Air Handling System	BCA Clause E2.2, AS/NZS 1668.1 – 2015 & AS 1668.2 – 2012
15.	Paths of Travel	EP&A Reg 2000 Clause 186
16.	Perimeter Vehicular Access	BCA Clause C2.4
17.	Portable Fire Extinguishers	BCA Clause E1.6 & H3.11, AS 2444 – 2001
18.	Required Exit Doors (power operated)	BCA Clause D2.19 (b)(iv)
19.	Smoke Hazard Management System	BCA Part E2 & AS/NZS 1668.1 – 2015
20.	Warning and Operational Signs	AS 1905.1 –2015~~,~~ BCA Clause C3.6, D2.23, E3.3

13. Appendix C - Fire Resistance Levels

The table below represents the Fire resistance levels required in accordance with BCA 2019:

Table 4 TYPE B CONSTRUCTION: FRL OF BUILDING ELEMENTS	**Class of building—FRL: (in minutes)** *Structural adequacy/Integrity/Insulation*			
	2, 3 or 4 part	**5, 7a or 9**	**6**	**7b or 8**
EXTERNAL WALL (including any column and other building element incorporated within it) or other external building element, where the distance from any fire-source feature to which it is exposed is—				
For *loadbearing* parts—				
less than 1.5 m	90/ 90/ 90	120/120/120	180/180/180	240/240/240
1.5 to less than 3 m	90/ 60/ 30	120/ 90/ 60	180/120/ 90	240/180/120
3 to less than 9 m	90/ 30/ 30	120/ 30/ 30	180/ 90/ 60	240/ 90/ 60
9 to less than 18 m	90/ 30/–	120/ 30/–	180/ 60/–	240/ 60/–
18 m or more	–/–/–	–/–/–	–/–/–	–/–/–
For non-*loadbearing* parts—				
less than 1.5 m	–/ 90/ 90	–/120/120	–/180/180	–/240/240
1.5 to less than 3 m	–/ 60/ 30	–/ 90/ 60	–/120/ 90	–/180/120
3 m or more	–/–/–	–/–/–	–/–/–	–/–/–
EXTERNAL COLUMN not incorporated in an *external wall*, where the distance from any *fire-source feature* to which it is exposed is—				
less than 3 m	90/–/–	120/–/–	180/–/–	240/–/–
3 m or more	–/–/–	–/–/–	–/–/–	–/–/–
COMMON WALLS and FIRE WALLS—	90/ 90 / 90	120/120/120	180/180/180	240/240/240
INTERNAL WALLS—				
Fire-resisting lift and stair *shafts*—				
Loadbearing	90/ 90/ 90	120/120/120	180/120/120	240/120/120
Fire-resisting stair *shafts*				
Non-*loadbearing*	–/ 90/ 90	–/120/120	–/120/120	–/120/120
Bounding *public corridors*, public lobbies and the like—				
Loadbearing	60/ 60/ 60	120/–/–	180/–/–	240/–/–
Non-*loadbearing*	–/ 60/ 60	–/–/–	–/–/–	–/–/–
Between or bounding *sole-occupancy units*—				
Loadbearing	60/ 60/ 60	120/–/–	180/–/–	240/–/–
Non-*loadbearing*	–/ 60/ 60	–/–/–	–/–/–	–/–/–
OTHER LOADBEARING INTERNAL WALLS				
and COLUMNS—	60/–/–	120/–/–	180/–/–	240/–/–
ROOFS	–/–/–	–/–/–	–/–/–	–/–/–

Annexure B Existing Fire Engineering Report

Fire Safety Engineering Report

creating intelligent fire safety solutions

Sydney
Melbourne
Hong Kong
Kuala Lumpur

Snackbrands (Building 7), 585-649 Mamre Road, Orchard Hills, NSW (Stage 1)

Project Address:	**585-649 Mamre Road, Orchard Hills, NSW**
Date:	**22 May 2019**
Document ref:	**214318**
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Prepared for:

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Document verification history

Issue No	Date	Document control - Purpose of issue	Prepared by	Checked by	Approved by
1-0	10/05/2019	Draft Fire Safety Engineering Report (FSER) issued for stakeholder comment	Kenny Leong	Parkan Behayeddin	Parkan Behayeddin
2-0	22/05/2019	Final Fire Safety Engineering Report (FSER) incorporating stakeholders and FRNSW comments	Kenny Leong	Parkan Behayeddin	Parkan Behayeddin

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Contents

List of Tables

List of Figures

0. Executive Summary

0.1 General

This executive summary has been prepared to provide a concise statement of the Performance Solution issues identified and addressed in the assessment. The details of the Building Solution so assessed are described in full.

The purpose is to provide a readily accessible source to the intent and outcomes of the assessment with respect to the Building Solution presented.

The FSER is intended to represent a transparent account of the assessment process and outcomes consistent with the documented FEB process and reflects the discussions and agreements between Scientific Fire Services Pty Limited (SFS), the design team and the relevant authorities based on the information provided to date.

The Client is to ensure that the relevant stakeholders and services consultants that have been involved in the project are in agreement with the proposals made in this document. Furthermore, it is the responsibility of the other designers and consultants (not SFS) to complete the detailed design of the various active and passive fire safety systems in accordance with the relevant design and installation Australian Standards and in accordance with the requirements listed in this report.

The reader should note the sections of this document that outline the scope of works, the assumptions and limitations and the fire safety objectives documented in this report. The building owner should be made aware of these sections of the FSER.

The executive summary must always be read in the context of the report as a whole.

0.2 Brief Building Description

The subject site is located on the Altis Property Partners First Estate site at Orchard Hills. The subject site is referred to as Building 7 on the industrial estate as illustrated below.

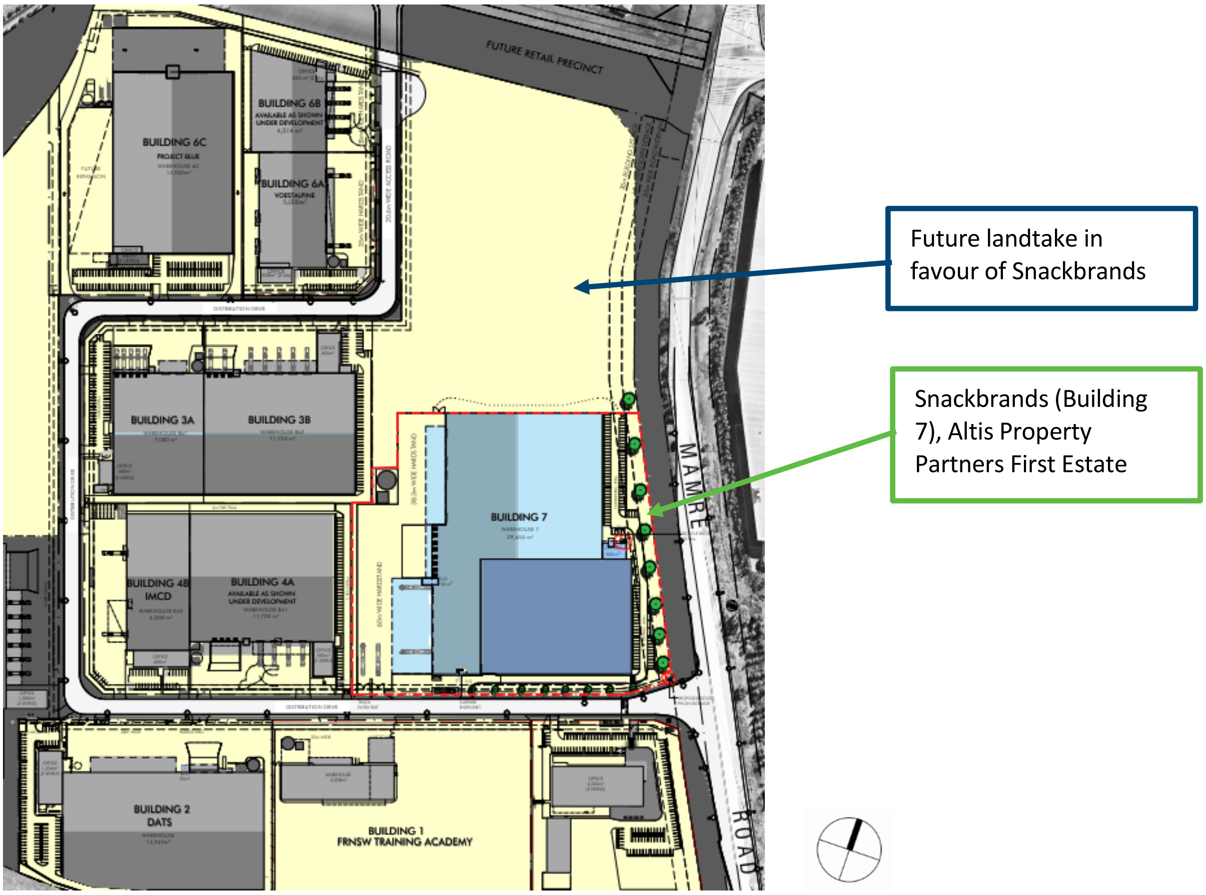

Figure 0.1: Altis Property Partners First Estate – Masterplan

With reference to Figure 0.1 above, the subject proposal can be referred to as Stage 1 where the vacant parcel of land to the north is proposed as a potential landtake in favour of Snackbrands enabling warehousing/manufacturing at a future point in time. This fire safety strategy will predominantly focus on the Stage 1 works with the view to futureproof the current design to facilitate the works which may occur in the future for Stage 2.

Snackbrands Australia is proudly Australian and very much still a family business. Snackbrands make Australia's favourite snacks including CC's, Cheezels, French Fries, Kettle Chips, Samboy Chips and Thins Chips just to name a few.

Figure 0.2: Snackbrands Products – (courtesy of https://www.snackbrands.com.au/Brands#ProductGridAllFour2592)

The subject development is proposed to comprise a Class 7b high bay warehouse comprising 11,023m^2 as well as a low bay warehouse consisting of 18,630m^2. The facility will also accommodate two (2) separate Class 5 office areas. The first of which is the main office portion comprising a total floor area of 500m^2 across two (2) levels. The second administrative space is the dock office which consists of 100m^2 over two (2) levels. In total, the Class 7b warehouse and Class 5 office areas shall accommodate a total floor area of 30,255m^2.

Figure 0.3: Perspectives – High Bay

Separately, the building shall also be provided with 2,665m^2 of awning structures.

Figure 0.4: Awning Structure

The Stage 1 portion subject building is considered to be a *'Large Isolated Building'* centrally situated on the site with vehicular access provided around the site. The external walls of the building are primarily pre-cast dado concrete panels with steel sheeting above.

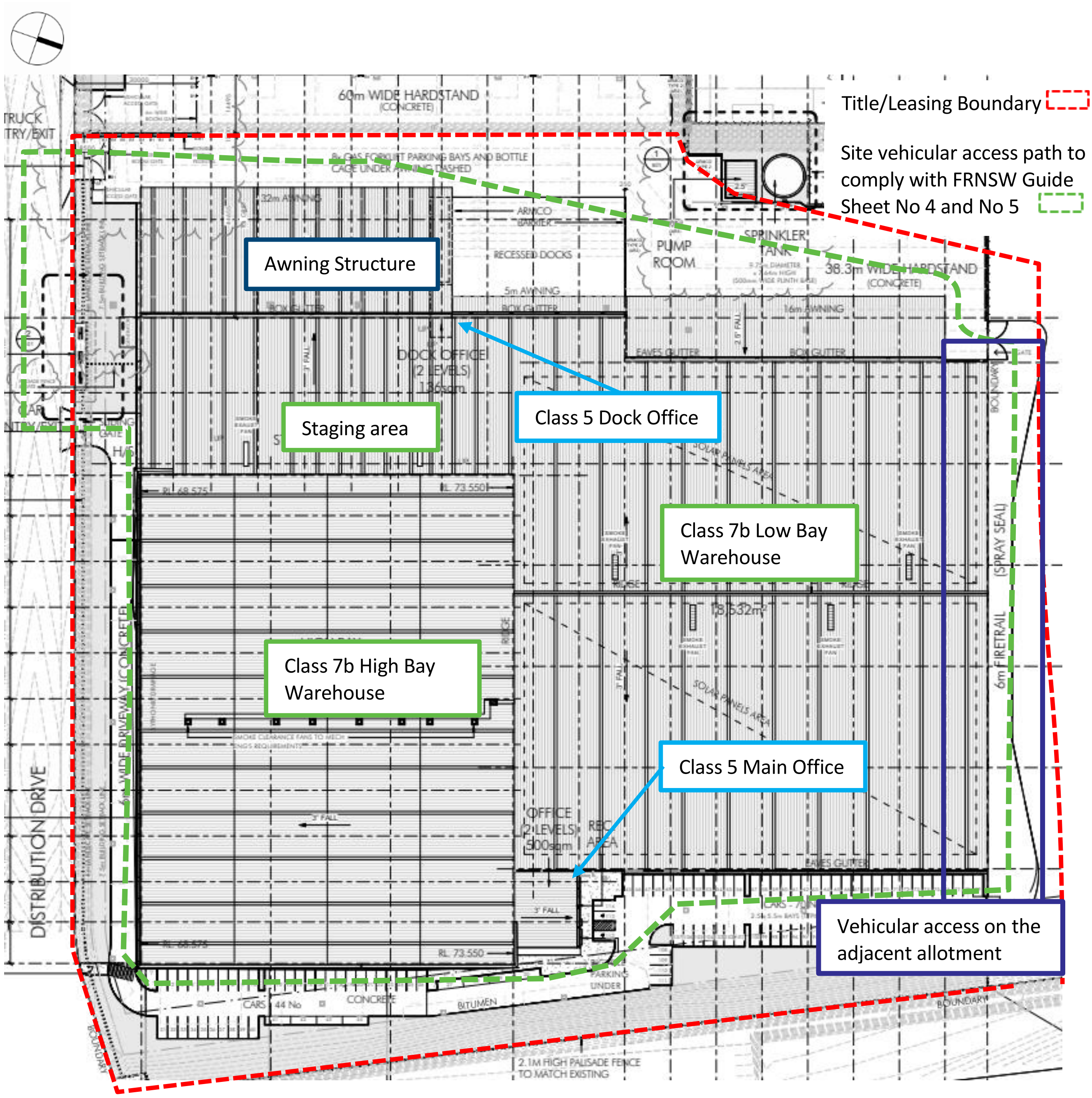

Figure 0.5: Site Plan

The building is provided with full vehicular perimeter access to four (4) sides. The entire building is proposed to be protected by automatic sprinklers systems throughout.

As the volume of the proposed building exceeds the maximum volume permitted in Table C2.2 of Volume One of the NCC, the building has been classified as a *'Large Isolated Building'* (LIB). The building is required by Clause C1.1 of the NCC to be constructed in accordance with Type C fire resisting construction. The building is identified to comply with the prescriptive provisions of the NCC with the exception of the design issues identified within this report.

0.3 Building Design Issues and Performance Requirements

There are design issues that have been identified by McKenzie Group Consulting (NSW) Pty Ltd that represent deviations from the traditional prescriptive design requirements of the Volume One of the National Construction Code (NCC). Rather than seeking compliance with the more traditional 'Deemed-to-Satisfy' (DtS) provisions of the NCC a 'Performance Solution' has been formulated such that the identified design issues achieve compliance with the minimum level of compliance with the NCC namely the Performance Requirements of the NCC. The following table lists the identified design issues, the corresponding Performance Requirements, the methods of meeting the Performance Requirements and the Assessment Methods. It should be noted that the DtS provisions and Performance Requirements listed in the following table were identified by the Certifying Authority and agreed by relevant stakeholders.

Table 0.1: Identified Design Issues

No.	Design Issue(s)	DtS Provision of the NCC	Performance Requirements	NCC Assessment Methods
1.	The following compliance issues have been identified with respect to the proposed perimeter vehicular access serving the warehouse: • The far side of the perimeter vehicle access along the eastern boundary of the site is up to 26m from the external wall of the building in lieu of 18m; and • The access provided to the north of the site is proposed to be on the adjacent allotment which is intended to be acquired by Snackbrands at a future date.	Clause C2.3 inter alia Clause C2.4	CP9	A0.3(a)(i) & A0.5(b)(ii) Consultation with FRNSW
2.	It has been identified that the exit travel distance to the alternative exits and distance between alternative exits within the warehouse/s portion/s exceeds the maximum prescribed exit travel distances. More specifically: • The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and • The distance between alternative exits exceed 60m (i.e.: up to 172m). Furthermore, it is proposed to omit the provision for an automatic smoke exhaust system (including associated smoke baffles and smoke detection system) within the building. In this instance, it is proposed to permit a manually operated smoke clearance system having a smoke clearance capacity of 1 air change per hour.	Clause D1.4 Clause D1.5 Clause E2.2	DP4 & EP2.2 EP2.2	A0.3(a)(i) & A0.5(b)(ii)
3.	The fire hose reel system shall be design and installed in accordance with AS2441.1:2005 with the exception of the following: • To permit the fire hose reel coverage shortfalls throughout the high bay area.	Clause E1.4 inter alia AS2441:2005	EP1.1	A0.3(b)(i) & A0.5(b)(ii)
4.	It is proposed to design and installed the fire hydrant system to be in accordance with Clause E1.3 from Volume One of the NCC and AS2419.1:2005 with the exception of the following: • Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and • It is proposed to permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only.	Clause E1.3 inter alia AS2419.1:2005	EP1.3	A0.3(a)(i) & A0.5(b)(ii) Consultation with FRNSW
5.	Directional and non-directional exit signs are to be installed throughout the building in accordance with Part E4 from Volume One of the NCC and AS2293.1:2005 with the exception that the mounting heights of exit signage within the warehouse storage portions of the building (except within the high bay area). In this instance, it is proposed to permit exit signs to be mounted at greater than 2.7m above the finished floor level within the warehouse portion only being the minimum required by the prescriptive provisions from Volume One of the NCC.	Clause E4.5, Clause E4.6, Clause E4.8 inter alia AS2293.1: 2005	EP4.2	A0.3(a)(i) & A0.5(b)(ii)

No.	Design Issue(s)	DtS Provision of the NCC	Performance Requirements	NCC Assessment Methods
6.	It is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. **Note:** As confirmed by Modcol Pty Ltd (refer to Appendix Q), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area.	Clause E4.5, Clause E4.6, Clause E4.8 inter alia AS2293.1: 2005	EP4.2	A0.3(a)(i) & A0.5(b)(ii)
7.	The FIP is located within the main office of the warehouse, which is not located within the main entrance (vehicular access) of the site.	Clause E1.8 inter alia AS1670.1:2015	EP1.6	A0.3(a)(i) & A0.5(b)(ii)

0.4 Methodologies

The following FSER has been undertaken generally in accordance with the International Fire Engineering Guidelines (IFEG) (ABCB, 2005). The assessment has considered the alternative solution to show compliance with the identified Performance Requirements of the BCA. The evaluation methodologies have been applied to demonstrate the Performance Requirements of the BCA as allowed under Clause A0.3 are complied with. The analysis has been undertaken by qualitative and quantitative analysis and system assessments as allowed under Clause A0.5 of the BCA. Specific methodologies adopted in relation to the identified design issues are further detailed in the body of this report.

0.5 Fire Safety Measures

The building incorporates a range of fire safety measures in accordance with the relevant Australian Standards. In summary, the BCA defines the fire safety measures and their applicable standards required to be installed within the building. Unless otherwise stated, the applicable standard of fire safety system installation (active and passive) must be compliant with the BCA and the relevant Australian Standards.

The other fire safety system features which are specific to the alternative solution proposed for this building are:

0.5.1 Fire Resistance and Type of Construction

1. Building elements throughout shall be constructed in accordance with the minimum Fire Resistance Level's (FRL's) commensurate with Type C fire-resisting construction; and
2. For Stage 1 works, the external walls located within 3m from the title/leasing boundary shall achieve a minimum FRL of up 90 minutes;

   Note: At a future point in time when Stage 2 works are proposed to be undertaken, a separate external wall achieving a minimum FRL of 90 minutes shall be designed and installed should it be located within 3m from the title/leasing boundary; and
3. Separation of the equipment rooms as prescribed by the DtS provisions from Volume One of the NCC shall be in accordance with Clause C2.12 from Volume One of the NCC (i.e. a minimum FRL of 120 minutes); and
4. Any electrical substations within the building shall be separated from any other part of the building as required by Clause C2.13 from Volume One of the NCC; and
5. As required, building materials, components and structures shall be suitably tested and approved to achieve the test criteria consistent with AS1530.1:1994 in order to satisfy the DtS provisions of the NCC and/or AS1530.4:2014. All building elements which require an FRL shall be designed, pre-fabricated and installed in accordance with the tested and approved prototype; and
6. As required, building elements and passive systems (requiring an FRL) shall be suitably tested to meet the test criteria consistent with the minimum requirements prescribed by the DtS provisions of the NCC and/or AS1530.4:2014. All building elements which require an FRL shall be designed, pre-fabricated and installed in accordance with the tested and approved prototype; and
7. All parts of the building must be constructed in an appropriate manner using materials that are fit for purpose as well as being provided with evidence of suitability with respect to fire resistance and fire hazard properties to the satisfaction of the building certifier; and
8. All building lining materials and assemblies, both internal and external are required to meet the minimum fire hazard properties in Clause C1.10 and Specification C1.10 from Volume One of the NCC; and
9. Should any openings and/or penetrations be proposed, the FRL of the penetrating element shall be reinstated commensurate with the FRL required for the building element. Appropriately tested fire stopping protection methods shall be proposed to the openings/penetrations; and

10. Enclosures beneath any required stairways may be permitted subject to strict compliance with Clause D2.8 from Volume One of the NCC.

0.5.2 Occupant Egress Provisions

1. Egress provisions must comply with Part D from Volume Once of the NCC serving unless otherwise identified herein; and
2. Permit occupant egress provisions serving the Class 7b warehouse portion/s as per the following:
   a. The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and
   b. The distance between alternative exits exceed 60m (i.e.: up to 172m); and
3. All emergency exit doors which may be locked due to security requirements are to open on General Fire Alarm (GFA) and/or power failure; and
4. Access into the high bay area shall be provided through readily accessible gates. Refer to Appendix X.

0.5.3 Fire Services and Equipment

1. The entire building shall be provided with automatic fire sprinkler protection in accordance with AS 2118.1:2017. The sprinkler system shall be as follows:
   a. It is proposed to design and install an automatic sprinkler system throughout the warehouse portion of the development in accordance with AS2118.1:2017 which currently is not a referenced Australian Standards by Volume One of the NCC (2016). The following requirements shall be adopted (as per the design brief extraction, refer to Appendix G):
      i. The Class 7b warehouse portion of the subject building is to be sprinkler protected with the installation of Storage Sprinklers incorporating K22 'fast response' sprinkler heads. The activation temperature of K22 storage sprinkler heads shall be no more than 100°C; and
      ii. As required, in-rack sprinklers are required within parts of the Class 7b storage areas (i.e. K22 sprinkler heads) in accordance with AS2118.1:2017, FM Global Guidelines and as per the fire protection services requirements and specifications; and
      iii. All other Class 7b storage and/or Class 8 manufacturing areas not protected with Storage Sprinklers (i.e. K22 "fast response" sprinkler heads) shall be designed and installed in accordance with the hazard classification strictly commensurate with AS2118.1:2017, FM Global Guidelines and as per the fire protection services requirements and specifications; and
      iv. Covered awnings forming part of the Class 7b warehouse portion of the subject building shall be sprinkler protected as per Specification E1.5 from Volume One of the NCC and AS2118.1:2017 to 'Ordinary Hazard 3' classification; and
      v. The Class 5 office portion of the subject building is to be sprinkler protected as per Specification E1.5 from Volume One of the NCC and AS2118.1:2017 appropriate to 'Light Hazard' classification and fitted with fast response sprinkler heads; and
      vi. Refer to Appendix N for further details; and
2. Where appropriate, the Storage Sprinkler system shall comply with the Factory Mutual (FM Global) Property Loss Prevention Data Sheet 2-0, "Installation Guidelines for Automatic Sprinklers" and Property Loss Prevention Data Sheet 8-9, "Storage of Class 1, 2, 3, 4 and Plastic Commodities." The design and installation of the Storage Sprinkler system shall be in strict accordance with the building geometry/height, achieve required minimum clearance, commodity/storage layout/height & hydraulic pressure/flow requirements; and
3. As required by the FRNSW, an aspirating fire detection and alarm system (i.e. VESDA) shall be designed and installed within the high bay area (only) in accordance with AS1670.1:2015; and

   Note: *As a conservative measure, the aspirating fire detection and alarm system (i.e. VESDA) a was not relied upon within the analysis/assessment to satisfy occupant/fire brigade life safety criteria.*
4. The automatic fire sprinkler system and fire detection system (including VESDA) must be interconnected to the Building Occupant Warning System (BOWS); and
5. The Building Occupant Warning System (BOWS) shall actuate upon activation of the automatic sprinkler system and/or the automatic fire detection system. The BOWS shall initiate a General Fire Alarm (GFA) throughout the building and hence achieve sound pressure levels in accord with AS1670.1:2015; and
6. The main Fire Indicator Panel (FIP) shall be located within the main office entry location at ground level. A Sub FIP may be provided to the dock office if required by the client; and
7. Installations activating the BOWS shall also be connected to a fire alarm monitoring system connected to a fire station or fire station despatch centre in accordance with AS1670.3:2004; and

8. The Class 7b warehouse portions of the building (only) shall be provided with a smoke clearance system/s, to the degree necessary, to allow a degree of smoke and hot gas venting from the warehouse portions of the building. In this instance, the smoke clearance system shall can be achieved via a manually operated smoke clearance fan system as per the following:
   a. Manual Operation (dedicated fire mode system for smoke clearance – fire brigade use only); and
      i. Manually operated smoke clearance fan(s) system shall be operable by means of activating a 'push button devices' located at the main FIP location and at any sub FIP; and
      ii. The warehouse portion shall have the capacity to vent a minimum of one (1) air change per hour throughout the respective warehouse portions; and
      iii. Designed and installed in accordance with Specification E2.2b with regards to the componentry such as control gear, wiring and operation temperature (i.e. 200°C for a period of 1 hour); and
      iv. Designed and installed with power supply wiring to the smoke clearance fan infrastructure must comply with AS1668.1:2015; and
   b. Make up air provisions shall be evenly distributed and must have a sufficient area size such that 1 air change to the warehouse;

   Refer to Appendix M for mechanical engineers' specifications for fan capacity, number and locations of fans as well as make up air provisions; and
9. Fire hydrants are to be located and installed in accordance with Clause E1.3 from Volume One of the NCC and AS2419.1:2005 with the exception of the following:
   a. Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and
      i. Provide additional external 'fall back' hydrant(s) to facilitate operations such that fire-fighters are able to utilise the fire hydrants located beneath the covered awnings. The external 'fall back' fire hydrants are to be located within 60m if the fire hydrants located beneath the covered awnings, be located as close as possible to the perimeter vehicular access location and furthermore are to be design and installed to achieve attack fire hydrant performance. Finally, fire hydrant coverage from the 'fall back' hydrant(s) must provide coverage to all fire hydrants located beneath the awning structures; and
10. Permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only. Refer to Appendix J for details; and
11. Where internal fire hydrants are required for coverage purposes, the internal fire hydrants are to be located in the building such as to allow progressive movements of fire fighters towards central parts of the building as per the below:
   a. When working from an external hydrant, the next additional hydrant should be located into the building not more than 50m from the external hydrant; and
   b. When working from an internal hydrant (either from within a fire isolated exit or passageway, within 4 metres of an exit or another additional fire hydrant), the next additional hydrant should be no located not more than 25m from that hydrant.
   c. Where additional hydrants are provided, a localised block plan should be provided at every fire hydrant pictorially and numerically illustrating the location of the next available additional hydrant. These localised block plans should be of a size appropriate to their notice and location and be of all weather-fade resistance construction; and
12. A fire hydrant ring main shall be designed and installed in accordance with the DtS provisions from Volume One of the NCC and AS2419.1:2005. Appendix T depicts the location of the fire brigade booster assembly; and
13. Any electrical substation(s) proposed for the site shall be situated no less than 10m from the fire hydrant booster assembly; and
14. The fire hydrants serving the proposed fire hydrant system are to be accessible for use by Fire & Rescue NSW (i.e. clear paths of travel); and
15. All on-site fire hydrants are to be fitted with forged Storz hose couplings which comply with Clause 7.1 of AS2419.1-2005. This clause states in part "hose couples shall be compatible with those used by the fire brigade serving the area". Storz hermaphrodite fire hose couplings must be fitted to all fire hydrants and the fire hydrant booster assembly connections as required by Appendix E of AS2419.1-2005. The Storz fittings must be manufactured to DIN 14303, aluminium alloy delivery couplings, in accordance with Appendix A of AS2419.2-1994. Blank caps must be provided in accordance with Clause 2.8 of AS2419.2-1994; and

16. Block plans are to be provided at the main Fire Indicator Panel (FIP) and any Sub FIP panel and at the fire hydrant booster assembly connection in accordance with Section 7.11 of AS2419.1:2005 and the FRNSW Tactical Fire-Fighting Plans Guideline (Policy No. 6, Version 02); and
17. The fire hose reel system shall be design and installed in accordance with AS2441.1:2005 with the exception of the following:
    a. It is proposed to omit the provision for fire hose reel coverage to the storage (i.e. racking portions) within the high bay zone as per Figure 11.1. Refer to Appendix K for details; and
18. Portable fire extinguishers shall be selected and mounted in accordance with Clause E1.6 from Volume One of the NCC and AS2444:2001; and
    a. Additional portable fire extinguishers shall be proposed in strategic locations within the storage portions of the high bay zone as per Figure 11.3; and
    b. Due to the potential presence of electrical switchboards within the high bay structure, the use of ABE portable fire extinguishers would safeguard occupants attempting to utilise portable fire extinguishers; and
    c. The provision for ABE type portable fire extinguishers should not only meet the minimum requirements of the Australian Standard for portable fire extinguishers. The provision for ABE type portable fire extinguishers should exceed the minimum requirements of the Australian Standard such that there is portable fire extinguisher coverage around the High Bay Zone in order to offset the omission of the fire hose reels; and
    d. Refer to Appendix V for details; and
19. Emergency lighting in accordance with AS2293.1:2005, with the exemption of the following:
    a. Omit the requirement for emergency lighting above the high bay racking system located within the high bay area. Refer to Figure 0.6 for further details; and
    b. Exit signs and directional exit signs are to be installed throughout the building in accordance with Clauses E4.5, E4.6 and E4.8 from Volume One of the NCC and AS2293.1:2005 with the exception that the mounting heights of exit signage within the warehouse portions (excluding the high bay areas). The directional and non-directional exit signs are to be "JUMBO" signs and furthermore, the top of the exit signs (within the warehouse portion only) shall be mounted no more than 6.0m above the finished floor level.

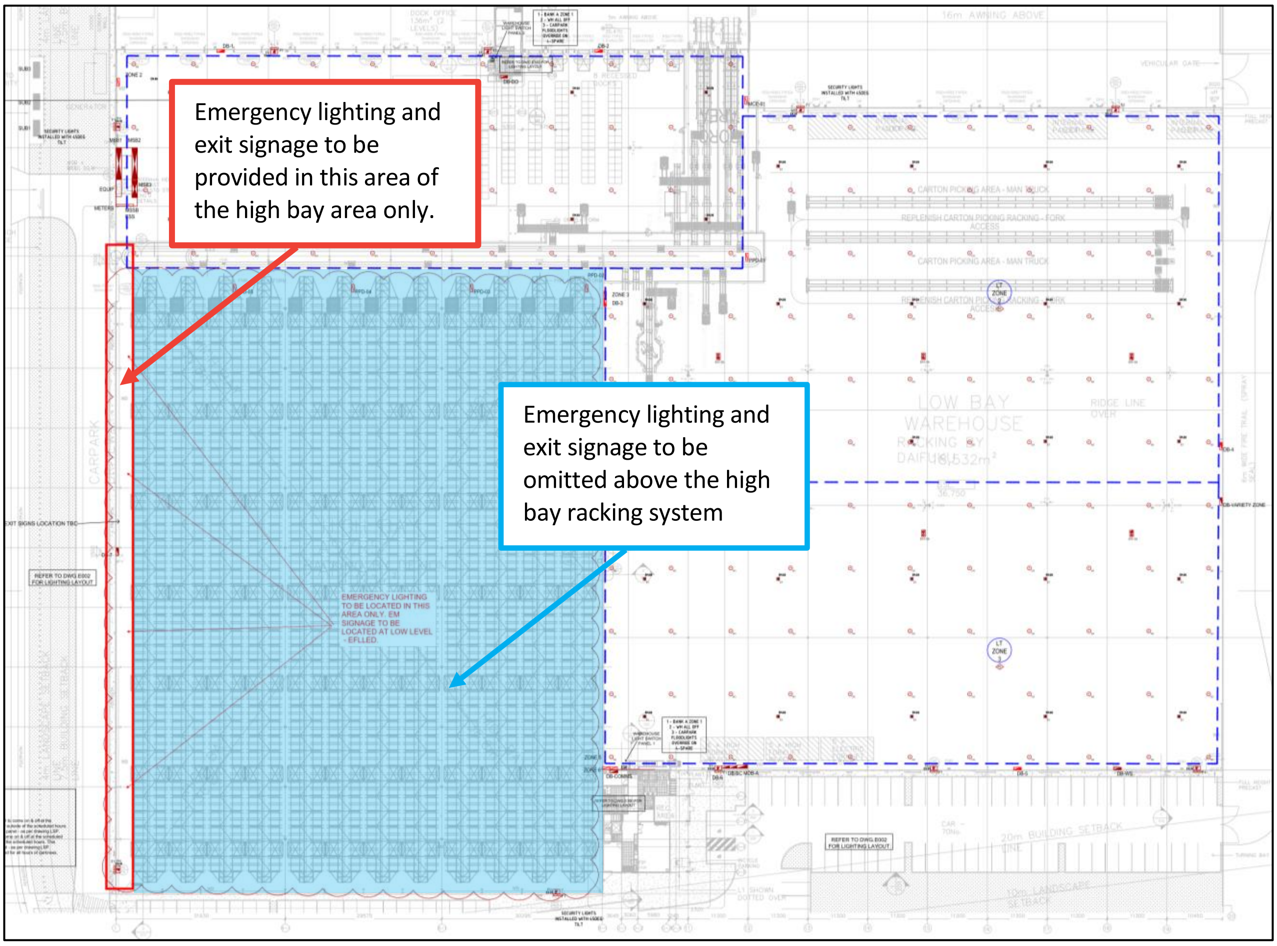

Figure 0.6: Location of emergency lighting and exit signage provided to the high bay area

    c. The high bay area shall be installed with low level LED Emergency spitfire lighting to the small maintenance corridor (only) located along the southern edge of the high bay area; and
    d. Jumbo Emergency Exit signage shall be provided over the doorways exiting the building.

    Note: There is no requirement for general lighting or emergency lighting throughout the high bay racking system as it is automated.

20. The high bay area that consists of the following electrical supplies; (DB:7, PPD-01, PPD-02, PPD-03, PPD-04, PPD-05, MCP-01 (Future), MCP-02 & PPD-06 (Future).
    a. All of these electrical supplies are fed directly from one of the three Mains Switchboards that are all located together in the Main Switch room.
    b. Each independent submain supply shall be labelled at each respective MCCB on the relevant MSB. Furthermore, drawings shall be provided within the MSB Room showing each of the noted electrical supplies for clarity should FRNSW require to de energise these DB's.

0.5.4 Vehicular Access and Open Space Provisions

1. The perimeter vehicular access serving the development shall be continuous and comply with the DtS provisions from Volume One of the NCC unless otherwise identified herein:
    a. A 6.0m wide perimeter vehicular access zone shall be created along the full length of the on the adjacent allotment such that the vehicular access on the adjacent allotment can be utilised as continuous perimeter vehicular access for Snackbrands (Stage 1); and
2. To further assist the attending fire brigades, additional signage shall be provided (externally along the building) from the vehicular entry location and along the perimeter access road directing fire crews to the location of the FIP which is situated within the building's main entrance. Refer to Appendix W for details; and
3. Any gates forming part of the perimeter vehicular access road that are proposed to be locked are required to be fitted with suitable conventional 003 padlocks or alternatively, the responding fire services shall be provided with building keys to enable fire-fighter access with a standard key; and
    a. A secure key box shall be provided and located at the front gate to house the building/site keys for the attending fire crew. The security code to the secure key box shall be provided to the FRNSW and this information shall form part of the emergency response plan to the site ((refer to Appendix W and Appendix P)); and
4. The vehicular access shall be designed to accommodate turning arcs for General Appliance Access (as prescribed within Policy No. 4: Guidelines for Emergency Vehicle Access); and
5. Maintain the perimeter vehicular access paths free of static storage and combustible materials at all times.

0.5.5 Storage and Handling of Dangerous Goods:

1. The client has not advised that any dangerous goods will be handled and situated within the development; and
2. As confirmed by Snackbrands (refer to Appendix S), a supply of full and empty 9kg gas bottles will be required for running gas forklifts. The gas bottles will be stored in Australian Standard gas bottle cages located external to the building under the awning. Snackbrands have confirmed the following number of gas bottles to be located on site at any one time as follows:
    a. 20 x 9kg full bottles; and
    b. 10 x 9kg full bottles
3. Further to the previous and with regards to the nature/quantity of materials stored within the subject building, the application of Clauses E1.10 and E2.3 have been deemed not to apply for this project (refer also to Appendix O for further details) and hence, there is specific requirement for any additional provisions to further assist with firefighting purposes over and above those forming part of the detailed trial design. This matter has also been confirmed by the PCA (refer to Appendix O) and the correspondence from Snackbrands confirming the nil storage of Dangerous Goods (refer to Appendix S); and
4. Should the storage and handling of dangerous goods be proposed at any point into the future, this fire engineering documentation would be required to be re-assessed by a competent fire safety engineer.

0.5.6 High Bay Area:

1. Further to the FEBQ comments, it is acknowledged by the design/certification team and the end user that an Emergency Management Procedure (EMP) has been documented and provided within the Fire Safety Engineering Report (FSER) (or as part of the Clause 144 submission) detailing the following (refer to Appendix P for details):
    a. How the high bay area is to function (on a day-to-day basis) and furthermore, the procedures for occupant access/restricted access to the high bay areas during these times; and
    b. Process/procedures during scheduled maintenance periods within the high bay area; and

c. High bay area shut down procedures whilst trained occupants are located with the ASRS/high bay zone.
d. Power isolation procedures including the availability of trained persons assisting with isolating the power in the event that the FRNSW arrive and are required to intervene and undertake firefighting operations.

Moving forward & to support the FSER/EMP, the normal operational & maintenance procedures shall be documented and subsequently implemented in the high bay area and shall be made available as part of the Clause 144 submission. For the purposes of the subject FEBQ submission, the following brief summary has been confirmed by Snackbrands:

a. The high bay area is to be isolated from the low bay areas by either full height fence or pedestrian fence and not accessible to any personnel under normal operating circumstances.
b. The high bay area will only be accessible by suitably trained maintenance personnel (i.e. machine shutdowns, power isolations etc.).
c. In case of an emergency, at least one (1) trained personnel per shift (i.e. Snackbrands employee) on site will be available to support FRNSW intervention including the non-business hours.
d. Snackbrands have advised that a maintenance schedule shall include the following activities:
    i. Preventative Maintenance Activity …. (Weekly)
    ii. Emergency Maintenance … only in the event of a breakdown/malfunction
    iii. Operational maintenance … trouble with products etc (pending quality of products …may be daily).

0.5.7 Management in Use Requirements:

1. Maintain paths of travel to an egress, stair entrances, pedestrian doorways and thoroughfares free of static storage and combustible materials at all times; and
2. Smoking shall not be permitted within the building; and
3. All fire safety measures and Management in Use requirements shall be incorporated into an Essential Services list. All fire safety measures shall be maintained in accordance with the requirements of AS1851 (or equivalent maintenance standard) as identified by Scientific Fire Services. Management in Use requirements shall be inspected and logged on an annual basis; and
4. Snackbrands Australia has confirmed that the future expansion area located within the high bay will not be used for storage or any other operational activities, refer to Appendix H for details; and
5. The recommendations forming part of the performance solution shall be identified as part of the Fire Safety Schedule for the subject premises and is to form part of the building's Essential Safety/Services List. Furthermore, the following notes shall be added to the Fire Safety Schedule for the subject building:
    a. In the event that Altis Property Partners sell the adjacent vacant property to Snackbrands. A reassessment will need to be undertaken to re-address the perimeter vehicular access provisions including any openings located within 3m from the title/leasing boundary for both building(s);
    b. Further to the previous, if the subject proposed building and the future building are to be owner operated by Snackbrands Australia, the entire development shall be treated as a united building whereby future egress door may be introduced between the subject proposed building and the future building which can be designed to be treated as horizontal exits if required.

0.6 Brief Statement on Acceptability of Proposed Performance Solution

The basis of the following assessment, conditions, methodologies and acceptance criteria, the general and specific objectives, relevant hazards, preventative measures, the proposed trial design etc. are however, considered to be detailed within this report. The above requirements are not limiting. Schedules and records must be in accordance with AS1851-2012. There shall be evidence of all inspection whether maintenance was required or not. It is drawn to the client's attention that if this maintenance is not undertaken as per these instructions he may be fully liable to legal responsibilities and without the cover of insurance.

0.7 Fire & Rescue Comment to FEBQ Submission

Scientific Fire Services Pty Ltd prepared the preceding Fire Engineering Brief (FEB) prior to this formal assessment being undertaken. The Fire Engineering Brief (FEB) (Ref. No.: 214318, version: 3.0, dated 18/03/2019) was issued to the design team, including the fire authority for comment. A Fire Engineering Brief Questionnaire (FEBQ) was formally submitted to Fire and Rescue NSW (FRNSW) for formal comment.

Scientific Fire Services Pty Ltd has consulted with the relevant stakeholders in relation to the general elements of the Fire Safety Engineering Report (FSER) and has documented the various elements of the FSER in accordance with agreements reached during the FEB and building design process.

Table 0.2: FRNSW comments and SFS response

No	FEBQ Reference: FEBQ Ver. 02 FEBQ Comments: FRNSW Response to FEBQ Ver. 01	FEBQ Reference: FEBQ Ver. 03 SFS Comments to FRNSW (SFS Response to FEBQ Ver. 02)	FEBQ Reference: FEBQ Ver. 04 FEBQ Comments (FRNSW Response to FEBQ Ver. 03)	SFS Comments to FEBQ Ver. 04	FSER Reference
1	– Preventative and protective measures – Fire Services and Equipment 1. ☐ Fire control centre	SFS to tick the relevant box relating to Fire Control Centre in the FEBQ. Refer to FEBQ (Ref. No. BFS19/371, v03) vi. Refer to the email attachments for further detail regarding FM Global Guidelines specific to this project; and	N/A	Noted and amended. No further action required.	Refer to Item 6 of Section 0.5.3 of this report
2	– Preventative and protective measures – Fire Services and Equipment 2. FRNSW: Clarification should be provided as to where this type of sprinkler system would be installed within the subject building.	The sprinkler system serving the warehouse shall be installed in accordance with AS2118.1:2017 and FM Global requirements as detailed in the relevant report prepared specific for this project (as attached in Appendix N).	**FRNSW:** Noted.	FM Global requirements specific for this project have be provided in this report.	Refer to Item 2 of Section 0.5.3 and Appendix N of this FSER.
3	– Preventative and protective measures – Fire Services and Equipment 5.	To permit the main Fire Indicator Panel (FIP) to be located within the main office which is not within the main entrance of the site: Additional signage shall be provided (externally) from the vehicular entry location and along the perimeter vehicular access road directing fire crews to the location of the FIP situated at the building's main entry location; and	**FRNSW:** Noted.	Performance solution associated with the location of the Fire Indicator Panel (FIP) has been addressed in this report.	Refer to Section 15 and Appendix W of this report.
4	– Preventative and protective measures – Fire Services and Equipment 6. Given the floor area proposed, FRNSW recommends that the location of a fire control centre be included in the assessment.	As highlighted by the FRNSW in its response to the FEBQ (v02) and as further confirmed by the PCA, the location of the fire control centre/FIP is not within the main entrance. The location of the fire control centre/FIP has been included into the FEBQ (v03) as an additional design issue to be addressed via a fire Performance Solution.	**FRNSW:** Noted. Given that the FEBQ is a standalone document, FRNSW recommend the relevant information be provided in this document for review. FRNSW also recommend the requested information should also be provided in the FER.	Noted. Information relative to the FIP location has been documented in this report.	Refer to Section 15 and Appendix W of this report.
5	– Preventative and protective measures – Fire Services and Equipment 11. FRNSW recommend any future submissions detail the location of the FBBA.	The location of the fire brigade booster assembly has been provided in Appendix O.	**FRNSW:** Noted. Given that the FEBQ is a standalone document, FRNSW recommend the relevant information be provided in this document for review.	Noted. Information relative to the fire brigade booster assembly location has been documented in this report.	Refer to Appendix T of this report.
6	– Preventative and protective measures – Fire Services and Equipment FRNSW: Including high bay area?;	With respect to the high bay area only, Modcol Pty Ltd (electrical engineering consultant) has confirmed (refer to Appendix C) that emergency lighting and exit signage is only provide to the small maintenance corridor located along the southern edge of the high bay area. This is the only occupant accessible areas (mostly by maintenance personnel) as the broader parts of the high bay area are restricted from occupant access. JUMBO emergency exit signage shall be provided over the doorways exiting the building. There is no requirement for emergency lighting and exit signs throughout the high bay racking system as it is automated. As highlighted by the FRNSW in its response to the FEBQ (v02) and as further confirmed by the PCA, the omission of emergency exit sign/lighting above the high bay racking system (only) will form part of the Performance Solution.	N/A	Performance solution to omit the requirement of emergency exit sign and lighting from the high bay racking system (only) has been addressed in this report.	Refer to Item 19 of Section 0.5.3, Section 14 and Appendix Q of this report.
7	– Preventative and protective measures – Fire Services and Equipment 20.	20. Emergency lighting shall be designed and installed throughout the building in accordance with AS2293.1:2005, with the exemption of the following: a. It is proposed to omit the requirement for emergency lighting above the high bay racking system located within the high bay area. Refer to Error! Reference source not found. for further details; and Note: The small maintenance corridor located along the southern edge of the high bay area shall be provided with emergency lighting; and	**FRNSW:** Noted.	Performance solution to omit the requirement of emergency exit sign and lighting from the high bay racking system (only) has been addressed in this report.	Refer to Item 19 of Section 0.5.3, Section 14 and Appendix Q of this report.

No	FEBQ Reference: FEBQ Ver. 02 FEBQ Comments: FRNSW Response to FEBQ Ver. 01	FEBQ Reference: FEBQ Ver. 03 SFS Comments to FRNSW (SFS Response to FEBQ Ver. 02)	FEBQ Reference: FEBQ Ver. 04 FEBQ Comments (FRNSW Response to FEBQ Ver. 03)	SFS Comments to FEBQ Ver. 04	FSER Reference
8	– Preventative and protective measures – Fire Services and Equipment 21.	21. Exit signs and directional exit signs are to be installed throughout the building in accordance with Clauses E4.5, E4.6 and E4.8 from Volume One of the NCC and AS2293.1:2005, with the exception of the following: a. The directional and non-directional exit signage within the warehouse portions (with the exception of the high bay racking area) of the building shall be "JUMBO" signs and shall be mounted greater than 2.7m above finished floor level. The exact mounting height shall be confirmed within the subsequent Fire Safety Engineering Report (FSER); and b. It is proposed to omit the requirement for exit signage above the high bay racking system located within the high bay area. Refer to Error! Reference source not found. for further details; and Note: The small maintenance corridor located along the southern edge of the high bay area shall be provided with emergency exit signs (i.e. Clevertronics EFLLED signage as detailed in the email attachments).	**FRNSW:** Noted.	Performance solution to permit the top of the exit signs within the warehouse portions (except from the high bay racking system) to be greater than 2.7m. Performance solution to omit the requirement of emergency exit sign and lighting from the high bay racking system (only) has been addressed in this report.	Refer to Section 13 of this report. Refer to Item 19 of Section 0.5.3, Section 14 and Appendix Q of this report.
9	6 – Preventative and protective measures – Vehicular Access and Open Space Provisions FRNSW recommends that the assessment take into consideration that the two nearest fire stations may not always be available to attend a fire call at this site	The Fire Brigade Intervention Model has been amended (in the FEB and FEBQ) to include a third fire station. A third fire station shall also form part of the FBIM calculation in the imminent Fire Safety Engineering Report (FSER). (Refer to Fire Brigade Intervention Model for an additional (i.e.: total of 3) fire station near the subject site)	**FRNSW:** Noted. This comment was more to alert to the fact that the responding crews may not have access to the building keys referred to above. Would crews without building keys be able to access the fence gates? This should be clarified in the FER.	The Fire Brigade Intervention Model (FBIM) calculations has considered three (3) fire stations as follows: • St. Marys Fire Station; and • Mount Druitt Fire Station; and • Penrith Fire Station. Furthermore, as a recommendation of his report, any gates forming part of the perimeter vehicular access road that are proposed to be locked are required to be fitted with suitable conventional 003 padlocks or alternatively, the responding fire services shall be provided with building keys to enable fire-fighter access with a standard key. In addition, a secure key box shall be provided and located at the front gate to house the building/site keys for the attending fire crew. The security code to the secure key box shall be provided to the FRNSW and this information shall form part of the emergency response plan to the site.	FBIM calculations provided in Section 7 of this report. Location of secure key box is provided in Appendix W of this report. Refer to Appendix P
10	6 – Preventative and protective measures – Storage and Handling of Dangerous Goods	2. As confirmed by Snackbrands (refer to email attachments for further detail regarding Dangerous Goods specific to this project), a supply of full and empty 9kg gas bottles will be required for running gas forklifts. The gas bottles will be stored in Australian Standard gas bottle cages located external to the building under the awning. Snackbrands have confirmed the following number of gas bottles to be located on site at any one time as follows: a.20 x 9kg full bottles; and b.10 x 9kg full bottles	**FRNSW:** FRNSW notes the advice provided by the PCA.	Relevant information associated with Dangerous Goods specific to this project has been provided in this report.	Refer to Section 0.5.5 and Appendix S of this report.

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11	6 – Preventative and protective measures – High Bay Area	Further to the FEBQ comments, it is acknowledged by the design/certification team and the end user that an Emergency Management Procedure (EMP) shall be documented and provided within the Fire Safety Engineering Report (FSER) (or as part of the Clause 144 submission) detailing how the high bay area is to function (on a day-to-day basis) and furthermore, the procedures for occupant access/restricted access to the high bay areas during these times. Similarly, the procedures will also include the process/procedure during scheduled maintenance periods within the high bay area and again, the high bay area shut down procedure whilst trained occupants are located with the ASRS/high bay zone. Details will also include power isolation procedures including the availability of trained persons assisting with isolating the power in the event that the FRNSW arrive and are required to intervene and undertake firefighting operations. Moving forward & to support the FSER/EMP, the normal operational & maintenance procedures shall be documented and subsequently implemented in the high bay area and shall be made available as part of the Clause 144 submission. For the purposes of the subject FEBQ submission, the following brief summary has been confirmed by Snackbrands: The high bay area is to be isolated from the low bay areas by either full height fence or pedestrian fence and not accessible to any personnel under normal operating circumstances. The high bay area will only be accessible by suitably trained maintenance personnel (i.e. machine shutdowns, power isolations etc.). In case of an emergency, at least one (1) trained personnel per shift (i.e. Snackbrands employee) on site will be available to support FRNSW intervention including the non-business hours. Snackbrands have advised that a maintenance schedule shall include the following activities: Preventative Maintenance Activity …. (Weekly) Emergency Maintenance … only in the event of a breakdown/malfunction Operational maintenance … trouble with products etc (pending quality of products …may be daily).	**FRNSW:** Noted.	The Emergency Management Procedures (EMP) has been provided in this report.	Refer to Section 0.5.6 and Appendix P of this report.
12	6 – Preventative and protective measures – Management in Use Requirements FRNSW: Please note that in the event dangerous goods are proposed to be stored/handled/used on site, additional requirements within the NCC would be required to be met (see further comment below). Where a Fire Safety Study or a risk assessment has been requested to be prepared by the consent authority, considerations from such study would need to be accounted for as part of the fire engineering assessment and would subsequently require further consultation with FRNSW. Regardless of whether or not storage of dangerous/hazardous goods are proposed within the subject building, FRNSW recommend providing clarification in the FER (and in the next version of the FEBQ if applicable) as to how Clauses E1.10 and E2.3 have been met, as these clauses relate to “suitable additional provision” for “fighting fire” or “additional smoke hazard management measures” “because of … the nature or quantity of materials stored, displayed or used in a building…” or “due to the … special type or quantity of materials stored, displayed or used in a building”.	As confirmed by Snackbrands, no dangerous goods will be stored within the building. A supply of full and empty 9kg gas bottles will be required for running gas forklifts. The gas bottles will be stored in Australian Standard gas bottle cages located external to the building under the awning. Snackbrands have confirmed the following number of gas bottles to be located on site at any one time as follows: •20 x 9kg full bottles; and •10 x 9kg full bottles. With regards to the nature/quantity of materials stored within the subject building, the application of Clauses E1.10 and E2.3 have been deemed not to apply for this project (refer also to Appendix R for further details) and hence, there is specific requirement for any additional provisions to further assist with firefighting purposes over and above those forming part of the detailed trial design. This matter has also been confirmed by the PCA (refer to Appendix R) and the correspondence from Snackbrands confirming the nil storage of Dangerous Goods (refer to Appendix Q); (refer to email attachments for further detail regarding Dangerous Goods specific to this project)	**FRNSW:** FRNSW notes the advice provided by the PCA.	Relevant information associated with Dangerous Goods specific to this project has been provided in this report.	Refer to Appendix S of this report.

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13	7 – Departures from the Deemed-to-Satisfy provisions Issue 1 - Open Space & Vehicular Access FRNSW recommends that the assessment take into consideration that the two nearest fire stations may not always be available to attend a fire call at this site.; FRNSW Comment: In principle support is provided subject to the analysis in the FER demonstrating compliance with the performance requirements of the NCC.	(Refer to Fire Brigade Intervention Model for an additional (i.e.: total of 3) fire station near the subject site) The Fire Brigade Intervention Model has been amended (in the FEB and FEBQ) to include a third fire station. A third fire station shall also form part of the FBIM calculation in the imminent Fire Safety Engineering Report (FSER).	**FRNSW:** Noted.	The Fire Brigade Intervention Model (FBIM) calculations has considered three (3) fire stations as follows: • St. Marys Fire Station; and • Mount Druitt Fire Station; and • Penrith Fire Station.	FBIM calculations provided in Section 7 of this report.
14	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW: References and/or justification should be provided for proposing a peak heat release rate of 8.7MW. Justification should also be provided as to why fast t2 growth rate was selected for this scenario, whereas all other growth rates utilise an ultra-fast t2 growth rate.	(Refer to justification in SB03: Fuel Controlled Fire – Forklift & Storage Pallet Fire (Core) below)	**FRNSW:** Noted.	Justification of a fast t^2 fire growth rate for SB03 is provided in Appendix F of this report. SB03 represents a combined timber pallet and forklift fire. As justified in Appendix F, a forklift resembles a small vehicle (i.e. car). Based on the statistical data, a timber pallet fire would achieve an ultra-fast t^2 growth rate while the growth rate of a forklift (i.e. car) will achieve a medium t^2. By combining the two (2), the superimposed graph of the growth rate is akin to a fast t^2 growth rate.	Refer to Appendix F of this report.
15	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW: The assumption of utilising a medium t2 fire growth rate with a peak heat release rate of 2.5MW for this scenario appears to be inconsistent with the assumption made on page 32 of this document. Clarification is required.	(the justification above were based on forklift fire compared to a small car fire on its own without the timber storage pallet fire)	**FRNSW:** Further details such as references should be provided to demonstrate that this growth rate assumption is appropriate for a forklift fire.	Refer to Item 14 above.	Refer to Appendix F of this report.
16	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management **FRNSW:** As per the previous comment, it appears that the information presented for this scenario (which considers both pallet fires and a forklift fire) is inconsistent with the information of this document. Clarification is required.	(minor adjustments have been made, the custom growth rate fire is a representative of a combined fire of forklift and pallet fire)	**FRNSW:** Noted.	Noted. Justification provided within this report.	Refer to Appendix F of this report.
17	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management	From the above, a soot yield value has been nominated based on the following points: •Taking into consideration the large volume and height of the warehouse facility, it can be assumed that in the event of a fire the amount of soot being deposited on the ceiling structure will be less in comparison to a smaller enclosure such as an office tenancy where more soot would be expected to be contained within the smoke layer; and •Due to the open nature of the warehouse, a fire is expected to be well ventilated involving a composition of materials with a range of soot yields extracted from text references (as listed above); and •The vast majority of material soot yields detailed above range from 0.007kg/kg to 0.172kg/kg; and •An average of the above equates to a soot yield of 0.070kg/kg. Based on the above, it is proposed to round up the average of 0.070kg/kg and conservatively adopt a soot yield value of 0.075kg/kg for fire modelling purposes.	N/A	Noted. Justification provided within this report.	Refer to Appendix D of this report.

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18	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW: Calculations used as part of estimating the weighted average value should be presented in the FER.	(it is proposed to round up the average of 0.070kg/kg and conservatively adopt a soot yield value of 0.075kg/kg for fire modelling purposes)	**FRNSW:** FRNSW recommend either a weighted average value or a much more conservative value be used in order to ensure that fuels with larger soot yields are sufficiently accounted for especially when the worst-credible fuel loads within the building could predominantly consist of these types of fuels.	Scientific Fire Services considers that the average approach is reasonable approach in determining the soot yield within the building. A "weighted" average soot yield is not deemed appropriate as the precise fuel load content and amount of fuel will vary due to the nature of the building function and use. Furthermore, it should be noted that there are aisleways between racks which does not contain any storage which further reduces the average of the soot yield commodity. In this regard, the analysis has adopted an average soot yield of 0.075kg/kg to represent the various materials stored throughout the building.	Refer to Appendix D of this report.
19	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management Summary of CFD Input Parameters: **FRNSW:** To adequately account for fire brigade life safety, FRNSW recommend the simulation time be based on the time to 'water on' as per fire brigade intervention operations.	(the extended simulation time to 2700 seconds includes the 'water on' intervention operations)	**FRNSW:** Noted.	The fire brigade intervention time was extended to 3000 seconds. At the completion of the fire and smoke modelling simulations (i.e. 3000 seconds), the temperature conditions maintained steady state conditions (i.e. temperatures do not exceed 100°C at 1.5m above the finished floor level for routine conditions). Although the FBIM time for the 3rd corresponding fire station (Penrith Fire Station) completed at 3363 seconds. The conditions beyond 3000 seconds is not likely to worsen as the temperature conditions maintained steady state conditions.	Refer to Section 7 of this report.
20	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management Summary of CFD Input Parameters: **FRNSW:** Please refer to comments regarding the estimation of this value.	(it is proposed to round up the average of 0.070kg/kg and conservatively adopt a soot yield value of 0.075kg/kg for fire modelling purposes)	**FRNSW:** Noted.	Noted.	Refer to Appendix D of this report.
21	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW: FRNSW recommend all inputs and assumptions used as part of the Pathfinder analysis be outlined in the FER. FRNSW: FRNSW acknowledge the limitations presented by high bay automated areas. However in the event of a fire or alarm, FRNSW are responsible for deeming the area safe and this will require crews investigating the source of the alarm. FRNSW recommends that the assessment discuss / include the following; FRNSW is of the opinion that suitable additional provisions should be made with regard to fire brigade intervention due to the nature in which the materials are stored within the automated portion pursuant to Part E1.10 of the BCA.	. (refer to email attachments for further detail regarding the content to be stored, and the requirements of Clause E1.10 of the BCA will not apply in this instance specific to this project)	**FRNSW:** Noted. However FRNSW considers that automated high bay racking does present a special hazard in respect to firefighting.	The high bay area is large volume consisting of an Automatic Storage and Retrieval System (AS/RS). It is not expected for this area to be heavily populated as only maintenance staff will be present. An aspirating (VESDA) smoke detection and alarm system in accordance with AS1670.1:2015 is required to be installed within the high bay area to provide early detection to the building occupants and early notification to the fire brigade. Furthermore, an Emergency Management Procedures (EMP) manual has been documented to assist fire brigade intervention.	Refer to Appendix J and Appendix U of this report for fire hydrant system coverage. Refer to Appendix P of this report for Emergency Management Procedures (EMP). Refer to Appendix T of this report for fire brigade booster assembly location drawing. Refer to Appendix U of this report for VESDA design layout.
22	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management With obvious restrictions to fire brigade intervention, FRNSW recommends that consideration be afforded to the inclusion of a VESDA system or similar in the automated high bay area in order to allow much earlier intervention.	(As the automated high bay area shall be provided with high ceiling sprinklers and in rack sprinklers in accordance with FM global as well as limited occupant access (maintenance staff only) to the fully automated high bay area, in this instance a VESDA system will not be provided)	**FRNSW:** Noted. However FRNSW recommendation was a proposal to assist with fire brigade intervention within a dangerous and complex structure.	An aspirating (VESDA) smoke detection and alarm system in accordance with AS1670.1:2015 is required to be installed within the high bay area to provide early detection to the building occupants and early notification to the fire brigade.	Refer to Appendix U of this report for VESDA design layout.

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23	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW interpretation is that for a fire/alarm in the high bay area, FRNSW will not be able to enter the area due to the dangers of electricity and no access to the higher levels; as such FRNSW will require trained personnel to be available ASAP.	(refer to the operational procedures attachments within the FEBQ submission email)	**FRNSW:** There appears to be no operational procedures attached with the submission. FRNSW recommend further details be provided to allow for an adequate assessment to be undertaken.	An Emergency Management Procedures (EMP) manual has been documented to assist fire brigade intervention.	Refer to Appendix P of this report for Emergency Management Procedures (EMP).
24	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management For alarms out of business hours, FRNSW recommends that trained personnel in the operation of the high bay area, be immediately notified upon alarm and attend site.	(refer to the operational procedures attachments within the FEBQ submission email)	**FRNSW:** There appears to be no operational procedures attached with the submission. FRNSW recommend further details be provided to allow for an adequate assessment to be undertaken.	The Emergency Management Procedures (EMP) manual details procedures for the attending fire brigade for alarms out of business hours.	Refer to Appendix P of this report for Emergency Management Procedures (EMP).
25	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW recommends that this information be provided at the FCC, all fire panels and access gate to the high bay storage in addition to signage informing FRNSW that no access to the high bay area is permitted without a trained maintenance personnel present.	(refer to the operational procedures attachments within the FEBQ submission email)	**FRNSW:** There appears to be no operational procedures attached with the submission. FRNSW recommend further details be provided to allow for an adequate assessment to be undertaken.	Details of gates and fences around the high bay areas have been provided in this report.	Refer to Appendix X of this report for
26	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management Details of the isolation of the electrical supply to the area and how this is conveyed to FRNSW crews is recommended to be discussed in the assessment.	(refer to the operational procedures attachments within the FEBQ submission email)	**FRNSW:** There appears to be no operational procedures attached with the submission. FRNSW recommend further details be provided to allow for an adequate assessment to be undertaken.	An Emergency Management Procedures (EMP) manual has been documented to assist fire brigade intervention. Main switchboard schematic drawing provided in this report.	Refer to Appendix P of this report for Emergency Management Procedures (EMP). Refer to Appendix Q of this report for Main switchboard schematic drawing.
27	7 – Departures from the Deemed-to-Satisfy provisions Issue 2 – Exit Travel Distance & Smoke Hazard Management FRNSW recommends that a proposed emergency management procedure be provided in the FER. This document is to include procedures to be followed in respect to power shutoff and access to high levels for FRNSW crews to investigate and extinguish fires.	(refer to the operational procedures attachments within the FEBQ submission email)	**FRNSW:** There appears to be no operational procedures attached with the submission. FRNSW recommend further details be provided to allow for an adequate assessment to be undertaken. FRNSW does not support the alternative solution. The responses have failed to alleviate FRNSW concerns provided in red. With a 36.8m high bay automated racking, no details have been provided how FRNSW are expected to access the structure to ensure complete extinguishment and allow handover to owner post fire event.	An Emergency Management Procedures (EMP) manual has been documented to assist fire brigade intervention.	Refer to Appendix P of this report for Emergency Management Procedures (EMP).
28	7 – Departures from the Deemed-to-Satisfy provisions Issue 3 – Fire Hydrants FRNSW: It is unclear how the above relates to hydrant locations.	(Refer to Fire Hydrant services drawings within Section 9 additional comments and attachments within the FEBQ submission email)	**FRNSW:** Noted. Given that the FEBQ is a standalone document, FRNSW recommend the relevant information be provided in this document for review. FRNSW also recommend the requested information should also be provided in the FER. FRNSW notes the area marked on the submitted drawings 'HYDRANT SHORT FALLS' however FRNSW recommends the proposed alternative solution being presented to FRNSW to assist with fire brigade intervention within this area be detailed here.	Fire hydrant assessment has been qualitatively and quantitatively assessed in this FSER. Furthermore, fire hydrant shortfall drawing has been provided.	Refer to Section 12 and Appendix J.
29	7 – Departures from the Deemed-to-Satisfy provisions Issue 3 – Fire Hydrants ☐ Quantitative FRNSW: Insufficient information provided to provide comment.	(Refer to fire hydrant services drawings within Section 9 additional comments and attachments within the FEBQ submission email)	**FRNSW:** Insufficient information has been provided in order to the demonstrate that the relevant Performance Requirement has been met. On this basis, FRNSW is unable to provide support for the proposed alternative solution.	Fire hydrant assessment has been qualitatively and quantitatively assessed in this FSER. Furthermore, fire hydrant shortfall drawing has been provided.	Refer to Section 12 and Appendix J.

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30	7 – Departures from the Deemed-to-Satisfy provisions Issue 4 – Fire Hose Reels FRNSW recommend the fire engineering analysis provide further discussions in relation to the size of the floor area covered by the omitted fire hose reel coverage, and the fire hazard within the area.	(Refer to fire hose reel services drawings within Section 9 additional comments and attachments within the FEBQ submission email)	**FRNSW:** The additional information presented with the submission does not appropriately and adequately demonstrate meeting Performance Requirement EP1.1 with regards to the size of the floor area of omitted coverage and the fire hazard. On this basis, FRNSW do not support the proposed alternative solution.	Fire hose reel shortfall assessment has been assessed in this FSER. Furthermore, fire hose reel shortfall drawing has been provided.	Refer to Section 11 and Appendix K of this report
31	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) **FRNSW:** For assessments where the height of the exit sign is assessed: An occupant should always be in a position to be able to see an exit sign. This should consider both the sign being within the occupants field of view, as well as occupants being able to see the exit sign through smoke.	Occupant field of view has been documented forming part of the methodology/acceptance criteria for this design issue and furthermore, the assessment shall be carried out and substantiated within the assessment in the FSER.	**FRNSW:** Noted.	Exit sign height assessment within the warehouse portions, with the exception of the high bay areas has been adequately addressed in this report.	Refer to Section 13 of this report.
32	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) • The visibility of exit signs should be assessed for all fire scenarios and the times assessed should be based on a minimum of the RSET multiplied by the required factor of safety. In assessing the visibility of exit signs, the following should be considered: o The visibility factor used in any CFD modelling should be considered. Generally, FRNSW consider that a Visibility Factor of 3 for light reflecting signs should be used in CFD models, as occupants need to be able to see other obstructions when trying to evacuate. o Should the Visibility Factor be 3 as recommended, a visibility of 10 metres would be considered appropriate for a standard sized exit sign based on light reflecting signs having a visibility of approximately 2.6 (8/3) times further, meaning that the equivalent visibility for an illuminated exit sign would be 26 metres, which is within the viewing distance (24 metres for a standard exit sign).	Visibility factor of 3 for light reflecting signs will be considered in the fire and smoke modelling simulations.	**FRNSW:** Noted.	Visibility factor of 3 for light reflecting signs has been considered in the fire and smoke modelling simulations.	Refer to Appendix D of this report.
33	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) It is noted that if exit signs with viewing distances of greater than 24 metres are to be used, then the visibility would need to be increased accordingly. It is noted that some designs may include jumbo sized exit signs.	Jumbo exit signs have been provided as part of the Performance Solution throughout the warehouse portions of the building.	**FRNSW:** Noted.	Jumbo exit signs have been provided as part of the Performance Solution throughout the warehouse portions (except within the high bay area) of the building.	Refer to Section 13 and Appendix Q of this report.
34	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) The proposed spacing and viewing distances of the proposed exit signs should be considered in the assessment to determine the appropriate visibility threshold for occupants to be able to see the exit signs. Alternatively, the resulting visibility may require exit signs to be spaced at closer intervals.	The proposed spacing and viewing distance of exit signs (mounted greater than 2.7m as detailed in Section 11) have been considered in the assessment methodology.	**FRNSW:** Noted.	Exit sign spacing and viewing distance (mounted greater than 2.7m) has been evacuated in this report.	Refer to Section 13 of this report.
35	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) The visibility or density of smoke should be taken at a conservative point, i.e. at least at the top of the height of the exit signs, and not at head height of occupants.	Noted and agreed		Assessment of occupant visibility to the top of the exit signs has been considered as part of the fire engineering assessment.	Refer to Section 13 of this report.

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36	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) The Trial Design should specify the exit signs that are required (i.e. standard or jumbo sized) and the required spacing between signs, based on the assessments undertaken on both field of view and visibility through smoke.	Noted and agreed		Noted and documented.	Refer to Section 13 of this report.
37	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) It needs to be demonstrated that the exit sign is not only in the viewing angle, but is also within the exit signs viewing distance and can be seen through any smoke.	Fire and smoke modelling simulations will determine the exit viewing distance	**FRNSW:** Noted.	Fire and smoke modelling simulations has determined the exit viewing distance.	Refer to Section 13 of this report.
38	7 – Departures from the Deemed-to-Satisfy provisions Issue 5 – Exit Signs (Excluding High Bay Area) At this point the first exit sign is out of the viewing angle, and it should be demonstrated that the second exit sign can now be seen.	Fire and smoke modelling simulations will determine that the second exit sign can be seen.	**FRNSW:** Noted.	Fire and smoke modelling simulations has determined that the second exit sign can be seen. Given the large volume of the warehouse and adequate safety factors (with respect to occupant visibility to exit signs), the evacuating occupants have ample time to identify the location of the second exit sign.	Refer to Section 13 of this report.
39	7 – Departures from the Deemed-to-Satisfy provisions Issue 6 – Exit Signs and Emergency (High Bay Area)	It is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. As confirmed by Modcol Pty Ltd (refer to Appendix T), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area. Clevertronics EFLLED signage (as detailed in Appendix P) shall be provided over the exit doorways serving the high bay area to assist occupant wayfinding. To omit the requirement for fire rose reel coverage to the High bay area. The 'Guide to the BCA' (ABCB, 2016) states that the intent associated with providing exit signage and lighting is "to assist in occupant wayfinding and minimise the risk of death or injury to occupants during an emergency because of an inability to find an exit". It is therefore considered that the main hazards specific to the issue to be considered in the assessment are: The potential for fire by-products (smoke and toxic gasses) to restrict the path of occupant travel (i.e. potential for tenability limits to be exceeded within the path of travel); and The potential for occupants to be trapped due to the inability to find an exit during a potential fire situation. The methodology adopted to address the design issue shall be a qualitative evaluation with respect to the building function and use of the high bay racking area, fire hazards, occupant characteristics (i.e. trained maintenance personnel), active fire safety systems (i.e. in-rack sprinklers) and the potential risk to occupant life safety within the high bay area. The basic objective and intent of this analysis pertains to the life safety of the building occupants within the high bay area during an evacuation. Thus, the primary acceptance criterion has been met having demonstrated that occupants can safely evacuate the high bay area with consideration to the building	**FRNSW:** It is understood that only a qualitative assessment shall be undertaken to assess the proposed alternative solution. Insufficient information has been provided in order to the demonstrate that the relevant Performance Requirement has been met. On this basis, FRNSW is unable to provide support for the proposed alternative solution.	As part of the Performance Solution, it is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. As confirmed by Modcol Pty Ltd (refer to Appendix R), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area. Clevertronics EFLLED signage (as detailed in Appendix S) shall be provided over the exit doorways serving the high bay area to assist occupant wayfinding. Exit signs are located above the exit doors. Furthermore, a quantitative ASET/RSET assessment has been undertaken demonstrating that the smoke layer height is maintained above the top of the exit sign (mounted at no more than 2.7m above the finished floor level) within the high bay area (maintenance corridor) for at least the time taken for occupants to evacuate the storage portion of the building.	Refer to Section 14, Appendix R and Appendix S of this report.

No	FEBQ Reference: FEBQ Ver. 02 FEBQ Comments: FRNSW Response to FEBQ Ver. 01	FEBQ Reference: FEBQ Ver. 03 SFS Comments to FRNSW (SFS Response to FEBQ Ver. 02)	FEBQ Reference: FEBQ Ver. 04 FEBQ Comments (FRNSW Response to FEBQ Ver. 03)	SFS Comments to FEBQ Ver. 04	FSER Reference
		function and use, fire hazards, occupant characteristics and active fire safety systems. N/A Fire Brigade Intervention to be assessed in subsequent Fire Safety Engineering Report (FSER) N/A N/A			
40	7 – Departures from the Deemed-to-Satisfy provisions Issue 7 – Fire Indicator Panel Location	With reference to AS1670.1:2015, the FIP is required to be located at the designated building entry point. In this instance, it has been identified that the FIP is located at the main office of the warehouse (eastern side of the site). Given the configuration of the site, the main vehicular entrance point is accessed via Distribution Drive (southern side). Therefore, the FIP location is not within the main entrance of the site. This is illustrated in Figure 13.1. The Guide to the BCA (ABCB 2016) details the intent behind the requirement for the fire indictor panel to be located within the main entrance of the site is to "To help fire brigade officers who will be carrying their equipment to reach the fire indicator panel and to make entry easier". It is therefore considered that the hazards for the location of the fire indicator panel relates to the required effort of the fire fighters in gaining access with their equipment and the effect the reduced clearance may have on the efficiency of fire access. The methodology adopted to address the design issue of the location of the fire indicator panel shall be a qualitative evaluation on the potential risk associated with the proposed location and the resulting impact on the attending fire brigade personnel. Furthermore; the assessment has evaluated and taken into consideration the panel locations which are considered to not have an impact on the fire brigade operations. The proposed design has been referred to the FRNSW as part of the design team stakeholder engagement, giving the fire authority an opportunity to provide comment as to the appropriateness of the design. The basic objective and intent of this analysis pertains to the life and operational safety of the attending fire brigade personnel while undertaking their standard operational procedures and the associated impact of the proposed location of the fire indicator panel and accessibility and functionality provisions. Thus, the primary acceptance criterion has been met having demonstrated that the proposed design satisfies fire-fighting Standard Operational Guideline's (SOG's) when identifying (i.e. locating) and accessing the fire indicator panel and introduces an equivalent level of operational and functional use to a DtS compliant solution. N/A Fire Brigade Intervention to be assessed in subsequent Fire Safety Engineering Report (FSER) N/A	It is unclear what the actual alternative solution is. Are there additional measures to assist crews locate the FIP from the main entrance? **FRNSW Comment:** In principle support is provided subject to the analysis in the FER demonstrating compliance with the performance requirements of the NCC and adequately addressing FRNSW comments.	Performance solution associated with the location of the Fire Indicator Panel (FIP) has been addressed in this report. To further assist the attending fire brigades, additional signage shall be provided (externally along the building) from the vehicular entry location and along the perimeter access road directing fire crews to the location of the FIP which is situated within the building's main entrance.	Refer to Section 15 and Appendix W of this report.

1. Introduction

1.1 General

This Fire Safety Engineering Report (FSER) has been prepared by Scientific Fire Services Pty Ltd (SFS) for Richard Crookes Pty Ltd. The report details the fire safety engineering assessment that has been undertaken on the proposed design of Snackbrands (Building 7), Orchard Hills, NSW (Stage 1) project.

The project is located at 585-649 Mamre Road, Orchard Hills, NSW and can be described as being comprised of the following BCA classifications.

Occupancy Use	BCA Classification
Industrial distribution centre (warehouse)	Class 7b (Storage)
Administration and docking office	Class 5 (Office)

The Building Solution proposed for this project, which is required to comply with the Performance Requirements of the National Construction Code 2016, Vol. 1, Building Code of Australia (BCA) (ABCB 2016), is a combination of Performance Solution and Deemed-to-Satisfy Solution elements in accordance with Clause A0.2 of the BCA.

Where requested, a Fire Engineering Brief (FEB) & Fire Engineering Brief Questionnaire (FEBQ) has been prepared. The FEB is the Performance-based Design Brief with specific reference to fire safety and is developed in collaboration with key stakeholders as part of the performance-based design and approval process.

A FEB [Ref. No.: 214318, dated 19/11/2018] and FEBQ [Ref. No.: FRB17/242-7, dated 01/04/2019, Ver.: V4: BFS19/938] was prepared for this project in accordance with the guidance of the International Fire Engineering Guidelines (IFEG)(ABCB 2005). This FSER includes the basis of the FEB and has taken into consideration relevant comments from the stakeholders.

1.2 Supporting Documentation

The assessment described in this report has been based on the referenced drawings prepared by Nettleton Tribe Partnership Pty Ltd. The drawings to which the assessment applies are listed in Appendix A.

The project issues, the proposed Building Solution and the intended assessment methodologies have been presented to and discussed with the relevant Fire Authority.

1.3 Scope

1.3.1 Regulatory Framework

The National Construction Code is a uniform set of technical provisions for the design and construction of buildings and other structures, and plumbing and drainage systems throughout Australia. It allows for variations in climate and geological or geographic conditions.

The BCA is given legal effect by building regulatory legislation in each State and Territory. This legislation consists of an Act of Parliament and subordinate legislation which empowers the regulation of certain aspects of buildings and structures, and contains the administrative provisions necessary to give effect to the legislation.

Each State and Territory's legislation adopts the BCA subject to the variation or non-requirement of some of its provisions, or the addition of extra provisions. These provisions are contained in Appendices to the BCA.

Any provision of the BCA may be overridden by, or subject to, State or Territory legislation. The BCA must therefore be read in conjunction with that legislation.

In accordance with BCA Clause A0.2, compliance with the BCA is achieved by satisfying the Performance Requirements.

The *Performance Requirements* can only be satisfied by a—

(a) *Performance Solution*; or

(b) *Deemed-to-Satisfy Solution*; or

(c) combination of (a) and (b).

In accordance with BCA Clause A0.3, a Performance Solution must comply with the BCA.

(a) A *Performance Solution* must—

  (i) comply with the *Performance Requirements*; or

(ii) be at least *equivalent* to the *Deemed-to-Satisfy Provisions*,

and be assessed according to one or more of the Assessment Methods.

(b) A *Performance Solution* will only comply with the NCC when the *Assessment Methods* used satisfactorily demonstrate compliance with the *Performance Requirements*.

A Performance Solution will only comply with the BCA when the Assessment Methods used satisfactorily demonstrate compliance with the Performance Requirements.

The relevant Performance Requirements against which the Performance Solution is assessed must be established in accordance with Clause A0.7 of the BCA.

Any Deemed-to-Satisfy Solution component of the project complying with the Deemed-to-Satisfy Provisions is deemed to comply with the Performance Requirements.

From Clause A0.5 of the BCA any of the following Assessment Methods may be used to show that a Performance Solution complies with the Performance Requirements:

The following *Assessment Methods*, or any combination of them, can be used to determine that a *Performance Solution* or a *Deemed-to-Satisfy Solution* complies with the *Performance Requirements*, as appropriate:

(a) Evidence to support that the use of a material or product, form of construction or design meets a *Performance Requirement* or a *Deemed-to-Satisfy Provision* as described in **A2.2**.

(b) *Verification Methods* such as—

(i) The *Verification Methods* in the NCC; or

(ii) such other *Verification Methods* as the *appropriate authority* accepts for determining compliance with the *Performance Requirements*.

(c) *Expert Judgement*.

(d) Comparison with the *Deemed-to-Satisfy Provisions*.

1.3.2 International Fire Engineering Guidelines

The IFEG document has been published by the ABCB for the purpose of providing guidance to experienced fire safety practitioners in the process and methodologies needed to demonstrate that a Performance Solution complies with the Performance Requirements.

IFEG is widely recognized as the appropriate document to be used as the basis of fire safety engineering assessments in Australia and other jurisdictions.

Since IFEG is a guideline document, the processes and methodologies adopted in an assessment may vary from those described in IFEG. However, any FEB and FSER documents prepared for a project should incorporate the essential information alluded to in IFEG.

1.3.3 General Objectives

The building regulatory objectives, though not explicitly stated in the BCA, are concerned with the issues of occupant life safety, fire services ability to perform their necessary tasks and protect adjoining properties. It is accepted that these objectives are satisfied by a Building Solution meeting the relevant Performance Requirements of the code.

The Fire Authority objectives are enshrined in State or Territory legislation. However, where appropriate, the Performance Requirements of the BCA require consideration of fire brigade intervention in the assessment process. In undertaking the appropriate assessment of fire brigade intervention and showing compliance with the Performance Requirements, it can be taken that the objectives of the relevant Fire Authority will be met.

SFS have not been advised of any additional regulatory objectives that were required to be considered during the assessment process for this project.

1.3.4 Client Objectives

The client has not identified any additional objectives for this project over and above those arising from the provisions of the BCA.

1.4 Stakeholders

The parties included in Table 1.1 and Table 1.2 have been identified as relevant stakeholders in this project.

The preparation of the FSER involves a consultative process. Input and collaboration has been sought from appropriate stakeholders as required.

Table 1.1: Project Stakeholders

Role	Company/Organisation	Representative
Client / Builder	Richard Crookes Construction P/L	Alex Hovy Ben Kilby Ana Cella Troy Daly Damien Silva
Client Representative / Project Manager	Project Strategy Pty Ltd	Stewart Johnson
Architect	Nettleton Tribe Partnership Pty Ltd	Matthew Andrews Michael Chung Donal Challoner
Fire Services Engineer	Niven Donnelly	Viorica Steinhaus Andrew Yalda
Mechanical Engineer	Eastwood Air Conditioning Pty Ltd	Daniel Montes Rita Kutty
Electrical Engineer	Modcol Pty Ltd	Luke Nichols
Fire Safety Engineers	Scientific Fire Services Pty Ltd	Parkan Behayeddin Kenny Leong Elhossein Elgizawy

Table 1.2: Regulatory Stakeholders

Role	Company/Organisation	Representative
Building Certifier	McKenzie Group Consulting (NSW) Pty Ltd	Geoffrey Pearce Asic Regmi
Fire Authority	FRNSW	Duke Ismael

1.5 Role of Scientific Fire Services Pty Ltd.

IFEG recognizes that the fire engineering process may be considered to be used for two purposes, namely in the design of fire safety systems and components or, in the evaluation of a given fire safety system or systems. In the former case, experienced fire safety engineers may contribute to the project design process by assisting in the development and selection of effective and efficient fire safety systems. Once the design process has progressed to the point where a possible Building Solution has been developed, the fire safety engineer may then undertake the assessment of the proposed design in the manner prescribed by IFEG.

The above process is considered to be consistent with the ‘application of the process’ defined in the IFEG document.

In this project, Scientific Fire Services have not contributed to the detailed design development of the project in the preparation of the Building Solution offered for assessment.

1.6 Qualifying Statements

1. This FSER relates to the design detailed in the referenced drawings identified in Appendix A. These drawings have been relied upon to be an accurate representation of the project buildings. Any changes to the design aspects of the project for which a Performance Solution is supplied, subsequent to the issuance of this report must be referred to the Fire Safety Engineer for further assessment to ensure the continued compliance of the Building Solution with the Performance Requirements.
2. Scientific Fire Services has relied on the Building Certifier/BCA consultant to identify all the issues of non-compliance with the Deemed-to-Satisfy provisions of the BCA. Apart from these design issues listed in this report, it is taken that the proposed design meets all other Deemed-to-Satisfy provisions. It is also assumed that all other regulatory requirements have been met unless these have been specifically identified for assessment and inclusion in the FSER.
3. Where a building has previously included a Performance Solution it is presumed, unless specifically identified otherwise, that the prior Performance Solution has been appropriately approved.
4. Unless otherwise stated, the assessment does not address any issues that are outside the requirements of the BCA.

5. The outcomes of the assessment of the Building Solution stated in the FSER do not apply to any other parts of the building not included in the assessment, nor to any other building projects unless so identified by Scientific Fire Services.
6. The fire safety engineering assessment methodologies have been based on the assumption of a single ignition and fire source, which is the expectation of a natural fire start. The assessment does not consider multiple fire start scenarios arising from arson or other such events such as bushfire.
7. Analysis of emergency incidents such as bomb threats or other such occurrences, requiring partial or total evacuation of the building does not form part of this assessment.
8. The provisions for fire safety in this building, as incorporated into the Building Solution, have been assessed purely from the perspective of fire safety and their usage under any other circumstances is beyond the scope of this assessment.
9. Unless it has been specifically identified as an issue to be considered, this assessment does not include any consideration of losses arising directly or indirectly from a fire in respect of buildings, contents, business interruption, environmental damages or other consequential losses
10. The FSER and the subsequent recommendations are considered to reflect the reasonable and practical efforts of Scientific Fire Services. The extent to which the fire safety requirements are implemented will affect the probability of achieving adequate fire safety margins.
11. The outcomes of the fire safety assessment are conditional upon the required fire safety systems being installed, commissioned, operational and maintained as required by the relevant regulations, standards and specifications.
12. It is important to note, however, that there can be no guarantee that fire ignition and fire damage will not occur. No liability is accepted for any losses arising from a fire in this facility.
13. The assessment undertaken for this project is concerned only with the final completed and functional building. The assessment does not address any issues arising during construction, partial usage, renovation or demolition unless these aspects have been specifically identified for assessment.
14. The fire safety assessment undertaken is based entirely on the usage of the building/tenancy as described in the report. Any subsequent deviation from the usage as described will render this assessment invalid until a review by a qualified Fire Safety Engineer has been carried out.
15. Any occupant numbers used in the assessment have been derived in accordance with the provisions of BCA Clause D1.13 and, where appropriate, in collaboration with key stakeholders. Any increase in the occupant numbers above that designated in the report will render this assessment invalid until a review by a qualified Fire Safety Engineer has been carried out.
16. Any changes to the occupant characteristics, arising from such aspects as variations or changes to the building usage, to those designated in the report will render this assessment invalid until a review by a qualified Fire Safety Engineer has been carried out.
17. Issues associated with workplace Occupational Health and Safety have not been considered as part of this fire safety assessment.
18. This FSER has been prepared for the client identified in the report. The report is not transferable to another client without both the client identified in the report and SFS consent.
19. No liability is accepted for the accuracy of the documents and drawings supplied upon which this FSER is based.
20. Changes to the design, as shown in the drawings listed, subsequent to this report date will require fire safety engineering review to ensure ongoing compliance with the Performance Requirements.
21. The storage, usage, handling and transport of any listed Dangerous Goods in this facility will not be considered in the subsequent fire safety assessment undertaken. It is presumed that all such matters relating to Dangerous Goods will be dealt with in accordance with all relevant regulations and by appropriate consultants.
22. Further to the previous and with regards to the nature/quantity of materials stored within the subject building, the application of Clauses E1.10 and E2.3 have been deemed not to apply for this project (refer also to Appendix O for further details) and hence, there is specific requirement for any additional provisions to further assist with firefighting purposes over and above those forming part of the detailed trial design. This matter has also been confirmed by the PCA (refer to Appendix O) and the correspondence from Snackbrands confirming the nil storage of Dangerous Goods (refer to Appendix S); and
23. Should the storage and handling of dangerous goods be proposed at any point into the future, this fire engineering documentation would be required to be re-assessed by a competent fire safety engineer.
24. SFS has no role or responsibility in the use and management of the facility.

2. Building Description and Occupant Profiles

2.1 Building Description

The subject site is located on the Altis Property Partners First Estate site at Orchard Hills. The subject site is referred to as Building 7 on the industrial estate as illustrated below.

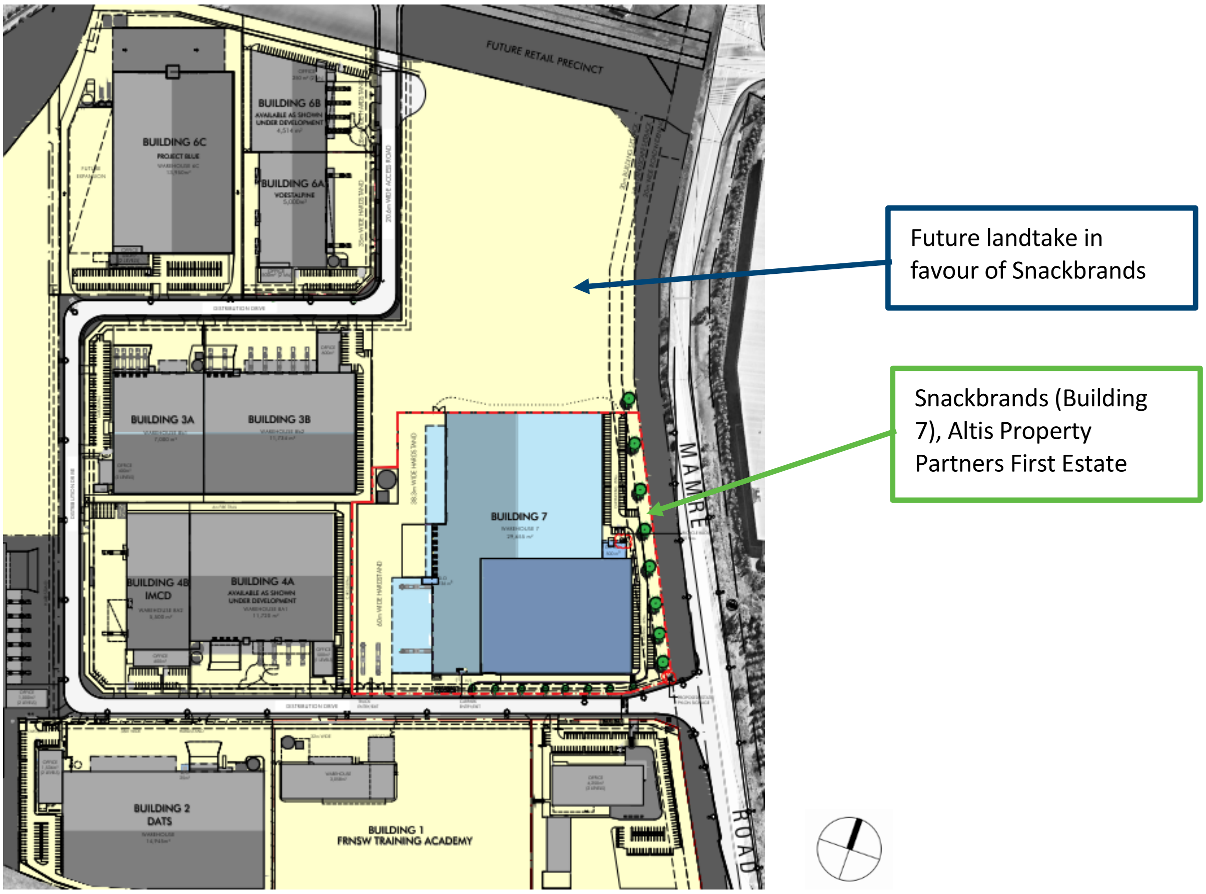


Figure 2.1: Altis Property Partners First Estate – Masterplan

With reference to Figure 2.1 above, the subject proposal can be referred to as Stage 1 where the vacant parcel of land to the north is proposed as a potential landtake in favour of Snackbrands enabling warehousing/manufacturing at a future point in time. This fire safety strategy will predominantly focus on the Stage 1 works with the view to futureproof the current design to facilitate the works which may occur in the future for Stage 2.

Snackbrands Australia is proudly Australian and very much still a family business. Snackbrands make Australia's favourite snacks including CC's, Cheezels, French Fries, Kettle Chips, Samboy Chips and Thins Chips just to name a few.

Figure 2.2: Snackbrands Products – (courtesy of https://www.snackbrands.com.au/Brands#ProductGridAllFour2592)

The subject development is proposed to comprise a Class 7b high bay warehouse comprising 11,023m^2 as well as a low bay warehouse consisting of 18,630m^2. The facility will also accommodate two (2) separate Class 5 office areas. The first of which is the main office portion comprising a total floor area of 500m^2 across two (2) levels. The second administrative space is the dock office which consists of 100m^2 over two (2) levels. In total, the Class 7b warehouse and Class 5 office areas shall accommodate a total floor area of 30,255m^2.

Figure 2.3: Perspectives – High Bay

Separately, the building shall also be provided with 2,665m^2 of awning structures.

Figure 2.4: Awning Structure

The Stage 1 portion subject building is considered to be a *'Large Isolated Building'* centrally situated on the site with vehicular access provided around the site. The external walls of the building are primarily pre-cast dado concrete panels with steel sheeting above.

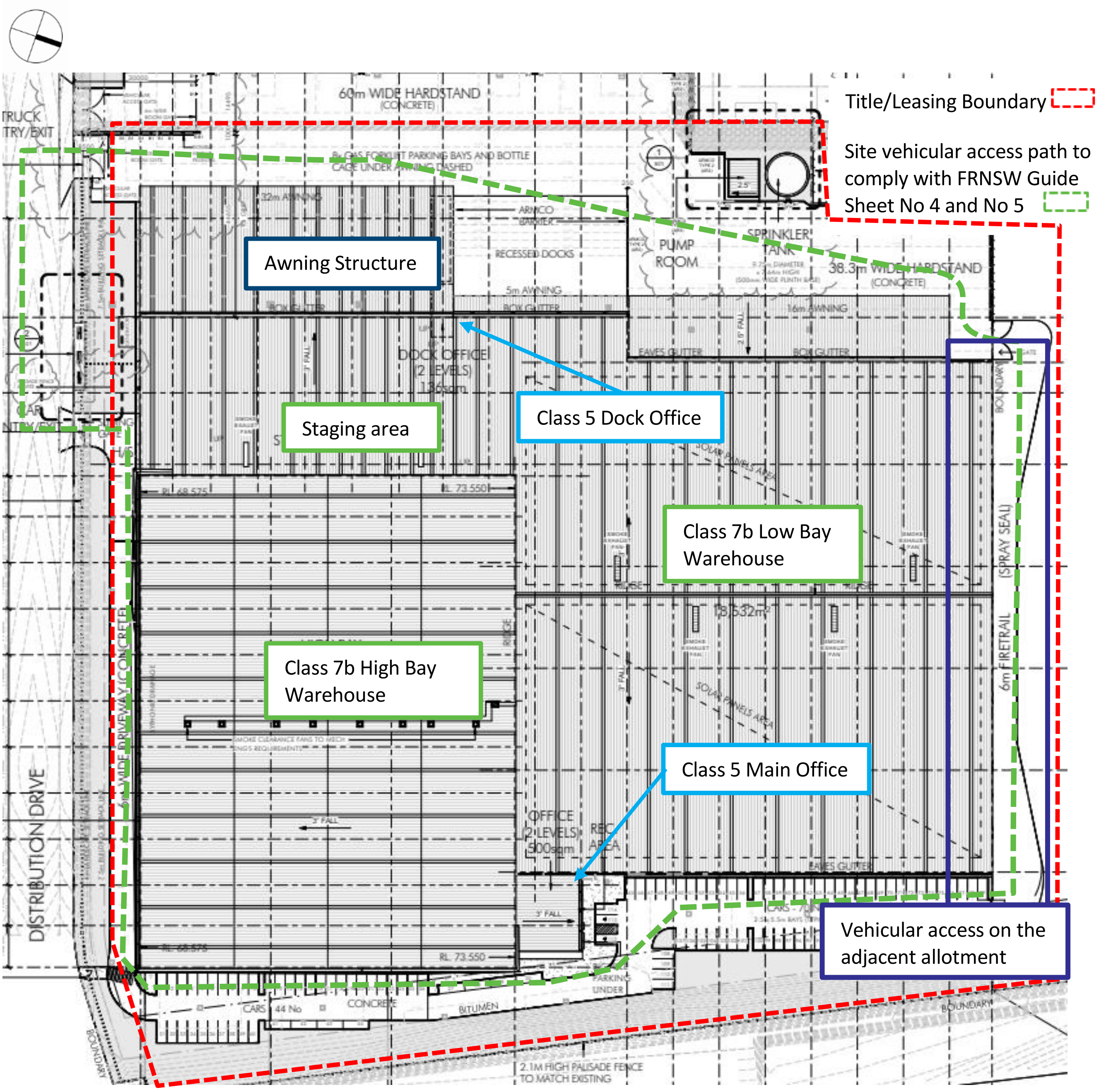


Figure 2.5: Site Plan

The building is provided with full vehicular perimeter access to four (4) sides. The entire building is proposed to be protected by automatic sprinklers systems throughout.

As the volume of the proposed building exceeds the maximum volume permitted in Table C2.2 of Volume One of the NCC, the building has been classified as a *'Large Isolated Building'* (LIB). The building is required by Clause C1.1 of the NCC to be constructed in accordance with Type C fire resisting construction. The building is identified to comply with the prescriptive provisions of the NCC with the exception of the design issues identified within this report.

The High Bay Warehouse Area:

The high bay area of the proposed development is 36.8m high & consists of fully automated storage and retrieval system (i.e.: AS/RS). It is noted that the AS/RS area has limited access and can only be accessed by maintenance staff and not by warehouse/office staff. The maintenance staff are noted to be experts and highly trained with the sortation equipment (AS/RS) and will have a clear idea of the floor and AS/RS layout for evacuation and emergency purposes. To further demonstrate the high bay portion of the warehouse, refer to Figure 2.6

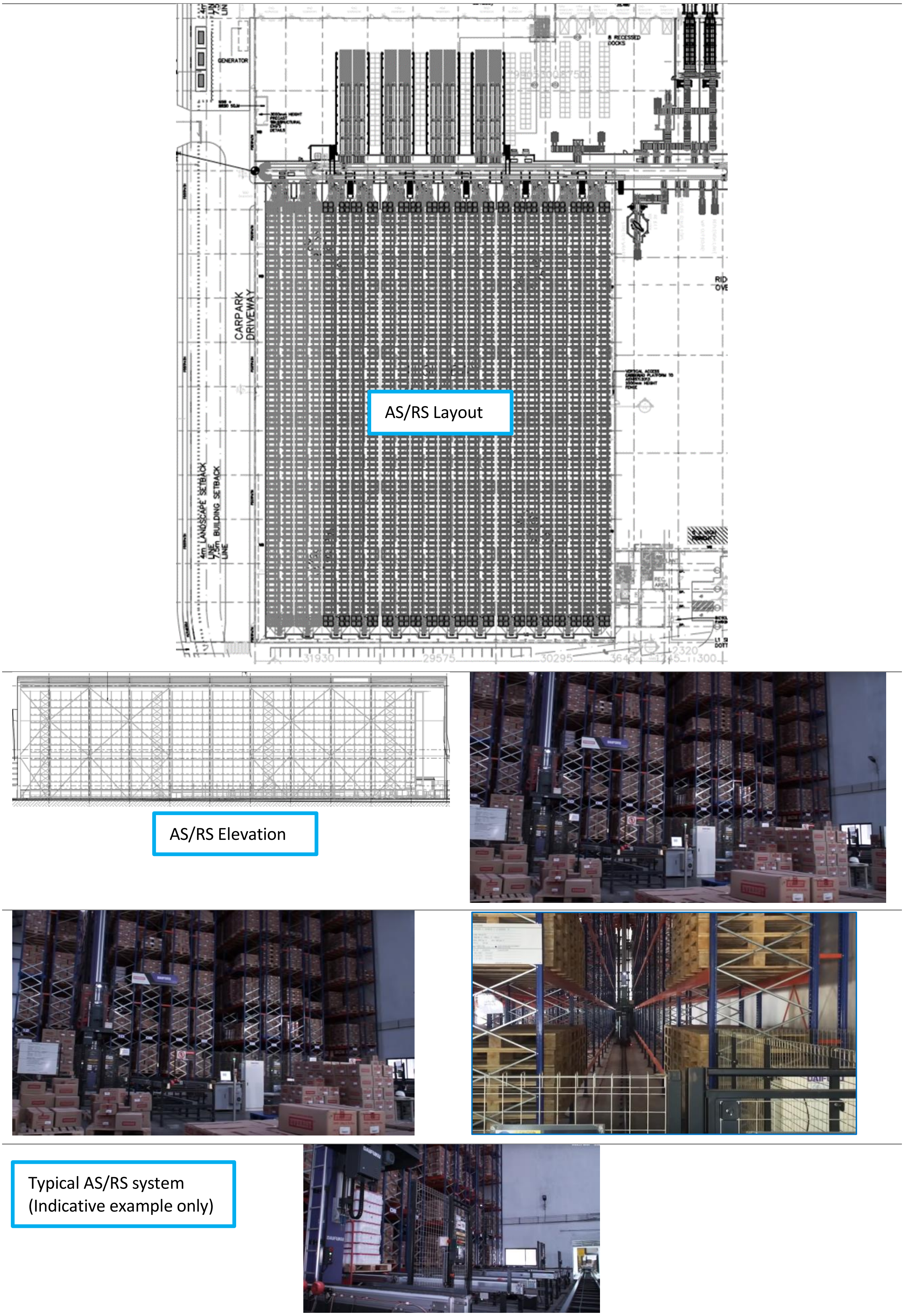


Figure 2.6: AS/RS illustration (Example) (reference: https://www.daifuku-logisticssolutions.com/en/case/food/)

The building description based on the BCA classification system is provided in Table 2.1.

Table 2.1: BCA Description of the building

Summary of Building/Tenancy	
Building Classification(s):	Class 5 (Office) & Class 7b (Storage)
Number of Storeys Contained:	Two (2)
Rise in Storeys:	Two (2)
Building Height:	Low Bay ridge / office = 13.7m High Bay ridge = 36.8m
Required Type of Construction:	Type C Construction

2.2 Occupant Profiles

2.2.1 Occupant Characteristics

Understanding the likely nature of the building's occupants is an important element of the FSER. As with the building, there are many characteristics that can be identified making complete characterisation a complex and difficult task. However, for the subject building development only a limited number of 'dominant characteristics' may affect the outcome, these are briefly described below.

Guidance provided by IFEG (2005); the Engineering Guide: Human Behaviour in Fire (SFPE 2003) and Proulx (2003) has been considered in the evaluation of dominant occupant characteristics for this fire safety engineering evaluation. Proulx gives the researched opinion that gender is having less effect on occupant response. Other researchers (Bryan 2003) suggest that females and aged residents are more likely to call for help. Men are more likely to attempt to extinguish the fire. Most occupants have a tendency to investigate (look for) the fire before deciding to evacuate.

The permanent occupant sub-group (staff) are anticipated as being of mixed gender and typically between the age of 18 & 60 years. The occupants are considered to be adequately mobile with no specific physical impairments that warrant attention with a more uniform level of physical and mental ability than other building classification. The staff members are considered to be familiar with the building environment in which they work and hence have an in depth understanding of the building layout and more specifically an understanding of the location of exits. It is expected that the staff would be trained in the buildings emergency procedures and also in first attack firefighting with hose reels. It is noted that any transient occupant sub-group (i.e. visitors) would potentially comprise persons from all gender and age groups with varying levels of physical and mental ability. However, it is likely that visitors would be escorted and supervised while in the facility. This being said it is expected that there will be limited public contact within the sortation and storage portion of the building and as such these occupants are considered to be members of the staff.

2.2.2 Occupant Numbers

Occupant numbers has been based on the information provided by the Client/PCA as per the following;

Location	Population
Office	25
Dock Office	6
Warehouse	30
ASRS system (High Bay Zone)	1-2 (maintenance staff on a regular basis)

Therefore, for the purpose of the analysis, the total number of occupant loading in the order of 75 occupants (conservative).

2.3 Summary of Building Occupant Egress Strategy

The occupant egress strategy to be adopted for the subject development is such that when occupants are confronted with an emergency fire situation the building occupants make their way to a place of safety without being unduly exposed to the effects of fire, heat and smoke. Similarly, the occupants using the paths of travel to the numerous emergency fire exits are protected by the effects of fire during evacuations.

The proposed configuration of the subject building contains fire exits that are uniformly distributed along the facade of the building directly to the outside. The intent behind the egress provisions provided throughout the subject warehouse development is to enable occupants to identify logical and obvious escape routes which lead to places of safety. The large open nature of the subject building is reflective of this approach to safe occupant egress.

In the event of an emergency fire situation egress from within the proposed subject building is provided in the form of the following:

- Egress directly to the outside from the main warehouse portion of the subject building.
- Fire exits evenly distributed throughout the subject building.

2.4 Conditional Statement

It is not anticipated that the occupant characteristics or the usage of the building will change significantly. Any such change would require a re-assessment of the fire safety levels. The evaluation will consider the occupant characteristics identified and the usage of the building as noted. Any changes in the building usage and consequent potential change to the occupant characteristics will require a re-evaluation of the fire safety systems.

3. Performance Solution Design Issues

The Building Certifier/BCA Consultant has identified the following design aspects of this project that do not comply with the Deemed-to-Satisfy provisions of the BCA. For each of these issues an alternate Performance Solution has been presented and is the subject of the assessment herein to demonstrate compliance with the relevant Performance Requirements.

Table 3.1 lists the Performance Solution design issues to be addressed in the assessment, the applicable BCA DtS provision to which the Performance Solution applies, the Performance Requirement(s) to be satisfied and the Assessment Method to be adopted in accordance with Clause A0.5 of BCA.

Table 3.1: BCA design issues pertinent to the proposed Performance Solution

No.	Design Issue(s)	DtS Provision of the NCC	Performance Requirements	NCC Assessment Methods
1.	The following compliance issues have been identified with respect to the proposed perimeter vehicular access serving the warehouse: • The far side of the perimeter vehicle access along the eastern boundary of the site is up to 26m from the external wall of the building in lieu of 18m; and • The access provided to the north of the site is proposed to be on the adjacent allotment which is intended to be acquired by Snackbrands at a future date.	Clause C2.3 inter alia Clause C2.4	CP9	A0.3(a)(i) & A0.5(b)(ii) Consultation with FRNSW
2.	It has been identified that the exit travel distance to the alternative exits and distance between alternative exits within the warehouse/s portion/s exceeds the maximum prescribed exit travel distances. More specifically: • The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and • The distance between alternative exits exceed 60m (i.e.: up to 172m). Furthermore, it is proposed to omit the provision for an automatic smoke exhaust system (including associated smoke baffles and smoke detection system) within the building. In this instance, it is proposed to permit a manually operated smoke clearance system having a smoke clearance capacity of 1 air change per hour.	Clause D1.4 Clause D1.5 Clause E2.2	DP4 & EP2.2 EP2.2	A0.3(a)(i) & A0.5(b)(ii)
3.	The fire hose reel system shall be design and installed in accordance with AS2441.1:2005 with the exception of the following: • To permit the fire hose reel coverage shortfalls throughout the high bay area.	Clause E1.4 inter alia AS2441:2005	EP1.1	A0.3(b)(i) & A0.5(b)(ii)
4.	It is proposed to design and installed the fire hydrant system to be in accordance with Clause E1.3 from Volume One of the NCC and AS2419.1:2005 with the exception of the following: • Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and • It is proposed to permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only.	Clause E1.3 inter alia AS2419.1:2005	EP1.3	A0.3(a)(i) & A0.5(b)(ii) Consultation with FRNSW

No.	Design Issue(s)	DtS Provision of the NCC	Performance Requirements	NCC Assessment Methods
5.	Directional and non-directional exit signs are to be installed throughout the building in accordance with Part E4 from Volume One of the NCC and AS2293.1:2005 with the exception that the mounting heights of exit signage within the warehouse storage portions of the building (except within the high bay area). In this instance, it is proposed to permit exit signs to be mounted at greater than 2.7m above the finished floor level within the warehouse portion only being the minimum required by the prescriptive provisions from Volume One of the NCC.	Clause E4.5, Clause E4.6, Clause E4.8 inter alia AS2293.1: 2005	EP4.2	A0.3(a)(i) & A0.5(b)(ii)
6.	It is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. **Note:** As confirmed by Modcol Pty Ltd (refer to Appendix Q), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area.	Clause E4.5, Clause E4.6, Clause E4.8 inter alia AS2293.1: 2005	EP4.2	A0.3(a)(i) & A0.5(b)(ii)
7.	The FIP is located within the main office of the warehouse, which is not located within the main entrance (vehicular access) of the site.	Clause E1.8 inter alia AS1670.1:2015	EP1.6	A0.3(a)(i) & A0.5(b)(ii)

4. Hazard Analysis

4.1 Introduction

The IFEG (2005) states that a systematic review should be conducted to establish potential fire hazards (both normal and special) of the facility under evaluation. A hazard is the outcome of a particular set of circumstances that has the potential to give rise to unwanted consequences. In regard to a building fire, a fire hazard means the danger in terms of potential harm and degree of exposure arising from the start and spread of fire and the smoke and gases that are thereby generated.

The fire related hazards in a facility can arise from the layout of the building including its location with respect to adjoining properties, the construction materials, the activities undertaken in the facility, the possible ignition sources and the fuel sources.

One of the first stages in reviewing potential fire hazards for a project is to examine available fire incident data for facilities having the same or very similar form and usage. This data may be international in origin and therefore must be used with care in order to establish possible hazards and a realistic measure of the possible unwanted consequences of fire.

Every hazard has a risk associated with it. The risk arising from a hazard is the frequency of an event involving that hazard, times, the expected consequences. A hazard may be eliminated, but there will always be an event frequency of occurrence and therefore always a positive value of risk associated with the hazard.

Fire safety engineering is essentially a risk management process wherein the outcome is to minimize the overall fire risk associated with a facility by mitigating or eliminating serious hazards, or by reducing the frequency of hazardous events.

The risk assessment process, of which hazard analysis forms part, is the means by which those hazardous events with the most serious consequences are identified. This then enables the most appropriate fire scenarios related to these events to be defined. This process then allows the analyses to be carried out to ensure that the fire safety systems and strategies employed are sufficient to satisfy the Performance Requirements.

Whilst the frequency of hazardous events (probability) is considered during the hazard analysis, the consequent analyses for the evaluation of the resultant fire scenarios are deterministic.

The following sections provide data specific to the occupancies involved in this assessment.

4.2 Summary of Project Specific Hazards

A thorough and comprehensive analysis of the fire hazards associated with the subject building has been provided in Appendix B of this FSER. A summary of the fire hazard analysis is provided in the following sub-sections presented below.

4.3 Hazards Specific to the Office Classification (Class 5)

In relation to the office portions of the building, the hazard analysis undertaken illustrates a number of consistent observations. A summary of the findings and observations have been provided below:

- The statistics indicate that an office building rates relatively low with respect to the risk of fire when compared to other buildings.
- Office hazards are generally low – approximately one tenth when compared to residential occupancies. (Refer to Figure B.1 and Figure B.2 in Appendix B.
- The principal sources of fire ignition in commercial type occupancies are associated with arson, cutting and welding, electrical distribution systems, in particular wiring and Commercial business equipment.
- Two thirds of all fires occur during normal working hours.
- The majority of the fires, which occur during working hours which are typically small and are confined to the object of fire origin.
- There are actually fewer severe fires during normal working hours.

4.4 Hazards Specific to the Storage Classification (Class 7b)

In relation to the warehouse portion of the building, the hazard analysis undertaken illustrates a number of consistent observations. A summary of the findings and observations have been provided below:

- The contents stored within the subject building shall generally be regarded as combustible and generally associated with contents expected in a warehouse environment.
- With regards to the general level of fire hazard, the occurrence and impact of a fire within storage/warehouse classifications constitutes approximately 8% of all fire in Australia, 2%-3% in the UK and 4% of all fires in the USA.

When compared to other classifications this equates to an overall low percentage where 60% of all fires in Australia occur in other buildings including residential and public assembly, 62% of fires in the UK are in dwellings and 79% of fires in the USA are noted to be within residential.

- Statistically the vast majority of fires occur while the warehouse is occupied. This is supported by the fact that the number of fires reported peaked at 3pm-5pm which were caused either by incendiary or suspicious circumstances. The other factors that contribute to the occurrence of a fire include electrical faults or failures and fires due to welding and cutting. In warehouses where sprinklers are not present the fires were identified to occur during 1am to 4am where 99.9% of fires reported to the fire brigade result in no fatalities.
- The majority of the fires which occurred within warehouse where sprinklers were present and the fire was large enough to activate the equipment, sprinklers operated 88% of the time and were effective 97% of the time. When sprinklers were said to fail 84% of the time was as a result of the system being shut off. When no automatic equipment was present, 52% of warehouses fires were confined to the room of fire origin while when sprinklers were present 80% were confined to the room of origin. The subject development is to be provided with a compliant automatic sprinkler system the expected fire scenario is that the fire will be at least contained.
- Data shows that the likelihood of a fire reduces as the size of the warehouse increased. This is expected to be a consequence of more sophisticated systems and management systems being adopted in larger warehouses.
- Warehouses are strictly controlled work environments where occupational health and safety and workplaces safety plays a key role. The occupant numbers are generally expected to be very low and from people related hazards perspective warehouse are considered to be low hazard occupancies.
- Racking fire can occur within the warehouse areas with the presence of combustible stored goods, racking and the like.
- Other ignition sources within the warehouse are forklifts. The fuel tanks of combustion engine forklift trucks and the batteries of electric motor forklift trucks can also be considered as part of the fuel loads.
- An electrical malfunction, spark or ember fire may be cause by the failure of the automated process which includes conveyors and sortation equipment which has potential to spread to other combustible goods (which can comprise of paper, plastic goods) conveyed across the equipment and machinery.

5. Approaches and Methods of Analysis

5.1 General

Consistent with the IFEG a quantitative deterministic absolute approach is to be adopted in the form of a 'timeline' analysis in order to measure the level of life safety achieved for the subject warehouse building.

The alternative to a deterministic approach is probabilistic. This requires extensive statistical data. Adequate statistical data exists for a limited range of fire related issues and therefore a probabilistic analysis is invariably based on a comparative basis to a fully complying deemed to satisfy design equivalent building.

Given the complexity of the issues to be evaluated in this case and the existence of applicable and validated computational tools a quantitative analysis is deemed appropriate and necessary. When an evaluation is carried out on an absolute basis, the results of the analysis are matched against the objectives or performance requirements without comparison to deemed-to-satisfy or other 'benchmark' designs. This is the approach adopted in this evaluation.

5.2 Life Safety Analysis Methodology

The evaluation methodology adopted relies on the construction of a timeline for the fire incident and occupant evacuation. With a timeline methodology the approach used is based on the determination of the Required Safe Evacuation Time (RSET) for people to evacuate and the Available Safe Egress Time (ASET) for evacuation (before untenable conditions are present within the egress paths). The requirement for occupant safety is as follows and further illustrated in Figure 5.1.

Required Safe Egress Time (RSET) < Available Safe Egress Time (ASET)

or

$$RSET < \lambda \times ASET$$

where

RSET $= t_d + t_{dc} + t_t$

ASET = time of untenable conditions (t_u)

λ = Safety factor

and

t_d = time of fire detection

t_r = occupant response time

t_{dc} = pre-movement time

t_t = travel time

t_u = time for untenable conditions

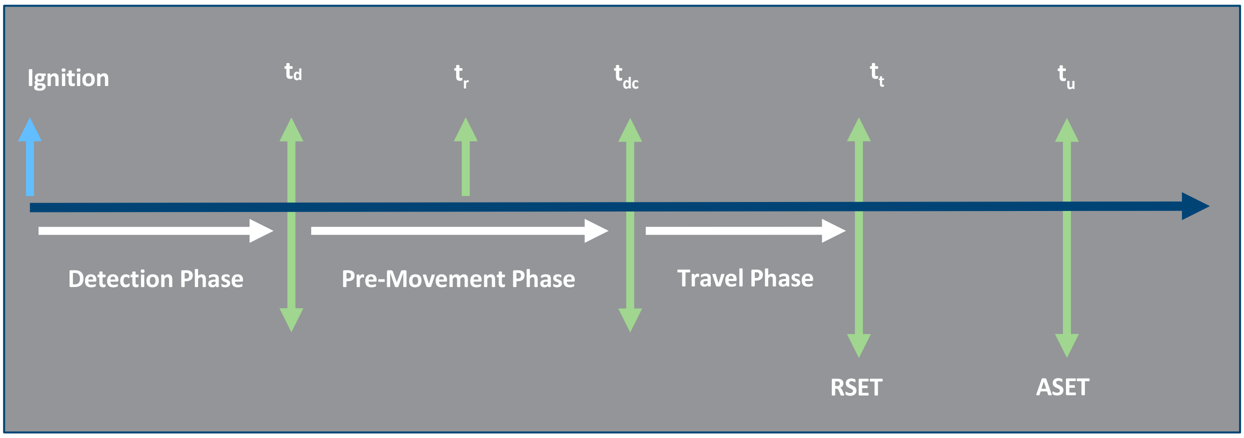


Figure 5.1: Schematic representation of the timeline analysis to be adopted

To undertake this analysis, the times for fire detection, occupant pre-movement, occupant travel and the time at which untenable conditions occur need to be calculated. These times are calculated with the assistance of 'fire' and 'evacuation' models.

5.2.1 Performance Objectives

The project objectives are essentially to ensure that the performance solution is developed which demonstrates that the regulation Performance Requirements are satisfied, and that the standard of fire safety is commensurate to that prescribed in Volume One of the NCC.

Elaboration of this core objective is provided in the following dot points:

- To satisfy the architectural vision and design specifications without compromising the code objectives.
- To preserve the functionality requirements of the open volume spaces for free circulation of occupants appropriate to the office/warehouse.
- To ensure a performance solution is developed which demonstrates that the code Performance Requirements are satisfied.

5.3 Method of Analysis

In order to address the identified issue, quantitative analysis will be undertaken for the subject building project.

Quantitative analysis will be in following forms:

- Computer simulation of fire development and smoke spread.
- Computer simulation of people movement.

5.4 Fire Modelling to Determine ASET

For the assessment of the subject development, the fire and smoke spread model Fire Dynamics Simulator (FDS Version 6.6.0) will be used to model the fire scenario. The NIST field model FDS is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flow. The FDS software is appropriate for low-speed, thermally driven flow with the emphasis on smoke and heat transport from fires (K B McGratten et-al 2016). The FDS model to be used is a deterministic 'fire model' which is used to predict the spread of heat and smoke in an enclosure or multiple enclosures. Visual presentations of the FDS simulation modelling results will be provided using the 'smokeview' program (K B McGratten et-al 2016).

CFD models, or as sometimes referred to, field models rely less on empirical correlations and are based on solving conservation equations for mass, momentum and energy. Fluid dynamics involves mathematical equations that describe the physical behaviour of fluids (gases and liquids) and are in the general form of three-dimensional, time-dependent, non-linear partial differential equations known as the 'Navier-Stokes' equations. The fire detection times are established by the time the automatic fire sprinkler system activates and/or by visual cues of smoke established in the FDS modelling to be undertaken. Further details of the Computational Fluid Dynamics model are presented in Appendix D.

5.5 Evacuation Modelling

5.5.1 Detection

The detection time has been based on determining the time at which the occupants in close vicinity of the fire see smoke from a developing fire and/or the time that the automatic fire sprinkler system operates within the facility and/or the time that the automatic fire detection and alarm system operates. Not relying solely on the automatic systems and Building Occupant Warning System (BOWS) operating is considered to be reasonable as a fire which is likely to have an impact on the building requiring evacuation is probably within the building itself and therefore detectable by the occupants well before automatic detection occurs. The BOWS will ensure that a building wide alarm is provided whereby any occupants located remote of the fire will receive warning to evacuate. The time at which the BOWS shall initiate is to be calculated through the activation of sprinkler heads and/or smoke detectors, utilising Alpert's Correlation.

According to studies conducted in 'Microeconomics Reform: Fire Regulation' (BRR 1991) at the time the smoke layer drops 5% from the ceiling height the occupants are expected to become aware of a fire via visual or olfactory cues. As such, it is considered that the smoke detection time for the building occupants will occur upon initiation of the BOWS or via visual cue. In the case of visual cue, fire detection shall be based the descent of the smoke layer from ceiling level. For conservatism, the time of visual fire detection shall be based on the time taken for the smoke layer to drop 10% from the ceiling height due to the fire being located in a large enclosure.

5.5.2 Pre-Movement

The pre-movement component of the evacuation process often has the greatest variability and hence is often the largest time part in the total evacuation process.

This is as a result of human behaviour and more specifically the variance in how people react/cope in certain situations. Various fire safety or fire protection engineering related publications identify appropriate pre-movement times for warehouse type occupancies with automatic detection and warning systems. Among these publications are The British

CIBSE (Chartered Institution of Building Services Engineers) Fire Engineering Guide E (CIBSE, 2010) and Society of Fire Protection Engineering Handbook (SFPE, 2008).

Most publications rely on BS7974-2001 "Application of fire safety engineering principles to the design of buildings – Code of practice" in identifying pre-movement times for different classifications of buildings with varied detection and warning systems and emergency evacuation procedures. Studies by prominent fire behaviour researchers (i.e. Proulx, Fahey, Brennan) have observed that perceived threat would reduce the response and pre-movement times. The presence of smoke or flames results in increased levels of threat for occupants. This concept has been relied upon in the development of a risk contours-based methodology which was presented in the Human Behaviour in Fires Conference in 2009 and later published as part of the proceedings (Horasan, Kilmartin 2009). The concept may be summarised as follows:

- In small buildings pre-movement times may be relatively short as the perceived threat of the fire is real and as such the occupants identify the risk whereby a decision to intervene or evacuate would be expected to follow intuitively. Furthermore applying a standard pre-movement time for the evacuating occupants to larger buildings may result in oversimplification of the evacuation process leading to inappropriate estimations either too speculative or overly conservative.
- The pre-movement time in this instance shall be determined based on statistical data, literature review and the visual cue of a fire. Therefore it is considered appropriate that any occupants located within the direct vicinity of the fire will become aware of a fire and will start their movement phase more rapidly hence it is expected that these occupants would have a reduced pre-movement time. Similarly occupants located remote from the fire will take considerably longer to decide on an appropriate course of action as a result of the fire not being a direct threat hence occupants further away from the fire will have an increased pre-movement phase. This phenomenon shall be considered in the occupant evacuation analysis to be undertaken.
- Where a fire is assumed to occur the immediate adjacent areas to the fire have been assumed to have a corresponding risk IR1 which the expected risk is assumed to be greater than all other areas within the building. Risk contours provide a visual indication of individual risk at any point. It is noted that the literature suggests that reasonable and conservative judgement for contour boundaries must be incorporated in the assessment. Therefore the surrounding areas of the fire origin (IR1) would have a relatively lower level of risk at IR2. Further away from the origin of fire the risk values, i. e. IR3, IR4 and IRn, are further reduced.

Table 5.1 is reproduced from the 4th International Symposium on Human Behaviour in Fire and details a qualitative summary of the expected risk phase.

Table 5.1: Contour risk phase (Table 1, 4th International Symposium on Human Behaviour in Fire, 2009)

Zone	Detection and response r_t	Delay d_t	Movement m_t	Magnitude comparison
IR1	Quick occupant response based on visual detection most likely prior to any automatic warning system activation.	Very short delay time due to abundance of cues and high perception of threat.	Movement speed a function of perceived threat, short movement time to the nearest safe area.	R_{t1}
				d_{t1}
				m_{t1}
IR2	Quick occupant response based on visual and/or automatic detection.	Longer delay time due to lower perception of threat.	Movement time a function of occupant numbers, exit widths and exit distribution.	$R_{t1}<r_{t2}$
				$d_{t1}<d_{t2}$
				$m_{t1}<m_{t2}$
IR3	Longer response time due to detection based on warning systems and absence or insignificance of visual cues.	Longer delay time due to even lower perception of threat.	Movement time a function of occupant numbers, exit widths and exit distribution.	$R_{t2}<r_{t3}$
				$d_{t2}<d_{t3}$
				m_{t3}^*
Irn	Longer response time due to detection based on warning systems and absence or insignificance of visual cues.	Longer delay time due to even lower perception or total absence of threat.	Movement time a function of occupant numbers, exit widths and exit distribution.	$R_{tn-1}<r_{tn}$
				$d_{tn-1}<d_{tn}$
				m_{tn}^*

An indicative illustration is provided in Figure 5.2, highlighting the potential contoured pre-movement approach relative to the area of fire origin (AFO).

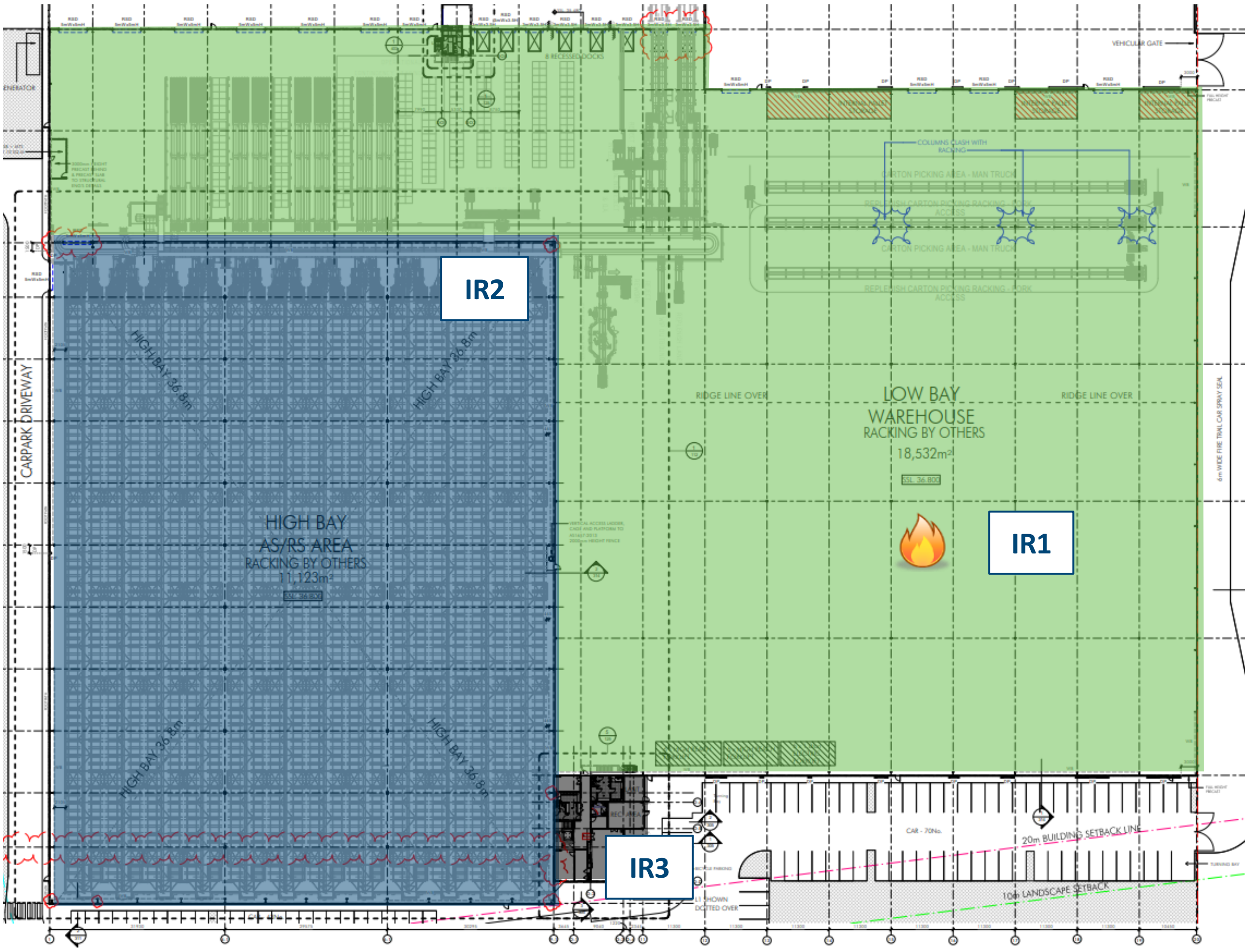


Figure 5.2: Indicative schematic of pre-movement contour summary

This concept has also been adopted and reflected by the New Zealand Department of Building and Housing as part of the Building Codes in the document titled “C/VM2 Verification Method: Framework for Fire Safety Design for New Zealand Building Code Clauses C1-C6 Protection from Fire”. The C/VM2 document recommends a sliding scale of pre-movement times based on an occupant’s location with respect to the fire origin.

Occupancies such as the subject warehouse are highly appropriate for adopting the risk contours approach. Visual access to other sections of the building is not always assured. Hence, in the event of a fire in one particular portion, the occupants within the immediate vicinity would become aware of the fire immediately while occupants located in other portions would rely on secondary warnings such as alarms, staff or other occupants moving away from the zone of fire origin.

The pre-movement time would incrementally increase for zones further away from a fire when located in the different operational sections of the warehouse or area of AFO. In the context of the AFO, the risk contour shall be divided into intervals and other remote zones based on the location of the fire and the position of storage racking arrangements and the like within the warehouse. The zone of fire origin shall be identified as IR1 (i.e. the highest perceived risk) and allocated the shortest pre-movement times.

The subject building is defined for evacuation modelling purposes in the form of the floor plans constructed which are to be used as the templates for the computer modelling software Pathfinder.

Occupant movement modelling will be conducted using Pathfinder, which determines the occupant travel times appropriate to the fire scenarios modelled. This software is based on real human behaviour, using data gathered from video analysis of individuals moving in crowds. The models are a PC-based program capable of simulating the evacuation of large numbers of people through geometrically complex buildings. Further details of the 3D Human Movement Simulation modelling are provided in Appendix E.

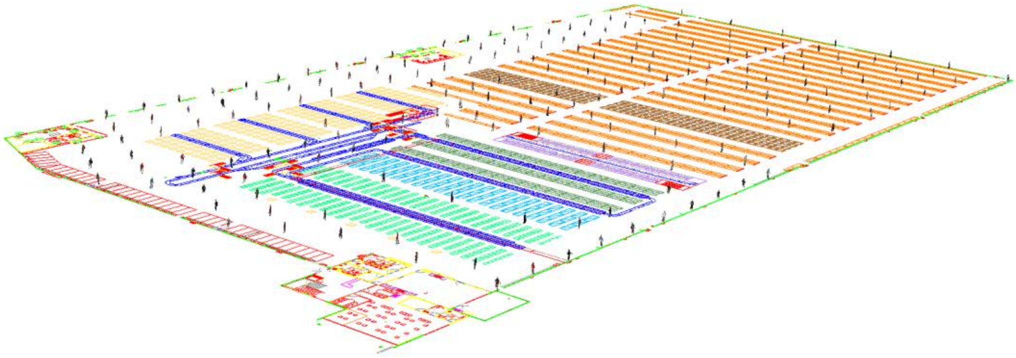


Figure 5.3: Pathfinder human simulation software example

Commonly used movement speeds for building occupants is 1.0m/s (Pauls 1995). Studies conducted by various researchers detailed in 'Egress Design Solutions' (2007) have established occupant movement speeds for different occupant groups (Refer to Table 5.2). The variations of particular occupants and the expected travel speeds are provided in Table 5.2.

Table 5.2: Horizontal walking speeds for varying occupant groups (Egress Design Solutions, 2007).

Occupant Group	Min. Walking Speed	Max. Walking Speed	Avg. Walking Speed
Children (<18 years old)	0.28 m/s	1.8 m/s	0.88 m/s
Young (18-29 years old)	0.25 m/s	1.9 m/s	1.12 m/s
Middle Aged (30-50 years old)	0.25 m/s	1.9 m/s	1.12 m/s
Disabled	0.25 m/s	1.3 m/s	0.77 m/s

The travel time component of the evacuation process in this class of building is generally based on a determination of the time for occupants to move to a place of safety. For the subject building, occupants located within the warehouse portions are expected to be able bodied occupants whom are trained to be able to manually handle stored goods and commodities within the building. Furthermore, the facility will rely on occupants to be abled bodied whom are licenced to operate vehicles including forklifts and also be in a position to be able to move stored goods either mechanically or manually. It is noted that in the office portion of the building physically impaired occupants may be expected. However in this instance the egress provisions within the office portion are understood to comply with the prescriptive provisions from Volume One of the NCC.

Based on the likely characteristics of the occupants, the geometry of the building and the proposed egress provisions, the occupants would be expected to traverse at their normal walking speed to the subject exit locations (Lord et al, 2005 & Fahy et al 2001). This is a result of a limited number of occupants present at any given time. The occupants located within the warehouse portions of the building are also expected to be alert at the time of the emergency fire situation and furthermore, trained in emergency evacuation procedures.

The occupant movement speed to be adopted as part of the subsequent fire safety engineering analysis is **0.8m/s**. According to the above literature the movement speed of **0.8m/s** is considered conservative when considering the average movement speeds for walking and ignoring the fact that the majority of these occupants would be moving in an emergency situation. Regardless of the marginal differences in speeds by adopting the relatively slower 0.8m/s movement speed, the proposed building design is likely to be further accommodated for in the applied safety factors (as detailed below) for the combined design scenarios.

5.5.3 Factors of Safety and Redundancies Summary

A factor of safety has been applied during or at the end of the numerical analysis in order to ensure sufficient levels of conservatism are introduced to the analysis and all uncertainties are compensated for. The magnitude of the factor used depends on:

- The reliability of the various components of the fire safety system.
- The results of an uncertainty analysis.
- The criteria used to determine acceptance.

For example, for the ASET/RSET assessment for occupant life safety the factor of safety to be adopted is aimed to be in excess of 1.5. In other words, the following criteria are met:

ASET > 1.5 x RSET

For the ASET/RSET assessment for fire services personnel safety the factor of safety to be adopted is aimed to be in excess of 1.5. In other words, the following criteria are met:

ASET > 1.5 x FBIM (commencement of water application)

Redundancy and factors of safety are two concepts that are considered concurrently. The redundancies in the design are considered in this analysis in order to ensure levels of conservatism. Factors of safety adopted for sensitivity studies where sprinkler failure scenarios are adopted will be reduced to 1. Therefore:

ASET > 1.0 x RSET

5.6 Adopted Tenability Criteria

5.6.1 Building Occupant Tenability Criteria

The tenability criteria for occupant life safety is based on information obtained via the SFPE Handbook and various other publications in relation to occupant tenability limits. These documents state that for occupant life safety the environmental conditions must be maintained so that excessive temperatures, low levels of visibility and high levels of toxicity do not endanger human life. Based on this approach, two distinct tenability criteria will be set out in relation to occupant life safety.

5.6.1.1 Primary Criteria: Occupants not exposed to the hot smoke layer

Condition: *The smoke layer <u>must remain above</u> a certain level from the floor*.

A smoke layer height commonly adopted universally in relation to tenability is 2 metres from the floor. This criterion is taken into consideration in conjunction with the radiant heat from the hot smoke layer. The radiant heat is required not to exceed 2.5kW/m^2, at head height. This equates to a temperature of approximate 183°C and an average human height of 1.9m. However, to add conservatism into the design the maximum allowable temperature is commonly increased to 200°C at a height above the floor level of 2m.

It should be noted that, while with zone models it is possible to demonstrate the hot smoke layer height clearly with relative ease, when CFD models are used a clear stratification is not expected to be demonstrated in the output. However, slices at 2m above floor levels will be provided for guidance. It is further noted that the secondary criteria listed above relates to smoke conditions where the smoke has descended to levels below the primary criteria of 2m smoke layer height.

The criteria of temperature and smoke visibility are only applicable should the smoke layer interface drop below 2m.

5.6.1.2 Secondary Criteria: Occupants exposed to the hot smoke layer

Condition: *The smoke layer <u>may descend below</u> a certain level from the floor, but the conditions must remain "tenable"*.

If the hot smoke layer descends below the layer height adopted in relation to Criteria One and occupants are exposed to the hot smoke layer a secondary set of criteria is taken into consideration in relation to tenability which include:

- Convective heat; and
- Visibility; and
- Toxicity

It is should be noted that the secondary criteria relate to smoke conditions where the smoke has descended to levels below the primary criteria of 2m smoke layer height. The criteria of convective heat, smoke visibility and toxicity are only applicable should the smoke layer interface drop below 2m.

Convective Heat

In relation to convective heat the objective is to limit the temperature to allow occupants to evacuate without being incapacitated due to burns or hyperthermia.

According to the SFPE handbook an acceptable temperature threshold for heat to not irritate or burn humans is taken as 60°C. However, this being said the skin and lung track can endure higher temperatures for extremely short periods of time up until the temperature reaches approximately 100°C at which time the effects of the convective heat may cause burns and/or hyperthermia in humans. Nevertheless, to be conservative it is proposed to adopt an acceptance criterion of 60°C within the hot smoke layer when the hot smoke layer drops below 2m.

Visibility

Reduction in visibility by smoke does not directly cause incapacitation of human bodies. However, poor visibility may hinder or prevent evacuation activities. Jin (1997) has shown that persons will move through smoke down to visibility of about 4m when in familiar surroundings and through smoke with a visibility of about 13m when in unfamiliar surroundings.

It can be expected that the predominant numbers of occupants egressing under fire evacuation conditions will be familiar with the building. However, there are relatively long travel distances for the occupants of some buildings to reach the stairs and/or exits and under these circumstances it is considered that a visibility of less than 10m may cause concern to the occupants to the extent that egress may be avoided. This visibility requirement relates to an optical density of the smoke layer of 0.1m^{-1}.

Consequently the criteria for tenability based on visibility will be that the optical density of the smoke layer below 2m does not exceed $0.1m^{-1}$. For small enclosures the visibility limit is set at 5 metres which equates to an Optical Density of approximately $0.2m^{-1}$.

Activation of sprinkler or other suppression systems has effects on smoke layer formation and visibility. However, research on quantifying these effects has not been reported in the literature. Since the effect of visibility on tenability is secondary, its reduction due to sprinkler spray is not regarded as a life safety criterion if it can be shown that the fire will be extinguished before excessive temperatures or toxic conditions are reached (FCRC, 1996).

Toxicity

It is now well recognised that exposure to toxic smoke products is one of the principal causes of death in fires (Purser, 1995). The parameters of toxicity are mainly dosage related. The time of exposure to any toxic gases and the intensity at which they are experienced are integrated to assess the impact of the exposure. There is now also recognition that the narcosis inducing effects of toxic gases are not independent but additive.

The most common toxic gas found in hot smoke layers is CO and research studies show that incapacitation due to CO occurs prior to incapacitation due to other toxic gases. Quintiere et al. (1982) considered an exposure dose of 43,000 ppm.min of carbon monoxide (CO) for smouldering fires to be untenable whilst the both NFPA and CIBSE Guide E suggest a more conservative CO exposure dose of 30,000 ppm.min.

Unless the fire is one in which the nature of the materials being burnt produces excessive amounts of carbon monoxide or other toxic products, then the CO exposure and other toxicity exposure time limits are usually much longer than the exposure times for occupants evacuating through smoke in typical buildings. In other words, for alert and awake occupants evacuating a building, incapacitation due to toxicity is not a common occurrence. The following table provides a summary of tenability criteria discussed above.

Table 5.3: Occupant Tenability Limits

Factor	Criteria
Primary Criteria	
Smoke Layer Height	> 2.0metres
and	
Radiant Heat Flux Received by Occupants	< $2.5kW/m^2$ (smoke layer temperature <200° C)
Secondary Criteria	
Smoke Layer Height	< 2.0 metres
and	
Smoke Temperature	< 60° C
and	
Visibility	> 10 m
and	
CO exposure dose	30,000 ppm.min

Note: References in relation to tenability limits are listed in Section 17 of this report.

5.6.2 Fire Fighter Tenability Criteria

The acceptance criteria for fire-fighter life safety shall be based on the information obtained from AFAC's Fire Brigade Intervention Model (FBIM) in relation to tenability limits.

Fire fighters undertaking fire-fighting activities do not have the equivalent tenability criteria as would the occupants within the building (Refer to Table 5.3 occupant tenability criteria and Table 5.4 fire fighter tenability criteria).

The AFAC's FBIM states the acceptable criteria in that fire-fighters should be able withstand a far greater radiant heat flux, temperature and work at a hot smoke layer height much less than that of the evacuating occupants. This is so, as fire-fighters are dressed in fire protective clothing and provided with breathing apparatus (i.e. standard A26 tunics with over trousers to an equivalent specification, fire hoods, gloves, helmets, and rubber boots). Therefore, a summary of the fire brigade tenability limits applicable to the subsequent fire safety engineering analysis of the subject building is provided in Table 5.4. This information is originally obtained from a paper written in the Fire Journal, January 1995. The project has been carried out by the UK Home Office Fire Experimental Unit.

Table 5.4: Fire brigade Tenability Limits

Factor	Criteria
Routine Condition – *Elevated temperatures, but not direct thermal radiation*	
Maximum Time	25 minutes
Maximum Air Temperature	100°C (in lower layer)
Maximum Radiation	1 kW/m^2
Hazardous Condition *– Where, fire-fighters would be expected to operate for a short period of time in high temperatures in combination with direct thermal radiation.*	
Maximum Time	10 minutes
Maximum Air Temperature	120°C (in lower layer)
Maximum Radiation	3 kW/m^2
Extreme Condition *– These conditions would be encountered in a snatch rescue situation or a retreat from a flashover.*	
Maximum Time	1 minute
Maximum Air Temperature	<160°C (in lower layer) & <280°C (in upper layer)
Maximum Radiation	<4kW/m^2
Critical Conditions *– Fire-fighters would not be expected to operate in these conditions, but could be encountered. Considered to be life threatening.*	
Maximum Time	<1 minute
Maximum Air Temperature	>235°C (in lower layer)
Maximum Radiation	>10 kW/m^2

*** Note:** All conditions (such as air temperature, visibility, humidity, incident thermal radiation, air flow past the fire-fighter, and time for which they are exposed) are relative to a height of 1.5m above floor level. The acceptance criteria has been achieved for routine conditions for all fire scenarios undertaken.

6. Design Fires and Evacuation Scenarios

6.1 Fire Scenarios

To evaluate the performance design in terms of occupant and fire-fighter safety a number of fire scenarios need to be considered. These fire scenarios examine the sequence of events from fire ignition to fire detection, occupant response and egress, fire suppression and development of untenable conditions within the egress paths.

The modelled fire scenarios will take account of factors, such as:

- Ignition sources.
- The nature, quantity, arrangement and burning behaviour of combustibles in each enclosure.
- Enclosure geometry.
- Number of enclosures and their relationship.
- Connections between enclosures.
- The fire protection measures in the building and their effect on the fire.

Time periods to be quantified for each fire scenario are detailed in the following sub sections:

6.1.1 Primary Events

- Time of fire detection
- Occupant pre-movement time
- Occupant travel time
- Time of untenable conditions

6.1.2 Secondary Events

- Suppression system activation time
- Smoke control system activation time
- Fire brigade intervention time

The number of possible fire scenarios in the proposed building can be very large and often there is insufficient data and resources to quantify them all. Therefore, detailed analysis and quantification is often limited to the most significant fire scenarios. The fire scenario detailed in the following sub-sections has been developed for the purposes of input into the timeline analysis. In addition, the core design fire scenario shall be used as input for the purposes of smoke and evacuation modelling.

Although the development of the design fire typically involves quantification of the worst credible fire scenario, other scenarios may need to be considered for the purposes of sensitivity analysis.

The contents stored within the subject building shall generally be regarded as combustible and generally associated with contents expected in a warehouse environment.

Given the simple geometric shape of the warehouse the location of the fire for modelling purposes is not considered critical unless it is located too close to the walls and there is a boundary effect on the plume. Within the warehouse a fire can be expected to ignite in any one place at any one time. Whilst the proposed location of the fire may not considered to be the greatest area of fire risk and is possibly an unlikely source of a major fire in conjunction with a maximum population present within the warehouse, it is used as it consists of fuel loads orientated vertically (within a racking system and pallet areas) thus the likelihood of rapid fire spread is expected to be increased.

The fire scenarios illustrated in Figure 6.1 have been adopted as part of this Performance Solution. In summary, the following fire scenarios are as follows:

1. **SB01: Sprinkler controlled scenario** (1st ring sprinkler activation) (core scenario – sortation system fire).
   a. An electrical malfunction within the non-storage portions of the Staging area (i.e.: ridge height of 13.7m) is considered to ignite combustible contents within the sortation system.
   b. The fire will grow at an ultra-fast t^2 growth rate and maintain its heat release rate upon activation of the sprinkler heads and hence the fire is not extinguished.
2. **SB02: Sprinkler delayed scenario** (2nd ring sprinkler activation) (sensitivity – storage rack fire).
   a. An electrical malfunction such as within the storage portions of the Low Bay Zone (i.e.: ridge height of 13.7m) is considered to ignite combustible contents within the storage rack.
   b. The fire will grow at an ultra-fast t^2 growth rate and maintain its heat release rate upon activation of the 2nd row of sprinkler heads and hence the fire is not extinguished.
3. **SB3: Fuel controlled scenario** (sprinkler system failure) (sensitivity scenario – forklift & storage pallet fire).

a. A forklift fire is considered to initiate before spreading to a nearby stack of timber storage pallets within the Low Bay Zone. Published research materials, a degree of engineering judgement and assumptions have been adopted to quantify the time when fire from the forklift is likely to spread to the timber pallets.

b. The fire will grow at a fast t^2 growth rate before reaching a peak heat release rate (PRR) of 8.7MW and maintain its heat release rate and hence the fire is not extinguished.

4. **SB04: In-Rack Sprinkler controlled scenario** (1st ring sprinkler activation) (core scenario – sortation system fire).
   a. An electrical malfunction such as hoist/automated lifts within the non-storage portions (AS/RS) of the High Bay Zone (on ground level) is considered to ignite combustible contents within the sortation system.
   b. The fire will grow at an ultra-fast t^2 growth rate and maintain its heat release rate upon activation of the sprinkler heads and hence the fire is not extinguished.
5. **SB05: Ceiling - Sprinkler controlled scenario** (1st ring sprinkler activation) (core scenario – sortation system fire).
   a. An electrical malfunction such as hoist/automated lifts within the non-storage portions (AS/RS) of the High Bay Zone (14m above the floor, 17.5m below the roof mounted sprinkler) is considered to ignite combustible contents within the sortation system.
   b. The fire will grow at an ultra-fast t^2 growth rate and maintain its heat release rate upon activation of the sprinkler heads and hence the fire is not extinguished.

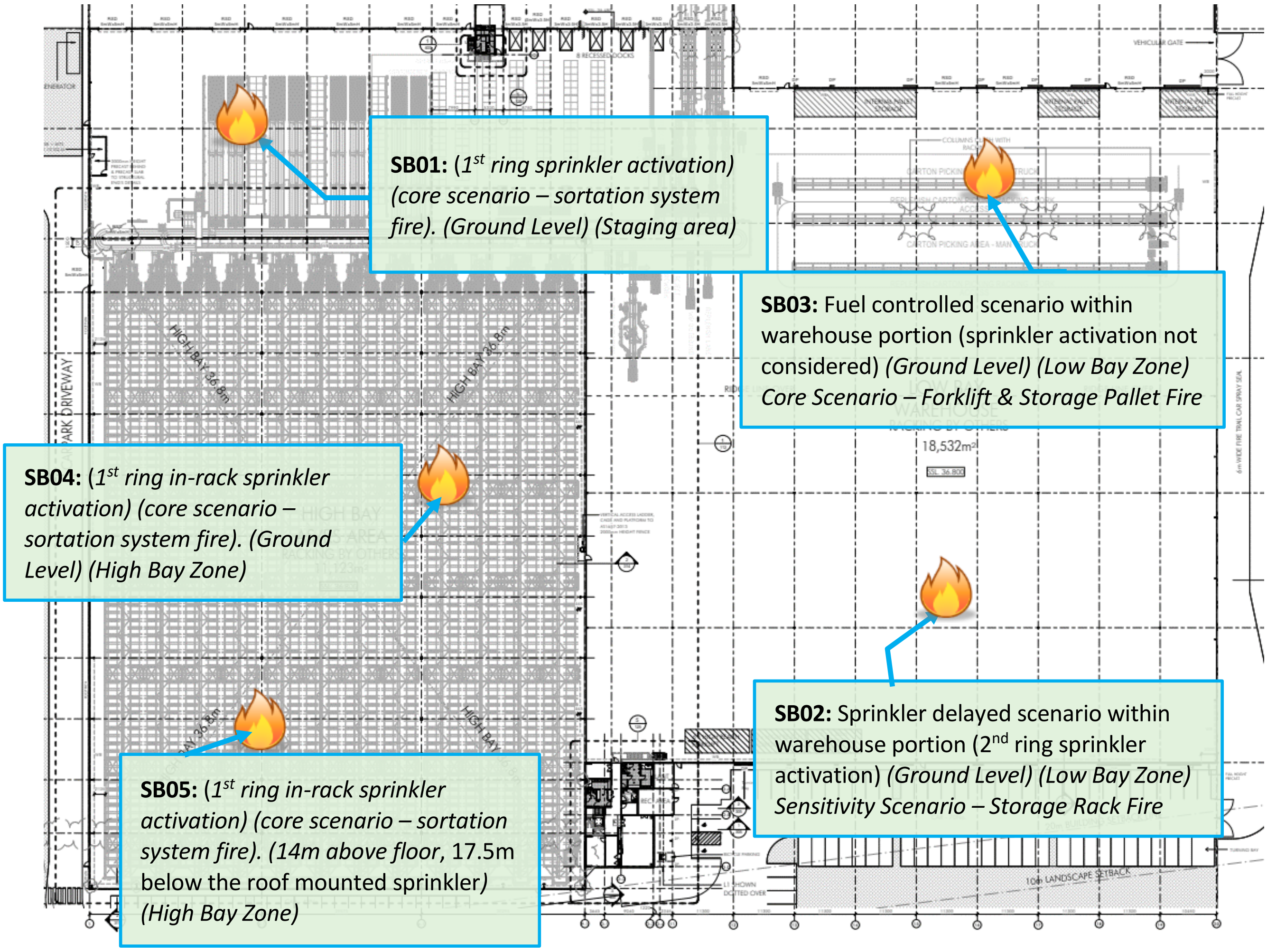


Figure 6.1: Design fire scenarios

6.2 Design Fire Scenarios

The design fire to be adopted for the identified fire scenarios having a potential to occur within the subject building must have consideration for the fuel load its orientation and the amount of ventilation. It should be noted that the building is to be provided with a sprinkler system throughout and therefore, it is more likely that within areas where sprinkler protection has been afforded the sprinklers will automatically operate and effectively control any potential fire and even suppress the fire as a result of the fast response sprinklers specifically designed, tested and approved for storage applications. Extensive studies carried out by a number of experts (including Hall, 2010) covering the past century of sprinkler protected buildings have confirmed that these systems are inherently reliable if well maintained and managed. Refer to Appendix C for further details.

It is unrealistic to adopt a single fire that represents the extreme worst case as the principal design fire and apply it to all fire scenarios required to be modelled. It is considered that systems appropriately designed, commissioned and maintained would work as designed and hence the worst-case design fire would be a fire that did not take into account such systems. For example, in a building with sprinklers, the principal design fire would not be that in which sprinkler system failure is assumed. This scenario would be considered but the tenability criteria adopted for the assessment of this scenario may be less conservative than that adopted for the sprinkler affected fires. Using the worst-case scenario as the controlling design fire would lead to unacceptable and extremely conservative designs. Assessments conducted to consider the potential impact of fires which are more severe than the principal design fire may be used to assess the sensitivity of the performance solutions applied.

The design fire for any location is therefore considered the *worst credible* fire size given the nature of the fuel type and disposition and elements being assessed. Refer to Appendix B for further details. Whilst there is a large amount of information concerning the burning rate of items, rarely is this information sufficiently generic to be universally adopted and what may be representative of current fuel loadings may not be the case in years to come. In any event it would be a rare assessment in which the specific items forming the fuel load had been tested to provide fire rate of heat release data.

6.2.1 Fire Growth Rates

In the standard fire growth rate curves the fires are classified by speed of growth. The fire growth rates are classified as ultra-fast, fast, medium and slow. The fire growth rates for different building materials are illustrated in Figure 6.2.

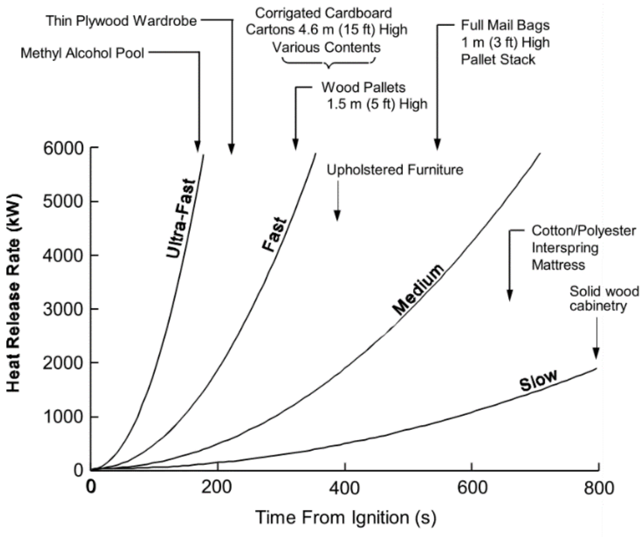


Figure 6.2: Standard Fire Growth Rate Curves (with some examples of fire test fuels) (NFPA)

In the development of credible design fires, the presence of automatic sprinklers has been considered. The main characteristics of the storage sprinkler system are that it is designed to not only control, but in most cases, extinguish a fire. In the case of other sprinkler systems, they are designed and installed based on the assumption that the system would only control the fire and limit fire spread beyond the area of first ignition.

Whilst determining credible design fires, a sprinkler-controlled design fire is assumed to remain at the heat release rate (HRR) following automatic sprinkler activation. With the suppression system, the fire may be modelled as decaying following the activation of the sprinklers to reflect the extinguishment capability of the system. The key design fire scenarios adopted for the core & sensitivity scenarios (i.e. FS01 & FS03) shall be based on the following assumptions:

- The design fire comprises an ultrafast t^2 fire growth rate. The t^2 fire growth rates is adopted as a global standard based on documents such as NFPA92, ISO TR 13388, Fire Engineering Design Guide (Buchanan) and BS476. The ultra-fast t^2 design fires reflect the extreme fuel type for commodities and distribution scenarios as listed in the tables below.

Table 1 Design fires as given in ISO TR 13388.

Design fire scenario	Category
Upholstered furniture and stacked furniture near combustible linings	*Ultra fast*
Light- weight furnishings	*Ultra fast*
Packing material in rubbish pile	*Ultra fast*
Non- fire retarded plastic foam storage	*Ultra fast*
Cardboard or plastic boxes in vertical storage arrangement	*Ultra fast*

Figure 6.3: Published Design Fire Growth Rates – ISO TR 13388

Fire growth rate	Growth time k (s)	Fire intensity coefficient α (MW/s^2)	Typical real fire
Slow	600	.00293	Densely packed wood products
Medium	300	.0117	Solid wooden furniture such as desks Individual furniture items with small amounts of plastic
Fast	150	.0466	High stacked wood pallets Cartons on pallets Some upholstered furniture
Ultrafast	75	.1874	Upholstered furniture High stacked plastic materials Thin wood furniture such as wardrobes

Table 4.3: Typical growth times for design fires

Figure 6.4: Published Design Fire Growth Rates – Fire Engineering Design Guide (Buchanan)

It is noteworthy that that the ultra-fast t^2 design fires nominated within this report are assumed to be controlled by the sprinkler system and not extinguished hence, resulting in a significantly higher total energy release over the duration of the fire. Based on the likely commodities expected within the building and the aforementioned literature, the fire modelling to be undertaken shall consider fire scenarios adopting ultra-fast t^2 fire growth rates.

6.2.2 Credible Design Fire Locations and Scenarios

It must be noted that in the context of the subject warehouse, the ignition source statistics may need to be adjusted based on the fact that smoking is not allowed and strictly controlled. Also it is not expected that hot works would not be carried out during operational hours. In environments where large numbers of occupants are present incendiary and suspicious fire lighting activities are not common.

It must be noted that in the context of the subject facility, the ignition source statistics may need to be adjusted based on the fact that smoking is not allowed and strictly controlled. Also it is not expected that hot works would not be carried out during operational hours. In environments where large numbers of occupants are present incendiary and suspicious fire lighting activities are not common. Based on these observations the most likely sources of ignition within the subject facility have been identified as:

- Mechanical failure or malfunction of a forklift ignites the block storage within Low Bay Zone; and
- An electrical malfunction such as with the High Bay Zone is considered to ignite combustible contents within the sortation system.

6.2.3 Methodology to Determine Sprinkler Activation Times

To determine the sprinkler activation time, Alpert's Correlation has been used based on the methodology prescribed by the IFEG (ABCB, 2005). The response equation for a heat detector head, or in this case a smoke detector, is given by the lumped mass heat transfer equation as follows:

$$\frac{dT_d}{dt} = \frac{\sqrt{u} \times \left(T_g - T_d\right)}{RTI}$$

As mentioned earlier, the overall evacuation time for a DtS building solution has been compared to the overall evacuation time for a performance solution. The overall evacuation time shall be equal to or less than the time taken for overall evacuation of a building solution compliance with the prescriptive provisions of the BCA. The formulas are calculated with reference to R.L. Alpert Fire Technology 1972 pp181-195.

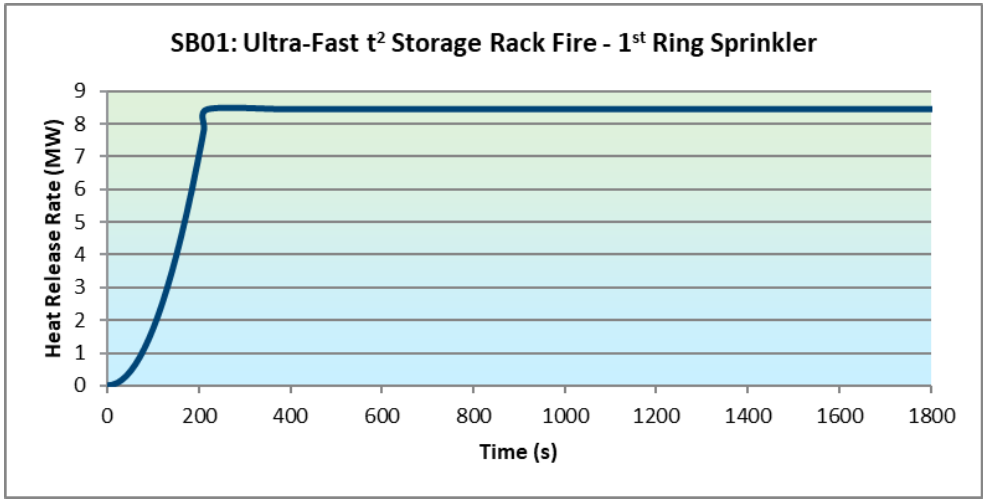
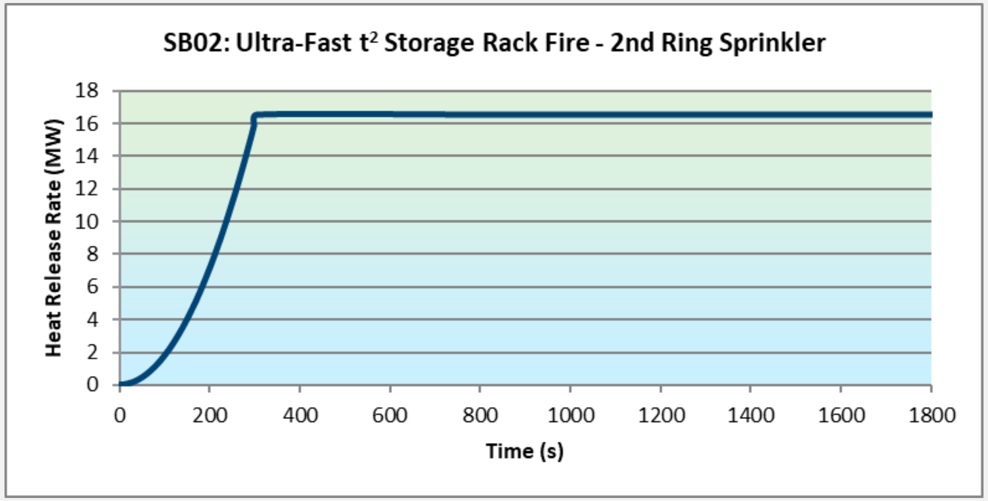
6.2.4 Sprinkler Head Activation Parameters

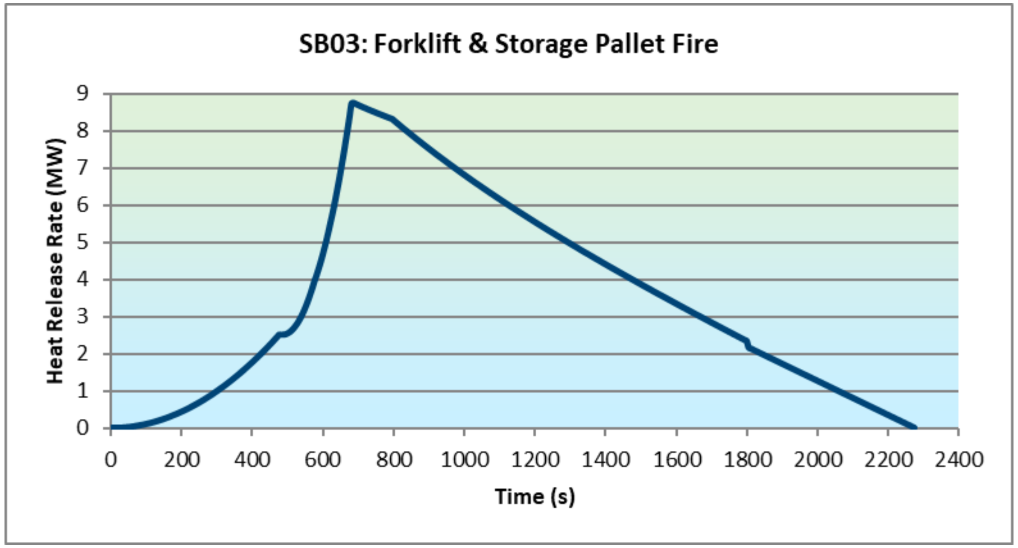
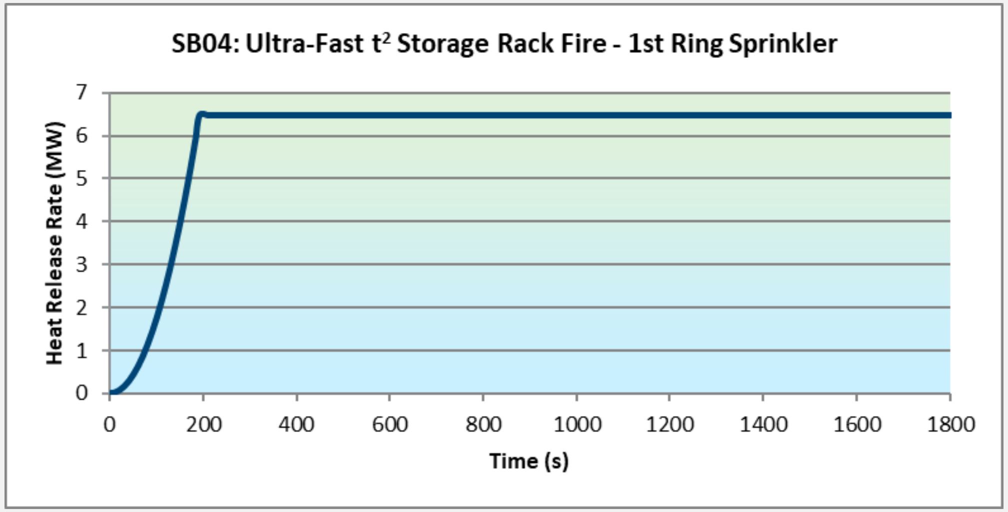
The entire building shall be provided with automatic fire sprinkler protection (Unless otherwise addressed herein) in accordance with AS2118.1:2017. The Class 7b distribution portion of the subject building is to be sprinkler protected with the installation of a Storage Sprinkler system incorporating the following:

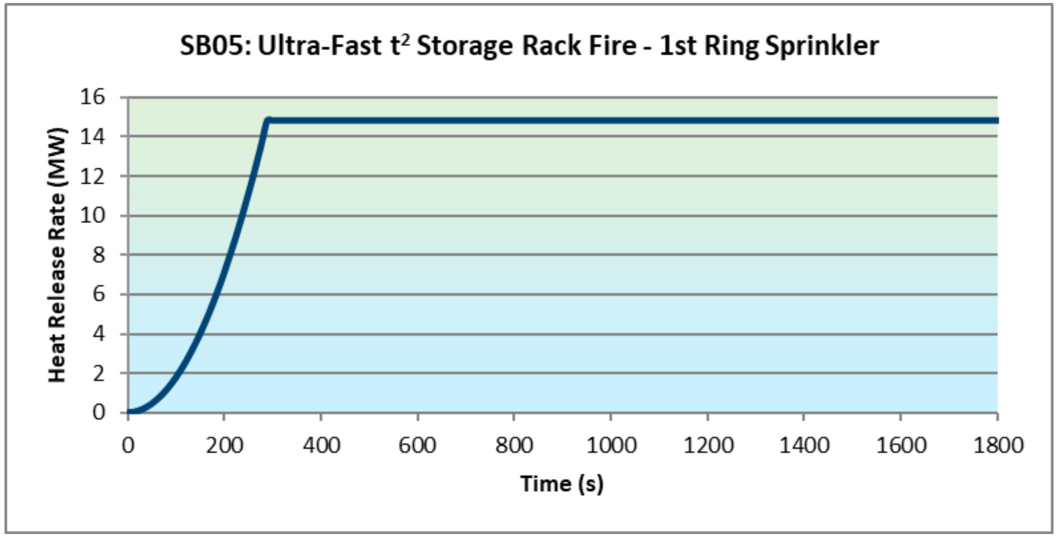
- The roof level of High Bay Zone shall be fitted with 'quick response' type heads with factor of K22. The activation temperature of storage sprinkler heads shall be no more than 100°C; and
- The in-rack areas of High Bay Zone shall be fitted with 'quick response' type heads with factor of K22. The activation temperature of storage sprinkler heads shall be no more than 100°C; and
- The Low Bay Zone shall be fitted with 'quick response' type heads with factor of K22. The activation temperature of storage sprinkler heads shall be no more than 100°C.

The high bay zone shall have a building ridge height to underside of roof sheeting of 36.8m while the low bay zone & Staging area shall be 13.7m. It is noted that the sprinkler activation time has been (conservatively) calculated using the maximum height to the eaves height within the two zones of the building. Therefore, the sprinkler height within the high bay zone and low bay zone & Staging area are 31.6 and 13.7m respectively. It should be noted that the in-rack sprinklers have been discounted as part of the calculations.

Table 6.1: Summary of design fires and design fire scenarios

Design Fire Scenario	Description	System Operation	Fire Growth Rate	Peak HRR	Schematic Design Fire
SB01: Sprinkler controlled scenario 1st ring sprinkler activation Core scenario – Sortation system fire. (Staging area)	Sortation system fire within the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 13.7m	Sprinkler system activates and controls fire at 218 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions.	Ultra-Fast t^2	8.5MW	
SB02: Sprinkler controlled scenario 2nd ring sprinkler activation Sensitivity scenario – Sortation system fire. (Low Bay Zone)	Sortation system fire within the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 13.7m	Sprinkler system activation is delayed (i.e. 2nd ring) and controls fire at 305 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions It should be noted the activation of in rack sprinklers has been discounted for this scenario.	Ultra-Fast t^2	16.6MW	

Design Fire Scenario	Description	System Operation	Fire Growth Rate	Peak HRR	Schematic Design Fire
SB03: Fuel controlled scenario Sprinkler activation not considered Sensitivity scenario – forklift & storage pallet fire. (Low Bay Zone)	A forklift fire is considered to initiate before spreading to a nearby stack of timber storage pallets. The fire shall reach the peak heat release rate (PHRR) of 8.7MW and maintain its heat release rate and hence the fire is not extinguished The fire is fuel controlled	Sprinkler activation is not considered to occur.	Fast t^2	8.7MW	
SB04: Sprinkler controlled scenario 1st ring sprinkler activation Core scenario – AS/RS system (High Bay Zone)	Sortation system fire within the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 36.8m (in-rack sprinkler height of 12m)	Sprinkler system activates and controls fire at 191 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions.	Ultra-Fast t^2	6.5MW	

Design Fire Scenario	Description	System Operation	Fire Growth Rate	Peak HRR	Schematic Design Fire
SB05: Sprinkler controlled scenario 1st ring sprinkler activation Core scenario – AS/RS system (High Bay Zone)	Sortation system fire within the high bay zone and potentially spreading to other boxed items (warehouse portion) (14m above the floor, 17.5m form the ceiling sprinkler)	Sprinkler system activates and controls fire at 289 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions.	Ultra-Fast t^2	14.9MW	

6.3 Evacuation Scenarios

For the assessment of the occupant movement during fires within the warehouse Pathfinder human movement simulation software is to be adopted as the computer evacuation modelling tool.

Pathfinder models movement of people in a building. It is based on real human behaviour, using data gathered from video analysis of individuals moving in crowds. Research results from around the world are used to augment the data, giving a unique level of accuracy and an unmatched capability for simulating building evacuation.

Two (2) types of evacuation models will be constructed for the purposes of the assessment. Based on the location of the design fires, the evacuation models will consider the following scenarios:

1. All exits available.
   a. Each evacuation scenario has taken into consideration the fire location. Hence, the distribution of occupants utilising each exit will vary between each fire scenario.
2. An exit blocked at a specific location. For example: a fire in the warehouse portion is assumed to block two (2) of the nearby exits for evacuating occupants and they are forced to use exits located along the other sides of the warehouse for egress provisions.

The location of the blocked exit scenarios are depicted in Figure 6.5. The evacuation scenarios proposed are summarised in Table 6.2 and illustrated in Figure 6.5.

Table 6.2: Adopted evacuation scenarios

Evacuation Scenario	Occupants	Available Exits	Evacuation Process
Core Evacuation Scenario	The building has full occupant loading	All exits are available and assumed to be clear/free of obstruction	Occupants evacuate after detection (visual cue or via sprinkler/detector activation, whichever is first) and pre-movement delays.
Sensitivity Evacuation Scenario	The building has full occupant loading	All exits are available with the exception of the door(s) located within direct vicinity of the fire(s). (refer to Figure 6.5)	Occupants evacuate after detection (visual cue or via sprinkler/detector activation, whichever is first) and pre-movement delays.

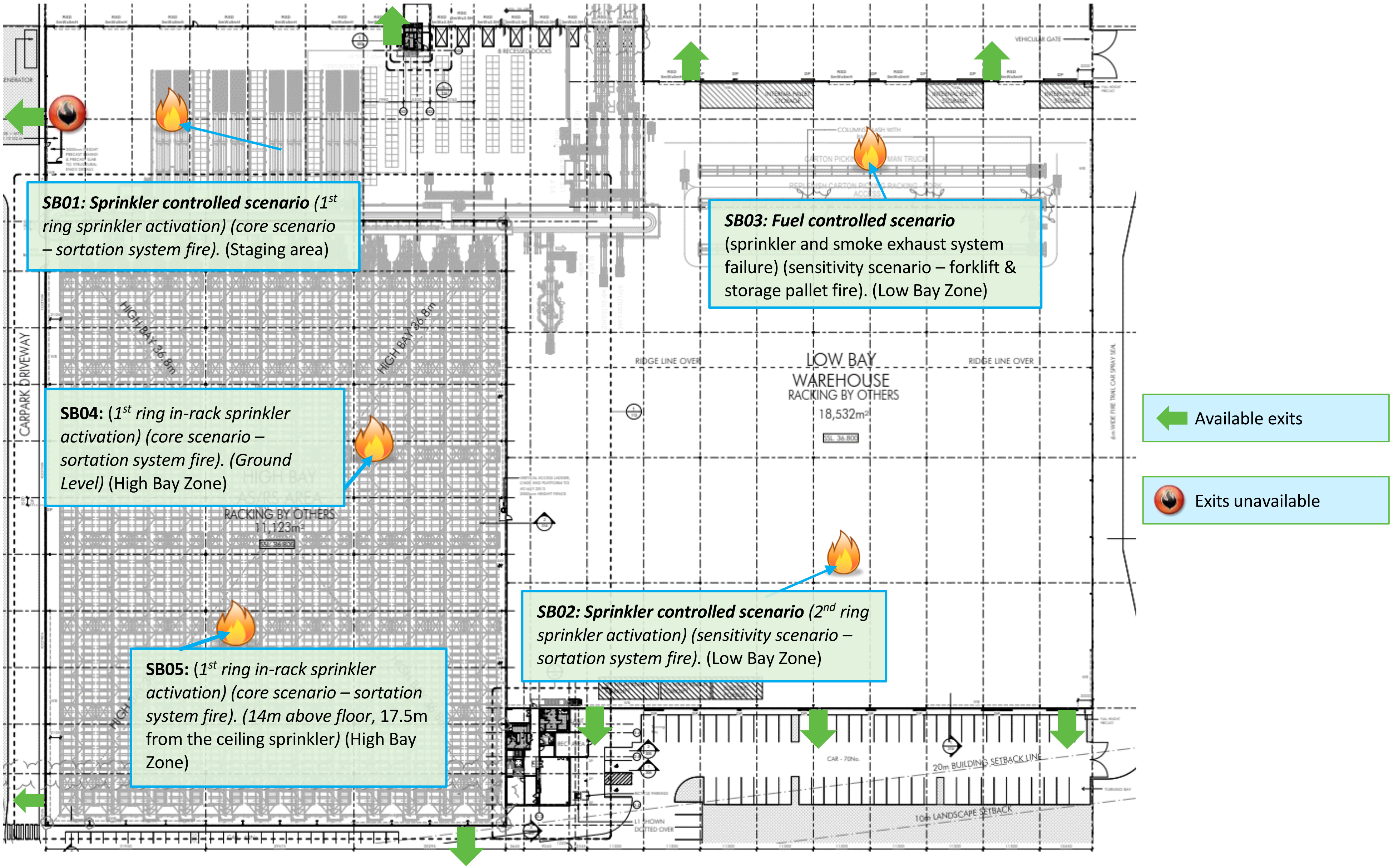


Figure 6.5: Combined design fire & evacuation scenarios

6.4 Overview of Design Fire & Evacuation Scenarios

For the assessment of the subject building, the fire and smoke spread model FDS will be used to model the fire scenarios within a representative main sortation and storage portion of the subject building. The following evacuation modelling will be undertaken based on the design fire scenarios presented below. A summary of the proposed design fires and fire scenarios are listed in Table 6.3.

Table 6.3: Summary of adopted fire & evacuation scenarios

Combined Scenario	Fire Scenario	System Activation	Evacuation Scenario Available Exits
SB01: Sprinkler controlled scenario 1st ring sprinkler activation Core scenario – Sortation system fire. (Staging area)	Sortation system fire within the non-storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 13.7m	Sprinkler system activates and controls fire at 218 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions.	***SB01 - Core Evacuation Scenario***: The building has a full occupant loading and all exits are available. All exits are available and assumed to be clear/free of obstruction. Occupants evacuate after fire detection (visual cue or via sprinkler activation, whichever is first) and pre-movement delays.
			SB02 - Sensitivity Evacuation Scenario: The building has a full occupant loading. Exit located in the warehouse portion is blocked assuming the exit is inaccessible in this area. The blocked exit and potential egress path reduces the number of available exits. The building occupants are therefore required to travel to the next safe available exit. Occupants evacuate after fire detection (visual cue or via sprinkler activation, whichever is first) and pre-movement delays.
SB02: Sprinkler controlled scenario 2nd ring sprinkler activation Sensitivity scenario – Sortation system fire. (Low Bay Zone)	Sortation system fire within the storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 13.7m	Sprinkler system activation is delayed (i.e. 2nd ring) and controls fire at 305 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions	***SB01 - Core Evacuation Scenario***: The building has a full occupant loading and all exits are available. All exits are available and assumed to be clear/free of obstruction. Occupants evacuate after fire detection (visual cue or via sprinkler activation, whichever is first) and pre-movement delays.
SB03: Fuel controlled scenario Sprinkler activation not considered Sensitivity scenario – forklift & storage pallet fire. (Low Bay Zone)	A forklift fire is considered to initiate before spreading to a nearby stack of timber storage pallets. The fire shall reach the peak heat release rate (PHRR) of 8.7MW and maintain its heat release rate and hence the fire is not extinguished The fire is fuel controlled	Sprinkler activation is not considered to occur.	***SB01 - Core Evacuation Scenario***: The building has a full occupant loading and all exits are available. All exits are available and assumed to be clear/free of obstruction. Occupants evacuate after fire detection (visual cue) and pre-movement delays.
SB04: Sprinkler controlled scenario 1st ring sprinkler activation Core scenario – AS/RS System (High Bay Zone)	Sortation system fire within the non-storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 36.8m (in-rack sprinkler height of 12m)	Sprinkler system activates and controls fire at 191 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions.	***SB01 - Core Evacuation Scenario***: The building has a full occupant loading and all exits are available. All exits are available and assumed to be clear/free of obstruction. Occupants evacuate after fire detection (visual cue or via sprinkler activation, whichever is first) and pre-movement delays.

Combined Scenario	Fire Scenario	System Activation	Evacuation Scenario Available Exits
SB05: Sprinkler controlled scenario 1st ring sprinkler activation Core scenario – AS/RS System (High Bay Zone)	Sortation system fire within the non-storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) (14m above the floor, 17.5m form the ceiling sprinkler)	Sprinkler system activates and controls fire at 289 sec Sprinklers do not suppress the fire, but only control the fire growth rate being typically representative of steady state conditions.	***SB01 - Core Evacuation Scenario***: The building has a full occupant loading and all exits are available. All exits are available and assumed to be clear/free of obstruction. Occupants evacuate after fire detection (visual cue or via sprinkler activation, whichever is first) and pre-movement delays.

7. Fire Brigade Intervention

7.1 Background

The Fire Brigade Intervention Model (FBIM) is an event-based methodology which quantifies Fire Brigade activities from the point from Fire Brigade notification through to search, rescue, fire control and extinguishment and overhaul activities. In this instance, Fire Brigade tenability is not proposed to be analysed and compared in terms of temperature and fire-fighter exposure limits, however Fire Brigade tenability is proposed to be analysed in terms of fire crew notification, intervention and fire control activity times for a response to the proposed building.

7.2 Fire Brigade Intervention Model (FBIM)

Fire Brigade tenability was proposed to be analysed and compared in terms of temperature and fire-fighter exposure limits. The Fire Brigade Intervention timeline will be estimated and assessed whereby Fire Brigade Intervention and/or fire-fighting operations is listed as sub-requirements of the relevant Performance Requirements of the BCA.

In this instance the design issues identified to require referral under Clause 144 of the Environmental Planning and Assessment Regulation 2000 relate to the rationalisation of fire safety measures associated with the length of the public corridor, travel distance issues, distance between alternative exits and the rationalisation of fire brigade operational equipment which may necessitate the requirement for Fire Brigade Intervention and fire-fighting operations to be assessed.

Fire brigade intervention is required to be analysed to determine the potential impact on the activities of the fire brigade. This relates primarily to the impact of potentially fire spread of the building elements or structure coupled with occupant and fire-fighter tenability limits with respect to the time required for fire brigade personnel to arrive and undertaken search, rescue and extinguishment activities. For the purpose of determining a time at which the local fire brigade would attend a potential fire located at the subject building, a Fire Brigade Intervention Model (FBIM) (AFAC, 2005) will be undertaken.

The two (2) nearest primary responding fire stations to the subject site via road travel are:

The nearest primary responding fire stations to the subject site via road travel have been illustrated in Figure 7.1. The relevant fire stations are as follows:

- St. Marys Fire Station (Marsden Road, Cnr Great Western Highway, St. Marys) located approximately 7.6km away; and
- Mount Druitt Fire Station (Cnr Belmore Road and Varian Street, Mount Druitt) located approximately 8.9km away; and
- Penrith Fire Station (290-294 High St, Penrith) located approximately 13.5km away.

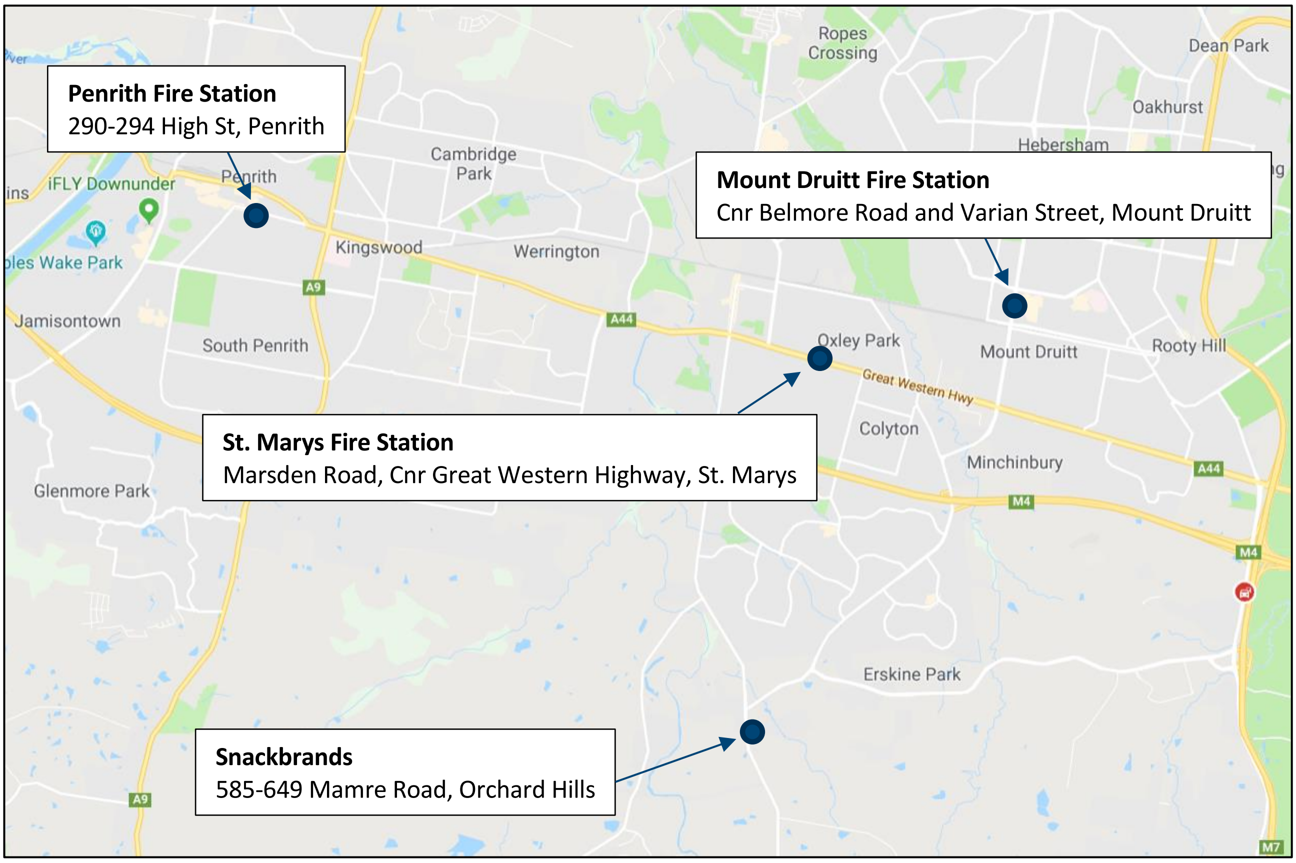


Figure 7.1: Primary responding Snackbrands (i.e. St. Marys, Mount Druitt & Penrith) to the subject site

In this instance, a FBIM has been undertaken from notification to commencement of water application as per the adopted fire scenario. The following assumptions and parameters were also adopted to determine Fire Brigade Intervention:

- Both of the above fire stations are fully manned.
- As per the prescriptive provisions of the NCC an automatic fire sprinkler system is be provided within the building. As part of the requirements under AS2118.1:2017 the sprinkler system is monitored to the Fire Brigade dispatch centre. As such, the fire services are called out upon activation of the automatic fire sprinkler system the nearest fire stations are sent to respond.
- The sprinkler activation times were determined using Alpert's Correlation (refer to Appendix F). The spread sheet model has computed the thermal response of a sprinkler head located near the roof. The formulas are calculated with reference to R.L. Alpert Fire Technology 1972 pp181-195.
- The activation of the automatic fire sprinkler system is expected to occur at 218 seconds. (Refer to Appendix F). Based on the data sheet provided for the storage system certain input parameters were incorporated for the estimated activation time which included the following:
  - The design fire for any location is therefore considered the *worst credible* fire size given the nature of the fuel type and disposition and elements being assessed.
  - Ultra-fast fire growth (CIBSE 2011).
  - 100°C activation temperature.
  - RTI 50 $m^{0.5}s^{0.5}$ (Fast response sprinkler head).
- A conservative travel speed for the FRNSW turn out times has been taken from the data provided in the FBIM for a major city outer suburb.
- Fire fighters including the Officer in Charge (OIC) would be required time to don BA gear and gather necessary information.
- Assume fire-fighters travel to the subject site and set up in the most practical area for the fire brigade appliances. The fire brigade is assumed to set up at the main entrance location in front of the building to assess the location of the fire.
- The occupants are assumed to be fully evacuated upon Fire Brigade arrival. The attending crew would be expected to receive information about the location of the fire via the Fire Indicator Panel (FIP) if it was not visible upon arrival.
- As the occupants are expected to be evacuated from the building forced entry is not expected.

- Attending fire crews would follow on-site signage to negotiate the location of the FIP. Refer to Appendix W.
- Fire crews deploying Standard Operational Procedures (SOP) and equipped with fire-fighting tools and protective clothing are unlikely to be at exposed to excessive fuel loads, ignition sources and extra ordinary hazards within the warehouse/production area when compared to a building solution compliant with the DtS provisions of the NCC.

7.2.1 Kerb Side Response Time

As illustrated in Figure 7.1, the nearest fire stations to the subject site are St Marys Fire Station, Mount Druitt Fire Station and Penrith Fire Station respectively. The anticipated primary response is detailed in Table 7.1.

Table 7.1: Primary Responding Stations

Fire Station	Address	Distance
St. Marys Fire Station	Marsden Road, Cnr Great Western Highway, St. Marys	4.6km
Mount Druitt Fire Station	Cnr Belmore Road and Varian Street, Mount Druitt	8.9km
Penrith Fire Station	290-294 High St, Penrith	13.5km

An FBIM has been carried out based on the average speed data for brigade travel. Table F2 from the FBIM manual (AFAC, 2005) provides the following average fire appliance response times.

Table 7.2: Fire Appliance Response Speeds

Graph	Region Classification	Speed (km/h)	
		μ	σ
F1.1	Major city central business district	26.8	11.3
F1.2	Major city inner suburb	26.3	11.9
F1.3	**Major city outer suburb**	**29.5**	**12.2**
_	Travel speed through site	8	-

The subject site is located in an outer suburb of a major city. Therefore, the time taken for the fire appliance to reach kerb site is calculated as detailed in the following table. To be conservative the travel time has been calculated based on a 70% percentile (i.e. k factor of 0.52) (AFAC, 2005).

Table 7.3: Fire Appliance Response Time

Fire Station	St. Marys Fire Station	Mount Druitt Fire Station	Penrith Fire Station
Approximate distance to site	7.6km	8.9km	13.5km
FRNSW Fire fighter appliance travel speed taken from FBIM V2.2 Table F1.	S = μ - (k x σ) S = 29.5 – (0.52 x 12.2) S = 23.2km/hr S = 23.2km/hr x (1000m/3600 sec) S = 6.4 m/s		
Appliance Response Time: (T = D/S)	T = 7600m / 6.4m/s T = 1187 seconds	T =8900m / 6.4m/s T = 1390 seconds	T =13500m / 6.4m/s T = 2109 seconds

As the fire within the building is assumed to be within the storage racks, the attending crew would be expected to enter at the main entrance to ascertain the fire's area of origin. The subject building is afforded with multiple exits dispersed evenly around the perimeter of the building where access is achievable to all locations within the warehouse/production floor.

As such, it is assumed that the attending crew would confirm the area of fire origin and initiate fire intervention activities accordingly. The initial attack personnel would be expected travel to the area of fire origin as per the core fire scenario with a charged line to provide initial fire suppression.

7.3 Time for Fire Brigade Intervention

The activities performed by the attending fire crews, the time associated per activity and the cumulative time from fire initiation until the commencement of water application onto the fire is tabulated in the following table.

Table 7.4: Fire Brigade Intervention Model Timeline

Activity	Time Per Activity (secs)	Cumulative Time (secs)	FBIM Details
Time to activate the automatic fire sprinkler system.	218	218	The estimated fire sprinkler system activation time (refer to Figure F.3)
Time for depressurization of the fire sprinkler system	180	398	Section 7 (FBIM) Table A, Chart 1 of FBIM.
Time delay for alarm verification	20	418	Section 7 (FBIM) Table B, Chart 1 of FBIM.
Time to dress, assimilate information and leave station.	90	508	Section 7 (FBIM) Table E, Chart 3 of FBIM.
Appliance Response Time (St. Marys Fire Station).	1187	1695	Refer to Table 7.3 of this report.
Total FBIM time from fire initiation to kerb side arrival of the subject building.	-	1695 **OR** 1898 **OR** 2617	**St Marys Fire Station** **OR** **Mount Druitt Fire Station** **OR** **Penrith Fire Station**
Time for vehicular travel within the site following wayfinding signage (i.e. 250m to the FIP at 8m/s).	312	2007	Time for vehicular travel from the FIP to the hydrant nearest the fire at 8m/s.
Time to don safety equipment (i.e. BA).	106	2113	Section 7 (FBIM) Table M, Chart 6 of FBIM. = 88.1 + (0.52x34.9).
Time for horizontal travel (i.e. 10m to the FIP at 0.8m/s).	13	2126	Time for horizontal travel from the appliance to the FIP at 0.8m/s.
Time for vehicular travel within the site (i.e. 60m to the hydrant at 8m/s).	75	2201	Time for vehicular travel from the FIP to the hydrant (worst case scenario) at 8m/s.
Flush the hydrant.	44	2245	Section 7 (FBIM) Table O, Chart 6 of FBIM. = 32.8+ (0.52x20.6).
Time to remove necessary tools from appliance.	42	2287	Section 7 (FBIM) Table P, Chart 6 of FBIM. = 32.5+(0.52x18.1).
Connect hose to boosted hydrant and charge (65mm).	79	2366	Section 7 (FBIM) Table V, Chart 11 of FBIM. = 59.6+(0.52x37.9).
Time for horizontal travel (i.e. 60m to the area of fire origin at 0.8m/s).	75	2441	Time for horizontal travel from the hydrant to the AFO (worst case scenario within the warehouse building) at 0.8m/s.
Total FBIM time from fire initiation to commence water control and extinguishment activities.	-	2441 **OR** 2644 **OR** 3363	**St Marys Fire Station** **OR** **Mount Druitt Fire Station** **OR** **Penrith Fire Station**

Referring to Table 7.4 above the approximate times for the closest fire stations have been provided. As detailed above in Table 7.4, the timeline FBIM indicates the following:

Table 7.5: Summary of FBIM Activity from St Marys Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	1695
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746

FBIM Event	Time (secs)
The cumulative time taken from fire initiation to commencement of water onto the fire	**2441**

Table 7.6: Summary of FBIM Activity from Mount Druitt Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	1898
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**2644**

Table 7.7: Summary of FBIM Activity from Penrith Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	2617
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**3363**

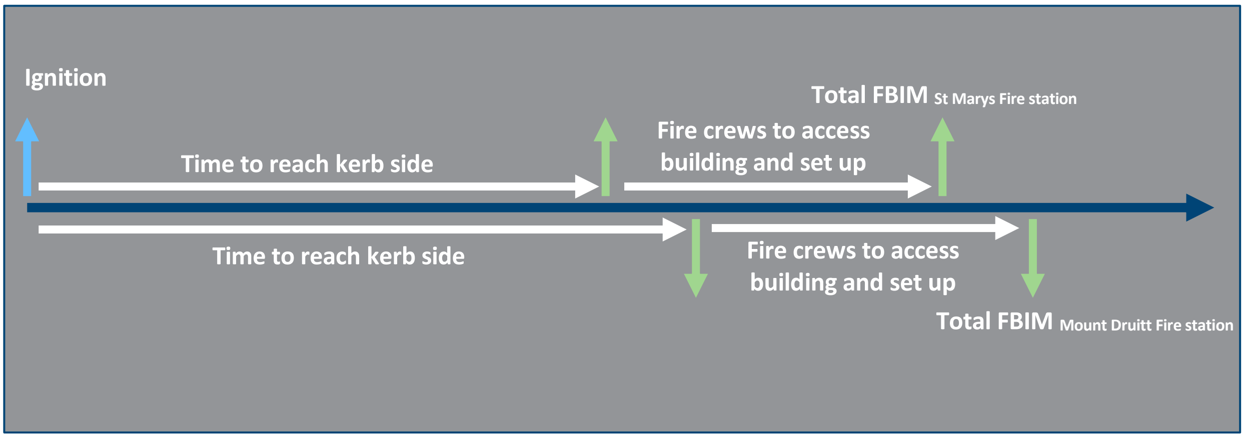


Figure 7.2: Schematic representation of the timeline analysis associated with FBIM (St Marys and Mount Druitt)

Figure 7.3: Schematic representation of the timeline analysis associated with FBIM (Penrith)

It is noted that the cumulative time is derived by incorporating a level of conservatism for estimated times for travel speeds, both vehicular, horizontal and the like. In a real fire scenario, the actual resultant time for fire brigade intervention procedures may be further reduced, however this is not to be relied upon.

8. Life Safety Analysis

8.1 General

The Life Safety Analysis (ASET/RSET) has been undertaken to determine the acceptability of the trial design which includes design issues that specifically relate to egress provisions and smoke hazard management design. To address these issues a holistic approach has been undertaken with consideration of the fire safety systems installed within the building to ensure tenability limits are not breached during the evacuation process.

8.2 Evacuation Analysis to Determine RSET

An evaluation of the evacuation time phases (fire detection, occupant pre-movement and occupant movement) has been undertaken to calculate the RSET. The main occupant group associated with a development of this nature are identified as staff and compromise persons from varying gender and age groups with a more uniform level of physical and mental ability. The proposed method adopted for determining each component is briefly described in the following subsections.

8.2.1 Detection Time

The detection time has been based on either the time required for the automatic sprinkler system to operate within the facility and/or the time for building occupants to detect the fire/smoke via olfactory and visual cues. The sprinkler activation time for each fire scenario, with the exception of the *SB03 (Fuel Controlled Forklift & Storage Pallet Fire)* scenario, has utilised a spread sheet calculation which incorporates Alpert's Correlation (refer to Appendix F). The detection time was based on the roof height of the building and adopted sprinkler system (i.e. activation temperature of 100°C and RTI of $50m^{-0.5}s^{-0.5}$). Refer to Appendix F for the details of the input parameters and output results for each of the detection times. Furthermore, with reference to Clause 8.13.1 of AS2118.1:2017, the delay times to depressurise the sprinkler system is in the order of 180 seconds.

Furthermore, the FDS modelling outcomes have demonstrated that occupant visual cues are expected to occur quicker than the time for the sprinkler to activate. Based on the studies conducted in 'Microeconomics Reform: Fire Regulation' (BRR, 1991), the time that the smoke layer drops 5% from the ceiling height is the visual smoke detection time by occupants. For conservatism, the detection time (occupant visual cues) has been based on the time for the smoke layer to drop 10% from the ceiling height over approximately 50% of the total floor area. Refer to Appendix D for the FDS modelling outcomes for occupant visual cues to occur. A summary of the detection time for each modelled scenario is noted to be as per Table 8.1.

Table 8.1: Allocated Detection times for the adopted design fire scenarios

Design Fire Scenario	Fire Location	Sprinkler Activation (Refer to Appendix F)	Occupant Visual Cue (T_d) (Refer to FDS outcomes)
SB01: *Sprinkler controlled scenario* *(1st ring sprinkler activation)* ***(core scenario – storage rack fire)***	Staging Area	398 seconds (218+180)	Staging Area: 250 seconds Low Bay: 250 seconds High Bay: 250 seconds
SB02: *Sprinkler delayed scenario* *(2nd ring sprinkler activation)* ***(sensitivity scenario – storage rack fire)***	Low Bay Warehouse	485 seconds (305+180)	Staging Area: 350 seconds Low Bay: 150 seconds High Bay: 425 seconds
SB03: *Sprinkler failure scenario* ***(Sensitivity scenario – forklift and pallet fire)***	Low Bay Warehouse	Sprinklers do not activate (1)	Staging Area: 380 seconds Low Bay: 300 seconds High Bay: 850 seconds
SB04: In-Rack Sprinkler controlled scenario *(1st ring sprinkler activation)* ***(core scenario – storage rack fire)***	High Bay AS/RS Area	371 seconds (191+180)	Not applicable (2)

Design Fire Scenario	Fire Location	Sprinkler Activation (Refer to Appendix F)	Occupant Visual Cue (T_d) (Refer to FDS outcomes)
SB05: Ceiling - Sprinkler controlled scenario *(2nd ring sprinkler activation)* ***(sensitivity scenario – storage rack fire)***	High Bay AS/RS Area	469 seconds (289+180)	Not applicable (2)

Notes:

1. It is noted that fire scenario *SB03 (Fuel Controlled Forklift & Storage Pallet Fire)* adopts a custom fire similar to a fast t^2 fire with no sprinkler activation or associated automatic detection activation given the nature and size of the fire selected. As the sprinkler system fails or is yet to operate and based on the function & use of the warehouse, visual detection of the fire is expected to occur. Hence, the detection time for occupant evacuation in the sprinkler failure scenario relies on occupant visual and olfactory cues. With reference to the FDS modelling outcomes, it is considered that occupants receive visual cues following the smoke layer descending approximately 10% of the ceiling height (BRR, 1991). Furthermore, the presence of assumed maximum occupant numbers means that any fire in the area is unlikely to develop far without detection by occupants. Potential reductions in occupant numbers could possibly increase the detection time but would definitely reduce movement time.
2. Due to the ceiling height of the High Bay AS/RS area being approximately 36m high and a limited number of occupants' present (i.e. maintenance staff), it is considered that occupant visual cues is not considered appropriate within this area. Therefore, the detection from within the High Bay AS/RS area was based on the activation of the automatic sprinkler systems.

8.2.1.1 Detection Cues for SB01

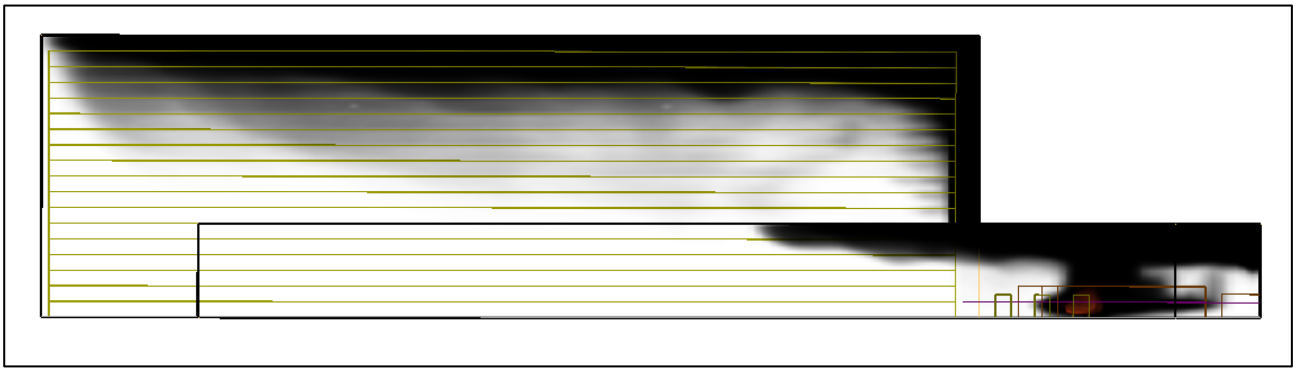


Figure 8.1: Time for occupant visual detection cues to occur (SB01, 250 seconds)

8.2.1.2 Detection Cues for SB02

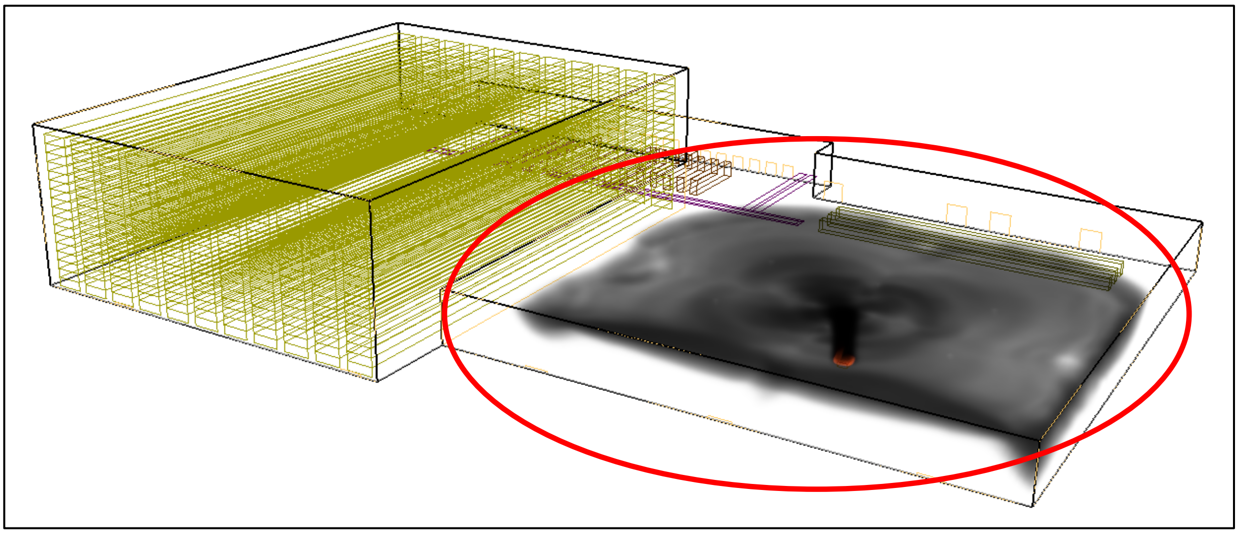


Figure 8.2: Time for occupant visual detection cues to occur at Low Bay Warehouse (SB02, 150 seconds)

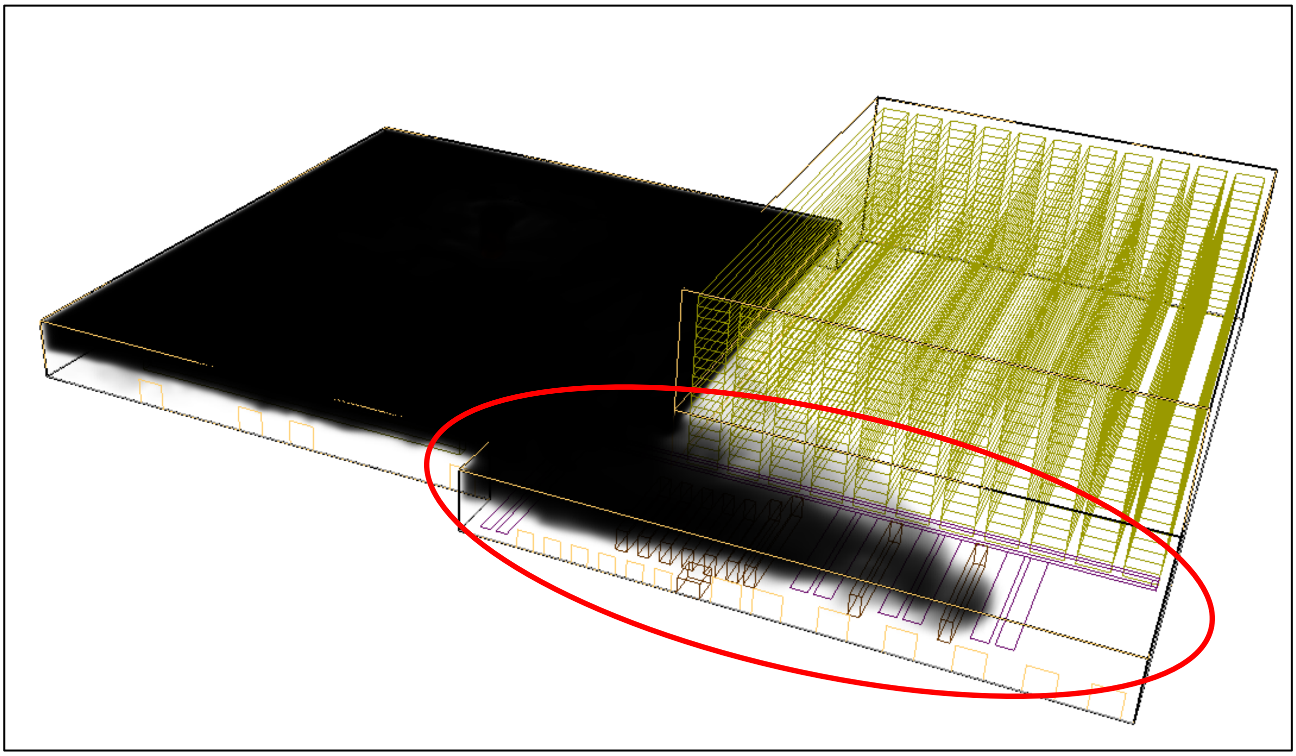


Figure 8.3: Time for occupant visual detection cues to occur at Staging Area (SB02, 350 seconds)

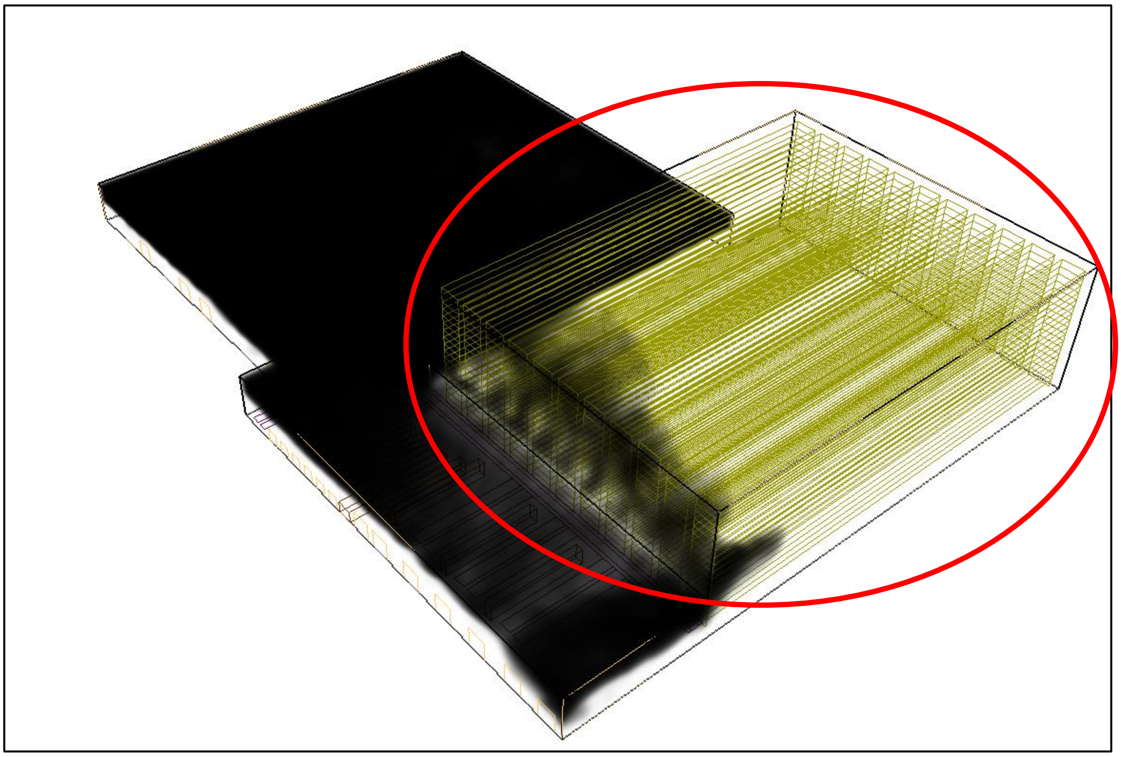


Figure 8.4: Time for occupant visual detection cues to occur at High Bay Area (SB02, 425 seconds)

8.2.1.3 Detection Cues for SB03

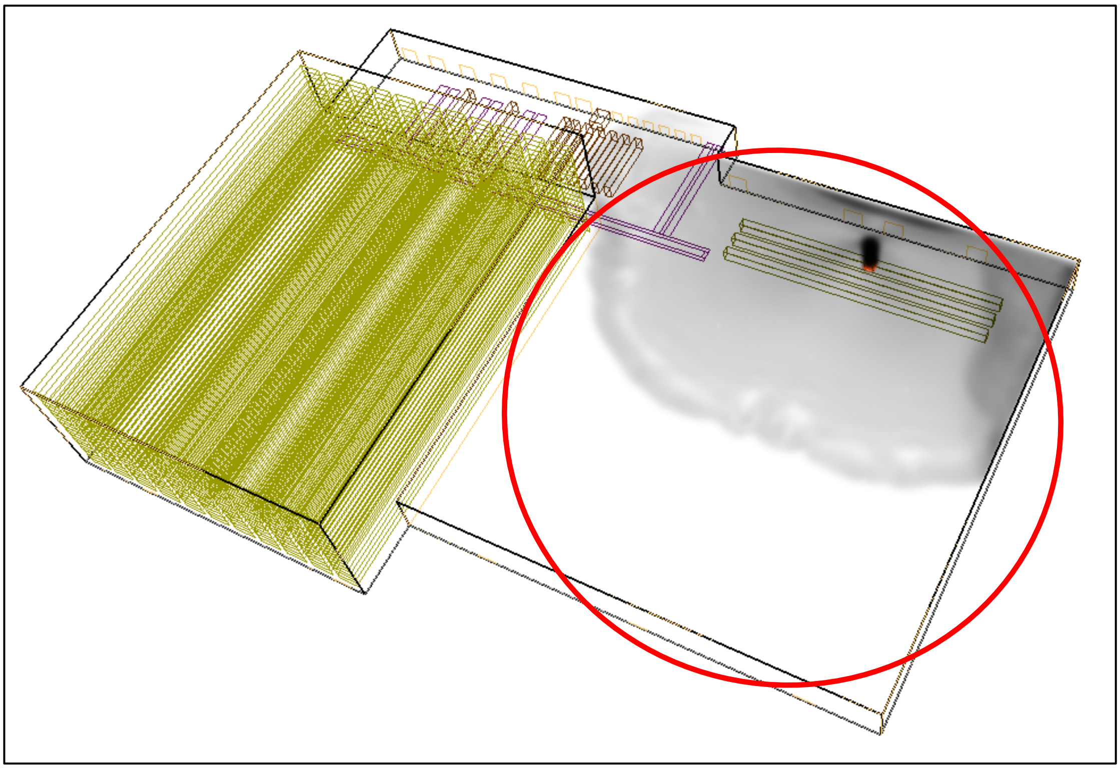


Figure 8.5: Time for occupant visual detection cues to occur at Low Bay Area (SB03, 300 seconds)

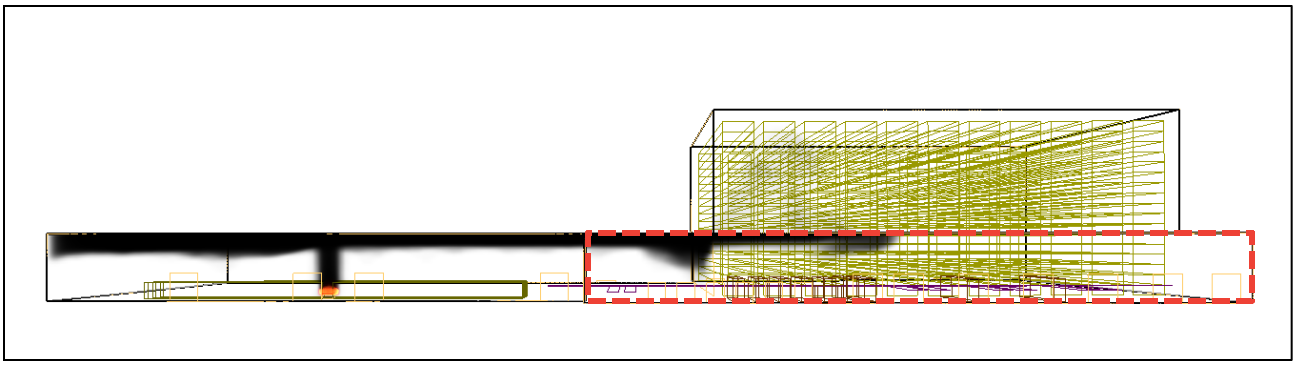


Figure 8.6: Time for occupant visual detection cues to occur at Staging Area (SB03, 380 seconds)

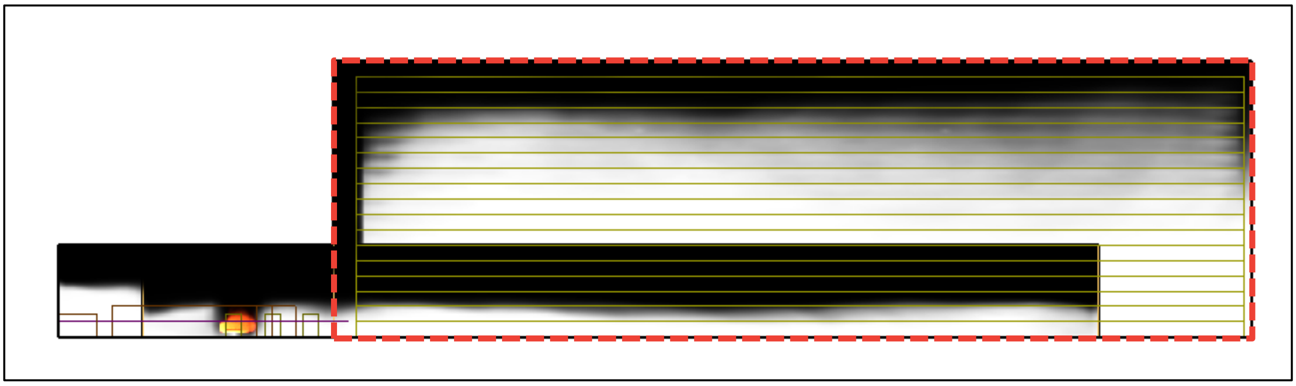


Figure 8.7: Time for occupant visual detection cues to occur at High Bay Area (SB03, 850 seconds)

8.2.2 Pre-Movement Time

The pre-movement component of the evacuation process as previously stated often has the greatest variability as occupant located within the direct vicinity of the fire will become aware of a fire and will start their movement phase more rapidly hence these occupants would have a reduced pre-movement time.

Similarly, occupants located remote from the fire will take considerably longer to decide on an appropriate course of action as a result of the fire not being a direct threat hence occupants further away from the fire will have an increased pre-movement time. This phenomenon has been considered in the occupant evacuation analysis.

Pre-movement times are established based on an analysis and interpretation of human behaviour studies from the literature and BS7974-2001 "Application of fire safety engineering principles to the design of buildings – Code of Practice".

In the immediate area where the fire initiates occupants are assumed to have a corresponding risk (i.e. IR1) which is expected to be higher than all other areas within the building (refer to Section 5.5). The surrounding areas would naturally have a relatively lower level of risk (i.e. IR2, IR3, IRn). Therefore, a contoured approach is considered a reasonable assumption. Based on the above, the following pre-movement times are considered appropriate for the evacuation analysis:

Occupancies such as the warehouses are highly appropriate for adopting the risk contours approach. Visual access to other section of the building is not always assured. Hence, in the event of a fire in one particular area the occupants within the immediate vicinity would become aware of the fire immediately while occupants located in other part would rely on secondary warnings such as alarms, staff or other occupants moving away from the zone of fire origin. The pre-movement time would incrementally increase for zones further away from the area of fire origin (AFO).

In the context of the subject warehouse, the building has been divided into intervals according to the configuration and internal layout. The pre-movement times for the evacuation scenarios are as follows:

- The pre-movement time for the zone of fire origin (AFO) is 60 seconds; and
- The pre-movement time for the adjacent zone of fire origin is 120 seconds; and
- The pre-movement time for the remote zone of the fire origin is 180 seconds.

8.2.3 Movement Time

A comprehensive people movement model has been constructed for the warehouse portion. For further details of the 3D Human Movement Simulation modelling refer to Appendix E. A number of separate evacuation models have been constructed for the purpose of the subsequent assessment and more over to develop a degree of conservatism within the design. While the exit paths of travel require the occupants to travel to the designated exits and then discharge to the open space, in order to demonstrate levels of redundancy consideration was given to cases where a potential fire may block an exit.

The travel time component of the evacuation process in this class of building is generally based on a determination of the time for occupants to move to a place of safety. The occupants are anticipated as being of mixed gender and typically between the age of 18 & 60 years. The occupants are considered to be adequately mobile with no specific physical impairments that warrant attention. Any transient occupant sub-group (i.e. visitors) would potentially comprise persons from all gender and age groups ranging from 18 to 60 years with varying levels of physical and mental ability.

Given the nature of the subject building, it is considered that the egress paths will allow occupants to move at their normal walking speed (Lord et al, 2005 & Fahy et al 2001). This is a result of a limited number of occupants present within a large enclosure at any given time. Studies conducted by various researchers detailed in 'Egress Design Solutions' (Meacham.B.J, and Tubbs, J.S, 2007) have established occupant average walking speeds for different occupant groups (refer to Table 8.2). Therefore, a conservative movement speed of building occupants shall be taken as **0.8 ms^{-1}.**

Table 8.2: Horizontal walking speeds for varying occupant groups (Egress Design Solutions, 2007).

Occupant Group	Min. Walking Speed	Max. Walking Speed	Avg. Walking Speed
Children (<18 years old)	0.28 m/s	1.8 m/s	0.88 m/s
Young (18-29 years old)	0.25 m/s	1.9 m/s	1.12 m/s
Middle Aged (30-50 years old)	0.25 m/s	1.9 m/s	1.12 m/s
Disabled	0.25 m/s	1.3 m/s	0.77 m/s

For the purpose of the analysis, a total number of occupant loading of 75 occupants has been adopted.

The following tables are a summary of the evacuation time results from the Pathfinder software output files. Note that the pre-movement time has been incorporated into the Pathfinder model. A detailed account of the evacuation modelling output is provided in Appendix E.

Table 8.3: Occupant movement times for adopted evacuation scenarios

Design Fire Scenario	Evacuation Scenario	Fire Location	$T_{pm} + T_m$ (seconds)
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB01C:** Core Scenario	Staging Area	147
		Low Bay Warehouse	165
		High Bay Warehouse	260
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB01S:** Sensitivity Scenario	Staging Area	147
		Low Bay Warehouse	165
		High Bay Warehouse	260
SB02: ***Sprinkler delayed scenario*** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	**SB02C:** Core Scenario	Staging Area	147
		Low Bay Warehouse	165
		High Bay Warehouse	260
SB03: ***Sprinkler failure scenario*** *(Sensitivity scenario – forklift and pallet fire)*	**SB03C:** Core Scenario	Staging Area	147
		Low Bay Warehouse	165
		High Bay Warehouse	260
SB04: **In-Rack Sprinkler controlled scenario** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB04C:** Core Scenario	Staging Area	185
		Low Bay Warehouse	225
		High Bay Warehouse	200
SB05: **Ceiling - Sprinkler controlled scenario** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	**SB05C:** Core Scenario	Staging Area	185
		Low Bay Warehouse	225
		High Bay Warehouse	200

***Note:** It should be noted that the pre-movement time for each scenario has been implemented into each evacuation scenario. The reason for this negligible variation in the movement time component of each model is attributed to the well distributed and uniform egress provisions provided within the subject building. Additionally, the subject building has a low occupant loading resulting in minimal to no queuing.

8.2.4 Total RSET

Combining all the elements of the evacuation process timeline as calculated in the previous sections of this report gives the overall Required Safe Egress Time (RSET) as detailed in Table 8.4. Graphic modelling outcomes for occupant movement simulations (Pathfinder) are depicted in Appendix E.

Table 8.4: Calculated RSET

Design Fire Scenario	Evacuation Scenario	Fire Location	T_d	$T_{pm} + T_m$	RSET
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB01C:** Core Scenario	Staging Area	250	147	397
		Low Bay Warehouse	250	165	415
		High Bay Warehouse	250	260	510
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)*	**SB01S:** Sensitivity Scenario	Staging Area	250	147	397
		Low Bay Warehouse	250	165	415

Design Fire Scenario	Evacuation Scenario	Fire Location	T_d	$T_{pm} + T_m$	RSET
(core scenario – storage rack fire)		High Bay Warehouse	250	260	510
SB02: ***Sprinkler delayed scenario*** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	**SB02C:** Core Scenario	Staging Area	350	147	497
		Low Bay Warehouse	150	165	315
		High Bay Warehouse	425	260	685
SB03: ***Sprinkler failure scenario*** (Sensitivity scenario – forklift and pallet fire)	**SB03C:** Core Scenario	Staging Area	380	147	527
		Low Bay Warehouse	300	165	465
		High Bay Warehouse	850	260	1110
SB04: **In-Rack Sprinkler controlled scenario** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB04C:** Core Scenario	Staging Area	371	185	556
		Low Bay Warehouse	371	225	596
		High Bay Warehouse	371	200	571
SB05: **Ceiling - Sprinkler controlled scenario** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	**SB05C:** Core Scenario	Staging Area	469	185	654
		Low Bay Warehouse	469	225	694
		High Bay Warehouse	469	200	669

8.3 Smoke Modelling Analysis to Determine ASET

Based upon the smoke modelling conducted, Table 8.5 provides an understanding of the outcomes of each model. The table specifically details the major occurrences in relation to the acceptance criteria as detailed in Section Appendix D of this report. Graphic modelling outcomes are depicted in Appendix D.

Table 8.5: Design fire scenario discussion

Design Fire Scenario	Design Fire Scenario Summary	Layer Height and Temperature at the Conclusion of the Modelling
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	Sortation system fire within the non-storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 13.7m	**Occupant Visual Cues:** It was observed that the smoke layer spread over approximately 50% of the roof/ceiling and dropped approximately 10% below the roof/ceiling at 250 seconds for occupant visual cues to occur. **Occupant Tenability Criteria:** **Visibility:** The model demonstrated acceptable tenable conditions (i.e. visibility >10m) within the warehouse portion as summarised below: • Staging area: 1900 seconds • Low bay warehouse: 3000 seconds • High bay warehouse: 1600 seconds **Convective Heat:** The smoke layer temperature (below 2.1m above the finished floor level) did not exceed 60°C for durations greater than 3000 seconds due to the convection of cool air (i.e. the building volume). **Conclusion:** The visibility criterion of less than 10m was the first tenability criterion being breached. As such, the determined the ASET for the sprinkler-controlled fire scenario are as follows: • Staging area: 1900 seconds • Low bay warehouse: 3000 seconds • High bay warehouse: 1600 seconds

Design Fire Scenario	Design Fire Scenario Summary	Layer Height and Temperature at the Conclusion of the Modelling
SB02: ***Sprinkler delayed scenario*** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	Sortation system fire within the storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 13.7m	**Occupant Visual Cues:** It was observed that the smoke layer spread over approximately 50% of the roof/ceiling and dropped approximately 10% below the roof/ceiling for occupant visual cues to occur within each portion of the warehouse as follows: • Staging Area: 350 seconds • Low Bay warehouse: 150 seconds • High Bay warehouse: 425 seconds **Occupant Tenability Criteria:** **Visibility:** The model demonstrated acceptable tenable conditions (i.e. visibility >10m) within the warehouse portion as summarised below: • Staging area: 1650 seconds • Low bay warehouse: 1800 seconds • High bay warehouse: 1600 seconds **Convective Heat:** The smoke layer temperature (below 2.1m above the finished floor level) did not exceed 60°C for durations greater than 3000 seconds due to the convection of cool air (i.e. the building volume). **Conclusion:** The visibility criterion of less than 10m was the first tenability criterion being breached. As such, the determined the ASET for the sprinkler-controlled fire scenario are as follows: • Staging area: 1650 seconds • Low bay warehouse: 1800 seconds • High bay warehouse: 1600 seconds
SB03: ***Sprinkler failure scenario*** *(Sensitivity scenario – forklift and pallet fire)*	A forklift fire is considered to initiate before spreading to a nearby stack of timber storage pallets. The fire shall reach the peak heat release rate (PHRR) of 8.7MW and maintain its heat release rate and hence the fire is not extinguished The fire is fuel controlled	**Occupant Visual Cues:** It was observed that the smoke layer spread over approximately 50% of the roof/ceiling and dropped approximately 10% below the roof/ceiling for occupant visual cues to occur within each portion of the warehouse as follows: • Staging Area: 380 seconds • Low Bay warehouse: 300 seconds • High Bay warehouse: 850 seconds **Occupant Tenability Criteria:** **Visibility:** The model demonstrated acceptable tenable conditions (i.e. visibility >10m) within the warehouse portion as summarised below: • Staging area: 1800 seconds • Low bay warehouse: 1800 seconds • High bay warehouse: 1800 seconds **Convective Heat:** The smoke layer temperature (below 2.1m above the finished floor level) did not exceed 60°C for durations greater than 3000 seconds due to the convection of cool air (i.e. the building volume). **Conclusion:** The visibility criterion of less than 10m was the first tenability criterion being breached. As such, the determined the ASET for the fuel-controlled fire scenario are as follows: • Staging area: 1800 seconds • Low bay warehouse: 1800 seconds • High bay warehouse: 1800 seconds

Design Fire Scenario	Design Fire Scenario Summary	Layer Height and Temperature at the Conclusion of the Modelling
SB04: **In-Rack Sprinkler controlled scenario** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	Sortation system fire within the non-storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) height = 36.8m (in-rack sprinkler height of 12m)	**Occupant Visual Cues:** Due to the ceiling height of the High Bay AS/RS area being approximately 36m high and a limited number of occupants' present (i.e. maintenance staff), it is considered that occupant visual cues is not considered appropriate within this area. *Therefore, the detection from within the High Bay AS/RS area was based on the activation of the automatic sprinkler systems (371 seconds (i.e. 191 + 180)).* **Occupant Tenability Criteria:** **Visibility:** The model demonstrated acceptable tenable conditions (i.e. visibility >10m) within the warehouse portion as summarised below: • Staging area: 3000 seconds • Low bay warehouse: 3000 seconds • High bay warehouse: 1000 seconds **Convective Heat:** The smoke layer temperature (below 2.1m above the finished floor level) did not exceed 60°C for durations greater than 3000 seconds due to the convection of cool air (i.e. the building volume). **Conclusion:** The visibility criterion of less than 10m was the first tenability criterion being breached. As such, the determined the ASET for the sprinkler-controlled fire scenario are as follows: • Staging area: 3000 seconds • Low bay warehouse: 3000 seconds • High bay warehouse: 1000 seconds
SB05: **Ceiling - Sprinkler controlled scenario** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	Sortation system fire within the non-storage portions of the high bay zone and potentially spreading to other boxed items (warehouse portion) (14m above the floor, 17.5m form the ceiling sprinkler)	**Occupant Visual Cues:** Due to the ceiling height of the High Bay AS/RS area being approximately 36m high and a limited number of occupants' present (i.e. maintenance staff), it is considered that occupant visual cues is not considered appropriate within this area. *Therefore, the detection from within the High Bay AS/RS area was based on the activation of the automatic sprinkler systems (469 seconds (i.e. 289 + 180)).* **Occupant Tenability Criteria:** **Visibility:** The model demonstrated acceptable tenable conditions (i.e. visibility >10m) within the warehouse portion as summarised below: • Staging area: 3000 seconds • Low bay warehouse: 3000 seconds • High bay warehouse: 3000 seconds **Convective Heat:** The smoke layer temperature (below 2.1m above the finished floor level) did not exceed 60°C for durations greater than 3000 seconds due to the convection of cool air (i.e. the building volume). **Conclusion:** The visibility criterion of less than 10m was the first tenability criterion being breached. As such, the determined the ASET for the sprinkler-controlled fire scenario are as follows: • Staging area: 3000 seconds • Low bay warehouse: 3000 seconds • High bay warehouse: 3000 seconds

The values listed in Table 8.5 are based upon the time at which the tenability criteria were breached or alternatively the time at which the model simulation was completed and steady state conditions within the enclosure were observed.

***Note:** The graphical modelling outputs for each fire scenario are provided in Appendix D. The fire models were terminated at 3000 seconds as conditions maintained steady state.

8.4 Evaluation of Results

8.4.1 Occupant Life Safety Summary

From the above analysis, the indication of the life safety of the occupants can be obtained by comparison of the ASET and RSET values for the scenarios examined (this comparison is provided in Table 8.6). Similarly, with consideration to the FBIM conducted in Section 7.

Based on the fire and evacuation modelling undertaken tenable conditions are maintained for a period greater than the required time with a sufficient safety factor. This value is greater than the time for Fire Brigade intervention to be undertaken (i.e. 2441 seconds). Hence, the acceptance criteria is considered to be satisfied and met (this comparison is provided in Table 8.6).

Table 8.6: ASET/RSET comparison for building occupants

Design Fire Scenario	Evacuation Scenario	Area	Occupant RSET (seconds)	Occupant ASET (seconds)	ASET/RSET Factor of Safety	Acceptance Criteria Satisfied
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB01C:** Core Scenario	Staging Area	397	1900	4.78	Yes
		Low Bay	415	3000	7.23	Yes
		High Bay	510	1600	3.14	Yes
SB01: ***Sprinkler controlled scenario*** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB01S:** Sensitivity Scenario	Staging Area	397	1900	4.78	Yes
		Low Bay	415	3000	7.23	Yes
		High Bay	510	1600	3.14	Yes
SB02: ***Sprinkler delayed scenario*** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	**SB02C:** Core Scenario	Staging Area	497	1650	3.32	Yes
		Low Bay	315	1800	5.71	Yes
		High Bay	685	1600	2.34	Yes
SB03: ***Sprinkler failure scenario*** *(Sensitivity scenario – forklift and pallet fire)*	**SB03C:** Core Scenario	Staging Area	527	1800	3.41	Yes
		Low Bay	465	1800	3.87	Yes
		High Bay	1110	1800	1.62	Yes
SB04: **In-Rack Sprinkler controlled scenario** *(1st ring sprinkler activation)* *(core scenario – storage rack fire)*	**SB04C:** Core Scenario	Staging Area	556	3000	5.40	Yes
		Low Bay	596	3000	5.03	Yes
		High Bay	571	1000	1.75	Yes
SB05: **Ceiling - Sprinkler controlled scenario** *(2nd ring sprinkler activation)* *(sensitivity scenario – storage rack fire)*	**SB05C:** Core Scenario	Staging Area	654	3000	4.59	Yes
		Low Bay	694	3000	4.32	Yes
		High Bay	669	3000	4.48	Yes

8.4.2 FBIM Summary

Table 8.7: ASET/FBIM comparison for attending fire crews

Modelled Design Fire Scenario	Attending Fire Brigade	Fire Brigade Intervention (seconds)	Fire-Fighter ASET (seconds)	Acceptance Criteria Satisfied
All modelled fire scenarios	St Marys Fire Station	2441	>3000	Yes
	Mount Druitt Fire Station	2644	>3000	Yes
	Penrith	3363	>3000	Yes

***Note:** At the completion of the fire and smoke modelling simulations (i.e. 3000 seconds), the temperature conditions maintained steady state conditions (i.e. temperatures do not exceed 100°C at 1.5m above the finished floor level for routine conditions).*

The Fire Brigade Intervention Model (FBIM) estimates the time for applying water onto a fire is in the order of 2441 seconds or approximately 40-41 minutes (from St Mary's fire station). In relation to Fire Brigade intervention, the model simulations were completed at 3000 seconds and demonstrated steady state conditions whereby temperatures did not exceed 60°C at 1.5m above the finished floor level for all adopted fire scenarios. Therefore, on-going routine (steady state) conditions were provided for the attending Fire Brigades. It is not expected that the conditions (i.e. temperature) would worsen beyond 3000 seconds. This is a result of the upper (hot) smoke layer mixing with the lower (cool) smoke layer (i.e. convection). Appendix D provides evidence that the temperature criteria within the subject warehouse for all scenarios are well below 100°C (approx. 60°C for fire-fighters to intervene).

Based on the outcomes of the quantitative fire and occupant evacuation modelling it is clearly demonstrated that the proposed suite of fire safety systems achieves adequate levels of life safety to ensure that occupants are able to safely evacuate from the building and attending fire-fighters are provided with adequate conditions to undertake Standard Operational Procedures (SOPs). In all instances presented above, the established acceptance criteria as stated in Section 5.5 of this report have been satisfied.

9. Open Space & Vehicular Access

9.1 Background to the Issue

The subject building is considered to be a Large Isolated Building (LIB) as the building exceeds the maximum volume limitations as permitted in Table C2.2 of Volume One of the NCC. In this regard, the building must be provided with vehicular access and open space provisions as permitted under Clause C2.4 of the NCC from Volume One of the NCC. In this instance, it is proposed to permit open space and vehicular access provisions as per the following:

- The far side of the perimeter vehicle access along the eastern boundary of the site is up to 26m from the external wall of the building in lieu of 18m; and
- The access provided to the north of the site is proposed to be on the adjacent allotment which is intended to be acquired by Snackbrands at a future date.

The overall layout & configuration of the site access provision is illustrated in Figure 9.1.

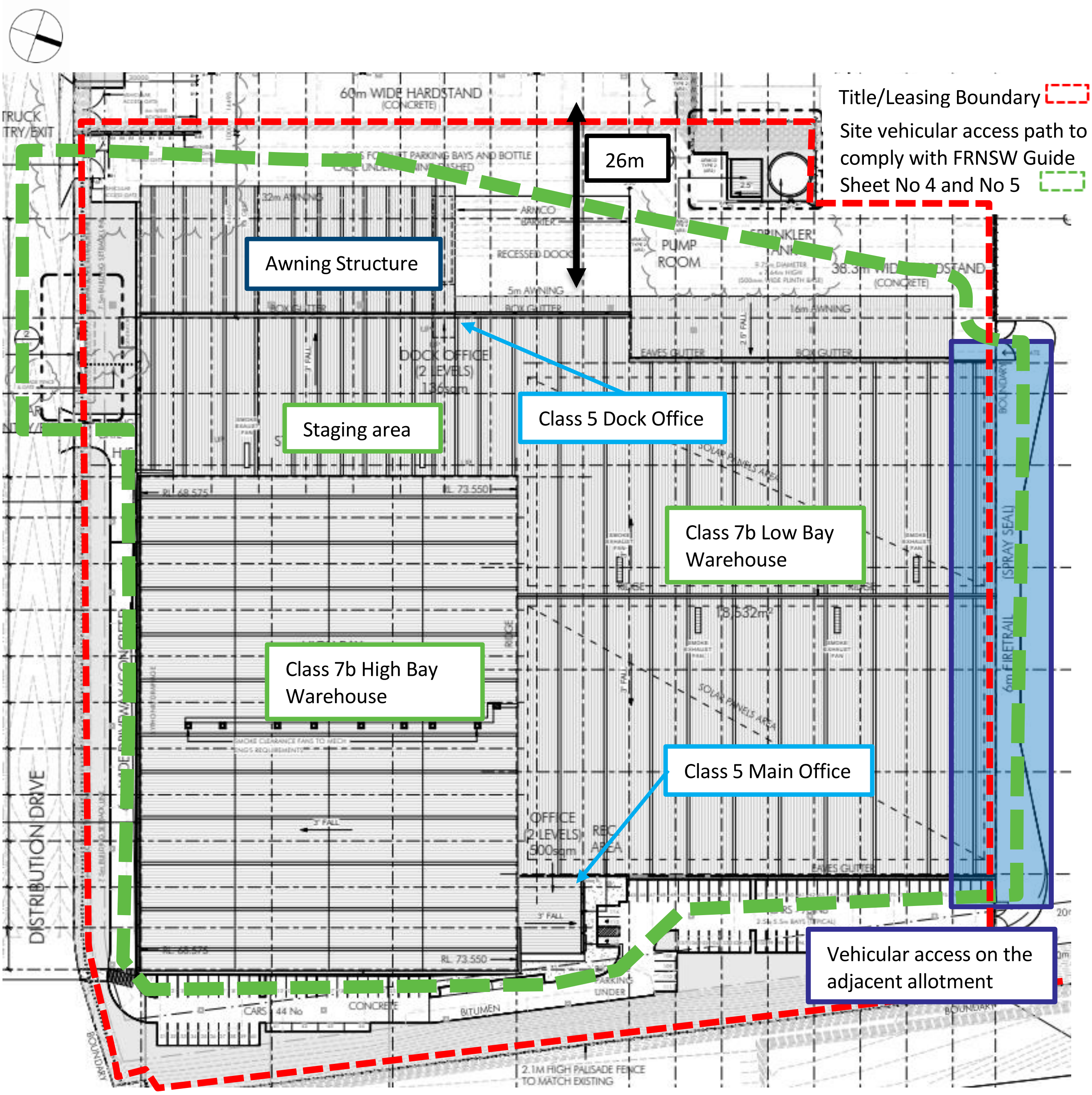


Figure 9.1: Site perimeter vehicular access

9.2 NCC Assessment Methodology

In accordance with the NCC Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine whether the *Building Solution* complies with the *Performance Requirement* CP9.

Table 9.1: Method of Analysis

Identified Design Issue	NCC Assessment Method	IFEG Method of Analysis
The following compliance issues have been identified with respect to the proposed perimeter vehicular access serving the warehouse: • The far side of the perimeter vehicle access along the eastern boundary of the site is up to 26m from the external wall of the building in lieu of 18m; and • The access provided to the north of the site is proposed to be on the adjacent allotment which is intended to be acquired by Snackbrands at a future date.	A0.5(b)(ii) such other *Verification Methods* as the *appropriate authority* accepts for determining compliance with the *Performance Requirements*.	A qualitative evaluation has been adopted based on direct consultation with Fire & Rescue NSW (FRNSW).

9.3 Hazard Specific to Open Space & Vehicular Access Provisions

The 'Guide to the NCC' (ABCB, 2016) states that the intent associated with provided perimeter vehicular access and open space provisions is *"To set the minimum requirements for open space around a building and the provision of vehicular access for the Fire Brigade".* It is therefore considered that the main hazards specific to the design issues requiring assessment are:

- The risk of objects or encroachments impeding Fire Brigade activities and thereby endangering the life and safety of occupants and property; and
- A potential fire may be rather significant from one side or part of the building therefore if access to this particular side was unavailable then it may negatively impact Fire Brigade activities; and
- The risk of obstruction on the vehicular access path impeding on vehicular access during Fire Brigade Intervention; and

9.4 Hazard Mitigation

The 'Guide to the NCC' (ABCB, 2016) identifies the importance of incorporating continuous perimeter access to the Fire Brigade and the risk associated with Fire Brigade access and fire spread without access. In this regard the following hazard mitigation systems, requirements and features of the design are noted:

- The subject building shall be provided with an automatic sprinkler system whereby Storage Sprinklers shall be provided within the warehouse portions which are designed to suppress a fire. The outcome of effective fire sprinkler suppression system operation is to mitigate smoke production through suppression. Therefore, the likelihood of a defensive attack and hence the requirement for an external aerial attack (which would require a full 6m width) is minimised; and
- A 6.0m wide perimeter vehicular access zone shall be created along the full length of the on the adjacent allotment such that the vehicular access on the adjacent allotment can be utilised as continuous perimeter vehicular access for Snackbrands (Stage 1); and
- Any gates forming part of the perimeter vehicular access road that are proposed to be locked are required to be fitted with suitable conventional 003 padlocks or alternatively, the responding fire services shall be provided with building keys to enable fire-fighter access with a standard key; and
  - A secure key box shall be provided and located at the front gate to house the building/site keys for the attending fire crew. The security code to the secure key box shall be provided to the FRNSW and this information shall form part of the emergency response plan to the site (refer to Appendix W and Appendix P); and
- Maintain the perimeter vehicular access paths free of static storage and combustible contents at all times; and
- Fire hydrant system compliant with the relevant Australian Standard unless otherwise addressed herein.

9.5 Methodology

A qualitative methodology has been adopted to address the proposed vehicular access provisions with consideration given towards the effectiveness and efficacy surrounding the following:

- Operational firefighting ability and any potential impacts on operational functions undertaken during firefighting operations;

- Potential firefighter impacts as a direct result of the function and use of the building, likely fire load and potential fire intensity and hazard in association with the active and passive fire mitigation systems;
- Fire appliance and other emergency vehicle access around the entire site including the ability to ensure emergency vehicles do not obstruct appliance manoeuvrability and access around the site.

The assessment methodology has also considered the Standard Operational Guideline's (SOG's) of firefighting personnel which is expected to be obtained following direct consultation with the FRNSW.

9.6 Acceptance Criteria

The acceptance has been met by demonstrating that the proposed vehicular access and open space provisions are satisfactory to accommodate access to and around the building in order to facilitate fire brigade intervention. The aim is to ensure the efficacy of fire-fighting operations is maintained such that there are no undue impacts on the deployment of safe Standard Operational Guideline's (SOG's).

Overall, the approach demonstrates that the proposed vehicular access allows for fire brigade personnel to undertake their operational procedures without access being unduly impacting on the efficacy of fire-fighting operations.

9.7 Evaluation of Open Space & Vehicular Access Provisions

9.7.1 FRNSW Consultation

The FEB was formally submitted to FRNSW for their review and comment relative to the fire-fighters requirement to travel along the perimeter of the building. As mentioned above, it is proposed to permit the far side of the perimeter vehicle access along the eastern boundary of the site is up to 26m from the external wall of the building in lieu of 18m and permit vehicular access via the northern side of the site, which forms part of the adjacent allotment.

The FRNSW has required a 6.0m wide perimeter vehicular access zone to be created along the full length of the on the adjacent allotment such that the vehicular access on the adjacent allotment can be utilised as continuous perimeter vehicular access for Snackbrands (Stage 1).

It is also noted that internal and external fire hydrant layout provides coverage to all areas with the exception of the high bay area. The subject building is provided with a fire hydrant system commensurate with AS2419.1-2005 with the exception of the following:

- Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and
- Permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only.

The above items relative to the fire hydrant design issues has been assessed in Section 12 of this FSER.

9.7.2 Sprinkler Protection

The subject building shall be constructed in accordance with Type C construction and is deemed to satisfy the NCC prescriptive provisions with respect to fire resistance. Based on the expected function & use of the building, building size, potential fire load, intensity and overall fire hazard, the building shall be provided with an automatic sprinkler system in accordance with AS2118.1-2017. Sprinkler protection is expected to limit the likelihood of fire development and spread, reducing the likelihood of the following:

- Catastrophic structural collapse; and
- Fire development and spread beyond the building; and
- Untenable conditions for occupant life safety; and
- Untenable conditions for fire-fighters undertaking fire-fighting operations.

Based on the above, it is considered that the FRNSW will have the ability to undertake an offensive fire attack. With respect to fire resisting construction, the building is compliant with the DtS provisions in terms of its proximity to the title boundary. Based on the reliability and effectiveness of the sprinkler system to control the development and spread of fire, any lightweight or non-fire rated materials used throughout the construction of the building are not likely to significantly contribute to the overall fire load within the building.

9.7.2.1 Sprinkler Effectiveness in Storage Facilities

As noted previously, all areas of the building will have a fully compliant AS2118.1:2017 sprinkler system installed. As detailed in Section C3.4 from Volume One of the NCC, sprinklers are deemed to be a reliable method of preventing fire spread. As such, the proposed sprinkler system is expected to control the development and spread of fire within the proposed building as intended under EP1.4 from Volume One of the NCC. Further, the effectiveness of the automatic fire sprinklers in limiting fire spread and growth is supported by statistics and studies undertaken into the effects of automatic fire sprinklers within buildings.

A potential fire within the sprinkler protected storage building is expected to be of reduced intensity due to the sprinkler protection system, and building structural elements would be subjected to lesser temperatures and exposure to fire conditions than would structural elements in a DtS compliant non-sprinkler protected building.

Sprinkler protection is expected to provide a reliable and effective means of maintaining tenable conditions for occupants and fire-fighters, structural adequacy, and limiting fire spread within a building and to adjacent building(s). Effective sprinkler activation and operation is also likely to reduce the generation of smoke and maintain low compartment temperatures.

Furthermore, automatic sprinklers have an inherently high reliability. The extensive study by Marryatt (1988) covering the past century of sprinkler protected buildings indicated that sprinkler systems which are soundly managed may have reliability as high as 99.5%. Research findings by Nash and Young (1991) and Bukowski *et al.* (1999) also confirmed the high reliability of sprinkler systems.

With sprinkler activation, it is evident that the effect of sprinklers on a fire is to wet down potential fuel sources, control or suppress the burning process and to cool the resultant smoke layer. It has been cited that the resultant smoke temperatures in a sprinkler-controlled fire are of the order of 100°C -120°C (CIBSE 1997; Sekizawa, 1996). This concept is illustrated in Figure 9.2.

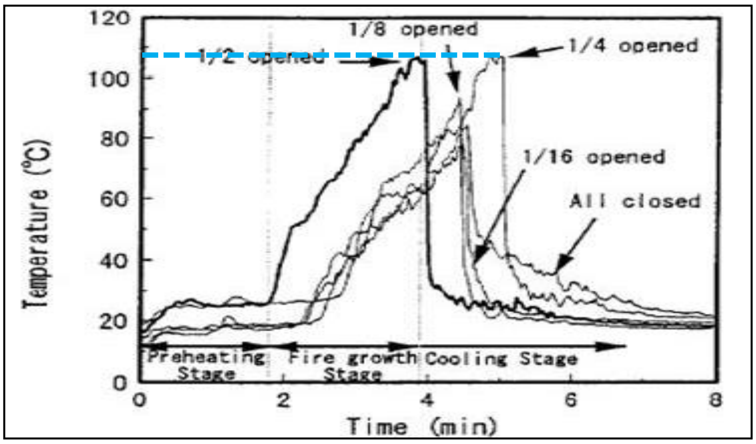


Figure 9.2: Sprinkler controlled room temperatures

Therefore, it is considered that the sprinkler system will reduce compartment temperatures to the degree necessary whereby occupant and fire fighter life safety are maintained for an extensive period of time.

As such, it can be seen that upon activation of a fully compliant and reliable sprinkler system that the structural members are unlikely to be exposed to severe fire development and high temperature conditions that could cause them to lose their strength and fail.

9.7.2.2 USA (NFPA) Statistical Incident Data

As mentioned previously, studies have shown that fire sprinkler systems operate and control fires in 81% to 99.5% of fire occurrences. The lower reliability estimates of 81.3% as well as some of the higher values of 87.6% appear to reflect significant bias in data in terms of small number of fire incidents and the lack of differentiation between fire sprinklers and other fire suppression systems. It must be noted that the higher reliability of fire sprinklers reported by Marryatt of 99.5% reflect fire sprinkler systems where inspections, testing and maintenance exceeded normal expectations and applies to installations specifically in Australia and New Zealand. The statistical data from the paper titled “US Experience with Sprinklers” indicate that sprinklers with appropriate maintenance are highly effective in reducing the loss of life and limiting fire spread. More recent data studies indicate that the operational reliability of automatic sprinkler systems may be decreasing. However, improvements in the data collection system enable a better evaluation of the data and based upon the August 2005 NFPA report, the operational reliability of sprinkler systems may be as high as 93%.

The sprinkler effectiveness in reducing loss of life, property and containing a fire to the area of fire origin has been documented in the paper titled “US Experience with Sprinklers” (NFPA 2003). The following statistical data is summarised based on data collected during the period of 1989 – 1999.

Table 9.2: Storage facilities – extent of flame damage

Extent of Flame Damage	Storage Facilities - Extent of Flame Damage	
	With Sprinklers	Without Sprinklers
	Fires	Fires
Confined to object of origin	450 (50%)	5,840 (19.9%)
Confined to area of origin	250 (27.8%)	4,150 (14.4%)
Confined to room of origin	60 (6.7%)	1,450 (4.9%)
Confined to fire-rated compartment of origin	10 (1.1%)	180 (0.6%)
Confined to floor of origin	20 (2.2%)	320 (1.1%)
Confined to structure of origin	90 (10%)	13,200 (45%)
Extended beyond structure of origin	20 (2.2%)	4,190 (14.3%)
Total	**900 (100%)**	**29,330 (100%)**

As can be seen from the above table, despite the reduced number of incidents recorded for sprinkler protected storage facilities, the percentage likelihood of fire confinement to the fire start location is considerably higher when compared to storage premises without sprinkler protection.

Table 9.3: Estimated reduction in 189-1998 civilian deaths per thousand

Property Use	Civilian Deaths per Thousand Fires		
	Without Sprinklers	With Sprinklers	Percentage Reduction
Public Assembly	1.1	0.0	100%
Residential	9.4	2.1	78%
Industrial	1.1	0.0	100%
Manufacturing	2.0	0.8	60%
Storage	**1.0**	**0.0**	**100%**

With reference to the above, civilian fatalities have been reduced by 100% during an entire ten-year period due to the presence of sprinklers within storage facilities.

Table 9.4: Percentage of operating sprinklers

Property Use	Percentage of Operating Sprinklers where Sprinklers were present	
	Percentage of Fires during 1989-1998	Percentage of Fires in 1999
Public Assembly	73.9%	70.2%
Educational	79.6%	76.2%
Offices	80.6%	81.1%
Industrial	85.9%	88.3%
Manufacturing	91.1%	90.7%
Storage	84.0%	84.5%

The table above indicates the percentage of fires that occurred in properties where sprinklers operated. The table suggests percentages to be somewhat lower than sprinkler performance statistics typically cited in older studies, however the percentages are considered to be misleading due to a number of partial installations, as well as structure fires not being large enough to activate an installed sprinkler system.

Furthermore, the graph depicted in Figure 9.3 it is clearly suggested that in terms of effectiveness in mitigating flame spread beyond the room of fire origin sprinklers are approximately 30% more effective than compartmentation arising from fire rated construction in a warehouse/storage building.

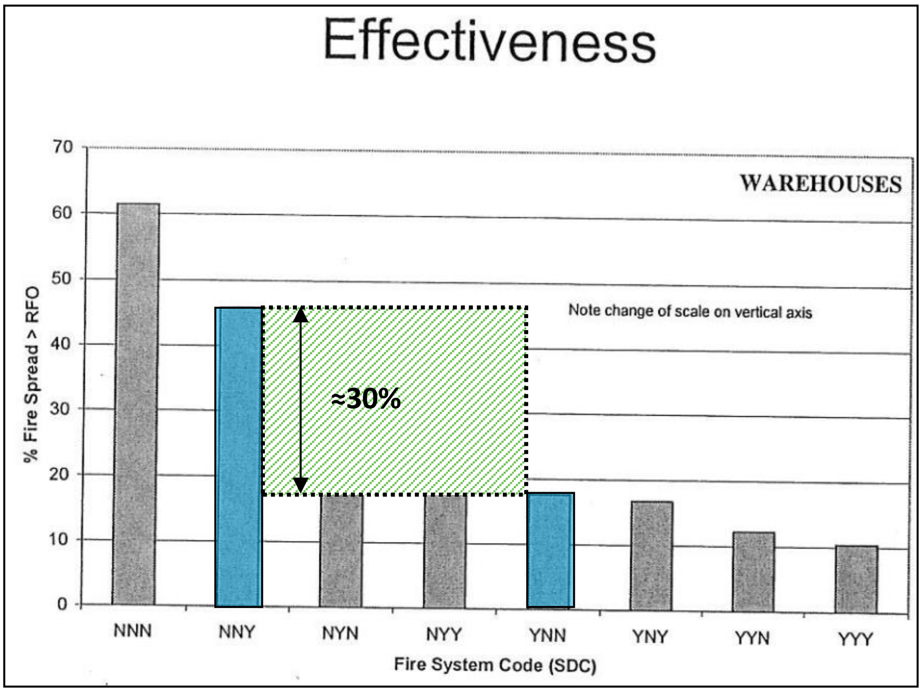


Figure 9.3: System effectiveness in warehouse/storage fires

9.7.2.3 Statistical Analysis – Summary

The statistical data indicates sprinklers are highly effective in reducing the loss of life (and property) during fires. When sprinklers are present, the likelihood of fire development and spread beyond the room of fire origin is considered to be low. With appropriate maintenance, sprinklers have a high reliability of activating and preventing or limiting fire spread. Although sprinkler systems are not completely designed to fully extinguish fires, its ability to effectively limit the development growth and spread provides the attending fire-fighters with the ability to extinguish a decaying fire.

9.7.3 Qualitative Evaluation for Open Space Provisions

One of the main purposes for a large isolated building to be provided with vehicular access is to enable fire crews to access all parts of the building and furthermore, enable the Fire Brigade to intervene to fight the fire, assist with evacuation and stop the spread of fire to another building (i.e. adjoining property). Although there are no openings or non-fire rated elements within the external walls that are located within minimum setback distances to a fire sources feature (e.g. title boundary). Therefore, the likelihood of excessive radiant heat flux levels received along the vehicular access locations or title boundaries are deemed to comply with the DtS provisions from Volume One of the NCC.

The open space provision is provided as a fire break between a potential fire within a building and fire appliance situated on the perimeter access road. It is important to note that the perimeter vehicular access road is permitted to be immediately adjacent to a sprinkler protected building. By having a vehicular access road at the eastern portion of the warehouse building is up to approximately 26m, in which provides more than an adequate fire shielding between a fire within the building and the fire appliance set-up location (refer to Figure 9.1). It is also important to highlight that the intent of the vehicular access roadway being located within 18m of the building is to ensure fire crews are located within reasonable proximity to fire hydrants.

9.7.4 Qualitative Evaluation for Perimeter Vehicular Access Provisions

Perimeter vehicular access is provided on all four (4) sides, the following description of the building's elevations in the context of fire appliances and/or firefighter access to the building.

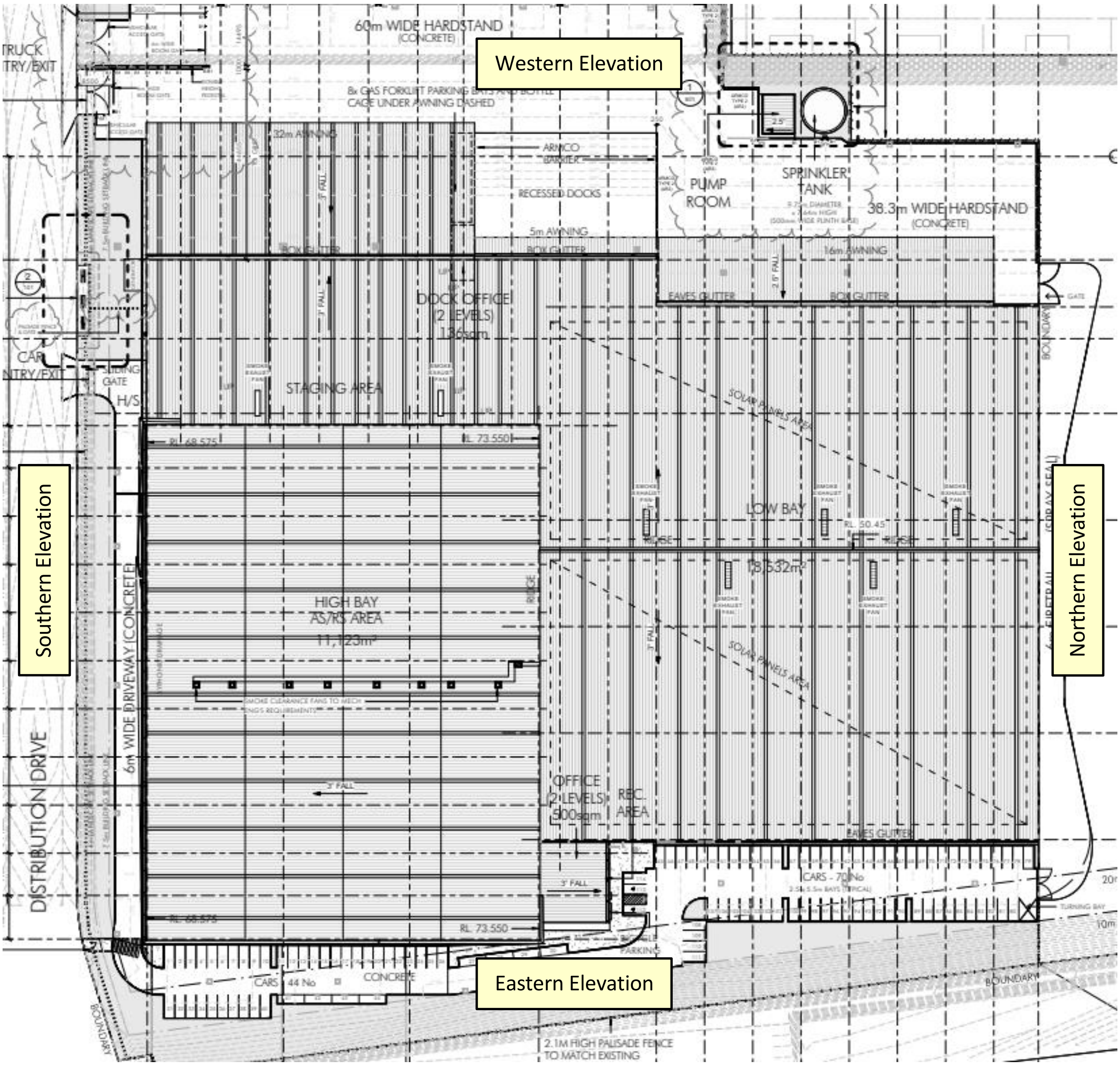


Figure 9.4: Elevation Layout

9.7.4.1 Southern Elevation

- The site can be accessed by two (2) points via Distribution Drive from the southern side of the site.
  - The attending fire brigades have the ability to utilise the car entry/exit point which provides a 6.0m wide driveway along the southern elevation; and
  - The attending fire brigades have the ability to utilise the truck entry/exit point which provides a vehicular access road along the western elevation; and
  - The vehicular hardstand is Figure 9.1; and
- The vehicular access road shall be designed and installed commensurate with the dimensions for an Aerial Appliance in accordance with FRNSW Policy No. 4: Guidelines for Emergency Vehicle Access); and
- The vehicular access shall be constructed having a load bearing capacity to permit the operation and passage of fire brigade appliances (i.e. Aerial Appliances); and
- The southern elevation is provided with two (2) PA doors allowing egress for occupants and access for firefighting personnel; and
- The building construction is traditional Type C fire resisting construction (i.e. precast concrete dado wall with non-combustible metal sheeting above); and
- All parts of the building (including all canopy/awnings) are fully sprinkler protected.

9.7.4.2 Western Elevation

- The western elevation consists of recessed loading docks and awning/canopy structures allowing vehicles to unload/load goods via the available docks; and
- The vehicular access road along the western elevations is provided with a varying unobstructed width (i.e. between 38m to 60m); and
- The vehicular access road shall be designed and installed commensurate with the dimensions for an Aerial Appliance in accordance with FRNSW Policy No. 4: Guidelines for Emergency Vehicle Access); and
- The building construction is traditional Type C fire resisting construction (i.e. precast concrete dado wall with non-combustible metal sheeting above); and
- The eastern elevation is provided with four (4) PA doors allowing egress for occupants and access for firefighting personnel.

9.7.4.3 Northern Elevation

- The northern side of the building is not provided with vehicular access. However, in order to achieve vehicular perimeter access, it is proposed to utilise the vehicular perimeter access of the adjacent allotment, which is intended to be acquired Snackbrands at a future date.
  - An unobstructed 6.0m wide perimeter vehicular access zone shall be created along the full length of the adjacent allotment (i.e. northern side) such that the vehicular access on the adjacent allotment can be utilised as continuous perimeter vehicular access for Snackbrands (Stage 1); and
  - The vehicular access shall be constructed having a load bearing capacity to permit the operation and passage of fire brigade appliances (i.e. Aerial Appliances); and
  - The northern elevation of the site shall be provided with perimeter fence gates (fitted with suitable conventional 003 padlocks) that form part of the perimeter vehicular access road.
- The vehicular access road shall be designed and installed commensurate with the dimensions for an Aerial Appliance in accordance with FRNSW Policy No. 4: Guidelines for Emergency Vehicle Access); and
- The building construction is traditional Type C fire resisting construction (i.e. precast concrete dado wall with non-combustible metal sheeting above).

9.7.4.4 Eastern Elevation

- Perimeter vehicular access along the eastern elevation is provide via the external car park achieving a minimum unobstructed width of 6.0m; and
- The vehicular access road shall be designed and installed commensurate with the dimensions for an Aerial Appliance in accordance with FRNSW Policy No. 4: Guidelines for Emergency Vehicle Access); and
- The office portion is also provided on this eastern elevation; and
- The eastern elevation is provided with four (4) PA doors allowing egress for occupants and access for firefighting personnel.

9.7.5 Fire Brigade & Firefighting Strategy

Further to the building elevations & ability to access the building & deploy a firefighting strategy:

The site can be accessed from Distribution Drive. Fire appliance access is provided along all four (4) sides, where vehicular access is provided with an unobstructed minimum width of 6m can be achieved. More specifically, fire crews can set up an offensive or defensive fire attack either at ground level directly into the building or alternatively, utilising aerial fire appliances. Furthermore, it should be noted that the vehicular perimeter access along the northern perimeter of the adjacent allotment, which is intended to be acquired Snackbrands at a future date. An unobstructed 6.0m wide perimeter vehicular access zone shall be created along the full length of the adjacent allotment (i.e. northern side) such that the vehicular access on the adjacent allotment can be utilised as continuous perimeter vehicular access for Snackbrands (Stage 1). Furthermore, the northern vehicular access road shall be constructed to achieve a load bearing capacity to permit the operation and passage of fire brigade appliances (i.e. Aerial Appliances).

9.7.5.1 Fire Brigade Intervention

A Fire Brigade Intervention Model (FBIM) was undertaken in Section 6 the outcomes of the model are detailed with the timeline indicating the following arrival and intervention times:

Table 9.5: Summary of FBIM Activity from St Marys Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	1695
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746

FBIM Event	Time (secs)
The cumulative time taken from fire initiation to commencement of water onto the fire	**2441**

Table 9.6: Summary of FBIM Activity from Mount Druitt Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	1898
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**2644**

Table 9.7: Summary of FBIM Activity from Penrith Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	2617
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**3363**

As a result, the conditions are considered to be ongoing at below routine levels and do not achieve the high levels associated with hazardous, extreme or critical conditions during fire-fighting operations. Furthermore, it is considered that due to the availability of multiple exits that are easily detectable and the aforementioned periods of tenability, the building occupants would have evacuated prior to Fire Brigade personnel arriving onsite.

9.8 Assessment Conclusion

The qualitative evaluation has demonstrated that the vehicular access provisions serving the subject site do not present an adverse impact for attending Fire Brigade personnel in the event of an emergency fire situation. Fire crews are provided with three-sided vehicular access as detailed above.

The acceptance criterion has been based on the ability for attending fire crews to deploy Standard Operational Guideline's (SOG's) and has been satisfied. Therefore, it is deemed that the proposed design satisfies the Performance Requirement of CP9 from Volume One of the NCC. This conclusion is contingent on the requirements detailed in Section 16.2 being implemented into the design.

10. Exit Travel Distance & Smoke Hazard Management

10.1 Background to the Issue

It has been identified that the exit travel distances within the warehouse portion exceed the maximum travel distances as permitted by the prescriptive provisions from Volume One of the NCC. In this instance, it is proposed to permit exit travel distances as per the following:

- The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and
- The distance between alternative exits exceed 60m (i.e.: up to 172m).

Furthermore, it is proposed to omit the provision for an automatic smoke exhaust system (including associated smoke baffles and smoke detection system) within the building. In this instance, it is proposed to permit a manually operated smoke clearance system having a smoke clearance capacity of 1 air change per hour.

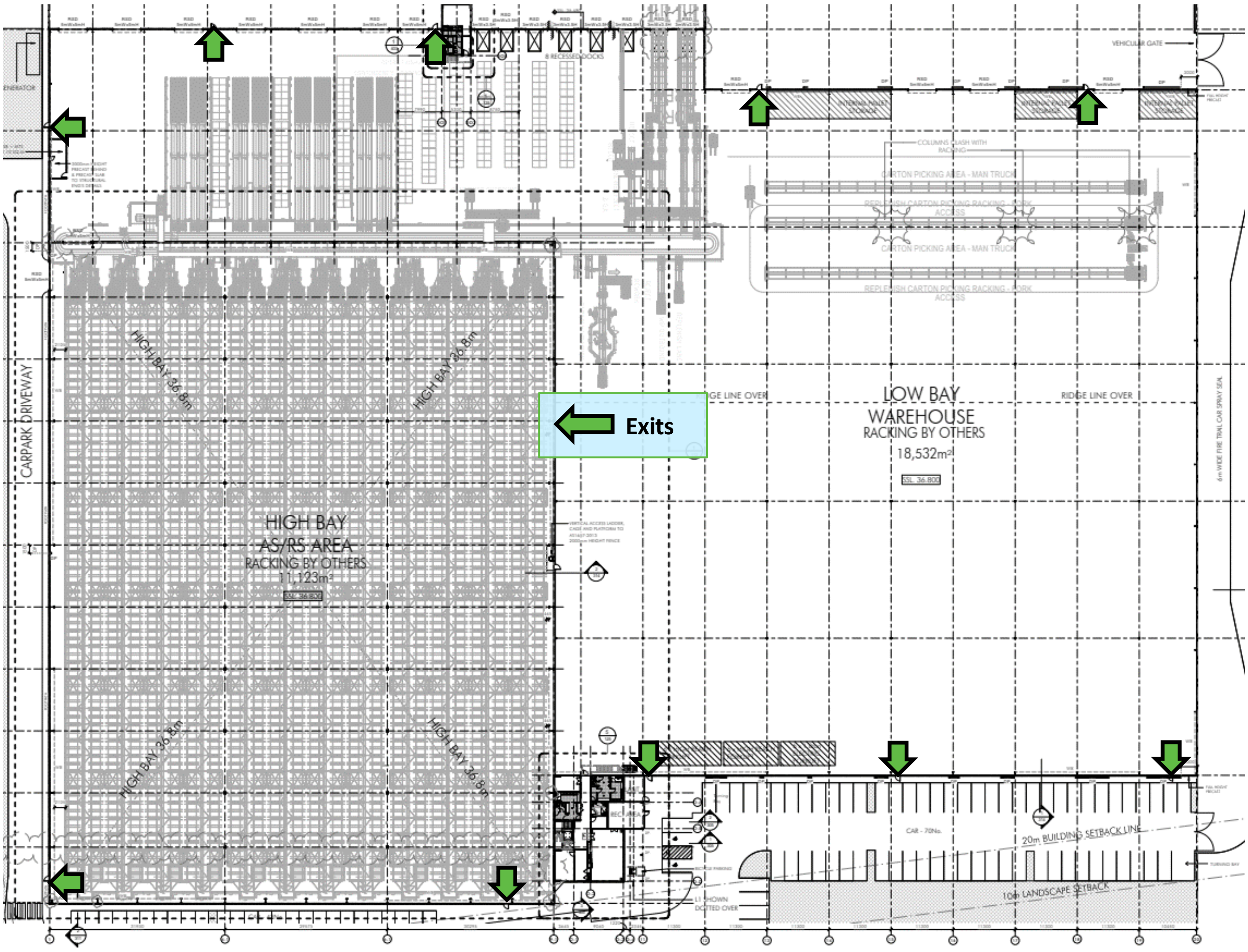


Figure 10.1: Exit locations within warehouse facility

10.2 NCC Assessment Methodology

In accordance with the NCC Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine whether the *Building Solution* complies with the *Performance Requirements of DP4 & EP2.2.*

Table 10.1: Method of Analysis

Identified Design Issue	NCC Assessment Method	IFEG Method of Analysis
<u>Warehouse Portions</u> It has been identified that the exit travel distances within the warehouse portion exceed the maximum travel distances as permitted by the prescriptive provisions from Volume One of the NCC. In this instance, it is	A0.5(b)(ii) such other *Verification Methods* as the *appropriate authority* accepts for determining compliance with the *Performance Requirements*.	A quantitative 'deterministic' & 'absolute' approach whereby an occupant and fire-fighter life safety assessment will be developed in the form of an ASET/RSET timeline analysis.

Identified Design Issue	NCC Assessment Method	IFEG Method of Analysis
proposed to permit exit travel distances as per the following: • The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and • The distance between alternative exits exceed 60m (i.e.: up to 172m). Furthermore, it is proposed to rationalise the provision for an automatic smoke exhaust system within the building. In this instance, it is proposed to permit a manually operated smoke clearance system having a smoke clearance capacity of 1 air change per hour.		

The design issues associated with the occupant egress will be evaluated by way of an overall holistic assessment that has been developed with consideration of all occupants within the warehouse. The exit travel distance issues have been addressed with consideration to the fire safety systems installed within the building to ensure tenability limits are not breached during the evacuation process or firefighting operations.

Similarly, the design issue associated with the omission of an automatic smoke exhaust system has been evaluated by way of an overall holistic assessment that has been developed with consideration of all fire safety systems proposed within the building, coupled with the life safety of the occupants and potential attending Fire Brigade personnel.

10.3 Hazard Specific to Exit Travel Distance and Smoke Hazard Management

The Guide to the NCC (ABCB, 2016) states that the intent behind providing a maximum travel distance of 40m to reach an exit is *"To maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate."* The guide further states that the intent behind providing a maximum travel distance of 60m between exit is *"To require that if an exit is inaccessible, access to any required alternative exit must be available within reasonable distance."*

It is therefore considered that the main hazards specific to the design issues requiring assessment are:

- Increase in travel time associated with the additional distance of travel; that is, time to evacuate will be increased from that of the NCC prescriptive design.
- Increase in potential obstructions within the path of travel to the alternative exit within the path of travel.
- Potential for fire by-products (smoke and toxic gasses) to restrict the path of travel where distance of travel is extended (i.e. potential for tenability limits to be exceeded within the path of travel).
- Increase in travel time associated with the additional distance of travel to an alternative exit after already travelling in the direction to an exit; that is time to evacuate will be increased from that of a prescriptive design.

The 'Guide to the NCC' (ABCB, 2016) states that the intent towards providing a smoke hazard management system within the building is "to minimise the risks associated with smoke to both the evacuating occupants and the attending fire fighters. It is therefore considered that the main hazards specific to the issue to be considered in the assessment are:

- The potential for fire by-products (smoke and toxic gasses) to restrict the path of occupant travel (i.e. potential for tenability limits to be exceeded within the path of travel).
- This issue is directly related to occupant evacuation and fire-fighter operation as the smoke hazard management system needs to ensure that conditions are acceptable for both to occur.

10.4 Hazard Mitigation

The Guide to NCC (ABCB, 2016) identifies the hazards as being directly related to the facilitation of occupant evacuation and Fire Brigade intervention activities in the event of an emergency fire situation. In this regard, the following hazard mitigation systems, requirements and features of the design are noted:

- The warehouse shall be afforded a smoke clearance system that will allow smoke and hot gas to vent from the building during fire brigade intervention; and
- The warehouse shall be provided with an automatic sprinkler system that is designed to suppress a fire. The impact of effective fire sprinkler suppression system operation shall mitigate smoke production through suppression. The propagation of smoke shall be significantly reduced after sprinkler head activation; and
- The occupants within the building will be familiar with their surroundings and will be familiar with the basic internal racking layout (way finding) design contained within the warehouse; and
- The large internal volume space provides a natural smoke reservoir for the hot smoke and toxic gases to accumulate allowing additional time for safe occupant evacuation; and

- Exit signage located and installed in accordance with Clauses E4.5 & E4.6 from Volume One of the NCC and AS/NZS 2293.1, with the exception of exit heights as detailed in Section 13 of this report.

10.5 Methodology

The methodology adopted to address the design issues associated with exit travel distances and omission of smoke hazard management systems has been based upon a quantitative 'deterministic' & 'absolute' analysis. The quantitative analysis demonstrates that evacuating occupants have the ability to evacuate to road or open space prior to the onset of untenable conditions. Furthermore, the same quantitative analysis demonstrates that the omission of a smoke hazard management system still provides fire-fighters with the ability to access the building within a timeframe which enables the commencement of water application activities prior to the onset of untenable conditions. The methodology and acceptance criteria associated with this deterministic and absolute approach is provided in significant detail within Section 5 and Section 6 of this report.

10.6 Acceptance Criteria

An ASET/RSET assessment has been undertaken to demonstrate occupant life safety. The factor of safety adopted was aimed to be in excess of 1.5 for the core scenarios. In this regard, the following criteria have been met:

ASET > 1.5 x RSET

For the ASET/RSET assessment for fire services personnel safety the factor of safety adopted was aimed to be in excess of 1.5. In this regard, the following criteria shall be met:

ASET > 1.5 x FBIM (commencement of water application)

Redundancy and factors of safety are two (2) concepts that are considered concurrently. The redundancies in the design have been considered in the analysis to ensure suitable levels of conservatism are achieved. The factors of safety adopted for sensitivity studies where system failure scenarios are adopted have been reduced to 1.0. In this regard, the following criteria has been met:

ASET > 1.0 x RSET

10.7 Assessment of Egress and Smoke Hazard Management

10.7.1 General

The issue pertaining to the safe egress of the building occupants relates to the distance to the nearest available exit and the risk of the travel path becoming untenable. Exit travel distance is a function of time. Therefore, in areas where an occupant receives early signs of a fire either visual or from olfactory cues they would be expected to react prompt and initiate evacuation. Conversely in areas where the occupants are remote from the area of fire origin (AFO) greater time may be required for the occupants to assess if the threat is real and evacuation of the building is required.

10.7.2 Occupant Life Safety

As detailed in Section 8 of this report, the outcomes of the Life Safety Analysis have demonstrated that occupants are able to safely evacuate the building prior to untenable condition. The fire and smoke modelling has demonstrated that tenable conditions have been provided within the storage warehouse with adequate time provided for occupants to safely evacuate the building. The building is afforded with multiple exit locations that are evenly distributed around the perimeter of the building. With multiple exits the occupants are able to access the most appropriate practicable path to safely evacuate the building and in the event that one exit is untenable there is always an option for an alternative exit in the near vicinity. Therefore, the factor of safety for both core and sensitivity studies have been met.

The egress simulations have included egress scenario simulations where exits were blocked assumed to be unavailable ensuring adequate redundancy was afforded in the assessment process. It is reiterated that in all events the established acceptance criteria has been satisfied with an adopted factor of safety. The risk associated with a potential fire has also been shown to be acceptable and the occupants are able to safely evacuate from the subject building.

The staff members are considered to be familiar with the building environment in which they work and hence have an in depth understanding of the building layout and more specifically an understanding of the location of exits. It is expected that the staff would be trained in the buildings emergency procedures and also in a position to provide an initial attack on a fire with fire hose reels provided within the building. In any event, it is expected that staff would be aware of the nearest exit locations and be well versed in assisting any building occupants to the available exits. Upon activation of the BOWS permanent and trained staff within the building would be expected to initiate the emergency evacuation procedures. It must be noted that the ASET/RSET assessment also assumed that the entire building occupant numbers were located in the warehouse portion.

It should be noted that the occupants within office portions are able to exit to an open space via the individual office exits. As such the number of occupants located in the warehouse would therefore be reduced and conversely reduce the time of building evacuation.

Visitors to the building may not be aware of emergency procedures however they would have a degree of familiarity of the exit in which they entered the building. Visitors would potentially comprise persons from all gender and age groups with varying levels of physical and mental ability. Staff would be able and expected to assist any visitors in the event that evacuation from the building was required. Essentially all of the building occupants are expected to receive a warning of a fire, either visual or transmitted by the BOWS due to the activation of the automatic fire sprinkler system, in a time which allows for safe evacuation.

10.7.2.1 Occupant Life Safety Analysis Outcomes

The level of life safety afforded to the building occupants based on the proposed egress design within the subject building has been supported by FDS modelling and occupant evacuation analysis as evidenced in the ASET/RSET life safety analysis detailed in Section 8. The ASET/RSET analysis included the following:

- Five (5) fire scenarios to determine occupant tenability within the warehouse; and
- Two (2) evacuation scenario types to determine evacuation time within the warehouse.

The life safety assessment (ASET/RSET) outcomes captured in Section 8 of this FSER have been analysed. The acceptance criteria in terms of life safety margins as detailed have been satisfied. The life safety analysis has demonstrated that occupants are provided with sufficient time to evacuate prior to the smoke layer to descend below 2.1m above the finished floor level.

From the analysis documented in Section 8, the indication of the life safety of the occupants has been obtained by comparison of the ASET and RSET values for the scenarios examined. More specifically the comprehensive ASET/RSET Timeline analysis conducted has demonstrated that the proposed egress provisions afford building occupants with adequate life safety margins.

The fire and evacuation analysis satisfied the acceptance criteria nominated in Section 5. The following criteria have been satisfied with regard to the core fire scenario:

ASET > 1.5 x RSET **Satisfied**

The fire and evacuation analysis satisfied the acceptance criteria nominated in Section 5. The following criteria have been satisfied with regard to the sensitivity fire scenario:

ASET > 1.0 x RSET **Satisfied**

Similarly, fire scenarios where fire/smoke modelling was conducted, the time required for fire services personnel to conduct intervention activities thus satisfying the acceptance criteria nominated in Section 5. The following criteria have been satisfied with regard to the core fire scenarios:

ASET > 1.5 x FBIM **Satisfied**

In summary and with consideration of the achieved levels of occupant life safety it is deemed that occupant life safety within the sortation and storage warehouse meets an accord with the Performance Requirements DP4 and EP2.2 in regard to occupant life safety.

10.7.3 Fire Brigade Intervention and Operations

The intent towards quantifying Fire Brigade arrival time and intervention time in this instance has been to determine whether the alternative solution is satisfactory (to the degree necessary) to ensure that the attending fire fighters are provided with a ‘safe’ entry point to undertake fire-fighting activities.

The approximate Fire Brigade arrival time for intervention activities has been estimated and assessed Section 7. The subject site is within the FRNSW jurisdictional area. A summary of the FBIM activity from St Marys, Mount Druitt Fire Station and Penrith Fire Station are as follows:

Table 10.2: Summary of FBIM Activity from St Marys Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	1695
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**2441**

Table 10.3: Summary of FBIM Activity from Mount Druitt Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	1898

FBIM Event	Time (secs)
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**2644**

Table 10.4: Summary of FBIM Activity from Penrith Fire Station

FBIM Event	Time (secs)
From fire initiation, the cumulative time taken for the nearest fire appliance to reach kerb side.	2617
Having arrived kerb side, the cumulative time taken for fire crews to access the building, ready to apply fire water	746
The cumulative time taken from fire initiation to commencement of water onto the fire	**3363**

It is expected that the attending fire crews will be able to intervene (i.e. commence fire control activities) in approximately 40-41 minutes (from St Marys fire station) and once they arrive of site can determine an appropriate place to undertake their operations given the site providing direct access to the buildings on site directly from street level. Hence, it is unlikely that the identified travel distance within the warehouse will have an adverse impact towards firefighting operations.

With reference to the fire fighter acceptance criteria and the established fire and smoke modelling outcomes, it is considered that the conditions within the area of fire origin are not likely to compromise the life safety of the attending fire fighters. The fire and smoke modelling outcomes have demonstrated that the temperatures within the Warehouse is not likely to exceed temperature levels greater than 100°C (i.e. 60°C below 1.5m) for fire fighters to undertaken fire intervention activities (Routine conditions) for the duration greater than 3000 seconds.

Therefore, with consideration of the achieved levels of fire fighter tenability it is deemed that fire fighters will be able to undertake their standard operational procedures within the warehouse and that the design is deemed to meet an accord with the Performance Requirements DP4 and EP2.2 in regard to fire brigade intervention.

10.8 Discussion of Assessment Outcomes

The risk to the occupants' life safety and to the attending Fire Brigade due to the identified design issues is low based on the quantitative and qualitative analysis undertaken. Therefore, the design issues pertaining to the exit travel distance issues and the omission of the smoke hazard management system within the subject building do not introduce an increased risk to life safety for the evacuating building occupants. Therefore, the building design and Performance Solution is considered to meet the relevant performance as required in Section 5. Furthermore, with consideration of the achieved levels of fire fighter tenability it is deemed that fire fighters will be able to undertake their standard operational procedures within the building, as such the subject building is deemed to meet the relevant performance as required in Section 5 to be considered acceptable.

As such the design issues associated with the identified exit travel distance issues and the omission of an automatic smoke exhaust system within the subject building is deemed to meet an accord with the relevant Performance Requirements DP4 and EP2.2 from Volume One of the NCC. This conclusion is contingent on the requirements as detailed in Section 16.2 being implemented into the design.

11. Fire Hose Reels

11.1 Background to the Issue

It is proposed to permit the fire hose reel system to be designed and installed in accordance with AS2441:2005 and furthermore, permit the following:

- To permit the fire hose reel coverage shortfalls throughout the high bay area.

Refer to Figure 11.1 for fire services drawings indicating the fire hose reel shortfalls.

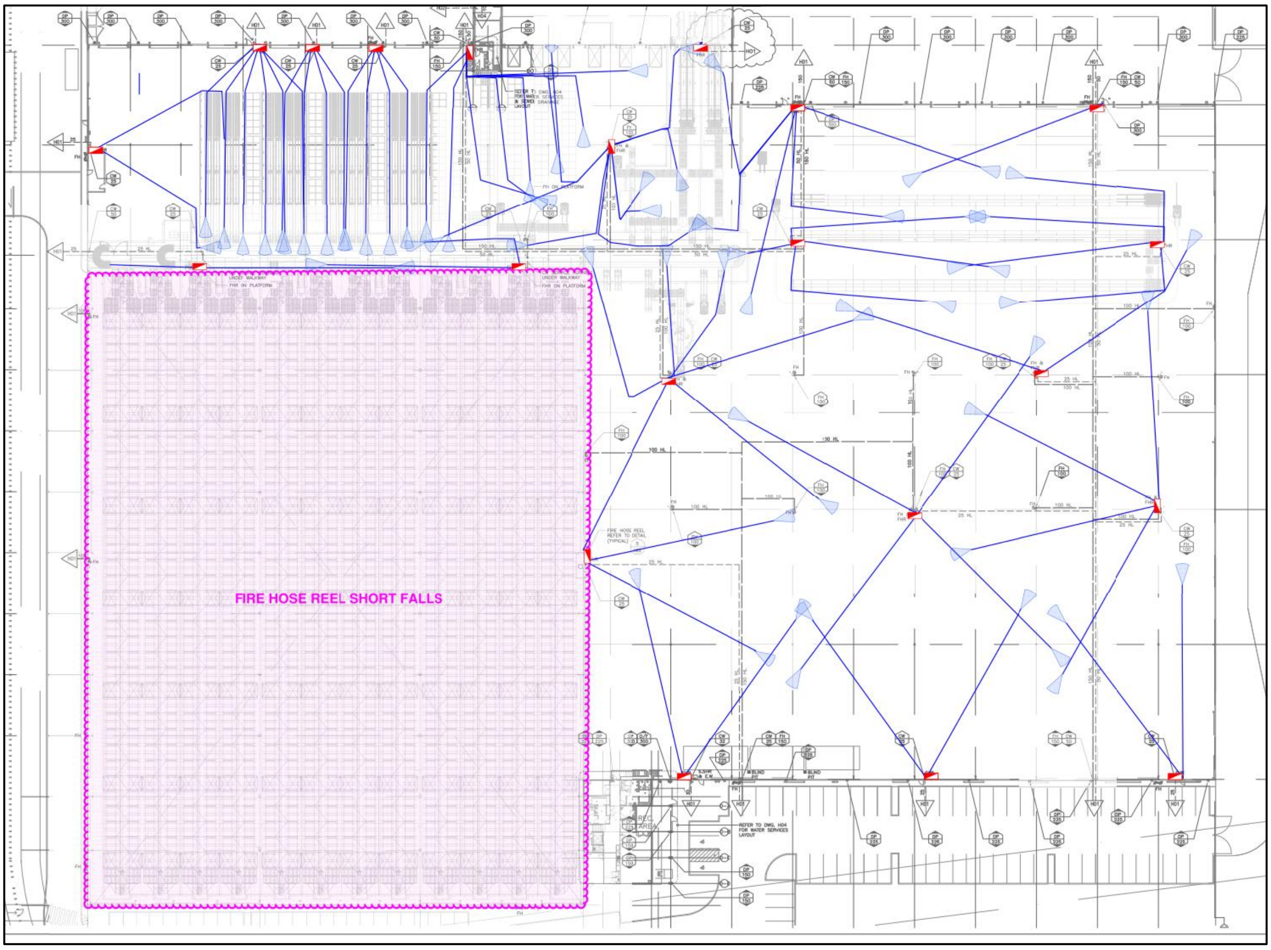


Figure 11.1: Fire Hose Reel shortfalls

11.2 Assessment Methodology

In accordance with the BCA Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine that the *Performance Solution* complies with the *Performance Requirements*.

Table 11.1: Methods of Analysis

Identified Design Issue	BCA Assessment Method	IFEG Method of Analysis
The fire hose reel system shall be design and installed in accordance with AS2441.1:2005 with the exception of the following: • To permit the fire hose reel coverage shortfalls throughout the high bay area.	A0.5(b)(ii) Verification method as the relevant authority accepts for determining compliance with the performance requirements. The associated Performance Requirement to be met is EP1.1	A qualitative risk-based approach has determined that the Performance Solution satisfies the relevant Performance Requirement.

11.3 Hazard Specific to Fire Hose Reels

The ‘Guide to the BCA’ (ABCB, 2016) states that that the reason for requiring fire hose reels is *“To enable, where appropriate, a building’s occupants to undertake initial attack on a fire”*. It is considered that the fire hose reel location may impact on an occupant's ability to utilise the hose reel affectively and to this end the hazards are considered to be as per the following:

- The location of the fire hose reel requires occupants to a) get to the fire, and b) to retreat back to a path of travel to an exit.
- Occupants could potentially be trapped as a result of attacking a fire and then retreating along a path that requires extra travel.

11.4 Hazard Mitigation to Fire Hose Reels

The Guide to BCA (ABCB, 2016) states that the hazards as being directly related to the facilitation of occupants and their ability to undertake first aid fire-fighting activities. In this regard, the following is noted

- The subject building shall be designed and installed with an automatic sprinkler system that is designed to suppress a fire. The outcome of effective fire sprinkler suppression system operation is to mitigate smoke production through suppression. The propagation of smoke is significantly reduced after sprinkler head activation.
- Portable Fire Extinguishers in accordance with Clause E1.6 from Volume One of the BCA and AS2444:2001:
  - Additional portable fire extinguishers shall be proposed as shown in Figure 11.3 within the building where fire hose reel coverage shortfalls occur; and
  - Due to the presence of electrical machinery, the use of ABE portable fire extinguishers would safeguard occupants attempting to utilise portable fire extinguishers; and
  - The provision for portable fire extinguishers should not only meet the minimum requirements of the Australian Standard for portable fire extinguishers. The provision for portable fire extinguishers should <u>exceed</u> the minimum requirements of the Australian Standard such that there is portable fire extinguisher coverage around the building in order to offset the fire hose reel coverage shortfall; and
- Occupants are not required to fight a potential fire however; they have the option "where appropriate" to fight the fire. It is considered that occupants would not fight a fire that is potentially too dangerous for them (occupant first attack firefighting training will identify this to some extent); and
- Occupants can retreat via multiple alternative paths as a result of the number and even distribution of exits afforded to the building; and
- No access to the high bay area is permitted without a trained maintenance personnel present; and
- The building is afforded with an automatic sprinkler system throughout which when appropriately activated, will ensure favourable conditions for any occupant that attempts to provide a first attack.

11.5 Method of Analysis

A qualitative assessment has been undertaken with consideration to firefighting in the developing stages, and early control or extinguishment which may reduce the hazard, allow more time for evacuation and prevent structural damage. Further the extended period of tenability of the area of fire origin reducing the risk of occupant exposure to the harmful products of fire. The qualitative analysis has considered the performance solution with the limited fire load, potential fire hazard, fire intensity risk of fire and smoke spread within the areas of fire hose reel coverage shortfalls deemed appropriate to negate the hazard identified thereby providing an adequate level of fire and life safety which meets the Performance Requirements of the NCC.

As part of the performance solution fire extinguishers has been provided within the building in strategic positions. In providing fire extinguishers in lieu of fire hose reels where coverage shortfalls occur is not expected to increase the risk to the building occupants or Fire Brigade personnel to the degree necessary in an event such as a fire.

11.6 Acceptance Criteria

The basic objective and intent of this analysis pertains to the possibility of fire growing into a fully developed fire within the areas of fire hose reel coverage shortfalls. The acceptance criteria has been met by demonstrating that no increased risk of a fire growing within the area is created via the shortfall of fire hose reel coverage to this area within the building.

11.7 Assessment of Fire Hose Reels

11.7.1 General

The Guide to the BCA (ABCB 2016) acknowledges that installation of suitable fire hose reel systems is provided to enable, where appropriate, a building's occupants the ability to undertake an initial attack on a fire. Furthermore, the size of the fire compartment, the potential harm and the degree of exposure arising from the ignition to the spread of fire all need to be considered before undertaking an initial attack on fire.

In this instance, it is proposed to permit fire hose reel shortfalls throughout the warehouse portions where shown in Figure 11.1. Additional portable fire extinguishers are proposed to be installed at strategic locations as shown in Figure

11.3 to compensate the fire hose reel shortfalls for the occupants to initiate early intervention. Fire extinguishers are provided for a 'first attack' firefighting measure generally undertaken by the occupants of the building before the fire service arrives.

11.7.2 Statistical Evaluation of Fire Hose Reels Usage

Generally, fire hose reels are provided to enable occupants to undertake initial attempts at fire control and extinguishment. As an alternative to fire hose reels, fire extinguishers are also installed in the built environment providing a means of manual fire suppression during the early stages of fires. Fire extinguishers are provided as a 'first attack' fire-fighting measure generally utilised by building occupants in an attempt to extinguish small fires (where safe to do so). However, most fires start as a small fire and may be extinguished if the correct type and amount of extinguishing agent is applied whilst the fire is in its infancy and controllable. This is an activity considered to be undertaken prior to fire brigade arrival. It is important that occupants are familiar with the use of either first aid fire-fighting equipment's.

Australian data for the period between 2003 and 2004 show that for a total of 813 recorded fires, fire hose reels did not appear as the means of suppression. From the statistical data provided, portable fire extinguishers were utilised for extinguishment purposes for a total of 96 fires (Brown, 2005). Refer to Figure 11.2 for further details.

Reported Major Method of Extinguishment for Fires in Commercial Premises from July 1, 2003, to June 30, 2004 (n = 813)

Major method of extinguishment	Reported fires
Hose line(s) deployed from fire apparatus tank	405
Self extinguished	73
Manual firefighting aid(s), for example fire blankets	64
Unknown portable fire extinguisher	50
Hose line(s) deployed from pump	49
Portable fire extinguisher(s) installed in premises	46
Hose line(s) deployed directly from hydrant	45
Portable fire extinguisher(s) carried on fire apparatus	32
Automatic extinguishing system(s)	29
Portable fire extinguisher(s) installed in neighboring premises	18
Monitor deployed by the fire service	2

Figure 11.2: Methods of Extinguishment in Commercial Buildings

It shall be noted that portable fire extinguishers shall be selected and installed throughout the building in accordance with the BCA Clause E1.6 and AS 2444-2001.

11.7.3 Fire Hose Reel Use and Potential Impact on Occupants

Fire hose reels require a degree of manoeuvrability in order for the occupant to extend the fire hose to access a fire. Fire hose reels are normally 36m in length. Access to the area may require the occupant to manoeuvre the fire hose reel around a number of corners and bends which may include walls and other obstructions. Physically, some occupants may find this difficult and in many cases, may delay the time for water to be applied to a fire. Occupants may be required to pass the hose through doorways which may also swing against the direction to which an occupant is moving to access a fire; hence there is the potential for the fire hose to be jammed within the doorway whilst being extended towards the fire.

The fire hose reel shortfalls occur within close proximity to conveyor systems as shown in Figure 11.3. As such there are many obstructions located throughout these areas where a fire hose reel system may become awkward and cumbersome to use. A portable fire extinguisher in this instance would therefore be more practical for initial firefighting around obstacles and corners.

11.7.4 Appropriateness of Portable Fire Extinguishment

As stated in the previous sections the shortfall fire hose reel coverage shall be compensated by the presence of portable fire extinguishers. Refer to Figure 11.3 for the location of the portable fire extinguishers.

It may be argued that an ABE type portable fire extinguisher have limited extinguishing agent within the cylinder (i.e. 4.5kg or 9 litres), however a limited agent capacity may be advantageous to the occupant such that when the extinguishing agent is exhausted, the occupant would have limited opportunity to continue to undertaking first aid fire-fighting and hence, would most likely evacuate the area of fire origin. In such a circumstance, a small fire may have developed to a size beyond the ability for an untrained occupant to continue firefighting and the most appropriate action would be to move towards an exit or place of relative safety.

Finally, and as mentioned previously, water application on fires caused by electrical equipment is inappropriate. The application of water from an installed fire hose reel may not be suitable for such fire situations. The availability for ABE type portable fire extinguisher shall be provided which would be suitable towards mixed fire hazards such as combustible materials, flammable liquids, greases and oils.

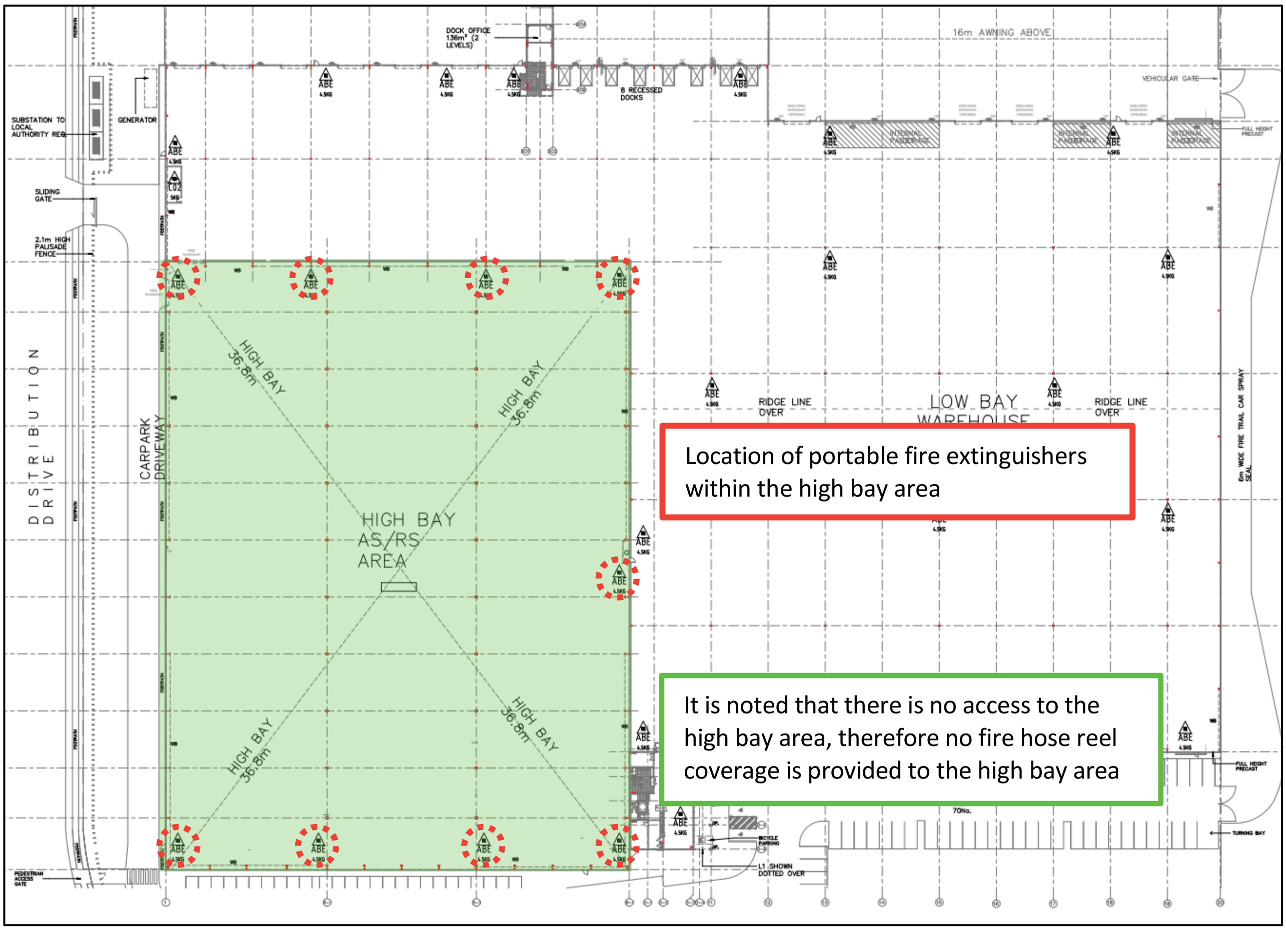


Figure 11.3: Location of portable fire extinguishers to compensate fire hose reel shortfall

11.7.5 Sprinkler Effectiveness in Storage Facilities

The building is protected throughout with an AS2118.1:2017 automatic fire sprinkler system unless otherwise detailed herein. The sprinkler system shall be interfaced with the main Fire Indicator Panel (FIP) to initiate the Building Occupant Warning System (BOWS) upon sprinkler head activation.

In the majority of cases where a sprinkler system is present and activates accordingly, the fires are confined to the object or area of fire origin. A summary of the key findings from the statistics are as follows:

- When sprinklers are present in the fire area, they operate in 93% of all reported structure fires large enough to activate sprinklers, excluding buildings under construction. When they operate, they are effective 97% of the time, resulting in a combined performance of operating effectively in 91% of reported fires where sprinklers were present and activated accordingly;
- Experimental evidence and numerical studies have demonstrated that sprinklers are very effective in controlling and suppressing fires;
- Sprinkler systems are designed to contain a fire. However, UK data shows that in 40% of the fires the fire is extinguished (UK Incident Statistics from London, 2008). Swedish data estimates 60% extinguishment (Swedish Incident Statistics, 2008);
- It has been cited that the resultant smoke temperatures in a sprinkler-controlled fire are reduced to 100°C -120°C (CIBSE 1997; Sekizawa, 1996, Milke, 2001, Madrzykowski, 2008) within 60 seconds of sprinkler activation.

In the context proposed design, the sprinkler protection afforded to the building shall activate to either control or suppress a potential fire event. Activation of the sprinkler system shall assist in maintaining low compartment temperatures (i.e. 100°C-120°C) reducing the overall impact imposed on occupants and fire personnel. Based on the above, statistical data indicates that fire sprinklers provide effective property protection and maintain life safety for building occupants and fire brigade personnel.

11.8 Discussion of Assessment Outcomes

Based on the rationale presented above, it becomes evident that the proposed additional portable fire extinguisher enables the occupants to access an extinguisher to undertake initial fire attack towards a fire occurring within the building (i.e. location of fire hose reel shortfall).

Portable fire extinguishers provide a portable fire-fighting means which would provide occupants with the ability to nominate the appropriate extinguishing agent before undertaking an initial attack on fire. Although portable fire extinguishers have limited agent capacity, once exhausted the occupant is likely to migrate towards an exit point. Practically, portable fire extinguishers are expected to be easier to use by an occupant without having to negotiate around fixed or movable obstructions.

Therefore, it has been demonstrated that the proposed design meets the acceptance criteria defined as it is deemed to allow occupants to undertake an initial attack on a potential fire more readily and with a level of ease and certainty that can often be absent when utilising a fire hose reel in that instance. Hence, the proposed design meets the Performance Requirement EP1.1 of the BCA.

12. Fire Hydrants

12.1 Background to the Issue

The fire hydrant system shall comply with AS 2419.1 2005 with the exception of the following:

- It is proposed that the external hydrants situated along the northern and southern elevation of the building to be located within 10m to the covered awning whilst utilising two (2) lengths of 30m hose for the purpose of achieving fire hydrant coverage; and
- It is proposed to permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only.

12.2 NCC Assessment Methodology

In accordance with the NCC Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine whether the *Building Solution* complies with the *Performance Requirements of EP1.3.*

Table 12.1: Method of Analysis

Identified Design Issue	NCC Assessment Method	IFEG Method of Analysis
The fire hydrant system shall comply with AS 2419.1 2005 with the exception of the following: • Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and • It is proposed to permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only.	A0.5(b)(ii) such other *Verification Methods* as the *appropriate authority* accepts for determining compliance with the *Performance Requirements*.	A qualitative and quantitative evaluation has been adopted based on direct consultation with Fire & Rescue NSW (FRNSW).

12.3 Hazard Specific to Fire Hydrants

The 'Guide to the NCC' (ABCB, 2016) states that the intent associated with providing external fire hydrants is to "*facilitate fire brigade fire-fighting operations". Additionally,* the 'Guide to the NCC' (ABCB, 2016) states that the intent associated with prescribing full fire hydrant coverage as being *"To require the installation of suitable fire hydrant systems to reduce the potential for fire-fighting personnel to encounter unsafe conditions during Fire Brigade intervention".*

It is considered that the fire hydrants are located such that a fire attack on a potential fire within the warehouse can be successfully undertaken even though a number of hydrants are located near an awning. It is therefore considered that the main hazards specific to the design issue requiring assessment are:

- A fire within the vicinity of the external fire hydrant beneath the awning, hence restricting its use; and
- Access to the hydrants under the awnings being restricted as a result of blockages associated with storing goods out of the weather.
- Limited access to fire hydrants within the storage portions of the high bay zone.

12.4 Hazard Mitigation

The 'Guide to the NCC' (ABCB, 2016) identifies the hazards as being directly related to the facilitation of Fire & Rescue NSW (FRNSW) being able to undertake Standard Operational Guideline's (SOG's) and intervention activities. In this regard the following hazard mitigation systems, requirements and features of the design are noted:

- Fire hydrants are to be located and installed in accordance with Clause E1.3 from Volume One of the NCC and AS2419.1:2005 with the exception of the following:
  - Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and
    - Provide additional external 'fall back' hydrant(s) to facilitate operations such that fire-fighters are able to utilise the fire hydrants located beneath the covered awnings. The external 'fall back' fire hydrants are to be located within 60m if the fire hydrants located beneath the covered awnings, be located as close as possible to the perimeter vehicular access location and furthermore are to be design and installed to achieve attack fire

hydrant performance. Finally, fire hydrant coverage from the 'fall back' hydrant(s) must provide coverage to all fire hydrants located beneath the awning structures; and

- Permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only. Refer to Appendix J for details; and
- Where internal fire hydrants are required for coverage purposes, the internal fire hydrants are to be located in the building such as to allow progressive movements of fire fighters towards central parts of the building as per the below:
  - When working from an external hydrant, the next additional hydrant should be located into the building not more than 50m from the external hydrant; and
  - When working from an internal hydrant (either from within a fire isolated exit or passageway, within 4 metres of an exit or another additional fire hydrant), the next additional hydrant should be no located not more than 25m from that hydrant.
  - Where additional hydrants are provided, a localised block plan should be provided at every fire hydrant pictorially and numerically illustrating the location of the next available additional hydrant. These localised block plans should be of a size appropriate to their notice and location and be of all weather-fade resistance construction; and
- A fire hydrant ring main shall be designed and installed in accordance with the DtS provisions from Volume One of the NCC and AS2419.1:2005. Appendix T depicts the location of the fire brigade booster assembly; and
- An alternative fire hydrant shall be available at all times whereby fire-fighters are unlikely to utilise the hydrant closest to the area of fire origin; and
- The building is afforded with automatic sprinkler system incorporating storage sprinklers throughout the warehouse. The covered awning shall also be protected in accordance with AS2118.1:2017. As a result, access to all fire hydrants will be able to be reached without implication of the hazards associated with covered awning.

12.5 Methodology

The methodology adopted to address the design issue relative to the fire hydrant situated beneath the covered awnings and omission of fire hydrant coverage from the storage portion of the high bay area has been based upon a qualitative evaluation. The evaluation to consider the impact imposed onto attending fire-fighter personnel as a result of the hydrants being located beneath the awning, presence of fire extinguishers within the storage portion of the high bay area and the impact of automatic sprinkler protection (i.e.: roof height and in-rack sprinkler).

Furthermore, the methodology adopted to address the design issues associated with fire hydrant coverage within the high bay area has been based upon a quantitative 'deterministic' & 'absolute' analysis. The quantitative analysis demonstrates that the attending fire crew have the ability to intervene (i.e. commencement of water application) prior to the onset of untenable conditions.

Consultation with Fire & Rescue NSW (FRNSW) has been undertaken to assess the impact of fire crews and their ability to safely access the subject hydrants whilst undertaking Standard Operational Guideline's (SOG's).

12.6 Acceptance Criteria

The basic objective and intent of the analysis pertains to fire-fighter life safety. Therefore, the primary acceptance criterion met by demonstrating that the proposed hydrant design and layout maintains efficacy for fire-fighting operations and the deployment of safe Standard Operational Guideline's (SOG's).

Furthermore, with respect to the quantitative ASET/GBIM assessment for fire services personnel safety the factor of safety adopted was aimed to be in excess of 1.5. In this regard, the following criteria shall be met:

ASET > 1.5 x FBIM (commencement of water application)

12.7 Assessment of Fire Hydrants

12.7.1 Hydrants Located Beneath Covered Awnings

As described above, the following qualitative evaluation is provided in order to demonstrate that the Fire Brigade intervention activities are facilitated with consideration of the hydrant being located within 10m of the covered awnings. To this affect the following qualitative arguments are presented:

- Full coverage of the warehouse is afforded if the identified fire hydrants are located near the awnings and are considered to be external whereby the warehouse is considered to comply with Volume One of the NCC to achieve full coverage.

- Additional fall-back hydrants are provided as shown in Appendix J as a redundancy to assist the attending fire-fighters in fire control and suppression activities where an external fire hydrant under the awning may be rendered unusable and difficult to access during fire-fighting operations.
- The purpose of the awnings is to cover the loading areas, which are not intended for storing goods as they are used as transit parking bays for delivery trucks during loading and unloading process. Therefore, it is unlikely that the hydrants would be blocked by static storage or other obstruction.
- The external awnings are located at a minimum height of approximately 9m clear above the finished floor level (i.e. hard stand level) and are fully open on three (3) sides which will allow for significant venting of any potential hot smoke that may impact on the fire-fighters adopting the hydrants. The natural venting capacity is illustrated in Figure 12.1.

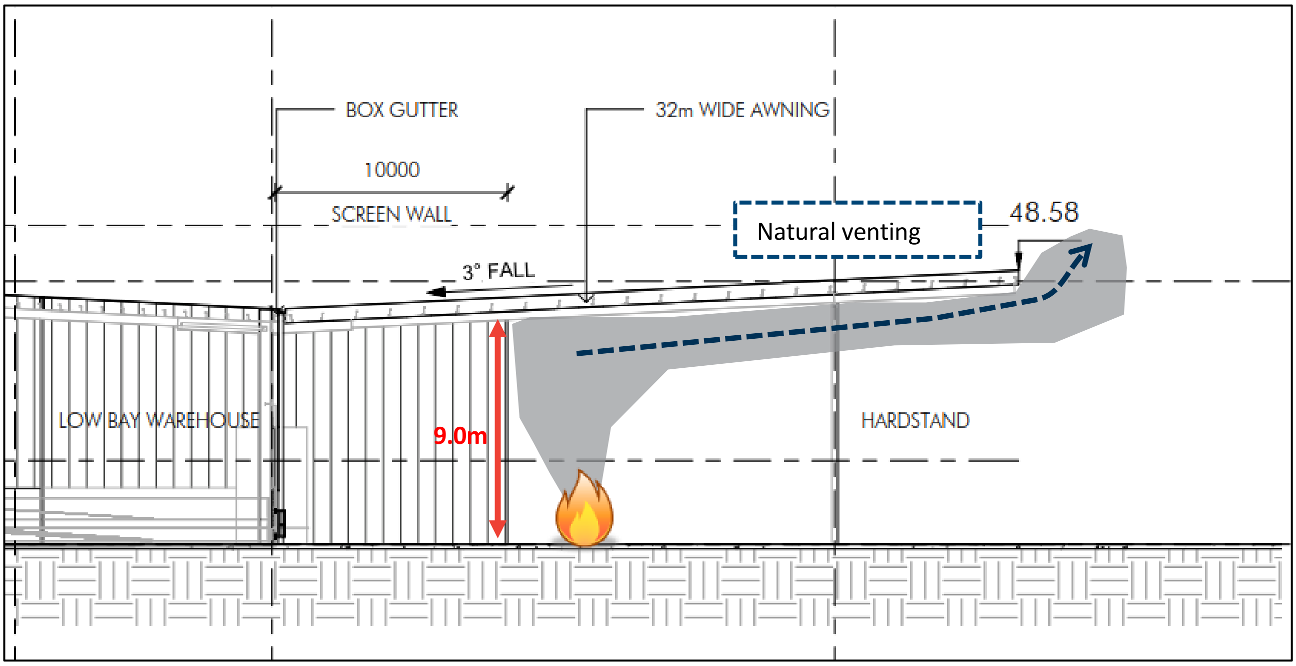


Figure 12.1: Natural venting through external awning

- External hydrants are provided around the building to facilitate the attending fire-fighters to adopt the most appropriate fire hydrant location. It is considered unlikely for attending fire-fighters to adopt an external hydrant that is located within close proximity to a potential fire. Therefore, should the external fire hydrants located within 10m of the external awning be inaccessible, additional fall-back hydrants (i.e. achieving attack hydrant performance) are provided to facilitate Fire Brigade intervention activities. The fall-back hydrants are to be located no greater than 60m from the fire hydrants located within 10m of the covered awning.
- The building is afforded with automatic sprinkler system incorporating storage sprinklers throughout the warehouse. The covered awning shall also be protected in accordance with AS2118.1:2017.

12.7.2 Hydrants Coverage Shortfall to the High Bay Areas

It is identified that the building is afforded with a number of fire safety systems. This is inclusive of automatic sprinkler system within the building is noted as a fire suppression system. In the unlikely event of a fire, the systems in place are expected to control and/or suppress the potential spread of the fire until the arrival of fire brigade personnel. As the statistics indicate in Section 9.7.2, the reliability of sprinklers is very high and it is unlikely that failure would occur. In combination with the other systems, the building will sufficiently allow for the safe extinguishment of a fire. Furthermore, it should be noted that the high bay AS/RS area is provided with in-rack sprinklers shall be provided with sprinklers to control and suppress a fire if it were to start.

With reference to Clause 3.2.2.2 *(for **internal fire hydrants**), all portions of the building shall be within reach (i.e. coverage) of a 10m hose stream issuing from nozzle at the end of a 30m length (i.e. 1 x 30m hose length) of hose laid on the ground.* This depicted in Figure 12.2. As part of the Performance Solution and in conjunction with FRNSW, it is proposed to permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only (refer to Figure 12.2).

Where internal fire hydrants are required for coverage purposes, the internal fire hydrants are to be located in the building such as to allow progressive movements of fire fighters towards central parts of the building as per the below:

- When working from an external hydrant, the next additional hydrant should be located into the building not more than 50m from the external hydrant; and
- When working from an internal hydrant (either from within a fire isolated exit or passageway, within 4 metres of an exit or another additional fire hydrant), the next additional hydrant should be no located not more than 25m from that hydrant.
- Where additional hydrants are provided, a localised block plan should be provided at every fire hydrant pictorially and numerically illustrating the location of the next available additional hydrant. These localised block plans should be of a size appropriate to their notice and location and be of all weather-fade resistance construction; and

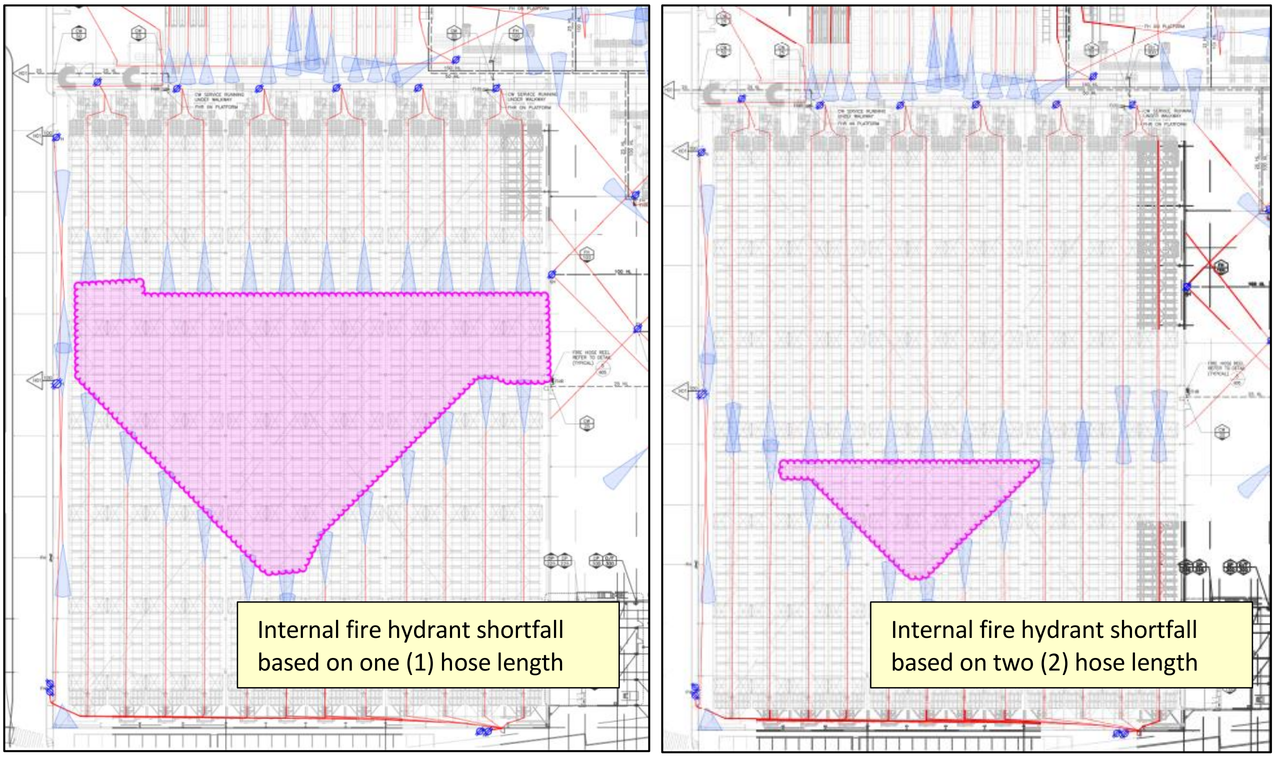


Figure 12.2: Fire hydrant shortfall to the high bay AS/RS area comparison between one (1) and two (2) lengths of internal fire hydrant hose coverage

From an operational perspective, fire personnel are likely to attack a high bay racking fire from the low bay zone and staging area of the facility using internal and external hydrants, which is open area, due to ability to run the hose reel out in relatively straight lines without the need to turn excessive number of corners.

Therefore, it is considered that the fire hydrant coverage to the high bay AS/RS area is operationally satisfactory for firefighting purposes. This is also evident based on the fire and smoke modelling simulations undertaken within the high bay AS/RS area (Fire Scenario: SB04 & SB05).

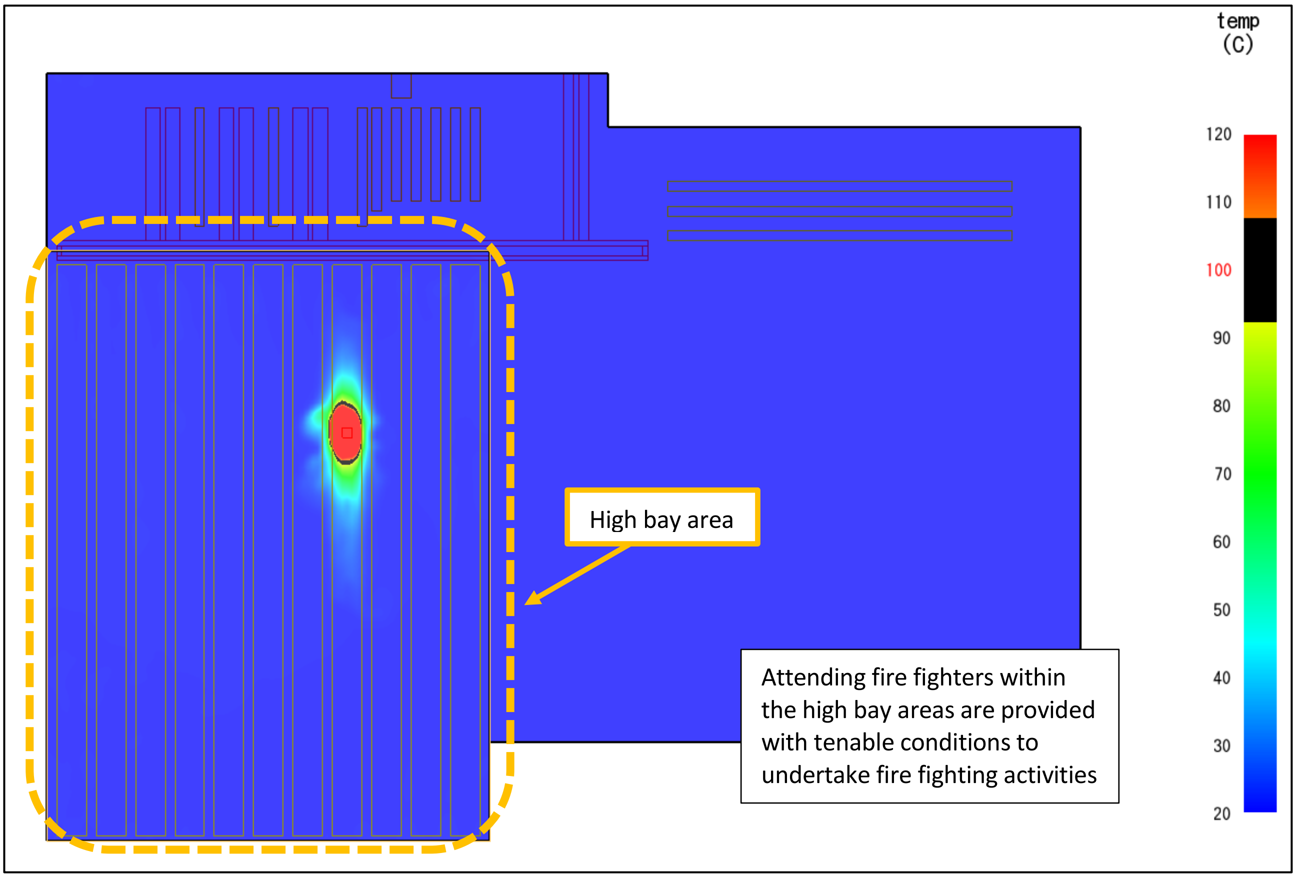


Figure 12.3: Temperature slice file at 1.5m above the FFL (Fire Scenario: SB04)

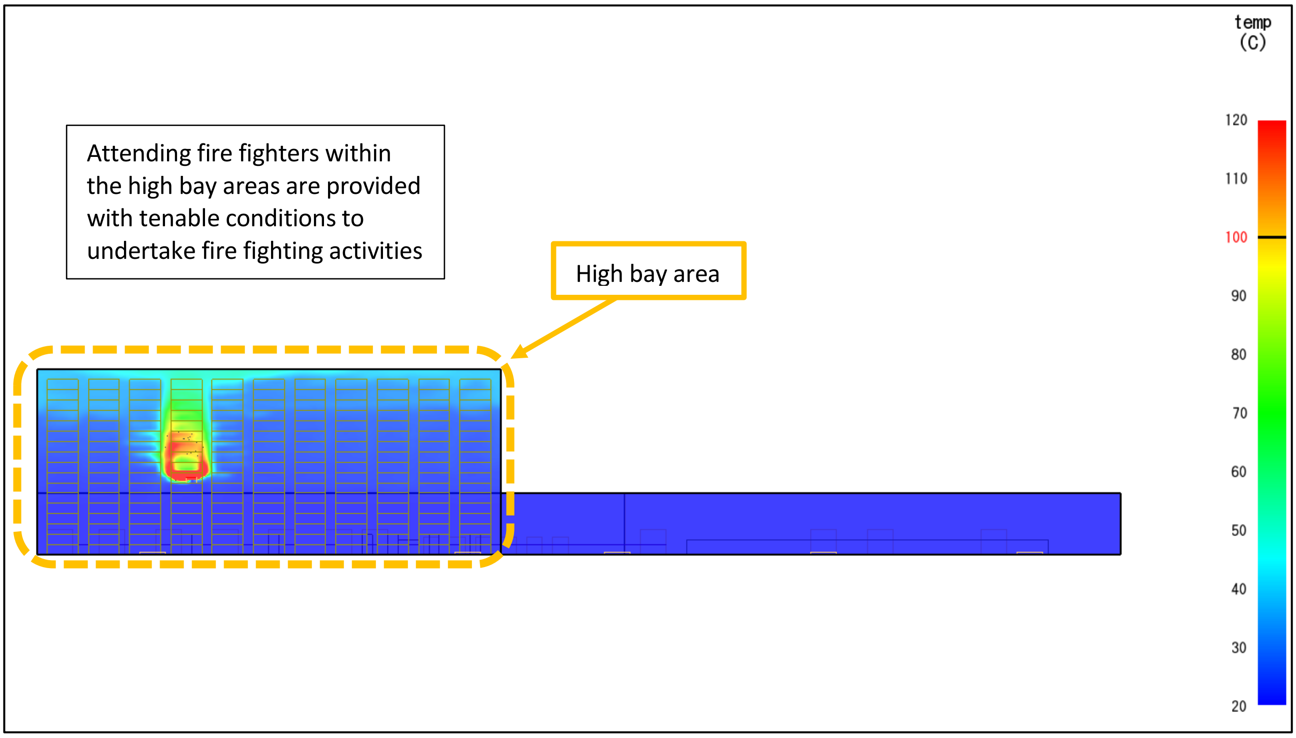


Figure 12.4: Temperature slice file through the fire (Fire Scenario: SB05)

12.8 Discussion of Assessment Outcomes

The qualitative evaluation has demonstrated that the fire hydrant system provisions serving the subject site do not present an adverse impact for attending Fire Brigade personnel in the event of an emergency fire situation. Fire crews are provided with appropriate hydrant shielding, additional provisions (including signage and strobe lights) to assist with locating the fire hydrant booster assembly, and fall-back hydrants for use in the unlikely case where an external hydrant is threatened by a fire.

The acceptance criterion has been based on the ability for attending fire crews to deploy Standard Operational Guideline's (SOG's) and has been satisfied. Therefore, it is deemed that the proposed design satisfies the Performance Requirement of EP1.3 from Volume One of the NCC. This conclusion is contingent on the requirements detailed in Section 16.2 being implemented into the design.

13. Exit Signs (Excluding High Bay Area)

13.1 Background to the Issue

Exit signs and directional exit signs are to be installed throughout the building in accordance with clauses E4.5, E4.6 and E4.8 of the NCC and AS2293.1-2005 with the exception that the mounting heights of exit signage throughout the warehouse portion (as highlighted in Figure 13.1). In this instance, it is proposed to permit the top of the exit signs to be mounted no greater than 6.0m above the finished floor level within the warehouse areas only in lieu of 2.7m as otherwise required by the prescriptive provisions from Volume One of the NCC.

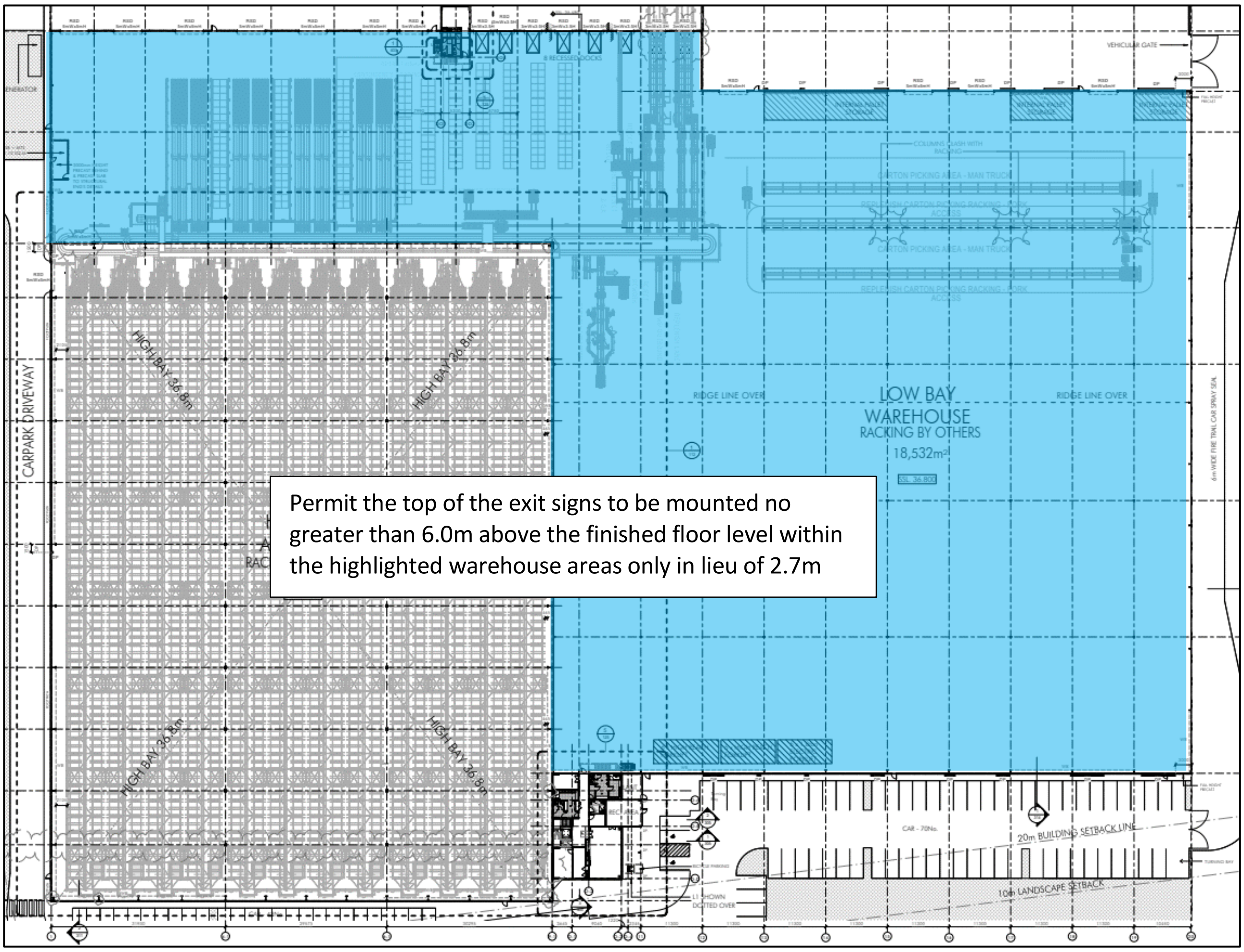


Figure 13.1: Location of exit signs permitted to be mounted no greater than 6.0m above the finished floor level

13.2 Assessment Methodology

In accordance with the NCC Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine that the *Building Solution* will comply with the *Performance Requirements*.

Table 13.1: Methods of Analysis

Identified Design Issue	NCC Assessment Method	IFEG Method of Analysis
Directional and non-directional exit signs are to be installed throughout the warehouse portion in accordance with Part E4 from Volume One of the NCC and AS2293.1:2005 with the exception that the mounting heights of exit signage within the warehouse storage portions (excluding the high bay area). In this instance, it is proposed to permit the top of the exit signs to be mounted no greater than 6m above the finished floor level within the warehouse portion only in lieu of 2.7m as required by the prescriptive provisions from Volume One of the NCC.	A0.5(b)(ii) Verification method as the relevant authority accepts for determining compliance with the performance requirements. The associated Performance Requirements to be met is EP4.2	A 'deterministic absolute' approach whereby an occupant and fire-fighter life safety assessment has been developed in the form of an ASET/RSET timeline analysis.

Fire and smoke modelling has been conducted to determine whether or not the smoke layer will impact the abilities for occupants to visualise the exit signs.

13.3 Hazard Specific to Exit Signs

The 'Guide to the NCC' (ABCB, 2016) states that the intent associated with mounting exit signage at the prescribed height is "t*o ensure exit signs are clearly visible at all times when the building is occupied."* It is therefore, considered that the main hazards specific to the issue to be considered in the assessment are:

- The potential for fire by-products (smoke and toxic gasses) to restrict the path of occupant travel (i.e. potential for tenability limits to be exceeded within the path of travel); and
- The potential for smoke to obscure the view of exit signs during a potential fire situation.

13.4 Hazard Mitigation to Exit Signs

The Guide to NCC (ABCB 2016) identifies the hazards as being directly related to the facilitation of occupant evacuation in the event of an emergency fire situation. In this regard, the following is noted:

- The warehouse is provided with an automatic sprinkler system that is designed to suppress a fire. The outcome of effective fire sprinkler suppression system operation is to mitigate smoke production through suppression. The propagation of smoke is significantly reduced after sprinkler head activation; and
- Exit Signage located and installed in accordance with Clauses E4.5 & E4.6 from Volume One of the BCA and AS/NZS 2293.1 with the exception of increased mounting heights of "directional exit' signs within the path of travel to an emergency exit on the ground floor only. The directional exits signs are to be "JUMBO" exit signs such that occupants can visualise the exit signs from a greater distance and as a result enhance the overall way finding performance; and
- The occupants within the building will be familiar with their surroundings and will be familiar with the basic internal racking layout (way finding) design of the distribution centre; and
- Rationalised smoke hazard management which shall be designed and installed based on the building geometry, potential fire hazard and occupant numbers/characteristics and occupant/fire-fighter tenability limits.
- The large internal volume space provides a natural smoke reservoir for the hot smoke and gases to accumulate allowing additional time for safe occupant evacuation.

13.5 Methodology

The methodology adopted addresses the exit sign provisions has been quantitatively assessed analysing the fire and evacuation modelling outcomes. In this instance, an ASET/RSET assessment has been undertaken demonstrating that the smoke layer height is maintained above the top of the exit sign (mounted at no more than 6.0m above the finished floor level) for at least the time taken for occupants to evacuate the storage portion of the building. Furthermore, the proposed mounting height the exit signs has been deemed acceptable with respect to their visibility via an analysis of the viewing angle and distance. The visibility of an exit sign is a function of the viewing angle as illustrated in Figure 13.2.

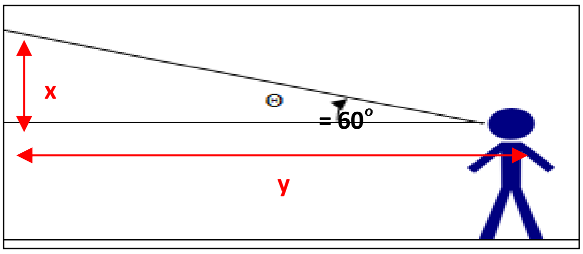


Figure 13.2: Exit signs viewing angle

Visibility is a function of the following variables:

- Signage Size.
- Field of Vision (x).
- Viewing Angle (ϴ).
- Viewing Distance (y).

For design purposes the variables can be calculated based on the following equations.

$\tan \Theta = x/y$ [Eq.1]

and

$x = \tan \Theta \cdot y$ [Eq.2]

and

$y = x/ \tan \Theta$ [Eq.3]

and

$\Theta = \tan^{-1}(x/y)$ [Eq.4]

13.6 Acceptance Criteria

The acceptance criteria shall be met by demonstrating that the smoke layer height can be maintained above the top of the exit sign (ASET) which is mounted at no more than 6.0m above the finished floor level for a period of time no less than the time taken for occupants to evacuate the storage portion of the building (RSET). Therefore, the following acceptance criteria shall be met:

ASET smoke layer at no greater than 6.0m above the FFL **> 1.0 x RSET**

In this instance ASET reflects the time when wayfinding is impaired due to loss of exit sign visibility.

In relation to the proposed mounting height the acceptance criteria shall be met by demonstrating the viewing the top of the exit signs located at no more than 6.0m above the floor level are very much within the field of view of a person.

13.7 Assessment of Exit Signs

It is proposed that in order to allow for pallet lifts to freely move through racking passageways and the high storage area configuration, the exit signs are installed at heights above the levels nominated by AS2293:2005 and required by the relevant prescriptive clauses of the NCC. The standard requires the signage to be mounted between 2.0m and 2.7m above floor level. For the subject building the exit signs are proposed to be installed at a height no greater than 6.0m above the finished floor level to allow pallet lifts to freely move through racking passageways and the high storage area configuration. The CFD modelling has been undertaken to assess the visibility throughout the warehouse during the evacuation process. The fire modelling conducted for the subject building has demonstrated that the hot smoke layer would remain above the height of 6.0m whereby the directional exit signage is not expected to become obscured for a period such that detection and pre-movement times are accounted for.

With reference to the core fire models undertaken (SB01), it was demonstrated that the smoke layer will drop below 6.0m at various times as summarised below:

SB01 - Sprinkler controlled scenario within the Staging Area

- Staging area: 1700 seconds
- Low bay: 1700 seconds
- High bay: 1300 seconds

Based on the occupant evacuation analysis, it is considered that the occupants are provided with adequate time to evacuate the building prior to the smoke layer to descending below 6.0m (i.e. obscuration of the exit signage).

With reference to the core fire and smoke model (SB01), it has been demonstrated that the smoke layer fell below 6.0m above the finished floor in certain pockets of the floor area only for the required RSET time. Therefore, it is considered that the occupants have the ability to view the exit signs for the duration required to evacuate the building and as such the performance solution is to mount the top of the directional exit signs 6.0m above the finished floor level has been satisfied as shown in Figure 13.3.

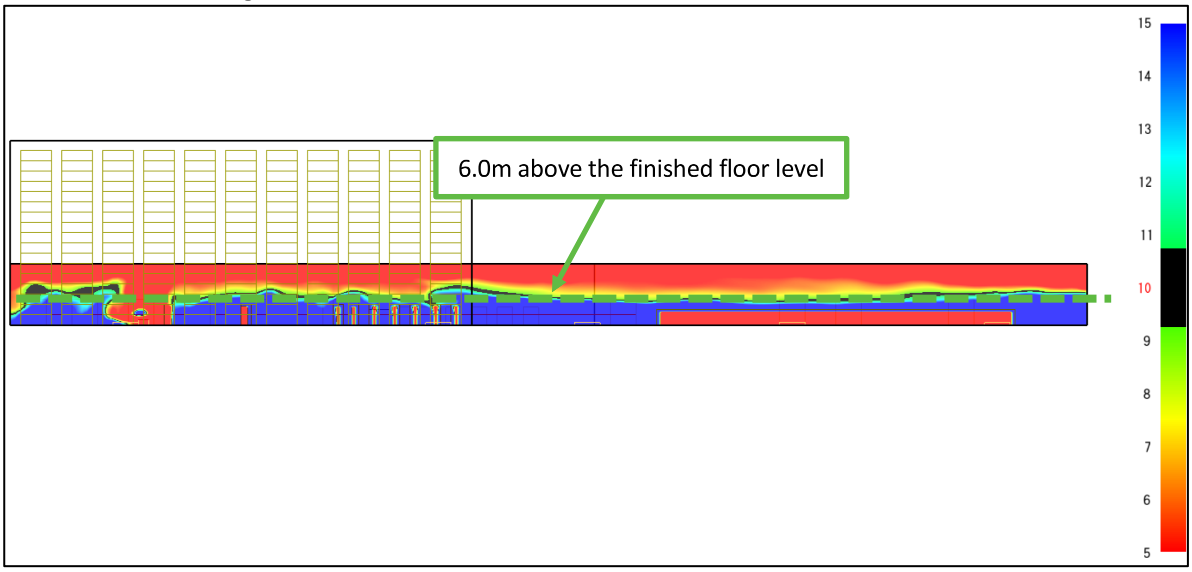


Figure 13.3: Visibility conditions within the Staging Area (Fire scenario: SB01, Time: 1700 seconds)

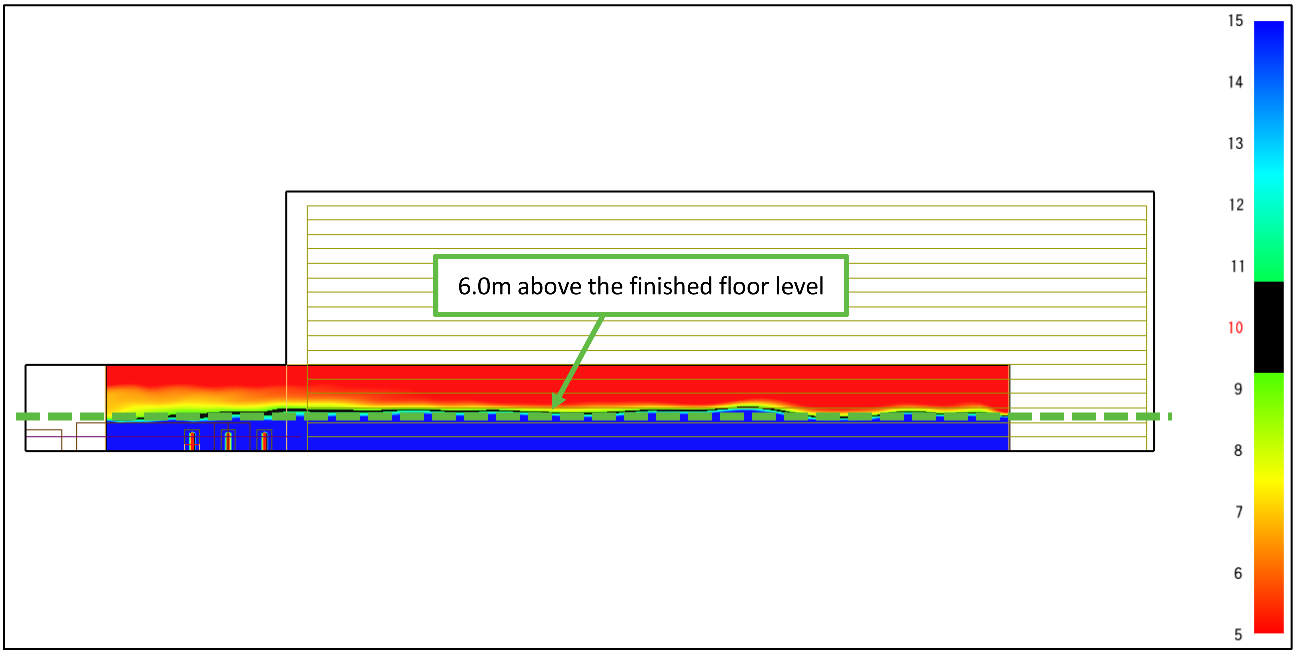


Figure 13.4: Visibility conditions within the Low Bay Area (Fire scenario: SB01, Time: 1700 seconds)

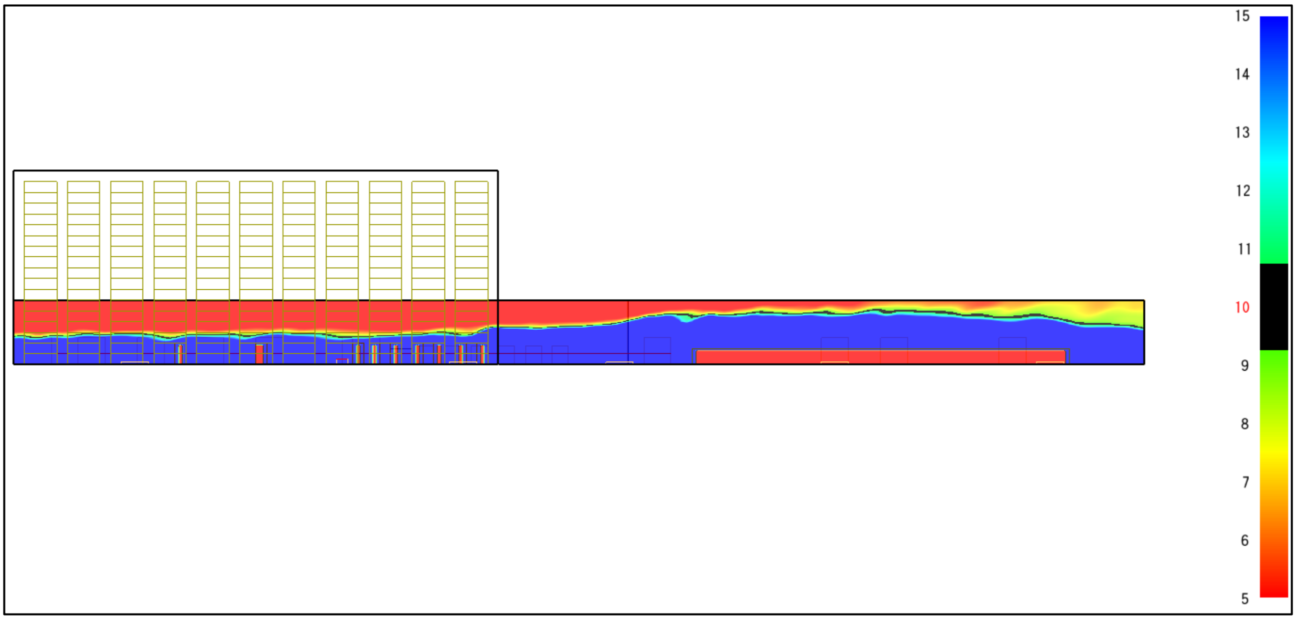


Figure 13.5: Visibility conditions within the Staging Area (Fire scenario: SB04, Time: 2100 seconds)

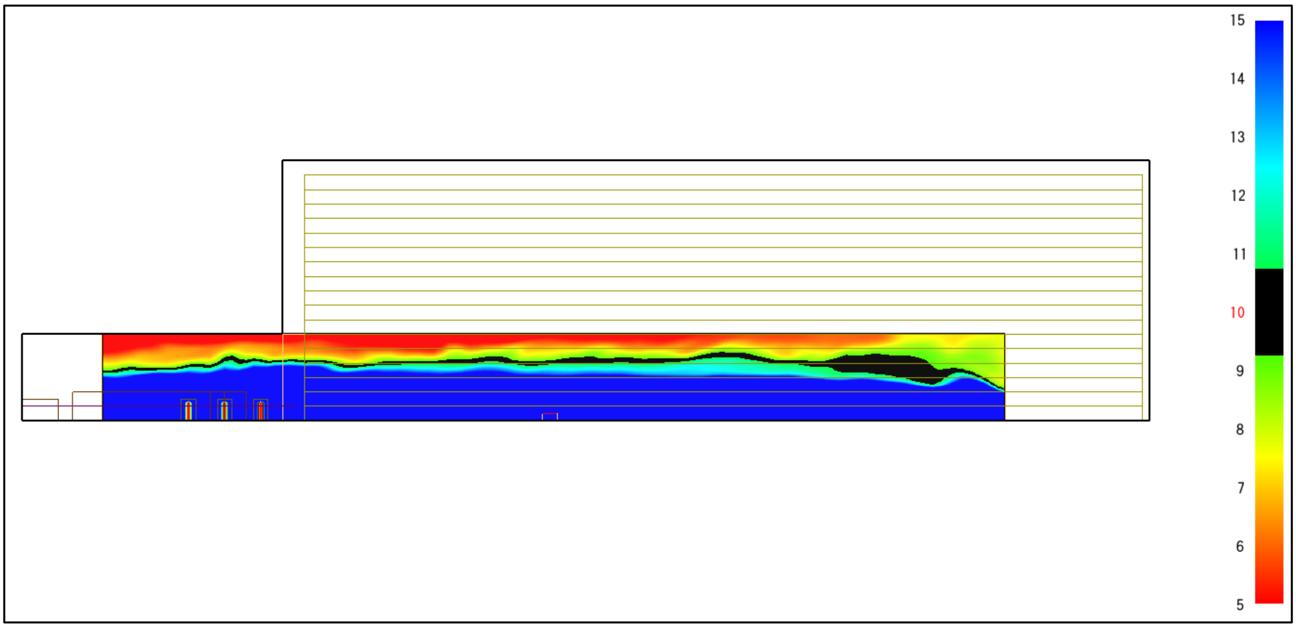


Figure 13.6: Visibility conditions within the Low Bay Area (Fire scenario: SB04, Time: 2500 seconds)

According to literature (SFPE 2003), visibility requirements for escape depend to a large extent on the size of an enclosure and occupants' familiarity with escape routes. People's response to obscuration of vision and its detrimental effects on movement speed and way finding efficiency is highly variable as familiarity, fire cues all become part of the evacuation process.

The subject warehouse facility as previously stated has racking and pallet stacks throughout the floor area with straight travel paths along each isle. There are no dead-ends within the warehouse. The exits are located on all sides of the building making alternative choices for egress available in almost any situation. Therefore, the building occupants travelling within the warehouse would be in a good position to see the top of the signs located at 6.0m above the floor level and head to one of the numerous exits provided.

As discussed in Section 10, the exit travel distance is not expected to increase the risk of occupant exposure to untenable conditions. Based on the CFD modelling, the increased exit height (6.0m) is not expected to inhibit the occupants from seeing and assessing the provided exits. As such the occupants are expected to be able to recognise the exit signs before conditions reduce to a level which increases the risk of occupant exposure to untenable conditions. It is noted that the CFD modelling conducted for the facility has demonstrated that the hot smoke layer will not obscure occupant visibility throughout building evacuation.

The modelling demonstrated that any signage mounted no more than 6.0m above floor level would also remain visible for the duration of evacuation and as such the acceptance criterion is satisfied. More specifically, the following demonstrates that the acceptance criterion has been satisfied.

Warehouse (Fire Scenario: SB01, Evacuation Scenario: SB01C)

- $ASET_{\text{smoke layer at 6.0m above the FFL}}$ > RSET

Humans have a horizontal field of view of more than 200° with the central 60° zone being identified as the binocular field. The vertical field of view ranges from 70° below horizontal to 60° above horizontal. Visual presence of a sign within a field of view is highly likely to result in recognition and consequently wayfinding. As shown in Figure 13.7 and Table 13.2 the exit signs located at 2.7m and 6.0m above the floor level are very much within the field of view of a person with average height at distances varying from 10m to 50m.

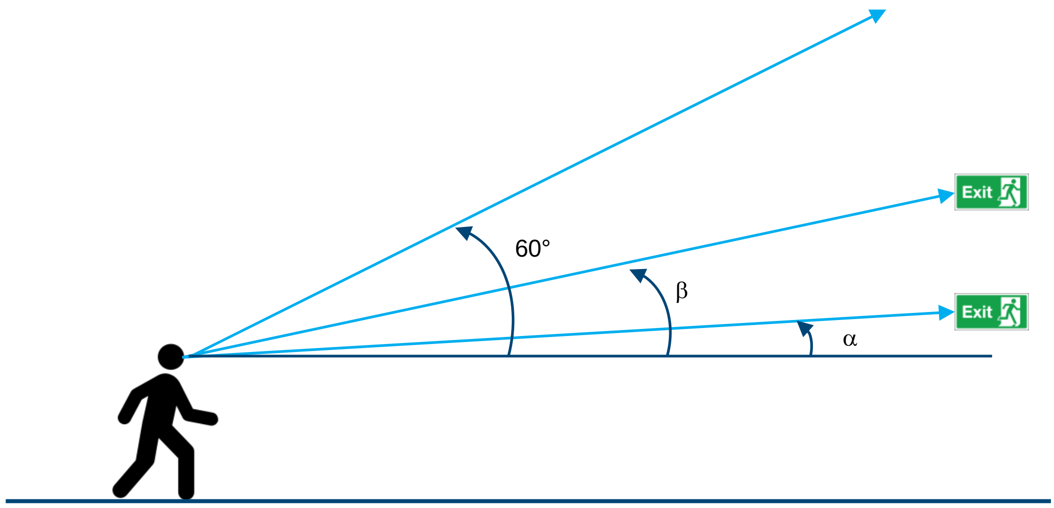


Figure 13.7: Field of view for exit signs at different heights

Table 13.2: Field of view for exit signs at different heights

Distance between occupant and the sign location (m)	Exit sign at 2.7 m (α = angle degrees above horizontal)	Exit Sign at 6.0m (β= angle degrees above horizontal)
10	5.1	22.8
20	2.6	11.8
30	1.7	8.0
40	1.3	6.0
50	1.0	4.8

Note: The above calculation is based on an average person height of 1.8m.

Based on the above, the proposed mounting exit sign height (i.e. no more than 6.0m) is deemed to be within the same field of vision to a DtS compliant design (i.e. 2.7). Therefore, it is considered that the proposed mounting exit sign height will not impact the building occupant's ability to visualise the exit signs.

In order to compensate for the sign mounting height being located above the levels prescribed (i.e. 2.7m), it is proposed to adopt larger signage. Research conducted in Japan by Jin (1991) demonstrated that there is a direct relationship between the conspicuousness of signage and the sign size in the context of the distance they are reviewed from. The three sign sizes considered in the study were 130mm x 360mm, 200mm x 600 mm and 400mm x 1200mm. As illustrated below Figure 13.8 demonstrates the relative conspicuousness based on signage size and the viewing distance.

The outcomes of the study were interpreted as a small exit sign being legible from 8m, where a medium sign can be legible from 30m and a large one from as much as 80m. In this instance the width of the building is approximately 30m. Therefore, the centre point of the building is approximately 15m. According to Figure 13.8 small size 'Jumbo' signs are expected to be generally visible at a distance of approximately 15m. The expected locations for the Jumbo signs shall be midway in the racking isles and as such it is expected that the medium size Jumbo signs would be in viewing distance at the height of 6.0m throughout the relevant stages of evacuation as demonstrated above.

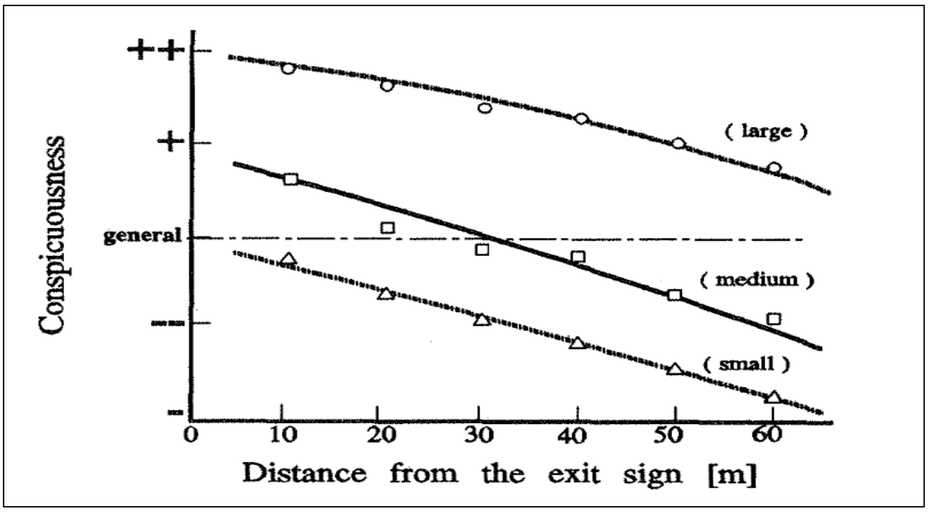


Figure 13.8: Relative conspicuousness of exit signage

The signs proposed for the subject building are proposed to be 130mm x 360mm. When interpolated, based on Jin's findings, this would result in legibility at distances over 8m. According to literature (SFPE 2003), visibility requirements for escape depend to a large extent on the size of an enclosure and occupants' familiarity with escape routes. People's response to obscuration of vision and its detrimental effects on movement speed and way finding efficiency is highly variable as familiarity, fire cues all become part of the evacuation process.

The building occupants are expected to be awake and alert, predominantly able bodied but not necessarily familiar with the building layout or the emergency procedures. As a result of the relatively simple geometries, the presence of staff, exit signage and multiple exit locations, way finding and familiarisation of the buildings are considered not to pose any significant life safety concerns for the building occupants.

As discussed in Section 10, the exit travel distance is not expected to increase the risk of occupant exposure to untenable conditions. Based on the CFD modelling the increased exit height (6.0m) is not expected to inhibit the occupants from seeing and assessing the provided exits. As such the occupants are expected to be able to visualise the exit signs well before conditions reduce to a level which increases the risk of occupant exposure to untenable conditions. It is noted that the CFD modelling conducted for the warehouse portion has demonstrated that the hot smoke layer will not obscure occupant visibility.

The modelling demonstrated that any signage mounted no more than 6.0m above floor level would also remain visible for the duration of evacuation and as such the acceptance criterion is satisfied.

13.7.1 Sprinkler Effectiveness

As noted previously, all areas of the building will have a fully compliant AS2118.1:2017 sprinkler system installed unless otherwise assessed herein. As detailed in Clause C3.4 from Volume One of the NCC, sprinklers are deemed as a reliable method of reducing the effects of a fire. As such, the proposed sprinkler system is expected to control the development and spread of fire within the proposed building. Furthermore, the effectiveness of the automatic fire sprinklers in limiting fire spread and growth is supported by statistics and studies undertaken into the effects of automatic fire sprinklers within buildings.

A potential fire within the sprinkler protected building is expected to be of reduced intensity and as such a reduction in the by-products produced in a fire would be expected. The result in the reduction in combustible material becoming involved in a fire is that there is far less smoke in the upper layer to reduce visibility.

Sprinkler protection is expected to provide a reliable and effective means of maintaining tenable conditions for occupants and fire-fighters, structural adequacy, and limiting fire spread within a building. Effective sprinkler activation and operation is also likely to reduce the generation of smoke and maintain low compartment temperatures.

13.8 Assessment Outcomes

The above quantitative/qualitative analysis has demonstrated that the location of the exit signage no more than 6.0m which while greater than the prescriptive requirement of 2.7m is not expected to negatively impact on the way finding performance of occupants in the event of an emergency fire situation. The assessment has demonstrated that an expected fire scenario within the storage facility will not obstruct the exit signage for the duration required for effective occupant egress performance. The quantitative/qualitative analysis has demonstrated that the acceptance criterion pertaining to the exit signage satisfies the Performance Requirement EP4.2 from Volume One of the NCC. This conclusion is dependent on the recommendations in Section 16.2 being implemented into the design.

14. Exit Signs and Emergency Lighting (High Bay Area)

14.1 Background to the Issue

It is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. As confirmed by Modcol Pty Ltd (refer to Appendix Q), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area. Clevertronics EFLLED signage (as detailed in Appendix R) shall be provided over the exit doorways serving the high bay area to assist occupant wayfinding.

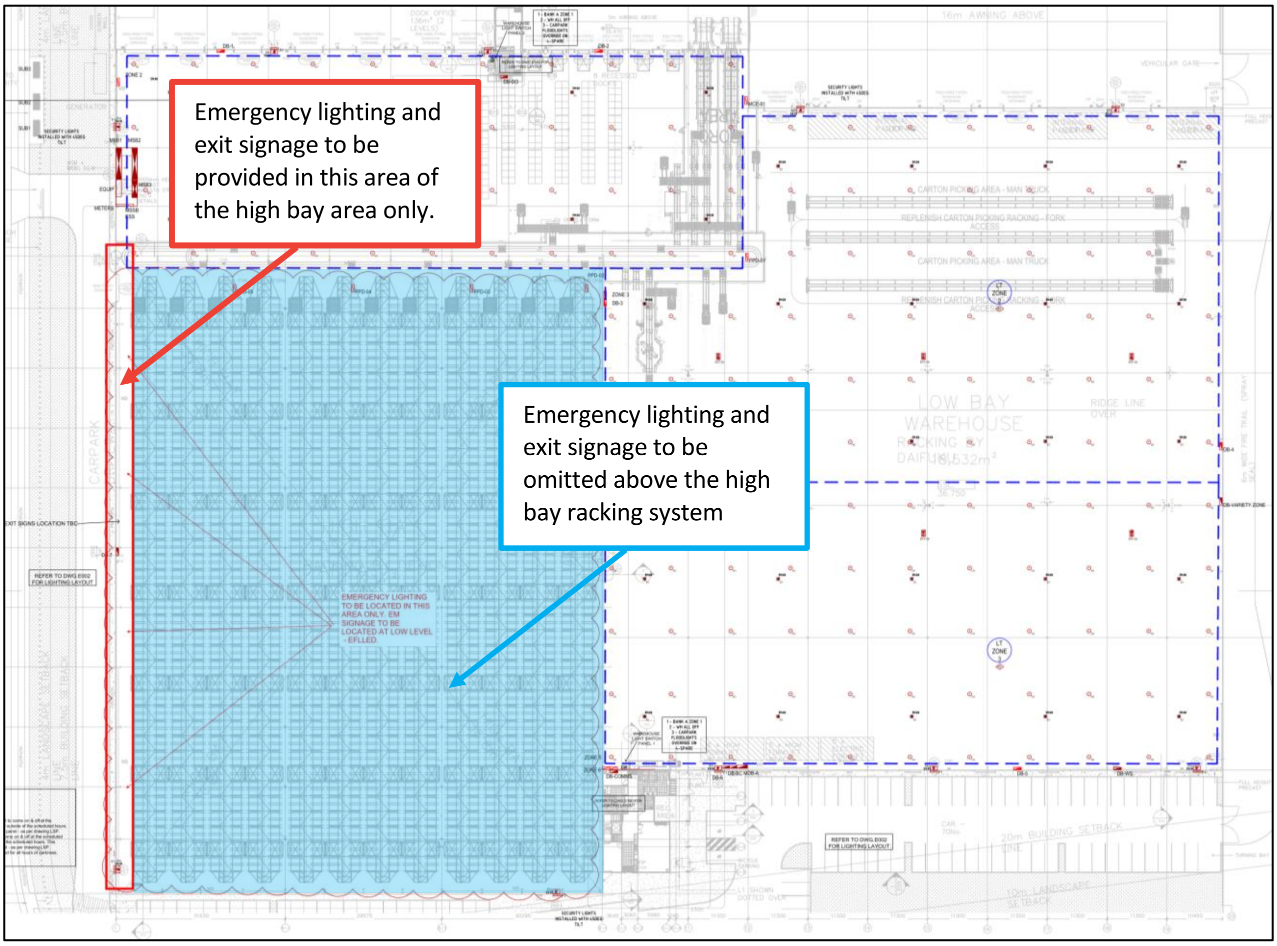


Figure 14.1: Location of emergency lighting and exit signage provided to the high bay area

14.2 Assessment Methodology

In accordance with the BCA Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine that the *Building Solution* has complied with the *Performance Requirements of EP4.2*.

Table 14.1: Methods of Analysis

Identified Design Issue	BCA Assessment Method	IFEG Method of Analysis
It is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. **Note:** As confirmed by Modcol Pty Ltd (refer to Appendix Q), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area.	A0.5(b)(ii) Verification method as the relevant authority accepts for determining compliance with the performance requirements. The associated Performance Requirements to be met is EP4.2	A qualitative and quantitative assessment has been undertaken to establish the acceptability of the omission of exit signage and lighting to the high bay racking area.

Fire and smoke modelling will be conducted to determine whether or not the smoke layer will impact the abilities of occupants to visualise the exit signs.

14.3 Hazard Specific to Exit Signs

The 'Guide to the BCA' (ABCB, 2016) states that the intent associated with providing exit signage and lighting is "*to assist in occupant wayfinding and minimise the risk of death or injury to occupants during an emergency because of an inability to find an exit".* It is therefore considered that the main hazards specific to the issue to be considered in the assessment are:

- The potential for fire by-products (smoke and toxic gasses) to restrict the path of occupant travel (i.e. potential for tenability limits to be exceeded within the path of travel); and
- The potential for occupants to be trapped due to the inability to find an exit during a potential fire situation.

14.4 Hazard Mitigation to Exit Signs

The Guide to BCA (ABCB 2016) identifies the hazards as being directly related to the facilitation of occupant evacuation in the event of an emergency fire situation. In this regard the following is noted:

- The warehouse is provided with an automatic sprinkler system that is designed to suppress a fire. The outcome of effective fire sprinkler suppression system operation is to mitigate smoke production through suppression. The propagation of smoke is significantly reduced after sprinkler head activation; and
- Proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable; and
- The small maintenance corridor located along the southern edge of the high bay area shall be provided with emergency lighting and exit signage in accordance with Clauses E4.5 & E4.6 from Volume One of the BCA and AS/NZS 2293.1
- The occupants within the building will be familiar with their surroundings and will be familiar with the basic internal racking layout (way finding) design of the distribution centre; and
- The large internal volume space provides a natural smoke reservoir for the hot smoke and gases to accumulate allowing additional time for safe occupant evacuation.

14.5 Methodology

The methodology adopted to address the design issue has been based on a qualitative evaluation with respect to the building function and use of the high bay racking area, fire hazards, occupant characteristics (i.e. trained maintenance personnel), active fire safety systems (i.e. in-rack sprinklers) and the potential risk to occupant life safety within the high bay area.

Furthermore, a quantitative ASET/RSET assessment has been undertaken demonstrating that the smoke layer height is maintained above the top of the exit sign (mounted at no more than 2.7m above the finished floor level) within the high bay area (maintenance corridor) for at least the time taken for occupants to evacuate the storage portion of the building.

14.6 Acceptance Criteria

The basic objective and intent of this analysis pertains to the life safety of the building occupants within the high bay area during an evacuation. Thus, the primary acceptance criterion has been met by demonstrating that occupants can safely evacuate the high bay area with consideration to the building function and use, fire hazards, occupant characteristics and active fire safety systems.

14.7 Assessment of Exit Signs within the High Bay Area

The high bay area is large volume consisting of an Automatic Storage and Retrieval System (AS/RS). It is not expected for this area to be heavily populated as only maintenance staff will be present. As advised by the client, a maximum of two (2) occupants will be present at any given time. During normal operations, the AS/RS will be unoccupied. During unscheduled maintenance periods, the AS/RS may be occupied in the event that troubleshooting is required or problem resolution (i.e. maximum of two (2) occupants at any one time).

As part of the proposed Performance Solution, it is proposed to omit the requirement for emergency lighting and exit signage above the high bay racking due to the racking system being an automated system and non-trafficable. As confirmed by Modcol Pty Ltd (refer to Appendix Q), emergency lighting and exit signage shall only be provided to the small maintenance corridor located along the southern edge of the high bay area (refer to Figure 14.2).

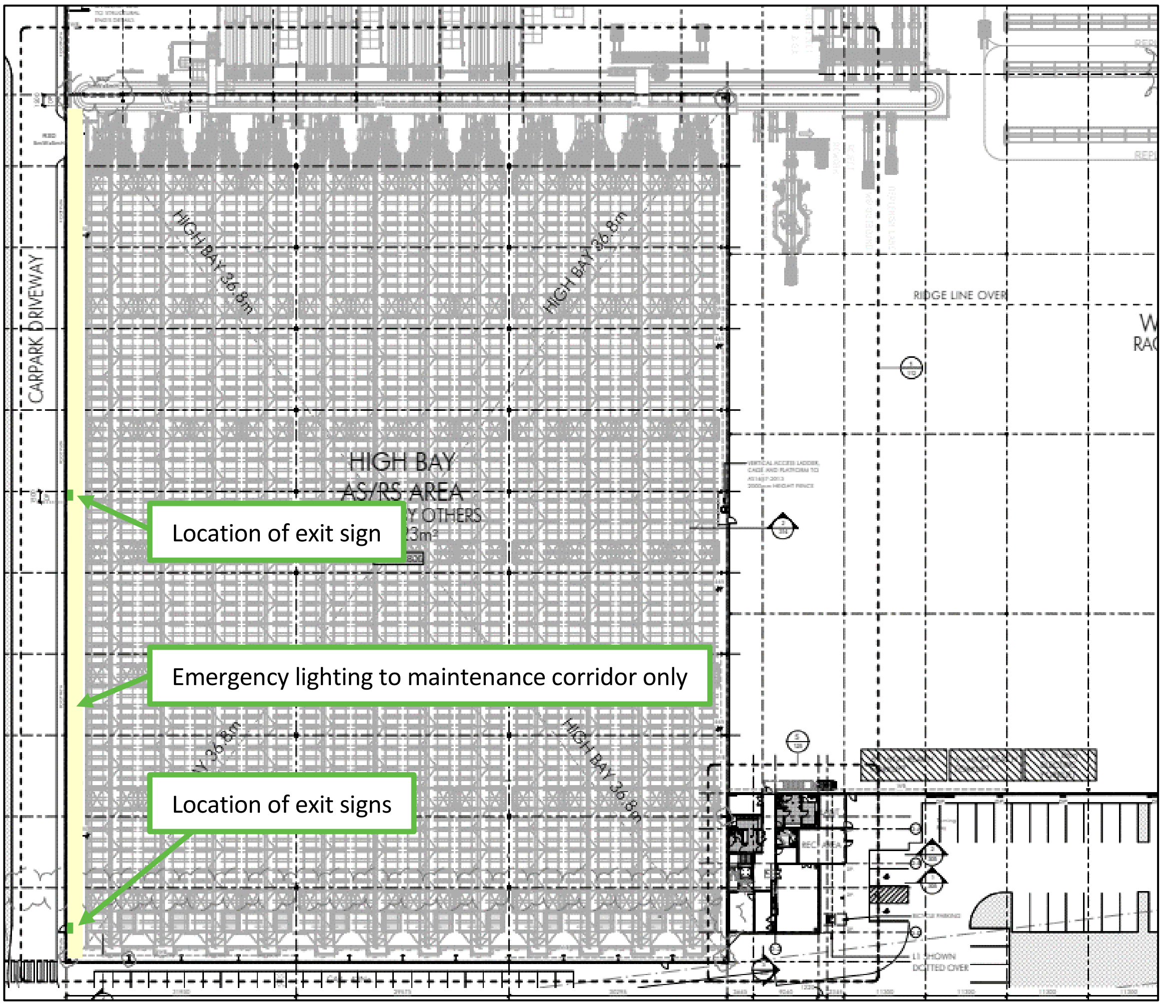


Figure 14.2: Location of exit signs and emergency lighting within the high bay area

The CFD modelling has been undertaken to assess the visibility throughout the trafficable maintenance corridor located along the southern edge of the high bay area. The fire modelling has demonstrated that the hot smoke layer would remain above the height of 2.7m whereby the directional exit signage is not expected to become obscured for a period such that detector and pre-movement times are accounted for.

As a recommendation by FRNSW, an aspirating smoke detection system (i.e. VESDA) is required to be provided within the high bay area to provide early notification to the building occupant and satisfy the operational firefighting concerns due to fire hydrant and fire hose reel shortfalls. As a conservative measure, the aspirating fire detection and alarm system (i.e. VESDA) a was not relied upon within the analysis/assessment to satisfy occupant/fire brigade life safety criteria.

With reference to the modelled fire models conducted within the high bay area (i.e. SB04 and SB05), it was demonstrated that conditions were maintained for extended period of time for building occupants to see the exit signs and to safely evacuate. Similarly, tenable conditions were maintained for attending fire crews to intervene.

Table 14.2: ASET and RSET comparison with respect to the high bay exit sign height

Design Fire Scenario	Evacuation Scenario	Area	$RSET_{Occupant}$ (seconds)	$ASET_{Exit\ sign}$ (seconds)	Factor of Safety	Acceptance Criteria Satisfied
SB04: **In-Rack Sprinkler controlled scenario**	**SB04C:** Core Scenario	High Bay	571	950*	1.6	Yes
SB05: **Ceiling - Sprinkler controlled scenario** *(2nd ring sprinkler activation)*	**SB05C:** Core Scenario	High Bay	669	3000*	4.48	Yes

***Note:** ASET has been based on 2.7m above the finished floor level along the southern edge of the high bay area (i.e. maintenance corridor as highlighted in Figure 14.1).

Table 14.3: ASET/FBIM comparison for attending fire crews

Modelled Design Fire Scenario	Attending Fire Brigade	Fire Brigade Intervention (seconds)	Fire-Fighter ASET (seconds)	Acceptance Criteria Satisfied
All modelled fire scenarios	St Marys Fire Station	2441	>3000	Yes
	Mount Druitt Fire Station	2644	>3000	Yes
	Penrith Fire Station	3363	>3000	Yes*

Note: *At the completion of the fire and smoke modelling simulations (i.e. 3000 seconds), the temperature conditions maintained steady state conditions (i.e. temperatures do not exceed 100°C at 1.5m above the finished floor level for routine conditions).*

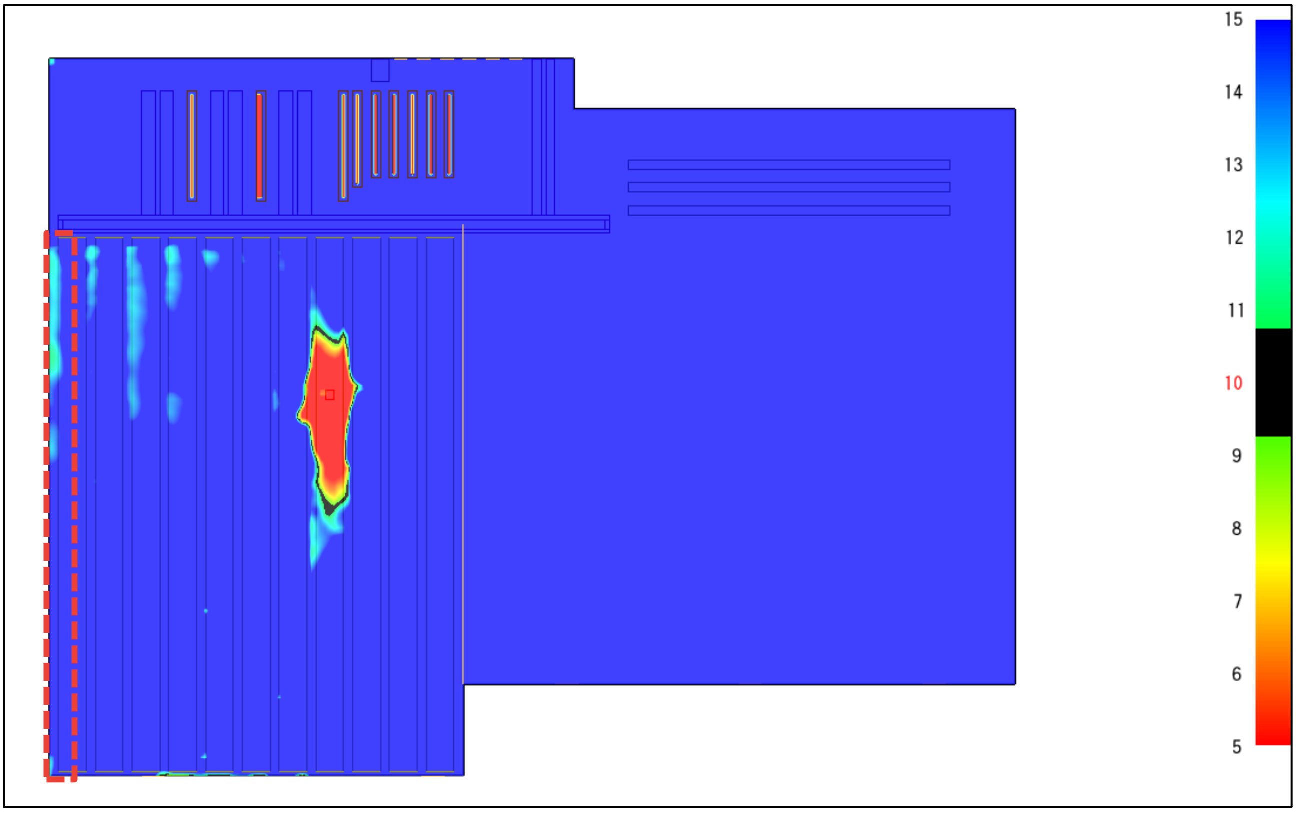


Figure 14.3: Visibility slice file at 2.7m above the finished floor at 950 seconds (Fire scenario: SB04)

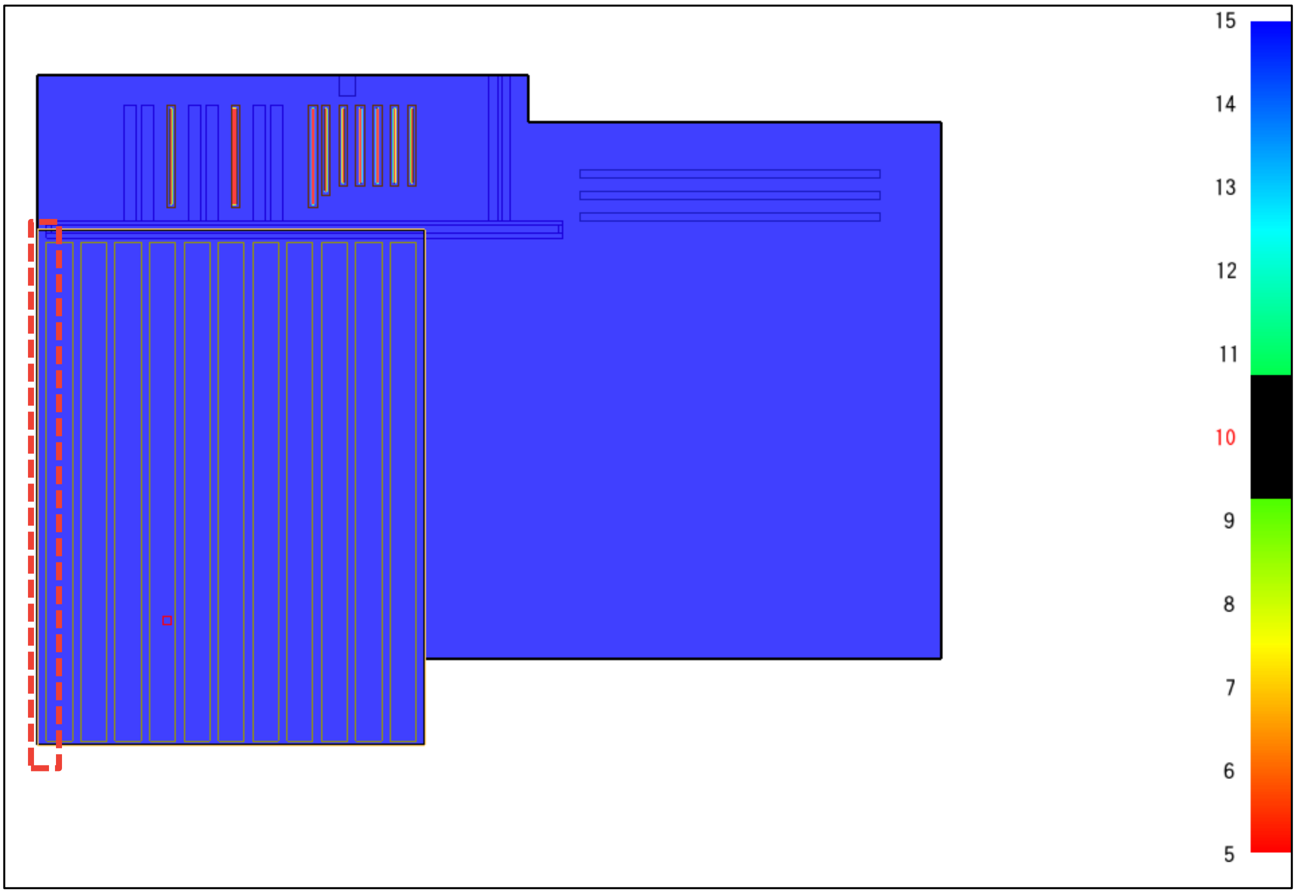


Figure 14.4: Visibility slice file at 2.7m above the finished floor at 3000 seconds (Fire scenario: SB05)

Further to the above, the building occupants are expected to be awake and alert, predominantly able bodied but not necessarily familiar with the building layout or the emergency procedures. As a result of the relatively simple geometries, the presence of staff, exit signage and multiple exit locations, way finding and familiarisation of the buildings are considered not to pose any significant life safety concerns for the building occupants.

As discussed in Section 10, the exit travel distance is not expected to increase the risk of occupant exposure to untenable conditions. Based on the CFD modelling outcomes, it is not expected to inhibit the occupants from seeing and assessing the provided exits. As such the occupants are expected to be able to visualise the exit signs well before conditions reduce to a level which increases the risk of occupant exposure to untenable conditions. It is noted that the CFD modelling conducted for the warehouse portion has demonstrated that the hot smoke layer will not obscure occupant visibility.

As noted previously, all areas of the building will have a fully compliant AS2118.1:2017 sprinkler system installed unless otherwise assessed herein. As detailed in Clause C3.4 from Volume One of the NCC, sprinklers are deemed as a reliable method of reducing the effects of a fire. As such, the proposed sprinkler system is expected to control the development and spread of fire within the proposed building. Furthermore, the effectiveness of the automatic fire sprinklers in limiting fire spread and growth is supported by statistics and studies undertaken into the effects of automatic fire sprinklers within buildings.

A potential fire within the sprinkler protected building is expected to be of reduced intensity and as such a reduction in the by-products produced in a fire would be expected. The result in the reduction in combustible material becoming involved in a fire is that there is far less smoke in the upper layer to reduce visibility.

Sprinkler protection is expected to provide a reliable and effective means of maintaining tenable conditions for occupants and fire-fighters, structural adequacy, and limiting fire spread within a building. Effective sprinkler activation and operation is also likely to reduce the generation of smoke and maintain low compartment temperatures.

14.8 Assessment Outcomes

The above quantitative analysis has demonstrated that the high bay area is generally non-trafficable due to the presence of the AS/RS and that the area will contain limited occupant numbers at any one time. The quantitative analysis has demonstrated that occupants (limited maintenance staff) within the high bay area (maintenance corridor) are provided with adequate time to evacuate prior to occupant visibility being obscured by smoke. Furthermore, the attending fire crew are provided with on-going tenable conditions to undertake fire bride intervention activities.

The assessment has demonstrated that an expected fire scenario within the high bay area will not obstruct the exit signage for the duration required for effective occupant egress performance. The quantitative/qualitative analysis has demonstrated that the acceptance criterion pertaining to the exit signage and emergency lighting satisfies the Performance Requirement EP4.2 from Volume One of the NCC. This conclusion is dependent on the recommendations in Section 16.2 being implemented into the design.

15. Fire Indicator Panel Location

15.1 Background to the Issue

With reference to AS1670.1:2015, the FIP is required to be located at the designated building entry point. In this instance, it has been identified that the FIP is located at the main office of the warehouse (eastern side of the site). Given the configuration of the site, the main vehicular entrance point is accessed via Distribution Drive (southern side). Therefore, the FIP location is not within the main entrance of the site. This is illustrated in Figure 15.1.

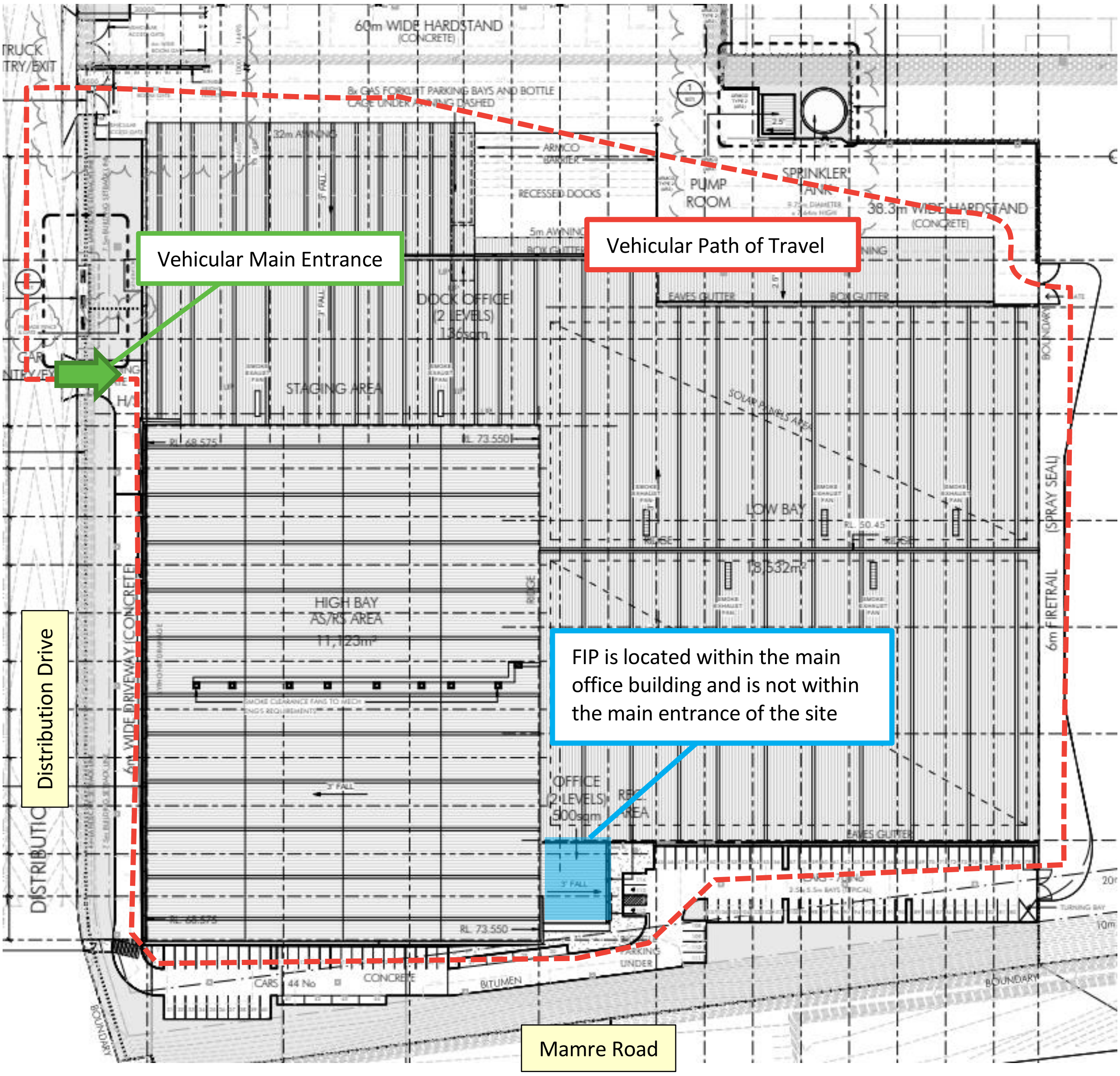


Figure 15.1: Location of the FIP

15.2 Assessment Methodology

In accordance with the BCA Clause A0.5 *Assessment Methods* the following assessment method has been adopted to determine that the *Building Solution* has complied with the *Performance Requirements of EP1.6*.

Table 15.1: Methods of Analysis

Identified Design Issue	BCA Assessment Method	IFEG Method of Analysis
The FIP is located within the main office of the warehouse, which is not located within the main entrance (vehicular access) of the site.	A0.5(b)(ii) Verification method as the relevant authority accepts for determining compliance with the performance requirements. The associated Performance Requirements to be met is EP1.6	A qualitative approach has been undertaken to assess the acceptability of the proposed configuration and access to the Fire Indicator Panel.

15.3 Hazard Specific to FIP Location

The Guide to the BCA (ABCB 2016) details the intent behind the requirement for the fire indictor panel to be located within the main entrance of the site is to *"To help fire brigade officers who will be carrying their equipment to reach the fire indicator panel and to make entry easier".*

It is therefore considered that the hazards for the location of the fire indicator panel relates to the required effort of the fire fighters in gaining access with their equipment and the effect the reduced clearance may have on the efficiency of fire access.

15.4 Hazard Mitigation to the FIP Location

The Guide to the BCA (ABCB 2016) identifies the hazards as being directly related to the facilitation of Fire & Rescue NSW personnel and their ability to undertake standard operational procedures/intervention activities. In this regard the following is noted:

- Fire brigade can park their appliances on hardstand provided and can direct access the fire indicator panel from an external location; and
- The main FIP is located within the main entrance. To assist with firefighting operations, signage shall be provided at the main entrance of the site stating that the FIP is located inside the main office building.
- Additional signage shall be provided (externally) from the vehicular entry location and along the perimeter vehicular access road directing fire crews to the location of the FIP situated at the building's main entry location

15.5 Methodology

The methodology adopted to address the design issue of the location of the fire indicator panel has been based on a qualitative evaluation on the potential risk associated with the proposed location and the resulting impact on the attending fire brigade personnel.

Furthermore; the assessment has evaluated and taken into consideration the panel locations which are considered to not have an impact on the fire brigade operations. The proposed design has been referred to the FRNSW as part of the design team stakeholder engagement, giving the fire authority an opportunity to provide comment as to the appropriateness of the design.

15.6 Acceptance Criteria

The basic objective and intent of this analysis pertains to the life and operational safety of the attending fire brigade personnel while undertaking their standard operational procedures and the associated impact of the proposed location of the fire indicator panel and accessibility and functionality provisions. Thus, the primary acceptance criterion has been met having demonstrated that the proposed design satisfies fire-fighting Standard Operational Guideline's (SOG's) when identifying (i.e. locating) and accessing the fire indicator panel and introduces an equivalent level of operational and functional use to a DtS compliant solution.

15.7 Assessment of the Fire Indicator Panel Location

15.7.1 Function and Use

The subject development is proposed to comprise a Class 7b high bay warehouse comprising 11,023m^2 (with a roof height of 36.8m) as well as a low bay warehouse consisting of 18,630m^2 (with a roof height of 13.7m). The warehouse is tenanted by Snackbrands Australia, whereby the building will be primarily used for storage and distribution of food products. It is not anticipated that any materials of excessive hazard will be stored in the facility

The staff members are considered to be familiar with the building environment in which they work and hence have an in depth understanding of the building layout and more specifically an understanding of the location of exits. It is expected that the staff would be trained in the buildings emergency procedures and also in a position to provide an initial attack on a fire with fire hose reels provided within the building. In any event, it is expected that staff would be aware of the nearest exit locations and be well versed in assisting any building occupants to the available exits. Upon activation of the BOWS permanent and trained staff within the building would be expected to initiate the emergency evacuation procedures.

15.7.2 Fire Brigade Intervention and Fire Fighter Tenability Limits

The Fire Brigade Intervention Model (FBIM) has been undertaken for the subject warehouse building is an event-based methodology which quantifies Fire Brigade activities from the point from Fire Brigade notification through to search, rescue around the perimeter, fire control and extinguishment and overhaul activities. In this instance, Fire Brigade Intervention is analysed in terms of fire crew notification, response, Fire Brigade access, facilities for the attending fire-fighters and ability to undertake operational activities.

The fire model outcomes achieved the acceptable tenable conditions as the temperatures of the smoke layer at 1.5m above the finished floor level did not exceed 100°C for the duration greater than 3000 seconds. The model was terminated at 3000 seconds as conditions reached steady state. Hence, the acceptable tenable criteria within the building were not breached.

Furthermore, fire fighters are expected to undertake intervention in tenable conditions as detailed in Section 8.4.2. The fire and smoke modelling outcomes have demonstrated that the hot layer maintained above 1.5m with a temperature in the lower layer of less than 100°C for ongoing periods of time. As a result, conditions are considered to be ongoing at below routine levels and do not achieve the high levels associated with hazardous, extreme or critical conditions during fire-fighting operations. Furthermore, it is considered that due to the availability of multiple exits that are easily detectable and the aforementioned periods of tenability the building occupants would have all evacuated prior to the fire fighters arriving on site.

It is note that the clearances for the FIP are provided as per the DtS, the use of the FIP will be primarily by attending fire brigade personal. The FIP is in a cupboard shared with FHR in the main entry lobby, when fire fighters are using the FIP, occupants will not be using the FHR at the same time.

To further assist the attending fire brigades, additional signage shall be provided (externally along the building) from the vehicular entry location and along the perimeter access road directing fire crews to the location of the FIP which is situated within the building's main entrance.

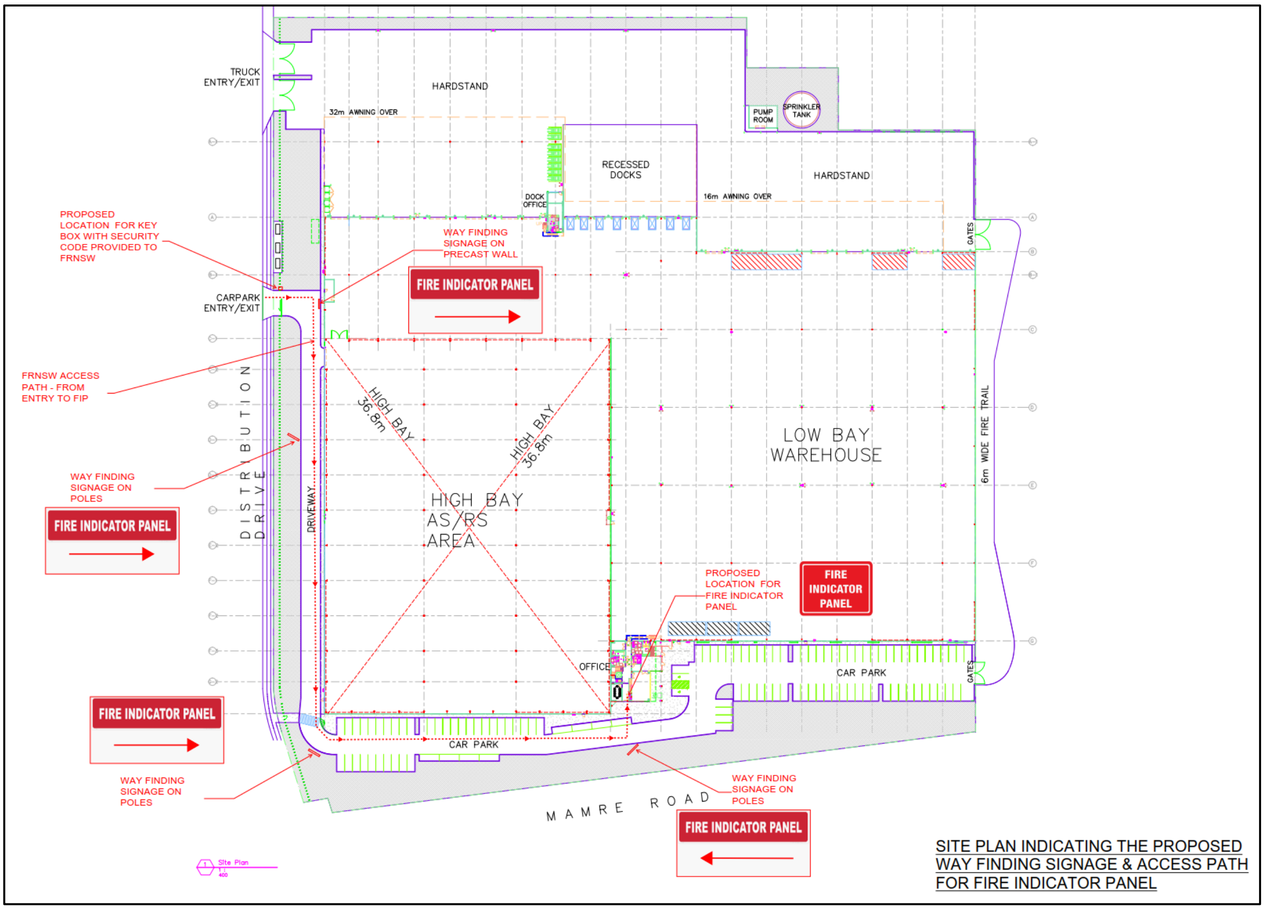


Figure 15.2: Location of signage provided to assist fire brigade wayfinding to FIP.

15.8 Assessment Conclusion

The qualitative analysis has demonstrated that the design issues relative to the FIP location does not present an adverse impact on Fire Brigade intervention activities in the event of an emergency fire situation. The proposed FIP location design is deemed satisfactory to the FRNSW as the proposed design and layout maintains the efficacy of fire-fighting operations.

Therefore, it is deemed that the proposed FIP location and layout is deemed to satisfy the Performance Requirement of EP1.6 from Volume One of the NCC. This conclusion is contingent on the requirements as detailed in Section 16.2 being implemented into the design.

16. Conclusion

16.1 General

The Fire Safety Engineering assessment detailed in this report demonstrates that the proposed Performance Solution aspects of the Building solution have been shown to meet the corresponding identified Performance Requirements of the BCA as listed in Table 3.1.

The assessment and verification methodologies employed have been in accordance with the requirements of the BCA and conform to the principles of IFEG.

The building incorporates a range of fire safety measures in accordance with the relevant Australian Standards. In summary, the BCA defines the fire safety measures and their applicable standards required to be installed within buildings. Unless otherwise stated, the applicable standard of fire safety system installation (active and passive) must be compliant with the BCA and the relevant Australian Standards.

The Client is to ensure that the relevant stakeholders and services consultants that have been involved in the project are in agreement with the proposals made in this document. Furthermore it is the responsibility of the other designers and consultants (not SFS) to complete the detailed design of the various active and passive fire safety systems in accordance with the relevant design and installation Australian Standards and in accordance with the requirements listed in this report.

16.2 Required Fire Safety Measures

The performance solution for the subject building consists in part of some features which are included within the prescriptive provisions of the NCC and additional features which are specific to this building alone. The combination of these 'DtS' and additional fire safety system features comprises the 'Performance Solution' which has been assessed herein.

Unless otherwise stated the required fire safety systems for the subject building are to be designed and installed in accordance with the DtS provisions of the NCC and relevant referenced Australian Standards. The proposed 'Performance Solution' applicable to the subject building, which has been the subject matter of this assessment, may be summarised as follows:

16.2.1 Fire Resistance and Type of Construction

1. Building elements throughout shall be constructed in accordance with the minimum Fire Resistance Level's (FRL's) commensurate with Type C fire-resisting construction; and
2. For Stage 1 works, the external walls located within 3m from the title/leasing boundary shall achieve a minimum FRL of up 90 minutes;

   Note: At a future point in time when Stage 2 works are proposed to be undertaken, a separate external wall achieving a minimum FRL of 90 minutes shall be designed and installed should it be located within 3m from the title/leasing boundary; and
3. Separation of the equipment rooms as prescribed by the DtS provisions from Volume One of the NCC shall be in accordance with Clause C2.12 from Volume One of the NCC (i.e. a minimum FRL of 120 minutes); and
4. Any electrical substations within the building shall be separated from any other part of the building as required by Clause C2.13 from Volume One of the NCC; and
5. As required, building materials, components and structures shall be suitably tested and approved to achieve the test criteria consistent with AS1530.1:1994 in order to satisfy the DtS provisions of the NCC and/or AS1530.4:2014. All building elements which require an FRL shall be designed, pre-fabricated and installed in accordance with the tested and approved prototype; and
6. As required, building elements and passive systems (requiring an FRL) shall be suitably tested to meet the test criteria consistent with the minimum requirements prescribed by the DtS provisions of the NCC and/or AS1530.4:2014. All building elements which require an FRL shall be designed, pre-fabricated and installed in accordance with the tested and approved prototype; and
7. All parts of the building must be constructed in an appropriate manner using materials that are fit for purpose as well as being provided with evidence of suitability with respect to fire resistance and fire hazard properties to the satisfaction of the building certifier; and
8. All building lining materials and assemblies, both internal and external are required to meet the minimum fire hazard properties in Clause C1.10 and Specification C1.10 from Volume One of the NCC; and

9. Should any openings and/or penetrations be proposed, the FRL of the penetrating element shall be reinstated commensurate with the FRL required for the building element. Appropriately tested fire stopping protection methods shall be proposed to the openings/penetrations; and
10. Enclosures beneath any required stairways may be permitted subject to strict compliance with Clause D2.8 from Volume One of the NCC.

16.2.2 Occupant Egress Provisions

1. Egress provisions must comply with Part D from Volume Once of the NCC serving unless otherwise identified herein; and
2. Permit occupant egress provisions serving the Class 7b warehouse portion/s as per the following:
   a. The exit travel distance exceeds 40m (i.e.: up to 115m) to an exit where two (2) exits are available; and
   b. The distance between alternative exits exceed 60m (i.e.: up to 172m); and
3. All emergency exit doors which may be locked due to security requirements are to open on General Fire Alarm (GFA) and/or power failure; and
4. Access into the high bay area shall be provided through readily accessible gates. Refer to Appendix X.

16.2.3 Fire Services and Equipment

1. The entire building shall be provided with automatic fire sprinkler protection in accordance with AS 2118.1:2017. The sprinkler system shall be as follows:
   a. It is proposed to design and install an automatic sprinkler system throughout the warehouse portion of the development in accordance with AS2118.1:2017 which currently is not a referenced Australian Standards by Volume One of the NCC (2016). The following requirements shall be adopted (as per the design brief extraction, refer to Appendix G):
      i. The Class 7b warehouse portion of the subject building is to be sprinkler protected with the installation of Storage Sprinklers incorporating K22 ‘fast response’ sprinkler heads. The activation temperature of K22 storage sprinkler heads shall be no more than 100°C; and
      ii. As required, in-rack sprinklers are required within parts of the Class 7b storage areas (i.e. K22 sprinkler heads) in accordance with AS2118.1:2017, FM Global Guidelines and as per the fire protection services requirements and specifications; and
      iii. All other Class 7b storage and/or Class 8 manufacturing areas not protected with Storage Sprinklers (i.e. K22 “fast response” sprinkler heads) shall be designed and installed in accordance with the hazard classification strictly commensurate with AS2118.1:2017, FM Global Guidelines and as per the fire protection services requirements and specifications; and
      iv. Covered awnings forming part of the Class 7b warehouse portion of the subject building shall be sprinkler protected as per Specification E1.5 from Volume One of the NCC and AS2118.1:2017 to ‘Ordinary Hazard 3’ classification; and
      v. The Class 5 office portion of the subject building is to be sprinkler protected as per Specification E1.5 from Volume One of the NCC and AS2118.1:2017 appropriate to ‘Light Hazard’ classification and fitted with fast response sprinkler heads; and
      vi. Refer to Appendix N for further details; and
2. Where appropriate, the Storage Sprinkler system shall comply with the Factory Mutual (FM Global) Property Loss Prevention Data Sheet 2-0, “Installation Guidelines for Automatic Sprinklers” and Property Loss Prevention Data Sheet 8-9, “Storage of Class 1, 2, 3, 4 and Plastic Commodities.” The design and installation of the Storage Sprinkler system shall be in strict accordance with the building geometry/height, achieve required minimum clearance, commodity/storage layout/height & hydraulic pressure/flow requirements; and
3. As required by the FRNSW, an aspirating fire detection and alarm system (i.e. VESDA) shall be designed and installed within the high bay area (only) in accordance with AS1670.1:2015; and

   Note: *As a conservative measure, the aspirating fire detection and alarm system (i.e. VESDA) a was not relied upon within the analysis/assessment to satisfy occupant/fire brigade life safety criteria.*
4. The automatic fire sprinkler system and fire detection system (including VESDA) must be interconnected to the Building Occupant Warning System (BOWS); and
5. The Building Occupant Warning System (BOWS) shall actuate upon activation of the automatic sprinkler system and/or the automatic fire detection system. The BOWS shall initiate a General Fire Alarm (GFA) throughout the building and hence achieve sound pressure levels in accord with AS1670.1:2015; and
6. The main Fire Indicator Panel (FIP) shall be located within the main office entry location at ground level. A Sub FIP may be provided to the dock office if required by the client; and

7. Installations activating the BOWS shall also be connected to a fire alarm monitoring system connected to a fire station or fire station despatch centre in accordance with AS1670.3:2004; and
8. The Class 7b warehouse portions of the building (only) shall be provided with a smoke clearance system/s, to the degree necessary, to allow a degree of smoke and hot gas venting from the warehouse portions of the building. In this instance, the smoke clearance system shall can be achieved via a manually operated smoke clearance fan system as per the following:
    a. Manual Operation (dedicated fire mode system for smoke clearance – fire brigade use only); and
        i. Manually operated smoke clearance fan(s) system shall be operable by means of activating a 'push button devices' located at the main FIP location and at any sub FIP; and
        ii. The warehouse portion shall have the capacity to vent a minimum of one (1) air change per hour throughout the respective warehouse portions; and
        iii. Designed and installed in accordance with Specification E2.2b with regards to the componentry such as control gear, wiring and operation temperature (i.e. 200°C for a period of 1 hour); and
        iv. Designed and installed with power supply wiring to the smoke clearance fan infrastructure must comply with AS1668.1:2015; and
    b. Make up air provisions shall be evenly distributed and must have a sufficient area size such that 1 air change to the warehouse;

    Refer to Appendix M for mechanical engineers' specifications for fan capacity, number and locations of fans as well as make up air provisions; and
9. Fire hydrants are to be located and installed in accordance with Clause E1.3 from Volume One of the NCC and AS2419.1:2005 with the exception of the following:
    a. Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and
        i. Provide additional external 'fall back' hydrant(s) to facilitate operations such that fire-fighters are able to utilise the fire hydrants located beneath the covered awnings. The external 'fall back' fire hydrants are to be located within 60m if the fire hydrants located beneath the covered awnings, be located as close as possible to the perimeter vehicular access location and furthermore are to be design and installed to achieve attack fire hydrant performance. Finally, fire hydrant coverage from the 'fall back' hydrant(s) must provide coverage to all fire hydrants located beneath the awning structures; and
10. Permit fire hydrant coverage shortfalls based on two (2) lengths of internal fire hydrant hose coverage in lieu of achieving complete fire hydrant hose coverage from one (1) length of internal fire hydrant hose coverage to the high bay area only. Refer to Appendix J for details; and
11. Where internal fire hydrants are required for coverage purposes, the internal fire hydrants are to be located in the building such as to allow progressive movements of fire fighters towards central parts of the building as per the below:
    a. When working from an external hydrant, the next additional hydrant should be located into the building not more than 50m from the external hydrant; and
    b. When working from an internal hydrant (either from within a fire isolated exit or passageway, within 4 metres of an exit or another additional fire hydrant), the next additional hydrant should be no located not more than 25m from that hydrant.
    c. Where additional hydrants are provided, a localised block plan should be provided at every fire hydrant pictorially and numerically illustrating the location of the next available additional hydrant. These localised block plans should be of a size appropriate to their notice and location and be of all weather-fade resistance construction; and
12. A fire hydrant ring main shall be designed and installed in accordance with the DtS provisions from Volume One of the NCC and AS2419.1:2005. Appendix T depicts the location of the fire brigade booster assembly; and
13. Any electrical substation(s) proposed for the site shall be situated no less than 10m from the fire hydrant booster assembly; and
14. The fire hydrants serving the proposed fire hydrant system are to be accessible for use by Fire & Rescue NSW (i.e. clear paths of travel); and
15. All on-site fire hydrants are to be fitted with forged Storz hose couplings which comply with Clause 7.1 of AS2419.1-2005. This clause states in part "hose couples shall be compatible with those used by the fire brigade serving the area". Storz hermaphrodite fire hose couplings must be fitted to all fire hydrants and the fire hydrant booster assembly connections as required by Appendix E of AS2419.1-2005. The Storz fittings must be manufactured to DIN 14303, aluminium alloy delivery couplings, in accordance with Appendix A of AS2419.2-1994. Blank caps must be provided in accordance with Clause 2.8 of AS2419.2-1994; and

16. Block plans are to be provided at the main Fire Indicator Panel (FIP) and any Sub FIP panel and at the fire hydrant booster assembly connection in accordance with Section 7.11 of AS2419.1:2005 and the FRNSW Tactical Fire-Fighting Plans Guideline (Policy No. 6, Version 02); and
17. The fire hose reel system shall be design and installed in accordance with AS2441.1:2005 with the exception of the following:
    a. It is proposed to omit the provision for fire hose reel coverage to the storage (i.e. racking portions) within the high bay zone as per Figure 11.1. Refer to Appendix K for details; and
18. Portable fire extinguishers shall be selected and mounted in accordance with Clause E1.6 from Volume One of the NCC and AS2444:2001; and
    a. Additional portable fire extinguishers shall be proposed in strategic locations within the storage portions of the high bay zone as per Figure 11.3; and
    b. Due to the potential presence of electrical switchboards within the high bay structure, the use of ABE portable fire extinguishers would safeguard occupants attempting to utilise portable fire extinguishers; and
    c. The provision for ABE type portable fire extinguishers should not only meet the minimum requirements of the Australian Standard for portable fire extinguishers. The provision for ABE type portable fire extinguishers should exceed the minimum requirements of the Australian Standard such that there is portable fire extinguisher coverage around the High Bay Zone in order to offset the omission of the fire hose reels; and
    d. Refer to Appendix V for details; and
19. Emergency lighting in accordance with AS2293.1:2005, with the exemption of the following:
    a. Omit the requirement for emergency lighting above the high bay racking system located within the high bay area. Refer to Figure 16.1 for further details; and
    b. Exit signs and directional exit signs are to be installed throughout the building in accordance with Clauses E4.5, E4.6 and E4.8 from Volume One of the NCC and AS2293.1:2005 with the exception that the mounting heights of exit signage within the warehouse portions (excluding the high bay areas). The directional and non-directional exit signs are to be "JUMBO" signs and furthermore, the top of the exit signs (within the warehouse portion only) shall be mounted no more than 6.0m above the finished floor level.

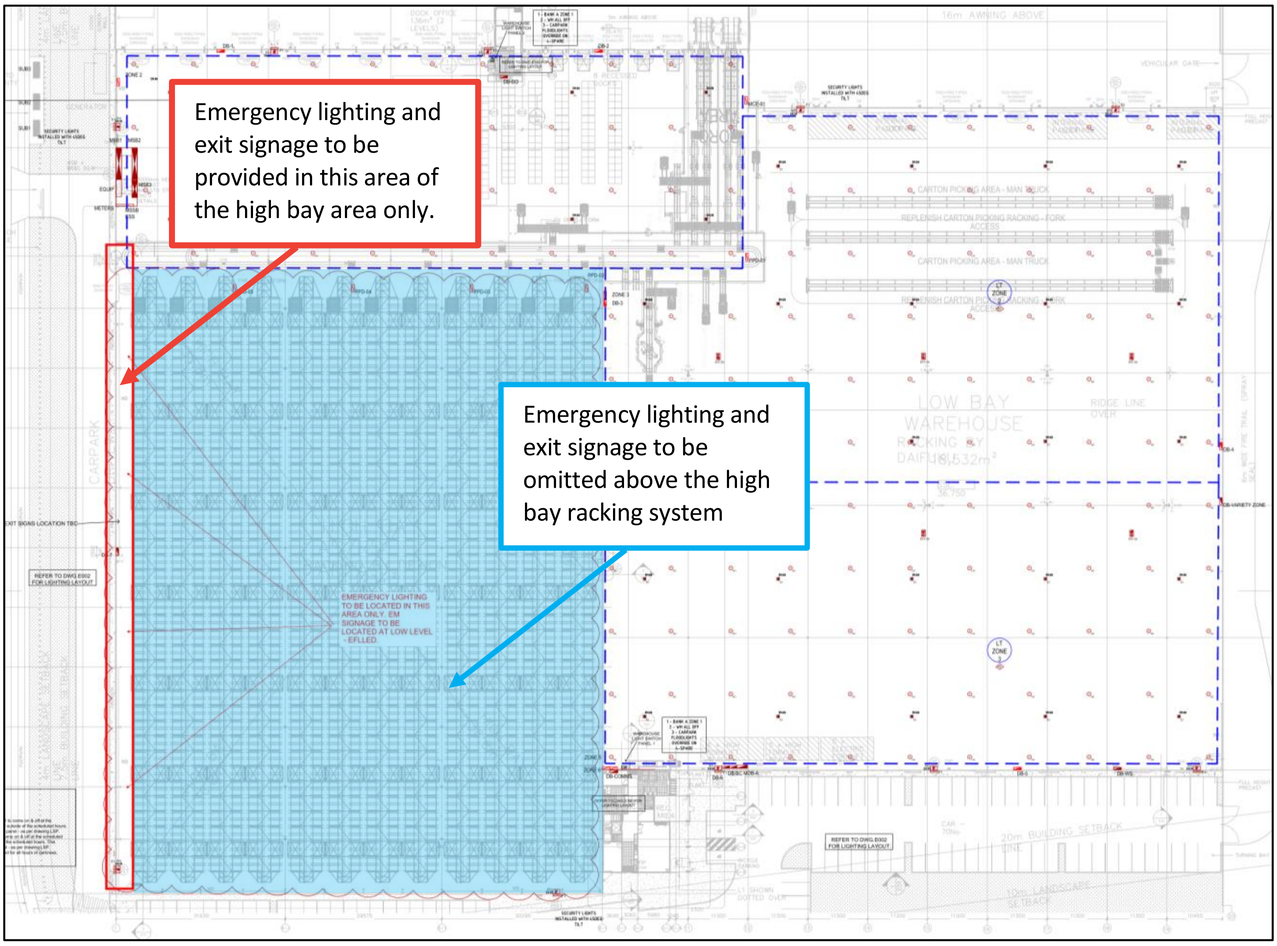


Figure 16.1: Location of emergency lighting and exit signage provided to the high bay area

a. The high bay area shall be installed with low level LED Emergency spitfire lighting to the small maintenance corridor (only) located along the southern edge of the high bay area; and

b. Jumbo Emergency Exit signage shall be provided over the doorways exiting the building.

Note: There is no requirement for general lighting or emergency lighting throughout the high bay racking system as it is automated.

20. The high bay area that consists of the following electrical supplies; (DB:7, PPD-01, PPD-02, PPD-03, PPD-04, PPD-05, MCP-01 (Future), MCP-02 & PPD-06 (Future).

a. All of these electrical supplies are fed directly from one of the three Mains Switchboards that are all located together in the Main Switch room.

b. Each independent submain supply shall be labelled at each respective MCCB on the relevant MSB. Furthermore, drawings shall be provided within the MSB Room showing each of the noted electrical supplies for clarity should FRNSW require to de energise these DB's.

16.2.4 Vehicular Access and Open Space Provisions

1. The perimeter vehicular access serving the development shall be continuous and comply with the DtS provisions from Volume One of the NCC unless otherwise identified herein:

   a. A 6.0m wide perimeter vehicular access zone shall be created along the full length of the on the adjacent allotment such that the vehicular access on the adjacent allotment can be utilised as continuous perimeter vehicular access for Snackbrands (Stage 1); and

2. To further assist the attending fire brigades, additional signage shall be provided (externally along the building) from the vehicular entry location and along the perimeter access road directing fire crews to the location of the FIP which is situated within the building's main entrance. Refer to Appendix W for details; and

3. Any gates forming part of the perimeter vehicular access road that are proposed to be locked are required to be fitted with suitable conventional 003 padlocks or alternatively, the responding fire services shall be provided with building keys to enable fire-fighter access with a standard key; and

   a. A secure key box shall be provided and located at the front gate to house the building/site keys for the attending fire crew. The security code to the secure key box shall be provided to the FRNSW and this information shall form part of the emergency response plan to the site ((refer to Appendix W and Appendix P)); and

4. The vehicular access shall be designed to accommodate turning arcs for General Appliance Access (as prescribed within Policy No. 4: Guidelines for Emergency Vehicle Access); and

5. Maintain the perimeter vehicular access paths free of static storage and combustible materials at all times.

16.2.5 Storage and Handling of Dangerous Goods:

1. The client has not advised that any dangerous goods will be handled and situated within the development; and

2. As confirmed by Snackbrands (refer to Appendix S), a supply of full and empty 9kg gas bottles will be required for running gas forklifts. The gas bottles will be stored in Australian Standard gas bottle cages located external to the building under the awning. Snackbrands have confirmed the following number of gas bottles to be located on site at any one time as follows:

   a. 20 x 9kg full bottles; and

   b. 10 x 9kg full bottles

3. Further to the previous and with regards to the nature/quantity of materials stored within the subject building, the application of Clauses E1.10 and E2.3 have been deemed not to apply for this project (refer also to Appendix O for further details) and hence, there is specific requirement for any additional provisions to further assist with firefighting purposes over and above those forming part of the detailed trial design. This matter has also been confirmed by the PCA (refer to Appendix O) and the correspondence from Snackbrands confirming the nil storage of Dangerous Goods (refer to Appendix S); and

4. Should the storage and handling of dangerous goods be proposed at any point into the future, this fire engineering documentation would be required to be re-assessed by a competent fire safety engineer.

16.2.6 High Bay Area:

1. Further to the FEBQ comments, it is acknowledged by the design/certification team and the end user that an Emergency Management Procedure (EMP) has been documented and provided within the Fire Safety Engineering Report (FSER) (or as part of the Clause 144 submission) detailing the following (refer to Appendix P for details):

   a. How the high bay area is to function (on a day-to-day basis) and furthermore, the procedures for occupant access/restricted access to the high bay areas during these times; and

   b. Process/procedures during scheduled maintenance periods within the high bay area; and

c. High bay area shut down procedures whilst trained occupants are located with the ASRS/high bay zone.
d. Power isolation procedures including the availability of trained persons assisting with isolating the power in the event that the FRNSW arrive and are required to intervene and undertake firefighting operations.

Moving forward & to support the FSER/EMP, the normal operational & maintenance procedures shall be documented and subsequently implemented in the high bay area and shall be made available as part of the Clause 144 submission. For the purposes of the subject FEBQ submission, the following brief summary has been confirmed by Snackbrands:

e. The high bay area is to be isolated from the low bay areas by either full height fence or pedestrian fence and not accessible to any personnel under normal operating circumstances.
f. The high bay area will only be accessible by suitably trained maintenance personnel (i.e. machine shutdowns, power isolations etc.).
g. In case of an emergency, at least one (1) trained personnel per shift (i.e. Snackbrands employee) on site will be available to support FRNSW intervention including the non-business hours.
h. Snackbrands have advised that a maintenance schedule shall include the following activities:
    i. Preventative Maintenance Activity …. (Weekly)
    ii. Emergency Maintenance … only in the event of a breakdown/malfunction
    iii. Operational maintenance … trouble with products etc (pending quality of products …may be daily).

16.2.7 Management in Use Requirements:

1. Maintain paths of travel to an egress, stair entrances, pedestrian doorways and thoroughfares free of static storage and combustible materials at all times; and
2. Smoking shall not be permitted within the building; and
3. All fire safety measures and Management in Use requirements shall be incorporated into an Essential Services list. All fire safety measures shall be maintained in accordance with the requirements of AS1851 (or equivalent maintenance standard) as identified by Scientific Fire Services. Management in Use requirements shall be inspected and logged on an annual basis; and
4. Snackbrands Australia has confirmed that the future expansion area located within the high bay will not be used for storage or any other operational activities, refer to Appendix H for details; and
5. The recommendations forming part of the performance solution shall be identified as part of the Fire Safety Schedule for the subject premises and is to form part of the building's Essential Safety/Services List. Furthermore, the following notes shall be added to the Fire Safety Schedule for the subject building:
    a. In the event that Altis Property Partners sell the adjacent vacant property to Snackbrands. A reassessment will need to be undertaken to re-address the perimeter vehicular access provisions including any openings located within 3m from the title/leasing boundary for both building(s);
    b. Further to the previous, if the subject proposed building and the future building are to be owner operated by Snackbrands Australia, the entire development shall be treated as a united building whereby future egress door may be introduced between the subject proposed building and the future building which can be designed to be treated as horizontal exits if required

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Appendix A. Architectural Drawings

Table A.1: Architectural drawings relied upon

Drawing Number	Drawing Name	Date	Revision
Architectural Drawings			
10736_101	Site Plan	10/05/2019	B
10736_111	Ground Floor Plan	17/05/2019	C
10736_112	High Bay Racking Layout Plan	12/12/2018	P4
10736_113	Roof Plan	12/12/2018	P4
10736_201	Building Elevation – Sheet 1	12/12/2018	P5
10736_202	Building Elevation – Sheet 2	12/12/2018	P5
10736_301	Building Sections	12/12/2018	P4
1175001-M-OLN-1000	Plan View Snack Brands Sydney	17/08/2018	A1
Fire Sprinkler			
FF-FS-300	High Bay in-Rack Fire Sprinklers Plan Layout	14/12/2018	A
FF-FS-301	High Bay in-Rack Fire Sprinklers Section Layout	14/12/2018	A
FF-FS-600	Warehouse Fire Extinguisher Layout	09/04/2019	A
Electrical Services			
E-001	Site Plan and Conduits	15/03/2019	P7
E-500	Single Line Diagram MSB	04/04/2019	P5
Hydraulic Services			
218070-H02	Ground Floor Plan	21/02/2019	C
Mechanical Services			
M01	High Bay and Low Bay Warehouse Roof Plan	05/02/2019	D

Appendix B. Detailed Hazard Analysis

B.1 Introduction

Consistent with the IFEG (2005) an analysis of hazards is undertaken. Fire hazard, as defined in the NCC, is the potential harm and degree of exposure of occupants to fire starts, and the spread of fire, smoke and gases generated.

Hazards are probabilistic – they cannot be eliminated and they do not mean that adverse consequences will occur. Bennetts et al (2000) explain that the purpose of hazard analysis is to identify design fires of greatest risk (which is the product of probability and consequence) as well as characteristics of buildings and occupants that increase or decrease this risk – that is risk from harm and exposure to fire. All fire safety systems should be evaluated for the same fires. The hazard analysis is central to all issues to be evaluated. Generally, there are not only characteristics of buildings and occupants that increase hazards but also characteristics that reduce hazards and help to ensure performance. Such characteristics are also identified in this section.

This section presents hazards and design fires that must be consistently addressed by all fire safety systems. It is inappropriate to have complementary subsystems designed for different fires. The subject building will contain fire hazards associated with the following classifications;

- Class 5 – Office
- Class 7b – Warehouse

B.2 Class 5 – Office

The subject building includes two office tenancies for general office purposes. Therefore, the primary use of this portion of the building is most similar to a Class 5 office with regards to fire hazard. As such the general level of hazard in office tenancies are considered appropriate. Office hazards are generally low – approximately one tenth when compared to residential occupancies. Refer to Figure B.1 and Figure B.2.

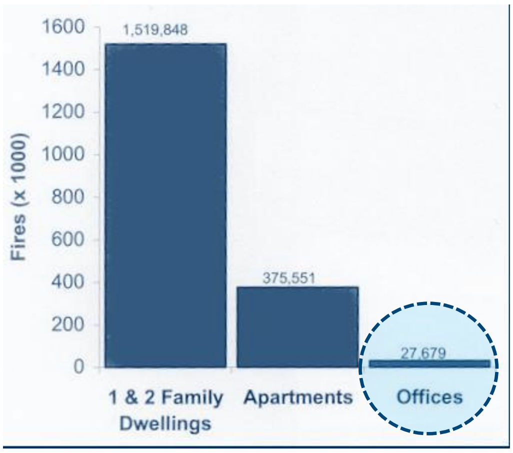

Figure B.1: Number of fires in different occupancies compared with Commercial buildings. (Bennetts and Thomas, 2000)

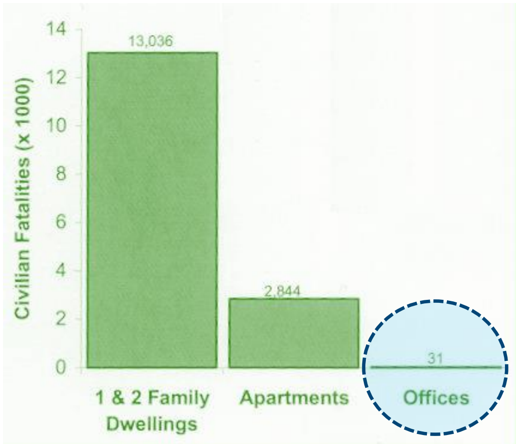

Figure B.2: Civilian fatalities in different occupancies compared with Commercial buildings. (Bennetts and Thomas, 2000)

Available data summarised in Table B.1 to Table B.3 (NFIRS 1991, Bennetts et-al 2000) indicate that the principal sources of fire ignition in Commercial type occupancies are associated with arson, cutting and welding, electrical distribution systems, in particular wiring and Commercial business equipment. However, the fatalities associated with this type of ignition source are very small.

The majority of the fatalities result from incendiary fires (and often involve liquid fuels). From the statistics (Bennetts et-al 2000), two thirds of all fires occur during normal working hours. The majority of the fires, which occur during working hours, are typically small and are confined to the object of fire origin.

There are actually fewer severe fires during normal working hours. This is because having people in the building is a very effective fire safety system since the presence of occupants almost ensures that a fire start will be noticed and dealt with before it gets large. As for fires which occur outside normal working hours when the building is likely to have fewer or no occupants, these fires may develop into fully developed fires. It was reported in Bennetts et-al (2000) that 70% of the fires during normal working hours are confined to the object or area of fire origin. The corresponding number during non-working hours is 48%. Also, the percentages of detectors operated are lower during normal working hours.

This demonstrated that the presence of occupants is the main factor in controlling the fire growth and that most of these fires are dealt with when they are small.

Table B.1: Ignition factors for office fires (Bennetts and Thomas, 2000)

Ignition Factor	Percentage of Ignitions	Percentage of Fatalities
Short circuit, other electrical failure, part failure leak	33 %	4 %
Arson & suspicious	22 %	10%
Abandoned material	11.5%	–
Combustibles close to heat source	7 %	2 %
Cutting, welding, misuse of heat of ignition	7 %	2.5%

Table B.2: Types of material causing ignition in Office fires (Bennetts and Thomas, 2000)

Type of Material Ignited	Percentage of Ignitions
Paper	20 %
Plastic	15%
Wood	20 %
Cardboard	6 %
PVC	4 %

Table B.3: Forms of material causing ignition in Office fires (Bennetts and Thomas, 2000)

Form of Material Ignited	Percentage of Ignitions
Electrical wiring	21 %
Rubbish	14 %
Sidewall and roof covering	6 %
Timber framing	6 %
Interior wall floor and ceiling coverings	6 %
Magazines	5%

The fuel loads typically expected within commercial office buildings are similar to the following items:

- Workstations
- Furniture – mostly timber and some plastic items
- Soft furnishings
- Paper documents

B.3 Class 7b – Warehouse

B.3.1 General

Large storage/ warehouse occupancies are those that involve the storage of wide variety of merchandise and materials. The occupants usually comprise the permanent staff working at the facility and occasionally transient persons involved in delivery of goods or services.

Compared to other occupancies the fire protection and life safety issues may be less complex in warehouses. However, due to significantly large volumes of fuel presence special attention is required.

Fire challenges in warehouse occupancies may arise from:

- Very large volumes diverse fuel content;
- High rack storage;
- Presence of multiple ignition sources such as electrical systems or forklifts or even in some cases delivery vehicles.

Typical combustible warehouse fuel loads may include flammable and combustible liquids, hazardous materials, plastic, aerosols and many other high-hazard commodities displayed in various solid piled, shelving and racking arrangements. Inherently, warehouse occupancies are demand-driven and require flexibility to adapt to changing market conditions and storage requirements. Hence, the hazard types and magnitudes may vary.

B.3.2 Fire Related Hazards

In order to identify the most appropriate fire scenarios and design fires in warehouse and storage occupancies a comprehensive hazard analysis is required. Such an analysis consistent with the IFEG (2005) has been conducted and is presented in the following sections of this appendix. The analysis approaches the key hazard and risk areas under three main headings:

1. Fire
2. Building
3. People

The statistical data presented as part of the hazard analysis are obtained from sources that are most recent and also most relevant to Australian warehouse occupancies. Where Australian data was not available, data from countries with similar socio-economic characteristics such as USA and UK were relied up on. The statistics provided and compared for different countries may not cover exactly the same periods but are still considered to be highly compatible from a chronological perspective. Any significant discrepancy between statistical data is presumed to originate from the different methods of occupancy classification and grouping and corresponding data collection adopted by each country.

There is good correlation between fire statistics within several countries that support the conclusion that fire fatalities in warehouse buildings are significantly less than residential buildings and other high hazard buildings. However, the stock and property damage can be extensive and firefighting conditions may be highly hazardous.

It should be noted this particular appendix concentrates on the “storage” components of a warehouse. Other areas of warehouses which comprise different classifications such as offices will be addressed separately when required.

B.3.2.1 Fire Starts and Consequences

Storage occupancies constitute approximately 8% of all fires in Australia according to data collected by fire brigades across Australia. (Refer to Figure B.3) In UK 2-3% and in the USA 4% of all fires are identified as being storage facility fires Figure B.4 and Figure B.5.

The discrepancy is presumed to originate from the different methods of occupancy classification and grouping and corresponding data collection adopted by each country. During 2005-2009, an estimated 1,310 warehouse structure fires were reported to U.S. fire departments each year, with associated losses of 2 civilian deaths, 22 civilian injuries and $162 million in property damage.

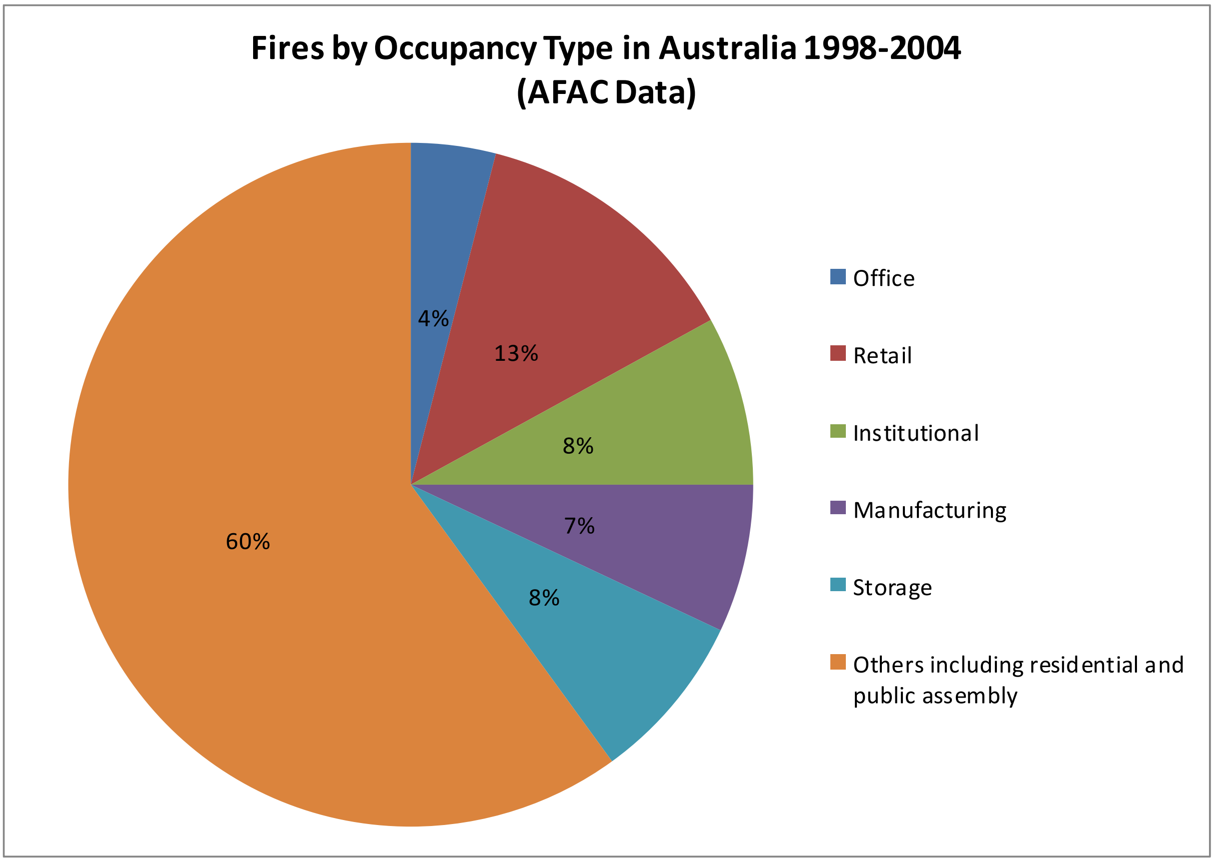

Figure B.3: (Source: Arup, 2008)

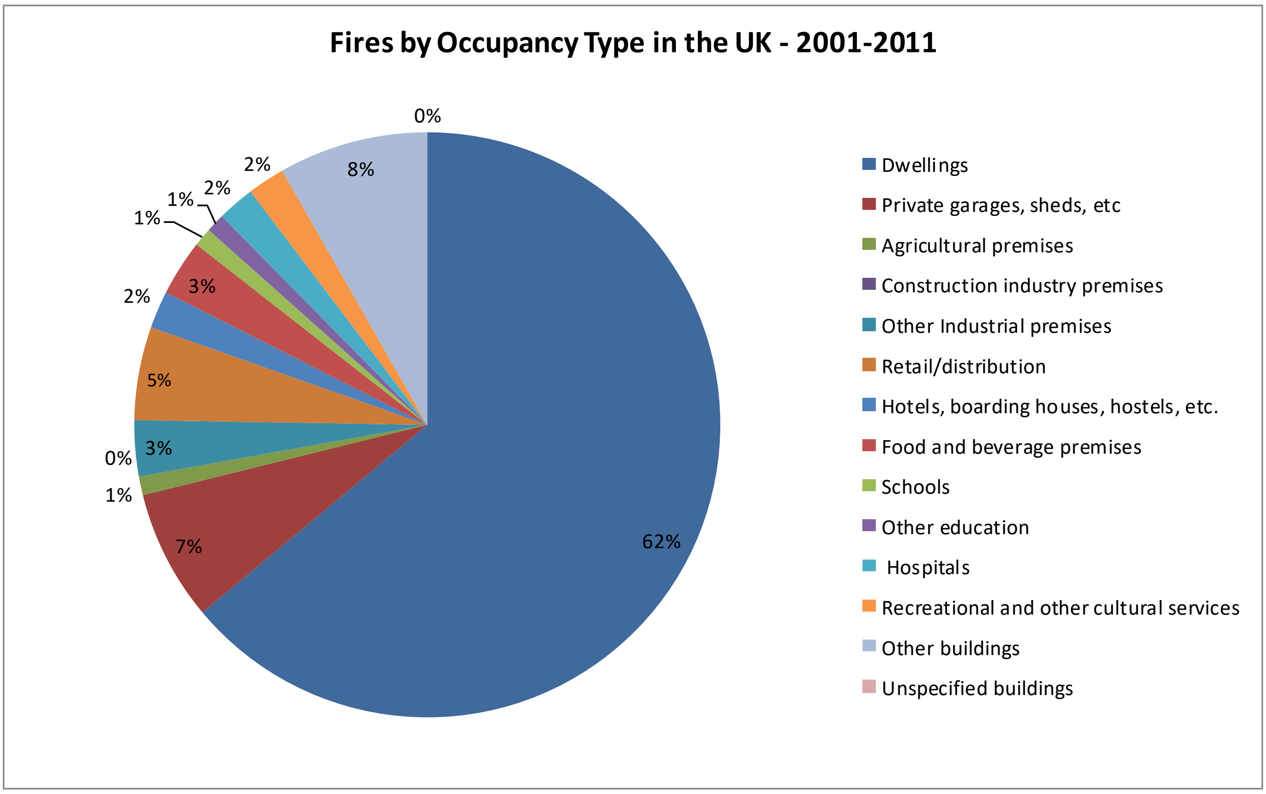

Figure B.4: (Source: CLG, 2011)

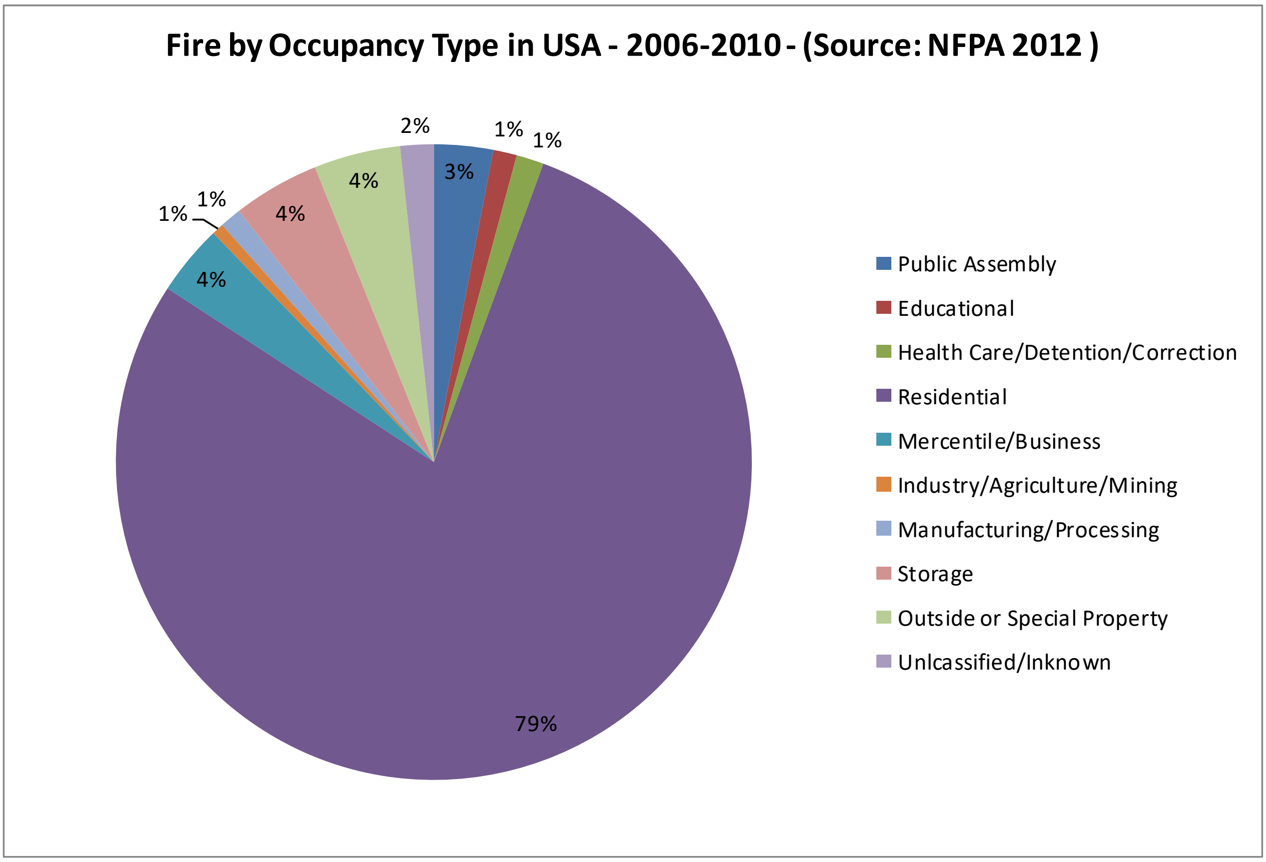

Figure B.5: (Source: NFPA, 2011)

As could be expected, a clear majority of fires in warehouse properties start in storage areas. This is a common occurrence for storage facility fires both in Australia and USA Figure B.6 and Figure B.7. The US data showed that the leading area of origin for these fires was an unclassified storage area (12% of fires), followed by shipping, receiving, or loading areas (7%) and a storage room, area, tank, or bin (5%) (See Figure B.7).

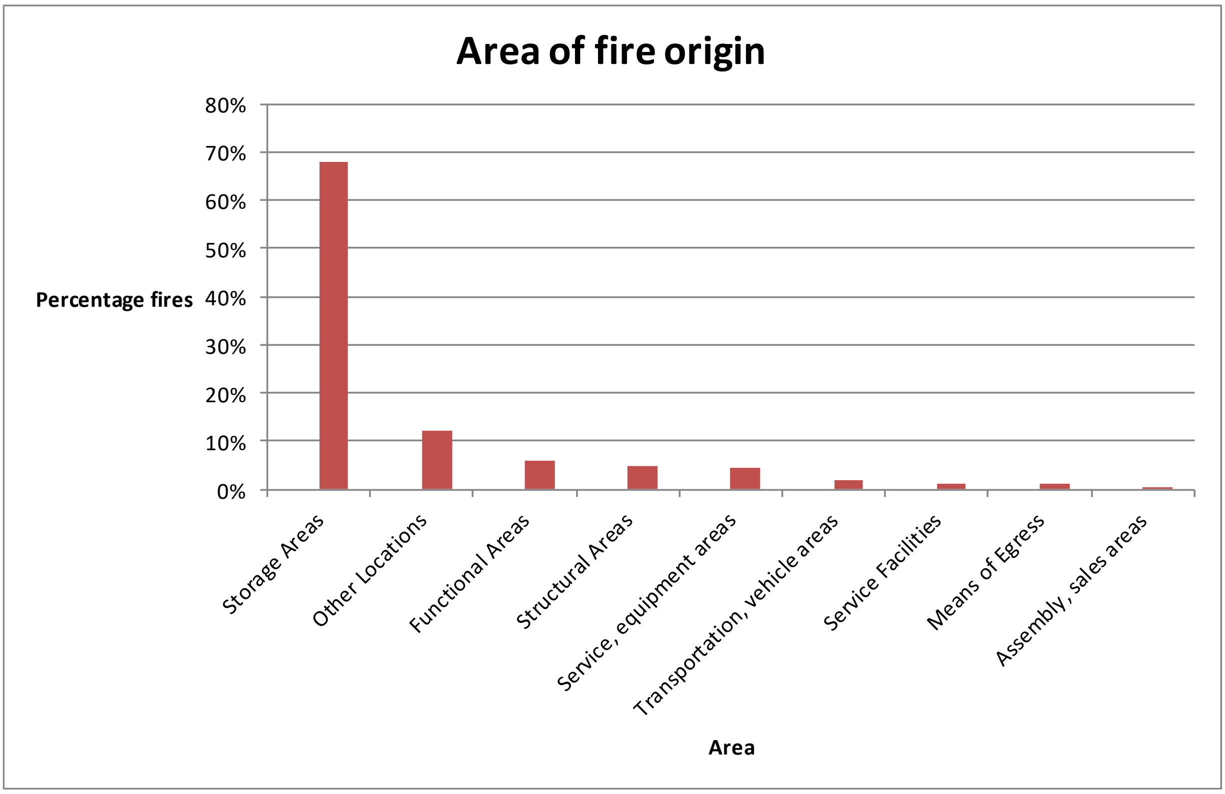

Figure B.6: Warehouse fires by location (Australia)

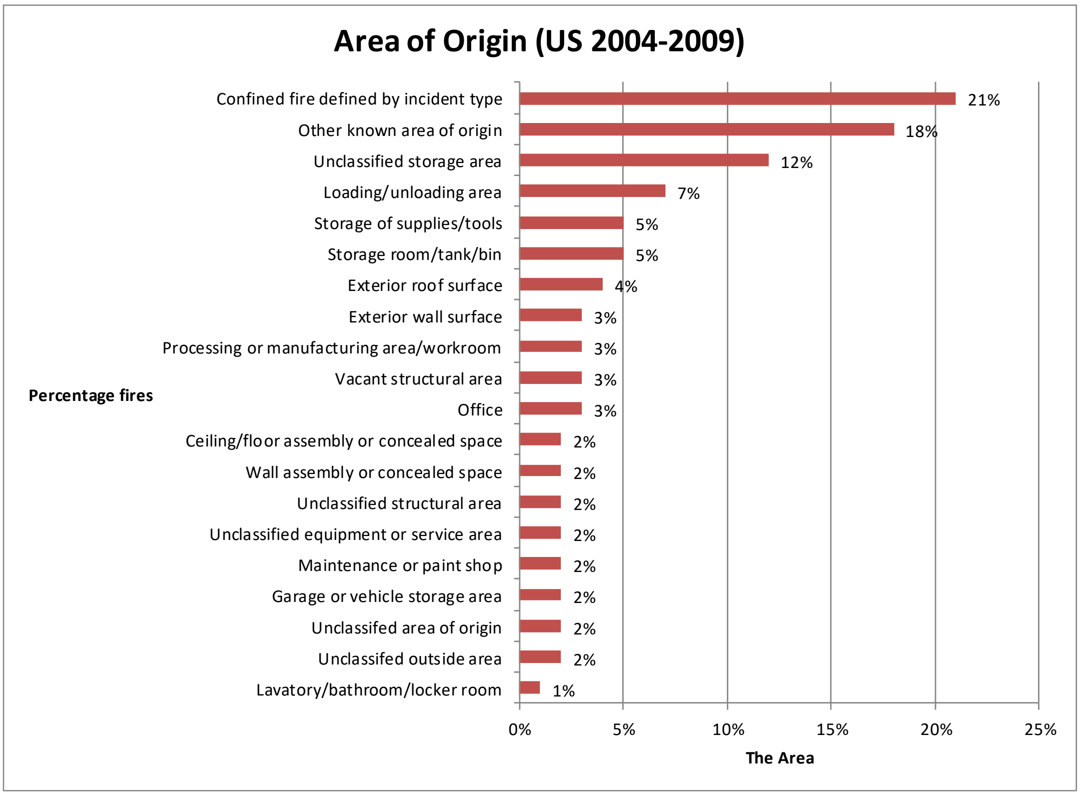

Figure B.7: Warehouse fires by location

B.3.2.2 Ignition Factors

Ignition factors are a significant component of fire hazards. 71% of the 5,144 storage property fires reported in Australia were included in the assessment of the ignition factors as which is depicted in Figure B.8. A major part of the ignition factors in storage property fires has been classified as ‘other’. However, it is shown that more than 25% of the fires were regarded as incendiary and suspicious. It was also noted that:

- 62% of the ignition factor category ‘Abandoned, discarded material’ was directly related to smoker’s material such as cigarettes, cigars and pipes.

- 66% of the ignition factor category 'Mechanical failure, malfunction' was directly related to short circuits or other electrical failures.

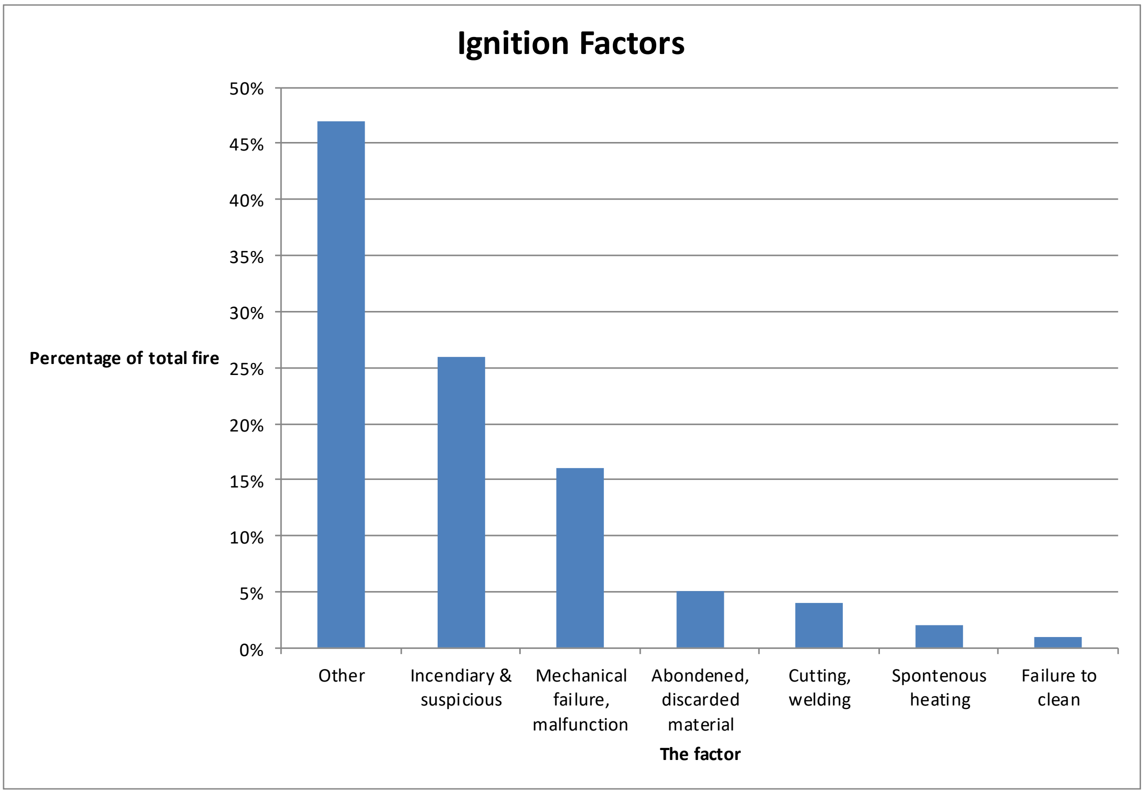

Figure B.8: Storage ignition factors (Australia)

Electrical failures also appear as a highly common ignition factor in US storage facility fires. Electrical failure or malfunction was the leading factor contributing to ignition (18% of fires), and these fires were responsible for 35% of the associated property damage in warehouses. A heat source too close to combustibles, or cutting or welding too close to combustibles were each factors in 8% of fires in warehouses (Evarts, 2012).

Fires in these properties are more common on weekdays and during the day, during normal business hours. Nearly one-in-five of these fires in US (18%, included under the "other" heading) are believed to be started intentionally. This is in line with the Australian data of 26%. As an ignition source arcing was the most common heat source (13% of fires) followed by a spark, ember, or flame from operating equipment (9%).

B.3.2.3 Ignition Sources

Nearly one-third of the US fires (31%) didn't involve any kind of equipment in the ignition of the fire, 12% involved electrical distribution or lighting equipment, and 9% involved heating equipment. 15% were due to the failure of equipment or heat source. Arcing was the leading heat source in these fires, accounting for 13% of incidents. A spark, ember, or flame from operating equipment was the heat source in 9% of fires and 18% of property damage (Evarts, 2012).

From the available data (I R Thomas 2001), the principal sources of ignition in factory/warehouse buildings are incendiary and suspicious. These two categories contributed to more than one third of the civilian fatalities for fires of known ignition factor. Other factors included electrical faults or failures (e.g. short circuit) and welding and cutting, which contributed to slightly more than 20% of the civilian fatalities for fires of known ignition factor.

From the same statistics on fires by time of day for warehouse, fire occurrence peaked at 3-5pm. The distribution of flashover fires, flaming fires and smouldering (local) fires for warehouse are 54%, 26% and 20%, respectively. Also, the occurrence of all these fires peaked at 3-5pm. The reason for this time is not clear from the statistics other than that the warehouse can be assumed to be operational during this period.

From the ten years statistics of fires in Factory/Warehouse without sprinklers (1 am to 4 am), there are a total of 5526 fires which resulted in 5 civilian fatalities, and no fire fighter fatalities. Also, 99.9% of fires reported to fire brigade resulted in no fatalities. Smoking bans within the facility are presumed to apply but would need to be policed in all areas of the facility.

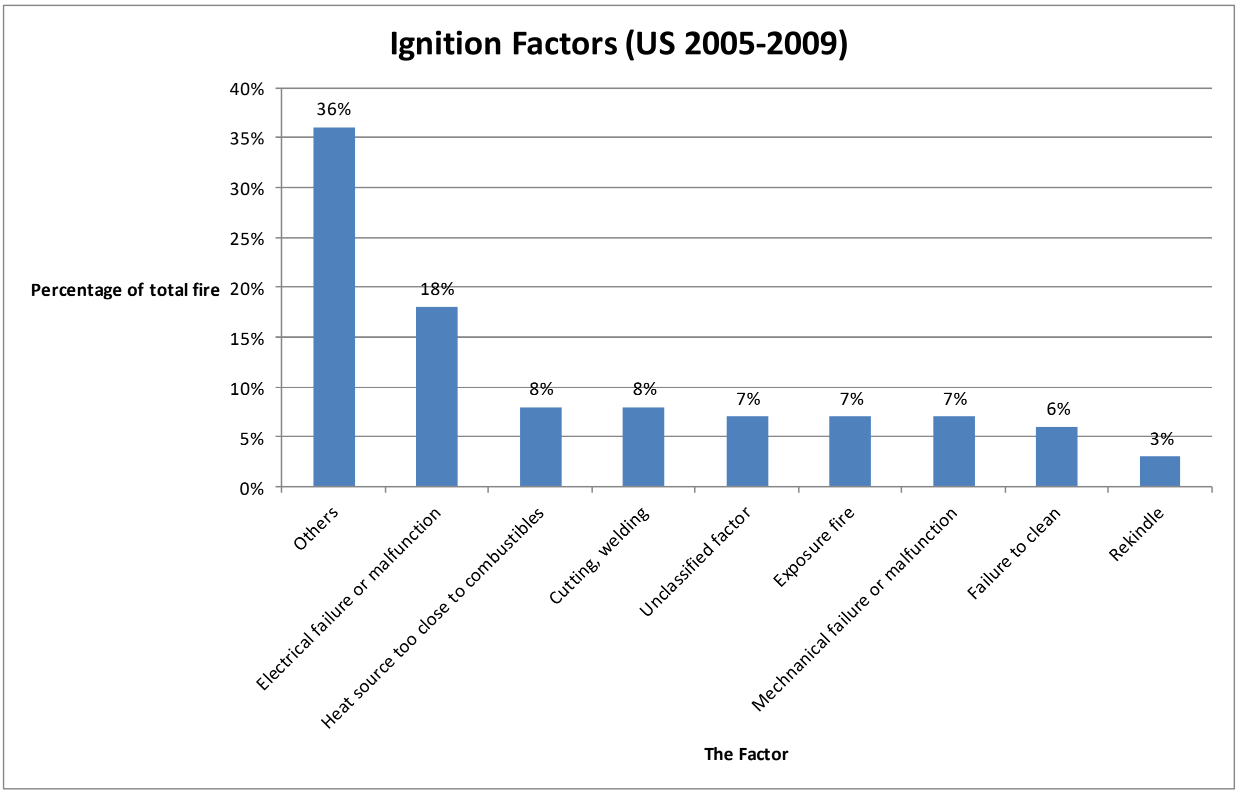

Figure B.9: Storage ignition factors (US)

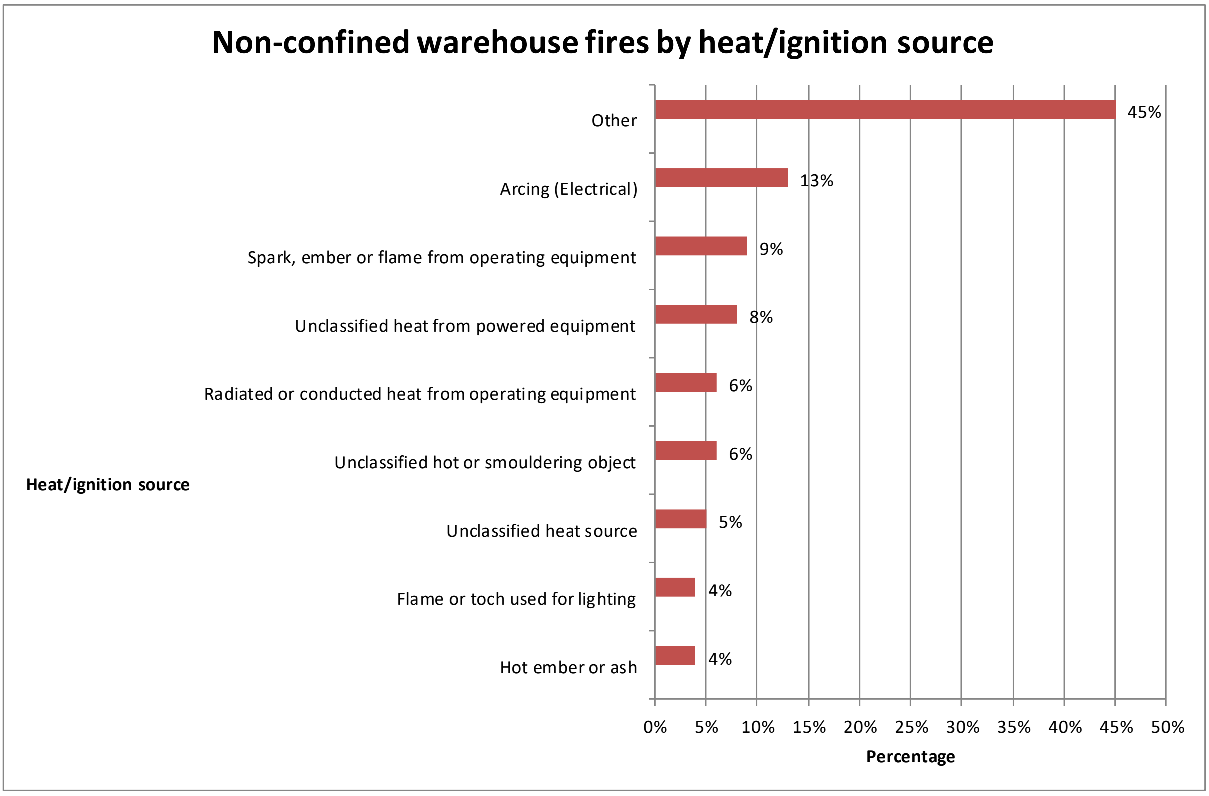

Figure B.10: Warehouse fires by ignition source

It must be noted that in the context of the ‘cross-dock’ logistics warehouse, the ignition source statistics may need to be adjusted based on the fact that smoking is not allowed and strictly controlled. Also, it is not expected that hot works would not be carried out during operational hours. Based on these observations the most likely sources of ignition in a distribution warehouse haven been identified as:

- Electrical malfunction
- Mechanical failure or malfunction
- Spark or ember from operating equipment

B.3.2.4 Fire Spread and Impact of Sprinklers

More than two-thirds (68%) of structure fires in warehouses are confined to the floor of origin. In his May 2011 report, "U.S. Experience with Sprinklers", John Hall provides analysis specific to warehouse properties. In warehouse properties (excluding cold storage), Sprinklers were present in 35% of reported structure fires. Most systems (82%) were wet pipe sprinklers, and 17% were dry pipe sprinklers.

In most cases, sprinklers operate and operate effectively. When wet pipe sprinklers were present, and the fire was large enough to activate the equipment, sprinklers operated 88% of the time, and were effective 97% of the time (making a combined effectiveness rating of 85%). When sprinklers (any kind, not just wet pipe) were said to have failed to operate in storage properties (the numbers for warehouses specifically were too small to perform the necessary analysis), 84% of the time, the reason was that the system had been shut off. In the (3%) of cases where sprinklers operated but were ineffective, 40% of the time, water did not reach the fire.

When no automatic extinguishing equipment was present, 52% of warehouse fires were confined to the room of origin, but when sprinklers were present, 80% were confined to the room of origin. Property damage per fire was 38% lower on average, in incidents where wet pipe sprinklers were present, versus those without automatic extinguishing equipment.

B.3.2.5 Hazards related to Materials on Site

Based on US data, sawn wood, including all finished lumber was the most common type of material first ignited (12% of fires), followed by plastic (9%) (See Figure B.11).

Figure B.11: Fires related to materials on site

B.3.2.6 Impact of the Warehouse Size on the Fire

There is a relation between the storage facility size and the number of fires. Estimated number of fires occurring in different building sizes, over a five-year period for UK is provided in Table B.4 - 1994-1998 (UK Data)

Table B.4: Number of fires occurring in different warehouse building sizes

Size Category (m2)	Size Range (m2)	Number of fires in 1994-1998	Estimated number of fires per 1000 buildings per year
100	56-178	438	59±20
300	178-560	282	10±3
1000	560-1780	205	6±2

Size Category (m2)	Size Range (m2)	Number of fires in 1994-1998	Estimated number of fires per 1000 buildings per year
3000	1780-5600	96	6±2
10000	5600-17800	42	10±5
30000	17800-56000	10	16±15
100000	56000-178000	7	90±192

The data shows that the likelihood of fire reduces as the size of the warehouse increases. This is expected to be a consequence of more sophisticated systems and management measures being adopted in larger warehouses.

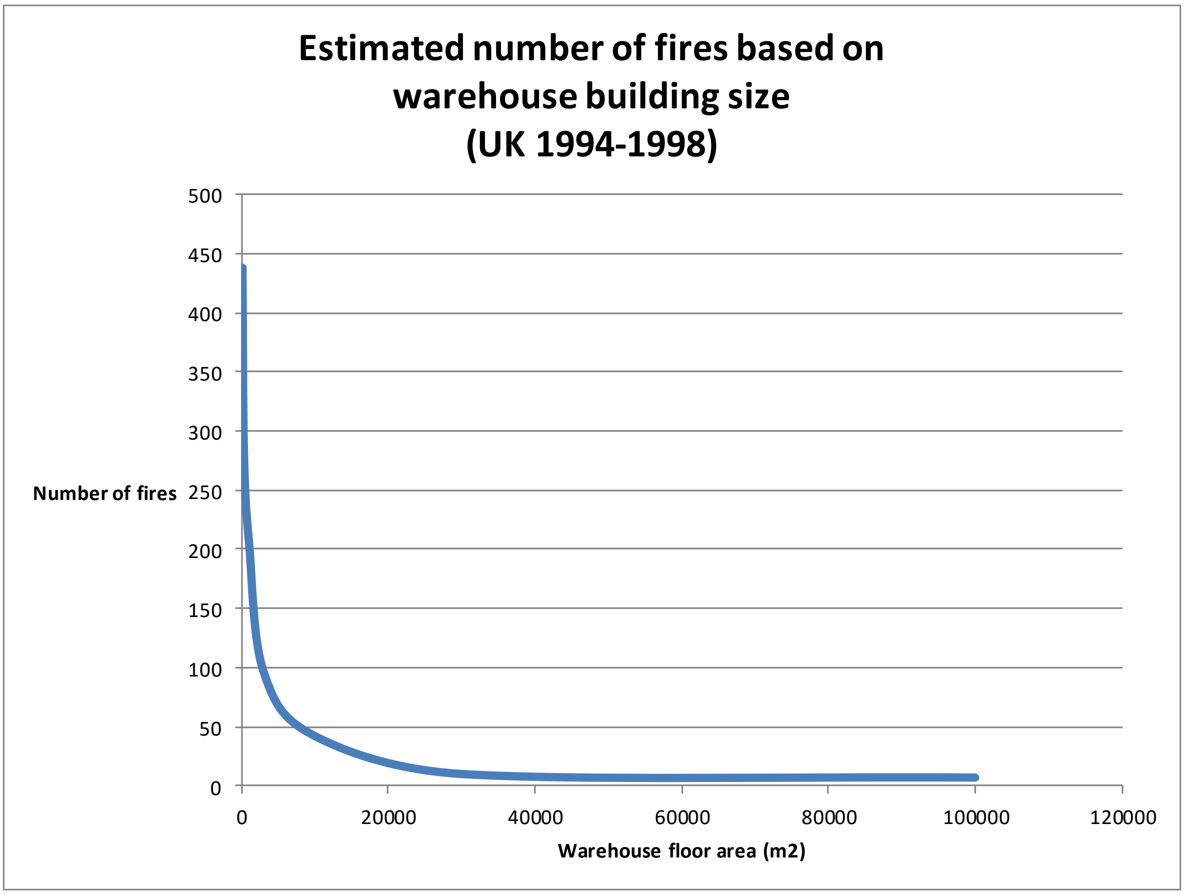

Figure B.12: Estimated number of fires occurring in different warehouse building sizes

The following table (Refer to Table B.5) provides the relationship between the warehouse size and the extent of damage from a fire.

Table B.5: Average area damaged (all causes) per fire, as a function of warehouse size (UK Data)

Size Category (m2)	Size Range (m2)	Area of Fire Damage (m2)	Area of Total Damage (m2)
100	56-178	22±5	77±15
300	178-560	88±21	261±63
1000	560-1780	318±90	807±227
3000	1780-5600	1361±558	2883±1179
10000	5600-17800	2779±1723	7229±4460
30000	17800-56000	2977±3741	19003±23710
100000	56000-178000	44981±70509	55987±87645

B.3.2.7 Combustible Fuel Loads and Distribution

The behaviour of fire with respect to growth and development is a function of the fuel load density and distribution along with the ventilation conditions.

Fuel loads vary significantly for different type of warehouses. The Fire Code Reform Centre research into fire safety of shopping centres has indicated that the combustible content of warehouses in shopping centres can vary from quite low

(Refer to Figure B.13). Swiss data, reported in the IFEG (ABCB, 2005), suggests that the fuel load in manufacturing and storage is likely to be in the range of 1180 MJ/m^2, which equates approximately to 150 kg/m^2 wood equivalent fuel load. provides a summary of fuel loads for different types of storage facilities (IFEG, 2005).

The fire load within a warehouse, however, is not necessarily a reflection of how a fire will develop and spread. For example, a carpet storage facility would have a high fire load, consisting of rolls of carpet, but igniting the carpet could be very difficult because of the density of the material in roll form as well as a low rate of spread due to its storage method. Another storage facility, with a lesser fire load, may be more susceptible to fire ignition, rapid fire growth and spread due to the nature and configuration of the fuel load.

Figure B.13: Photograph of a typical storage rack and combustible materials within a warehouse facility

The following table (Refer to Table B.6) highlights various types of occupancies and estimated fuel loads.

Table B.6: Fuel loads for storage facilities

Type of occupancies	Fabrication [MJ/m^2]	Storage [MJ/m^2/m]	Type of occupancies	Fabrication [MJ/m^2]	Storage [MJ/m^2/m]
Accumulator mfg	400	800	Cordage plant	300	600
Adhesive mfg	1000	3400	Cordage store	500	
Animal food preparing, mfg	2000	3300	Cork products mfg	500	800
Artificial flower mfg	300	200	Cosmetic mfg	300	500
Artificial leather mfg	1000	1700	Decoration studio	1200	2000
Artificial silk mfg	300	1100	Door mfg, wood	800	1800
Barrel mfg, wood	1000	800	Dry-cell battery	400	600
Basket ware mfg	300	200	Edible fat mfg	1000	18900
Bed sheeting production	500	1000	Fertiliser mfg	200	200
Bicycle assembly	200	400	Fireworks mfg	special	2000
Bitumen preparation	800	3400	Floor covering mfg	500	6000
Blind mfg, venetian	800	300	Foamed plastics fabrication	3000	2500
Box mfg	1000	600	Foamed plastics processing	600	800

Type of occupancies	Fabrication [MJ/m²]	Storage [MJ/m²/m]	Type of occupancies	Fabrication [MJ/m²]	Storage [MJ/m²/m]
Broom mfg	700	400	Hosiery mfg	300	1000
Brush mfg	700	800	Household appliances, mfg	300	200
Butter mfg	700	4000	Jewellery shop	300	1300
Cable mfg	300	600	Jute, weaving	400	1300
Candle mfg	1300	22400	Lacquer mfg	500	2500
Candy mfg	400	1500	Library	2000	2000
Cane products mfg	400	200	Lingerie mfg	400	800
Cardboard box mfg	800	2500	Liqueur mfg	400	800
Cardboard mfg	300	4200	Match plant	300	800
Cardboard products mfg	800	2500	Milk, condensed, evaporated mfg	200	9000
Carpet mfg	600	1700	Milk, powdered, mfg	200	10500
Cast iron foundry	400	800	Nitrocellulose mfg	Special	1100
Celluloid mfg	800	3400	Oilcloth mfg	700	1300
Chemical plants (rough average)	300	100	Oilcloth processing	700	2100
Shoe polish mfg	800	2100	Optical instrument mfg	200	200
Ski mfg	400	1700	Packing material, industry	1600	3000
Soap mfg	200	4200	Paper mfg	200	10000
Synthetic resin mfg	3400	4200	Paper processing	800	1100
Telephone apparatus mfg	400	200	Parking building	200	
Tyre mfg	700	1800	Parquetry mfg	2000	1200
Tobacco products mfg	200	2100	Perambulator mfg	300	800
Umbrella mfg.	300	400	Pharmaceutical's, packing	300	800
Vegetable, dehydrating	1000	400	Pharmaceutical mfg	300	800
Veneering	500	2900	Plastic mfg	2000	5900
Veneer mfg	800	4200	Plywood mfg	800	2900
Vinegar mfg	80	100	Printing, ink mfg	700	3000
Waffle mfg	300	1700	Refrigerator mfg	1000	300
Washing agent mfg	300	200	Rubber goods mfg	600	5000
Washing machine mfg	300	40	Rubber processing	600	5000
Watch assembling	300	40	Salad oil mfg	1000	18,900

B.3.2.8 People Related Hazards – Warehouse Staff

The occupant related hazards in warehouse and storage facilities can be approached from two perspectives:

1. Occupant densities
2. Occupant behaviour

Occupant numbers in warehouse buildings are generally expected to be very low. National Construction Code prescribes the unit area per person for storage facilities as 30 m². This is a highly unrealistic criterion for large warehouses. In a 20,000m² warehouse, based on the NCC criteria, the total number of occupants would exceed 660. In reality, the numbers are more likely to be less than 50. Many modern large warehouses have automated systems which would reduce the population even further (see Figure B.14)

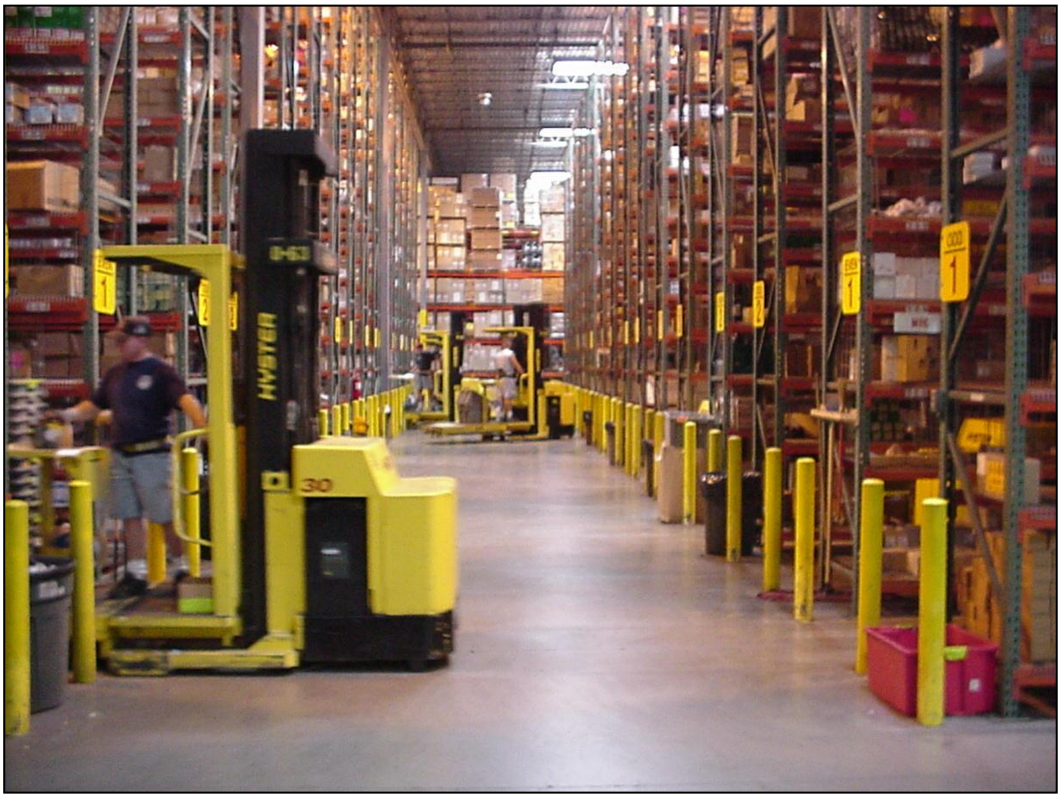

Figure B.14: Warehouse Occupants (Indicative picture only)

In relation to occupant behaviour, warehouses are strictly controlled work environments where occupational health and safety and workplace safety plays a key role in daily operations. In the event of a fire the permanent staff would be trained on how to behave. The behaviour of transient persons (i.e. truck and or delivery drivers) would be dictated and controlled by permanent staff accompanying them.

From a people related hazards perspective warehouses are considered to be low hazard occupancies.

B.3.2.9 Building Related Hazards

The problem with large warehouses is that they are mostly very large. While the general warehouse building layout can be relatively simple, the presence of racking and the complexity of some racking layouts can introduce hazards mostly in relation to way finding.

The large floor areas and high ceilings in warehouses result in presence of a large smoke reservoir at high level. In the event of fires for extended periods of time smoke related untenable conditions are avoided. Even in warehouses without any specific smoke control system, the presence of multiple roller shutter doors with heights mostly exceeding 3 metres results in effective smoke venting and creation of steady state conditions where smoke layer is permanently maintained at levels sufficiently above the evacuating occupants.

B.3.2.10 Recent Australian fire incidents

The following recent (2012) warehouse fire incidents are obtained from various Australian state and territory fire brigade web sites and confirm the likelihood of different ignition types discussed within this hazard analysis. Most fires in the list were a consequence of electrical faults or suspicious/mischievous behaviour.

- Laverton North (VIC) Paper recycling warehouse fire: ignition cause yet to be determined.
- Northmead (NSW): Warehouse fire: ignition cause yet to be determined.
- Acacia Ridge (QLD): Warehouse fire: suspicious fire start
- Dandenong South (VIC): Warehouse fire: electrical fault fire start
- Canterbury (NSW): Furniture warehouse fire: electrical fault fire start
- Latrobe (TAS): Warehouse fire: ignition cause yet to be determined
- Collingwood (VIC): Warehouse fire: suspicious fire start

B.3.3 Conclusions

Storage occupancies constitute approximately 8% of all fires in Australia according to data collected by fire brigades across Australia. In UK 2-3% and in the USA 4% of all fires are identified as being storage facility fires. The discrepancy is presumed to originate from the different methods of occupancy classification and grouping and corresponding data collection adopted by each country.

During 2005-2009, an estimated 1,310 warehouse structure fires were reported to U.S. fire departments each year, with associated losses of 2 civilian deaths, 22 civilian injuries and $162 million in property damage.

For warehouse fires in Australia and USA latest statistical data identify “incendiary and suspicious” and “Electrical / mechanical” as the most common ignition factors.

The fuel load distributions in warehouses are not uniform. There may be a number of warehouses or areas within individual warehouses with relatively high fuel load densities.

Most large warehouses are provided with sprinkler suppression systems and most of the time sprinkler systems are adopted. In most cases, sprinklers operate and operate effectively. When wet pipe sprinklers were present, and the fire was large enough to activate the equipment, sprinklers operated 88% of the time, and were effective 97% of the time (making a combined effectiveness rating of 85%). In relation to building occupants the key issues will be to establish realistic occupant behaviour based on the location of people with respect to the fire. The occupant number adopted should be based on observations and not the code prescribed numbers and hazards in relation to overcrowding should be addressed as a management issue as part of the assessment

The information presented in this hazard analysis appendix will provide a highly verified basis for the development of fire scenarios and design fires.

B.3.4 References

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Appendix C. Sprinkler System Reliability & Effectiveness

C.1 Reliability and Effectiveness

Automatic sprinklers are highly effective elements of total system designs for fire protection in buildings. They save lives and property, producing large reductions in the number of deaths per thousand fires, in average direct property damage per fire, and especially in the likelihood of a fire with large loss of life or large property loss. When sprinklers are present in the fire area, they operate in 93% of all reported structure fires large enough to activate sprinklers, excluding buildings under construction. When they operate, they are effective 97% of the time, resulting in a combined performance of operating effectively in 91% of reported fires where sprinklers were present in the fire area and fire was large enough to activate sprinklers. In homes (including apartments), wet-pipe sprinklers operated effectively 96% of the time (Hall, 2010).

Whether with a performance design or with a prescriptive code, the reliability of fire protection systems and features must be considered. Reliability includes both operational reliability and performance reliability. The operational reliability is a measure of the probability that a system or component will operate as intended when needed. The performance reliability is a measure of the adequacy of the system once it has operated (Koffell, 2005). For a sprinkler system, operational reliability accounts for the “readiness” of the system components, while performance reliability addresses the “capability” of the system to perform satisfactorily under specific fire exposures.

Table C.1: Historical data on operational reliability (Koffell, 2005)

Reference	Reliability of Success	Comments
Marryat[1]	99.5	Inspection, testing, and maintenance exceeded normal expectations and higher pressures
Maybee[2]	99.4	Inspection, testing, and maintenance exceeded normal expectations.
Powers[3]	98.8	Office buildings only in New York City
Powers[4]	98.4	Other than office buildings in New York City
Finucane et al[5]	96.9 – 97.9	
Milne[6]	96.6/97.6/89.2	
NFPA[7]	88.2 – 98.2	Data provided for individual occupancies – total for all occupancies was 96.2%.
Linder[8]	96	
Richardson[9]	96	
Miller[10]	95.8	
Powers[11]	95.8	Low rise buildings in New York City
US Navy[12]	95.7	1964 – 1977
Smith[13]	95	UK data
Miller[14]	94.8	
Budnick[15]	92.2/94.6/97.1	Values are lower in commercial uses (excludes institutional and residential)
Kook[16]	87.6	Limited data base
Ramachandran[17]	87	Increases to 94 percent if estimate number of fires not reported is included and based upon 33% of fires not reported to fire brigade
Factory Mutual[18]	86.1	1970 – 1977
Miller[19]	86	Commercial uses (excludes institutional and residential)
Oregon State Fire Marshal[20]	85.8	1970 – 1978
Taylor[21]	81.3	Limited data base

Reference	Reliability of Success	Comments

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Most automatic sprinkler systems are designed to control a fire but not necessarily to completely extinguish the fire. The NFPA fire data supports the concept that sprinkler systems can control fires but do not necessarily result in complete extinguishment. Table 2 indicates the percentage of fires where sprinklers are present and that are reported as being extinguished by a sprinkler system.

Table C.2: Sprinkler reliability and efficacy – US data (Hall, 2010)

Property	Percent where sprinklers operated (A)	Percent effective of those operated (B)	Percent where equipment operated effectively (AxB)
Residential homes and apartments	96%	100%	96%
Office / commercial	96%	99%	96%
Educational	75%	100%	75%
Heath care including Nursing home, hospital, clinic, doctor’s office, or development disability facility	90%	99%	89%
Large Retail / Department Store	95%	99%	94%
Warehouse and cold storage	85%	97%	93%
Hotel / Motel	88%	99%	87%
All public assembly	97%	97%	94%

For all occupancy classifications, when they operate, the effectiveness of the sprinkler systems is significantly high (97% to 100%). Operational probabilities vary in US data but for majority of classifications remain above 90%. The efficacy values show a similar trend.

C.1.1 Failures that may be Attributed to the Sprinkler Systems

Several of the causes of failure are attributable to the human factor. This leads to a discussion about which causes of failure that really should be attributed to the sprinkler system. Component failure, although it can be deduced to man, is assessed to be a failure that should be attributed to the sprinkler system. Besides that can just about any cause of failure be attributed to human handling of the sprinkler systems, and therefore it is primarily this that needs to be taken care of in order to increase the reliability.

C.2 Impact of Sprinkler Systems on Fire Temperatures and Heat Release Rates

With the presence of sprinklers, the likelihood of a fire growing to the extent where it will spread beyond the object of fire origin is considered unlikely. Sprinkler protection is expected to provide a reliable and effective means of maintaining tenable conditions for occupants and fire-fighters, structural adequacy, and limiting fire spread within the subject building as well as to adjacent building(s). Effective sprinkler activation and operation is also likely to reduce the generation of smoke and maintain low compartment temperatures thus mitigating smoke spread between adjacent compartments.

Experimental evidence and numerical studies have demonstrated that sprinklers are very effective in controlling and suppressing fires. Sprinkler systems are designed to contain a fire. However UK data shows that in 40% of the fires the fire is extinguished (UK Incident Statistics from London, 2008). Swedish data estimates 60% extinguishment (Swedish Incident Statistics, 2008).

Automatic sprinklers are capable of suppressing or controlling fires such that the temperature rise of fire product gases and radiant heat is significantly reduced. It is assumed that the hot layer gases remain at the same temperature, as they were when the sprinklers activate which is approximately 75-100°C. It is evident that the effect of sprinklers on a fire is to wet down potential fuel sources, control or suppress the burning process and to cool the resultant smoke layer. It has been cited that the resultant smoke temperatures in a sprinkler-controlled fire are reduced to 100°C -120°C (CIBSE 1997; Sekizawa, 1996, Milke, 2001, Madrzykowski, 2008) within 60 seconds of sprinkler activation. (Refer to Figures Figure C.1 to Figure C.4).

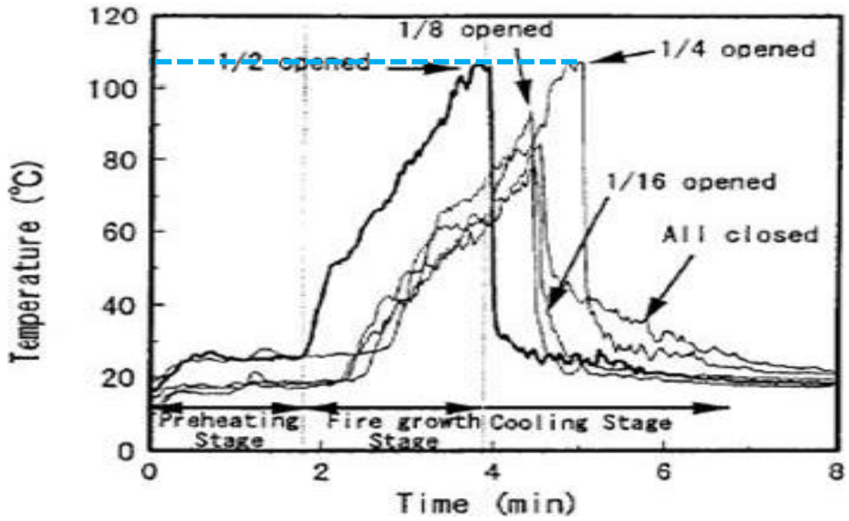


Figure C.1: Sprinkler controlled room temperatures (Sekizawa, 1996)

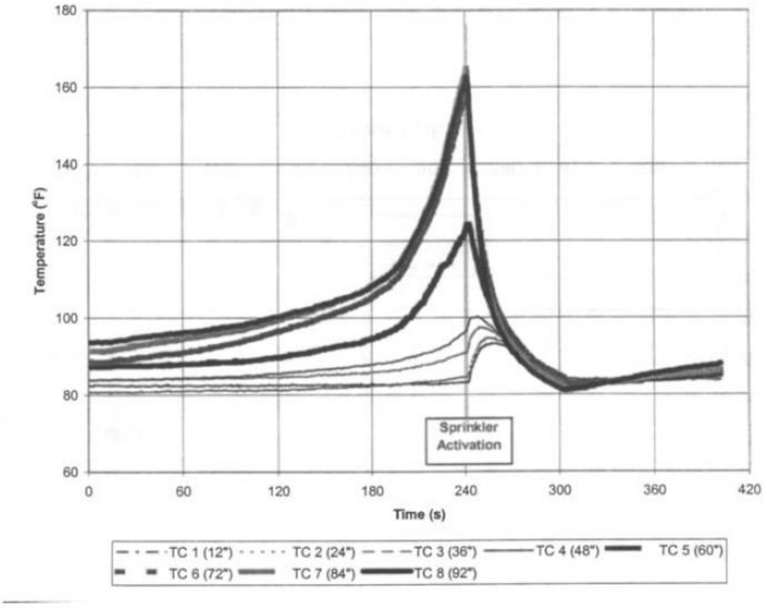


Figure C.2: Sprinkler controlled room temperatures (Milke, 2001)

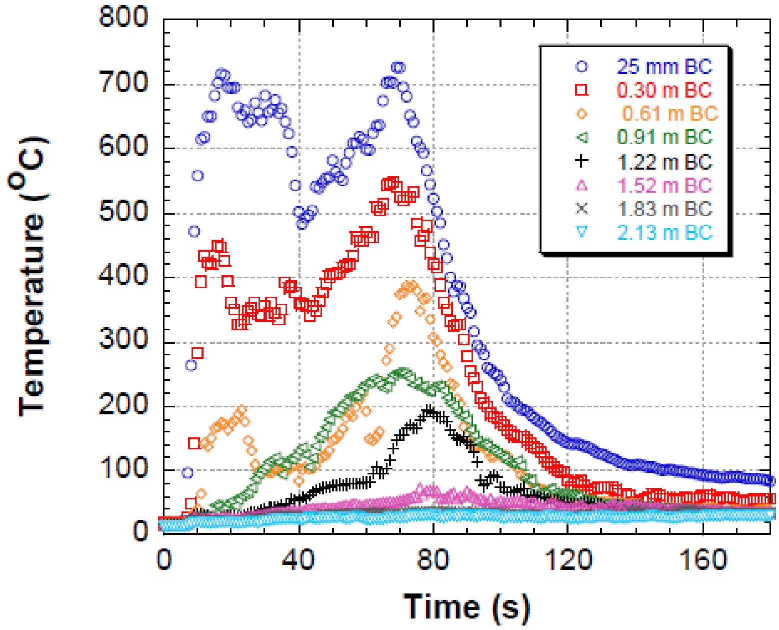


Figure C.3: Sprinkler controlled room temperatures (Madrzykowski, 2008)

With the presence of the sprinkler systems the risk of distress to building elements, barriers and the like is minimal. When a sprinkler system is activated in a room fire the heat release rate of the burning fuel is reduced or controlled to a relatively small level. Similarly the smoke and hot gas temperatures inside the room of fire origin are reduced or maintained due to the cooling effect of water spray.

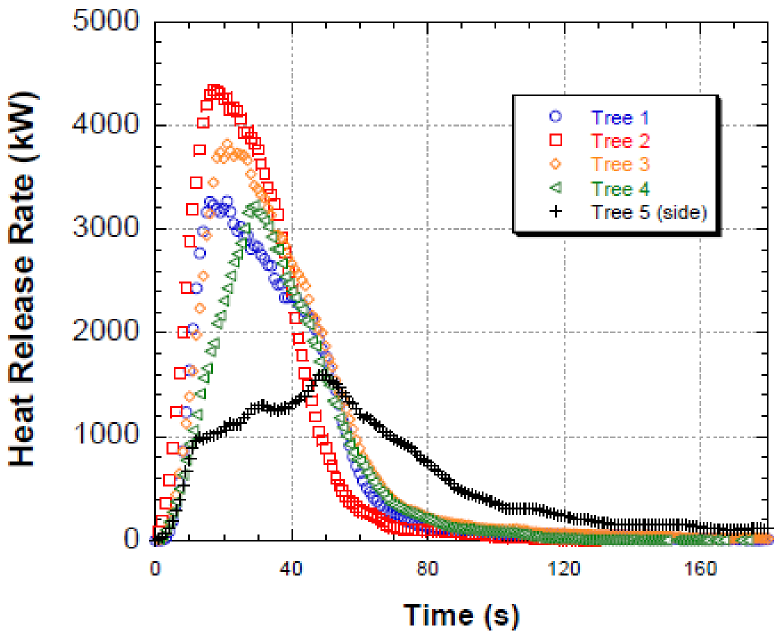


Figure C.4: Reduction in heat release rates with sprinkler activation (Madrzykowski, 2008)

C.3 Conclusion

Global data demonstrates that sprinkler systems are highly reliable especially in buildings where regular inspections and maintenance is conducted. The operational probability can be as high as 0.97, the effectiveness 100% and the efficacy 96% based on the classification of a building.

Once sprinklers activate the temperatures are expected to be reduced to less than 150°C within 60 seconds of the activation. The Heat Release Rate profiles also follow a similar trend.

Appendix D. Fire Dynamics Simulator (FDS)

D.1 General

D.1.1 Fire Dynamics Simulator

FDS is a powerful fire simulator which was developed at the National Institute of Standards and Technology (NIST). The NIST field model FDS is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flow. The FDS software is appropriate for low-speed, thermally driven flow with the emphasis on smoke and heat transport from fires (K B McGratten et-al 2002).

The FDS model to be used is a deterministic 'fire model' which is used to predict the spread of heat and smoke in an enclosure or multiple enclosures. Visual presentations of the FDS simulation modelling results has been provided using the 'smokeview' program (K B McGratten et-al 2002).

The NIST FDS is a CFD model, or sometimes referred as a field model. Field models rely less on empirical correlations and are based on solving conservation equations for mass, momentum and energy. Fluid dynamics involves mathematical equations that describe the physical behaviour of fluids (gases and liquids) and are in the general form of three-dimensional, time-dependent, non-linear partial differential equations known as the ‘Navier-Stokes’ equations.

- **Current FDS release version:** FDS 6.7.1
- **Current Smokeview release version:** SMV 6.7.4

D.1.2 Applications of the Fire Dynamics Simulator Software

The FDS software models have been used to establish (but not limited to) the following applications:

- Low speed transport of heat and combustion products from a fire; and
- Radiative and convective heat transfer between gas and solid surfaces/materials; and
- Pyrolysis; and
- Flame spread and fire growth; and
- Activation of devices such as a smoke detector(s), heat detector(s), sprinkler head(s), etc; and
- Sprinkler sprays and suppression by water.

D.2 Project Specific Input Parameters

D.2.1 CFD Fire Surface Area Justification

The area of the fire surface used for the fire needs to be justified such that it represents a credible fire scenario. The Fire Dynamics Simulator Technical Reference Guide Volume 3: Validation (i.e. page 57). To calculate the most appropriate area of the fire surface the Fire Froude Number $\dot{Q}^*$ has to be calculated. The fire Froude Number is a non-dimensional quantity for plume correlations and flame height estimates. It is essentially the ratio of the fuel gas exit velocity and the buoyancy-induced plume velocity.

It should be noted that jet fires are characterized by large Froude numbers. Typical accidental fires have a Froude number near unity (i.e. 1). Typical accidental fires are the common fire scenario used in ASET/RSET analysis. Furthermore, An Introduction to Fire Dynamics (Drysdale page 130) states that turbulent jet fires occur when Q* > 5 and pool fires occur when Q* < 1. The Fire Froude Number $\dot{Q}^*$ is shown below:

$$\dot{Q}^* = \frac{\dot{Q}}{\rho_\infty c_p T_\infty \sqrt{gD} D^2}$$

Eq.1

where:

D:	characteristic fire diameter
Q :	total heat release rate, kW;
$\rho\infty$:	density at ambient temperature, kg/m^3 = 1.2;
Cp :	specific heat of gas, kJ/kg.K = 1.0;
$T\infty$:	ambient temperature, K = 298;
g :	acceleration of gravity, m/s^2 = 9.81.

Table 17.1: Calculated Froude number

Fire Scenario	Total HRR (kW)	Fire Dimension	Calculated Fire Diameter	Calculated Q*
SB01	8500	1.5m x 1.5m	1.693	2.104
SB02	16600	2.0m x 2.0m	2.257	2.001
SB03	8700	2.0m x 2.0m	2.257	1.049
SB04	6500	1.5m x 1.5m	1.693	1.609
SB05	14900	2.0m x 2.0m	2.257	1.796

From the above calculations, it was concluded that the diameter size adopted for the above fire scenarios was appropriate to simulate an accidental fire, 1< (Q^*) <5, would was the basis for the fire scenario.

D.2.2 Visibility C Factor

In FDS analysis where visibility is used as tenability criteria the C factor if the signage (if there is any) is a key parameter. In the context of the current project a C factor 3 has been adopted based on the presence of non-illuminating signage.

D.2.3 Boundary Conditions

The boundary conditions for the smoke modelling were as follows:

- Air Temperature inside computational domain = 20°C.
- External Air Temperature = 25°C.
- Outside walls are adiabatic.
- The model is surrounded by free, neutral pressure boundaries.

D.2.4 Adopted Fuel

The adopted Fuel input is as per the following:

- SOOT_YIELD = (refer to justification below)
- NU_O2 = 3.7
- NU_CO2 = 3.4
- NU_H2O = 3.1
- MW_FUEL = 87.
- EPUMO2 = 11020.

D.2.5 Adopted Soot Yield

For warehouse facilities, it is difficult to determine the exact nature of fuel loads given the size of variances in use. However, the soot yield within the warehouse is determined based on the likely distribution and characteristics of such combustible materials that would be expected within a typical warehouse facility.

Soot yield is the smoke represented by carbon particles distributed through the gas layers. Typically, fire modelling inputs are in the form of a yield (mass of carbon per mass of fuel pyrolysed in g/g or kg/kg).

Soot yield values for well-ventilated free burning fires involving “sooty” fuels are in the range 0.008 –0.18 g/g with lesser values appropriate for clean burning fuels and wood products. As part of the FDS model to be conducted the soot concentrations have been determined based on referenced data and/or a weighted average of soot yield. The average soot yield is based on a function of the soot yield characteristics for a range of likely materials expected within the building. Soot yield values for the expected commodities are as follows:

Table D.1: Soot Yields appropriate to a variety of materials

Fuel	Soot Yield (kg/kg)
Polyurethane (rigid) Foam	0.125
Plastics (Nylon)	0.075
Corrugated Paper Boxes	0.061
Silica	0.020
Polyester	0.091
Hydrocarbon	0.059

Fuel	Soot Yield (kg/kg)
Butadiene	0.125
Wood	0.015
PVC	0.172
Synthetic material (PMMA)	0.022
Synthetic material (PE)	0.007

From the above, a soot yield value has been nominated based on the following points:

- Taking into consideration the large volume and height of the warehouse facility, it can be assumed that in the event of a fire the amount of soot being deposited on the ceiling structure will be less in comparison to a smaller enclosure such as an office tenancy where more soot would be expected to be contained within the smoke layer; and
- Due to the open nature of the warehouse, a fire is expected to be well ventilated involving a composition of materials with a range of soot yields extracted from text references (as listed above); and
- The vast majority of material soot yields detailed above range from 0.007kg/kg to 0.172kg/kg; and
- An average of the above equates to a soot yield of 0.070kg/kg.

Based on the above, it is proposed to round up the average of 0.070kg/kg and conservatively adopt a soot yield value of 0.075kg/kg for fire modelling purposes.

D.3 CFD Input Parameters

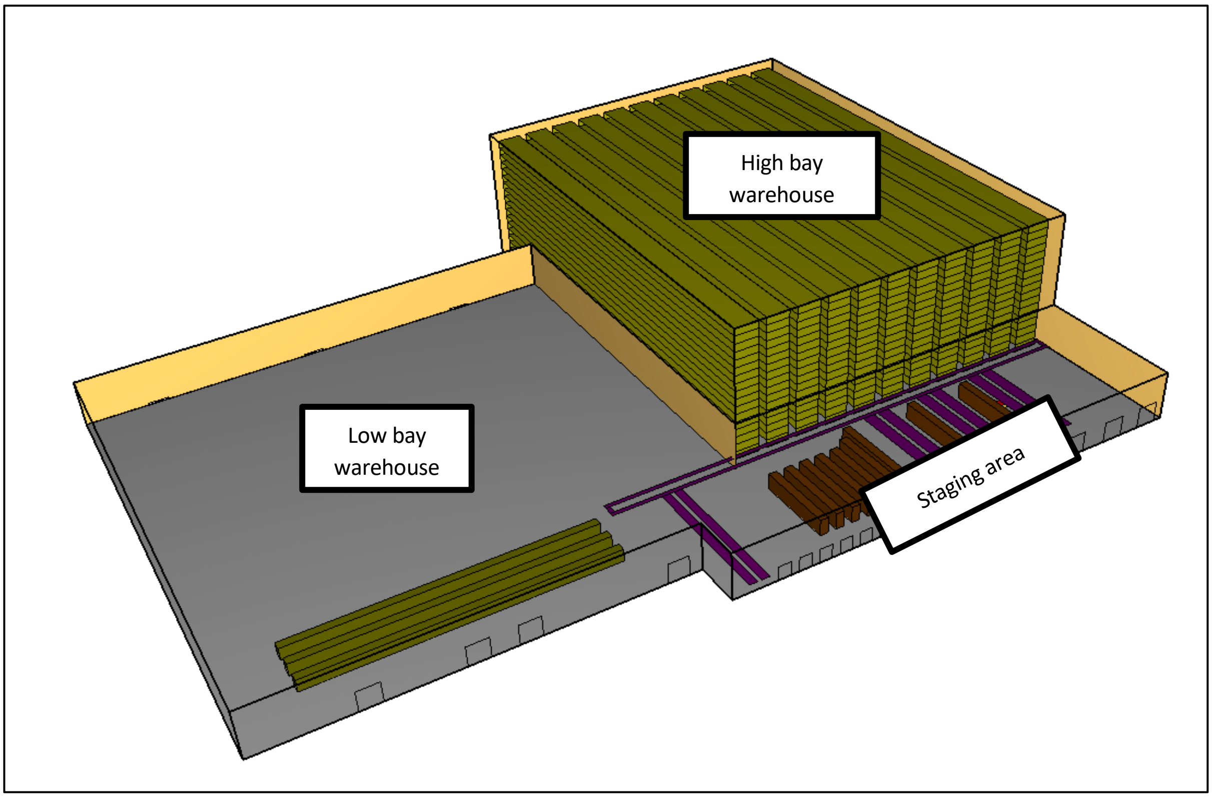
D.3.1 Summary of CFD Input Parameters

General / Domain Parameters	
Number of meshes	Sixty-three (63)
Type of mesh (e.g. Cartesian)	Cartesian Grid (FDS Default)
Mesh Size	1.0m x 1.0m x 0.5m
Material Properties	The floor to be modelled as concrete, the roof to be modelled as steel and the partition walls and ceiling to be modelled as plasterboard. These have been calculated using the standard materials database provided within FDS.
Boundary Conditions	Outside walls are adiabatic surface to determine modelled boundary profiles. The model is surrounded by free, neutral pressure boundaries
Steady-State or Transient	Steady state environment has been adopted.
Simulation Time	3000 seconds. Extended simulation time to account for conditions for fire brigade life safety
Fire Parameters	
Reaction Properties	Reaction properties based on the composition of materials such as plastics, wood, etc. NU_O2 = 3.7 NU_CO2 = 3.4 NU_H2O = 3.1 MW_FUEL = 87. EPUMO2 = 11020.
Soot Yield (value and means of including in model)	0.075kg/kg has been adopted for the fire scenarios to represent warehouse commodities.
Visibility Factor (or other parameters used to obtain Visibility output)	The visibility factor of 3 has been adopted representative of a reflecting sign (i.e. non-illuminated signage) at visibility distance of 10m.

<table>
<tr><th colspan="5">General / Domain Parameters</th></tr>
<tr><td rowspan="6">Heat Release Rate Per Unit Area (HRRPUA)</td><td>Fire Scenario</td><td>PHRR (kW)</td><td>Fire Dimensions</td><td>HRRPUA</td></tr>
<tr><td>SB01</td><td>8500</td><td>1.5m x 1.5m</td><td>3777 kW/m^2</td></tr>
<tr><td>SB02</td><td>16600</td><td>2.0m x 2.0m</td><td>4150 kW/m^2</td></tr>
<tr><td>SB03</td><td>8700</td><td>2.0m x 2.0m</td><td>2175 kW/m^2</td></tr>
<tr><td>SB04</td><td>6500</td><td>1.5m x 1.5m</td><td>2888 kW/m^2</td></tr>
<tr><td>SB05</td><td>14900</td><td>2.0m x 2.0m</td><td>3725 kW/m^2</td></tr>
<tr><td rowspan="6">Means of achieving fire growth rate (e.g. ramp, multiple fire objects, etc.)</td><td>Fire Scenario</td><td>Growth Rate</td><td rowspan="6" colspan="2"></td></tr>
<tr><td>SB01</td><td>Ultra-Fast t^2</td></tr>
<tr><td>SB02</td><td>Ultra-Fast t^2</td></tr>
<tr><td>SB03</td><td>Custom</td></tr>
<tr><td>SB04</td><td>Ultra-Fast t^2</td></tr>
<tr><td>SB05</td><td>Ultra-Fast t^2</td></tr>
<tr><td rowspan="6">Fire locations (including height above floor)</td><td>Fire Scenario</td><td>Fire Location</td><td>Ceiling Height</td><td rowspan="6"></td></tr>
<tr><td>SB01</td><td>Staging Area</td><td>13.7m</td></tr>
<tr><td>SB02</td><td>Low Bay Area</td><td>13.7m</td></tr>
<tr><td>SB03</td><td>Low Bay Area</td><td>13.7m</td></tr>
<tr><td>SB04</td><td>High Bay Area</td><td>36.8m</td></tr>
<tr><td>SB05</td><td>High Bay Area</td><td>36.8m</td></tr>
<tr><td>Mechanical smoke exhaust</td><td colspan="4">N/A</td></tr>
<tr><td>Mechanical supply air</td><td colspan="4">N/A</td></tr>
<tr><td>Jet fans</td><td colspan="4">N/A</td></tr>
<tr><td>Natural vents</td><td colspan="4">N/A</td></tr>
<tr><td>Natural make-up air</td><td colspan="4">Leakage based on number of openings through external walls.</td></tr>
<tr><td>Assumed building leakage</td><td colspan="4">Leakage based on number of openings through external walls.</td></tr>
<tr><td rowspan="6">Sprinklers (RTI, spacing, location, distance to fire, temperature rating, etc.)</td><td>Sprinkler Parameters</td><td>Value</td><td rowspan="6" colspan="2">Note: The sprinkler parameters have been based on roof sprinklers and any in-rack sprinklers have been discounted as a conservative measure.</td></tr>
<tr><td>Activation Temperature</td><td>100°C</td></tr>
<tr><td>Response Time Index</td><td>50m$^{0.5}$s$^{0.5}$</td></tr>
<tr><td>Sprinkler Head Height</td><td>At ceiling height</td></tr>
<tr><td>Sprinkler Head Spacing</td><td>3.1m x 3.1m</td></tr>
<tr><td>Radial Distance to Fire</td><td>2.2m</td></tr>
<tr><td rowspan="5">Detectors (RTI, spacing, location, distance to fire, temperature rating, activation obscuration, etc.)</td><td>Smoke Detector Parameters</td><td>Value</td><td rowspan="5" colspan="2">Note: VESDA System provided to the high bay area as part of FRNSW requirements. VESDA System was discounted in the fire engineering assessment as a conservative approach.</td></tr>
<tr><td>Activation Obscuration</td><td>N/A</td></tr>
<tr><td>Smoke Detector Height</td><td>N/A</td></tr>
<tr><td>Smoke Detector Spacing</td><td>N/A</td></tr>
<tr><td>Radial Distance to Fire</td><td>N/A</td></tr>
</table>

D.4 CFD Outcomes

D.4.1 Model Overall Layout



D.4.2 Core Fire Scenario: SB01C & SB02C

D.4.2.1 Staging Area

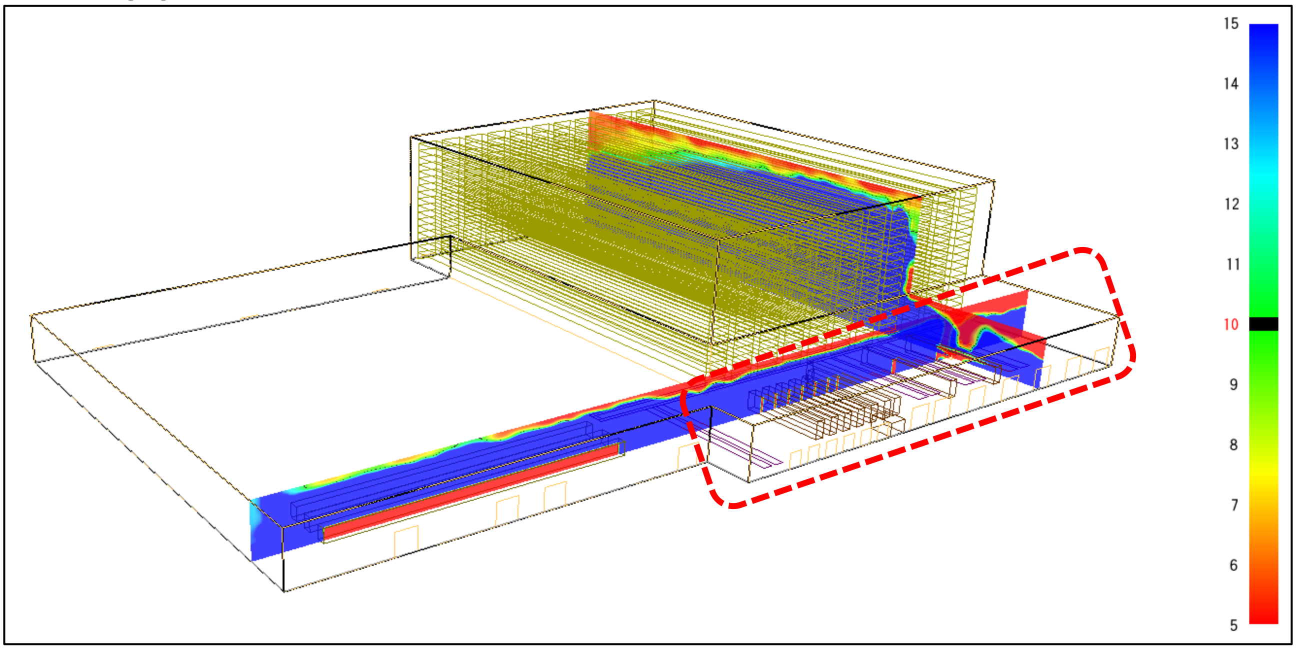


Figure D.1: Visibility Slice File at 397 seconds (RSET)

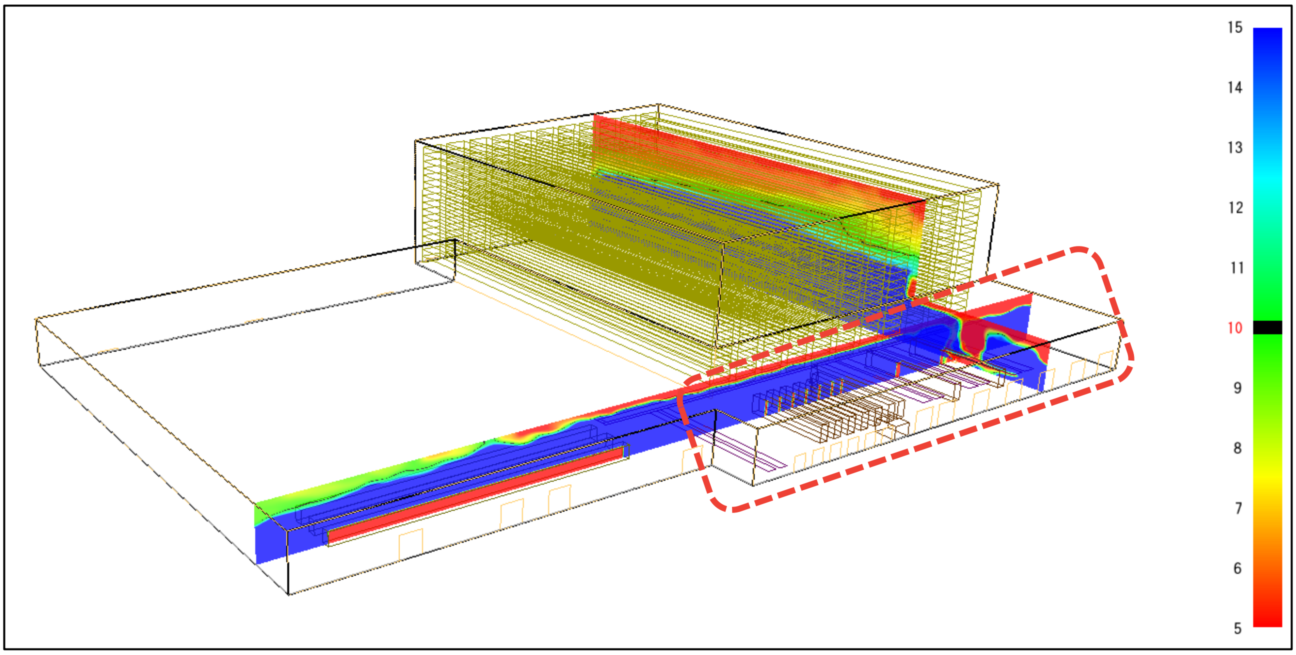


Figure D.2: Visibility Slice File at 596 seconds (1.5 x RSET)

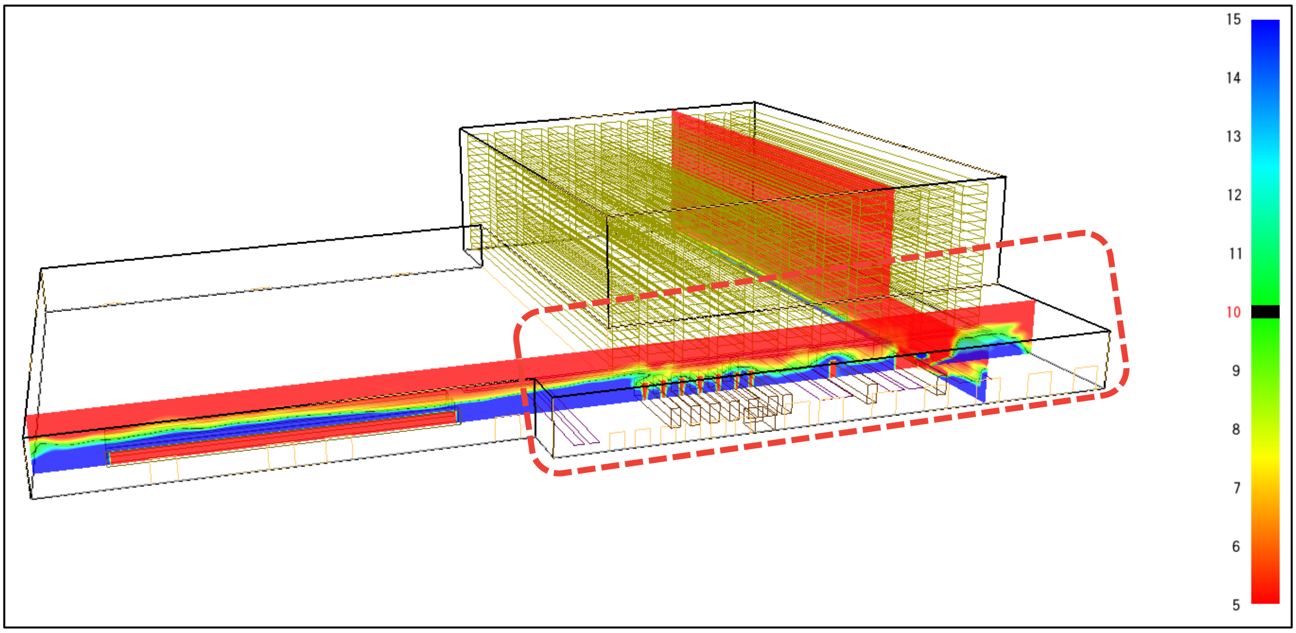


Figure D.3: Visibility Slice File at 1900 seconds (ASET)

D.4.2.2 Low Bay Warehouse

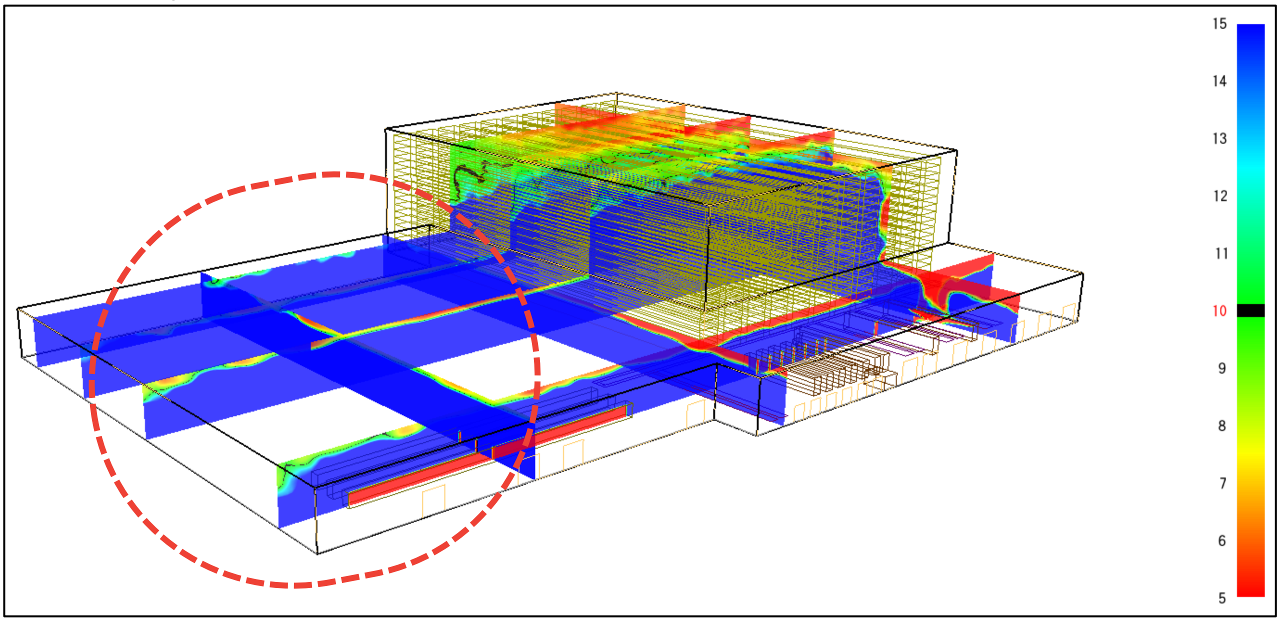


Figure D.4: Visibility Slice File at 415 seconds (RSET)

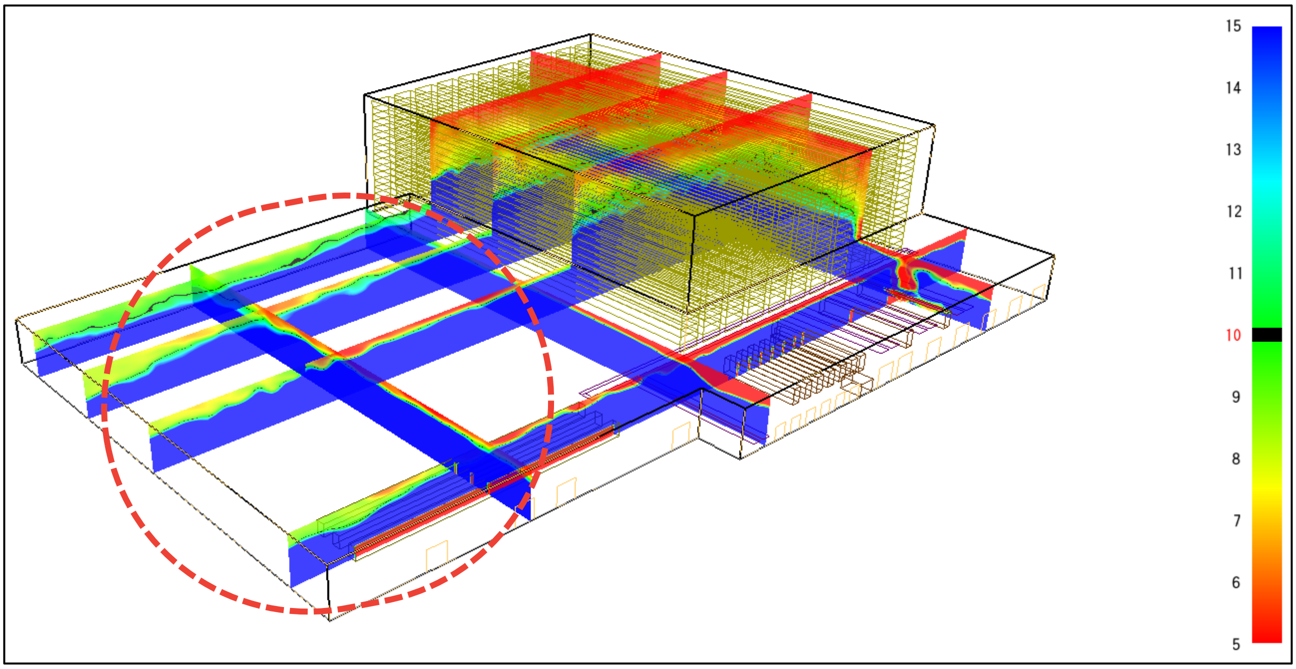


Figure D.5: Visibility Slice File at 563 seconds (1.5 x RSET)

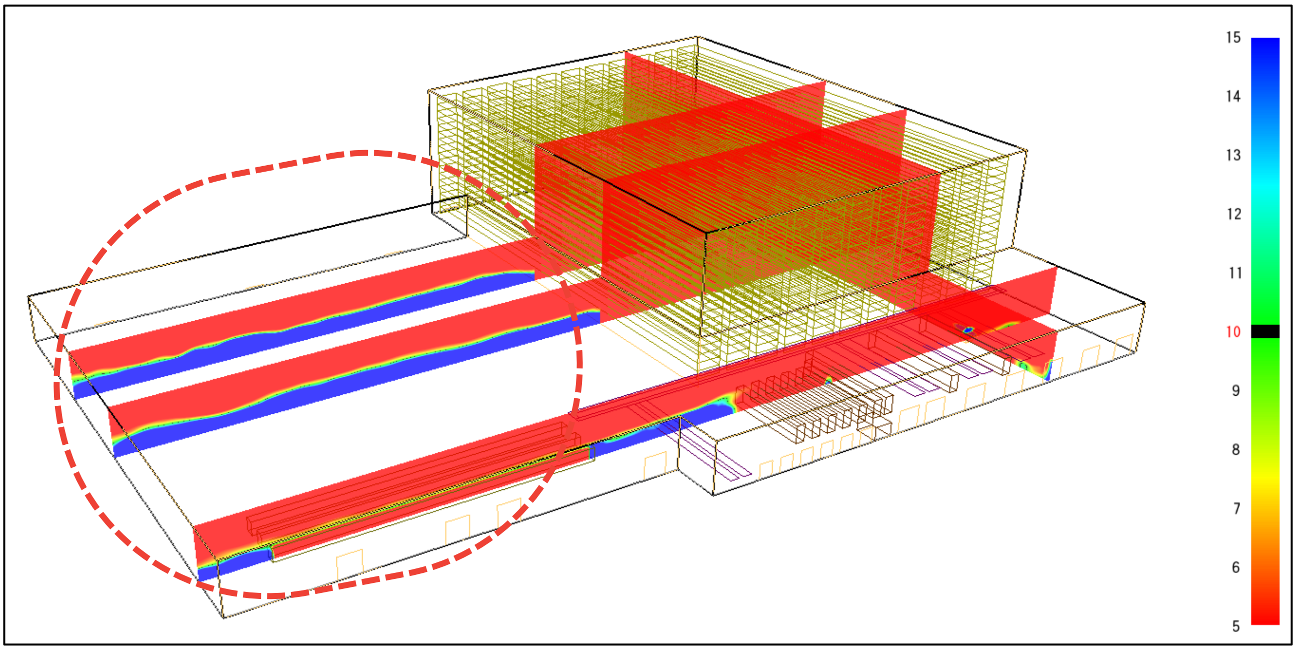


Figure D.6: Visibility Slice File at 3000 seconds (ASET)

D.4.2.3 High Bay Warehouse

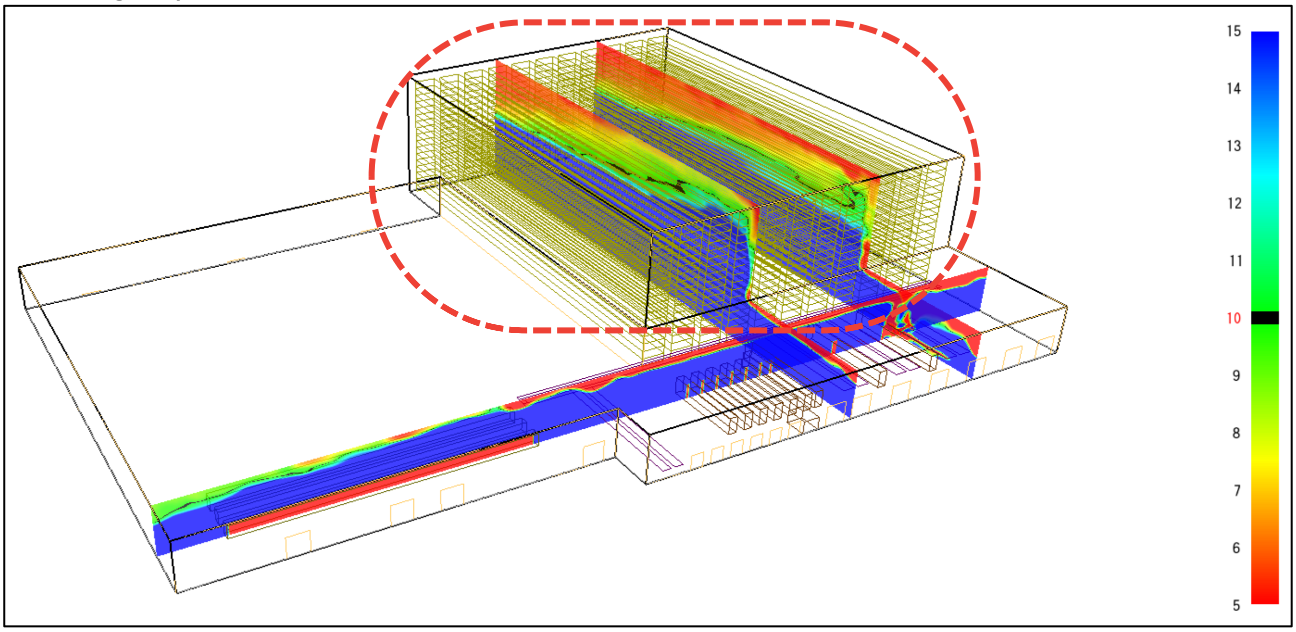


Figure D.7: Visibility Slice File at 510 seconds (RSET)

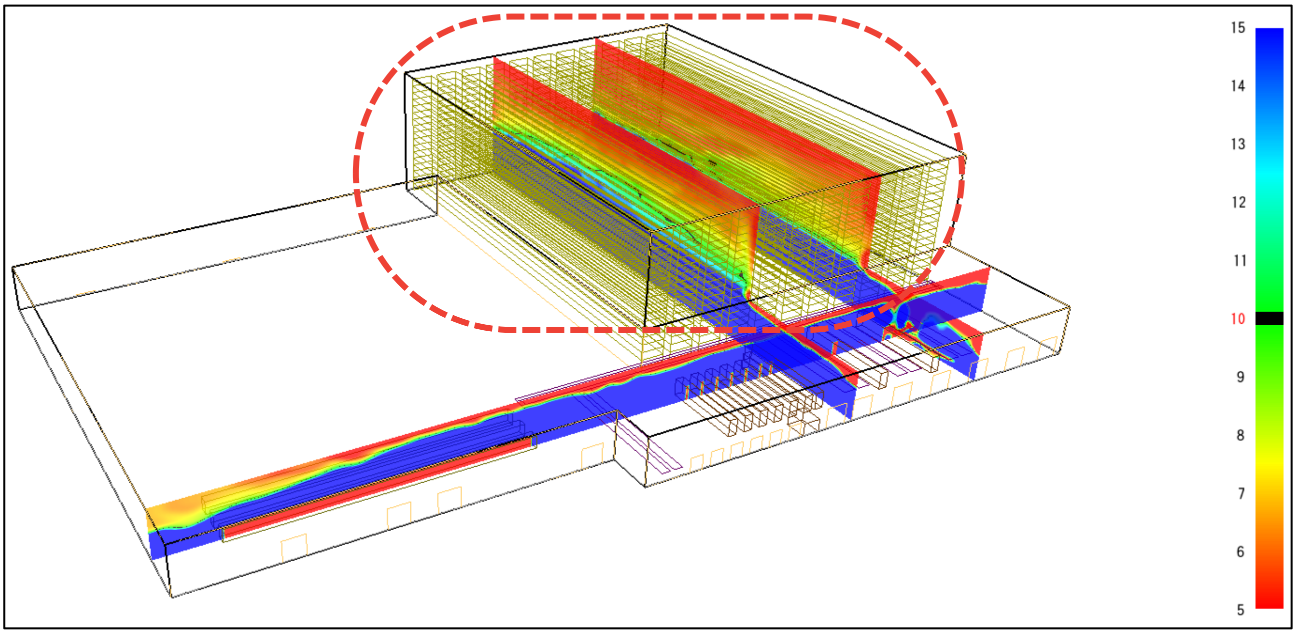


Figure D.8: Visibility Slice File at 563 seconds (1.5 x RSET)

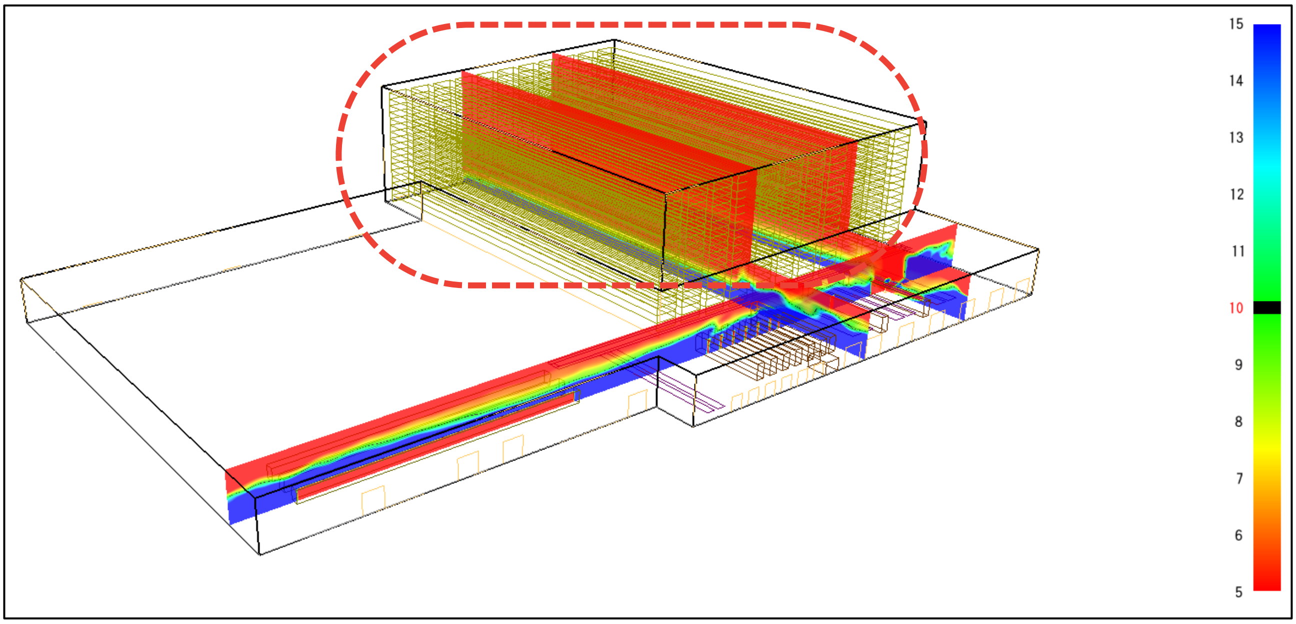


Figure D.9: Visibility Slice File at 1600 seconds (ASET)

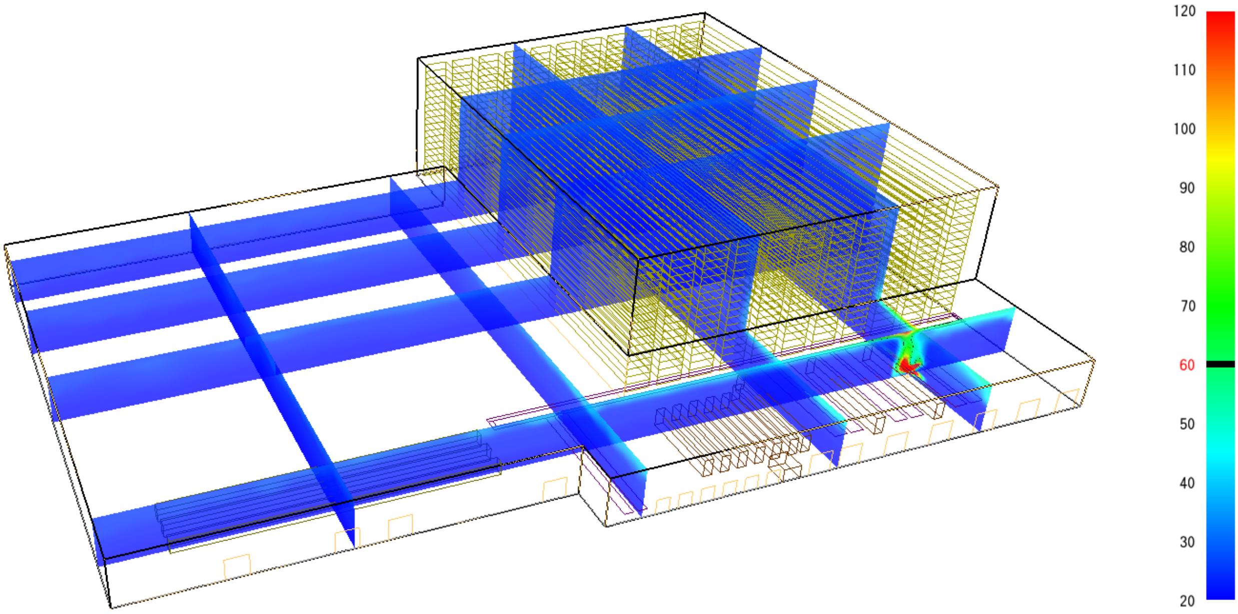


Figure D.10: Temperature Slice File at 3000 seconds

D.4.3 Sensitivity Fire Scenario: SB01S

D.4.3.1 Staging Area

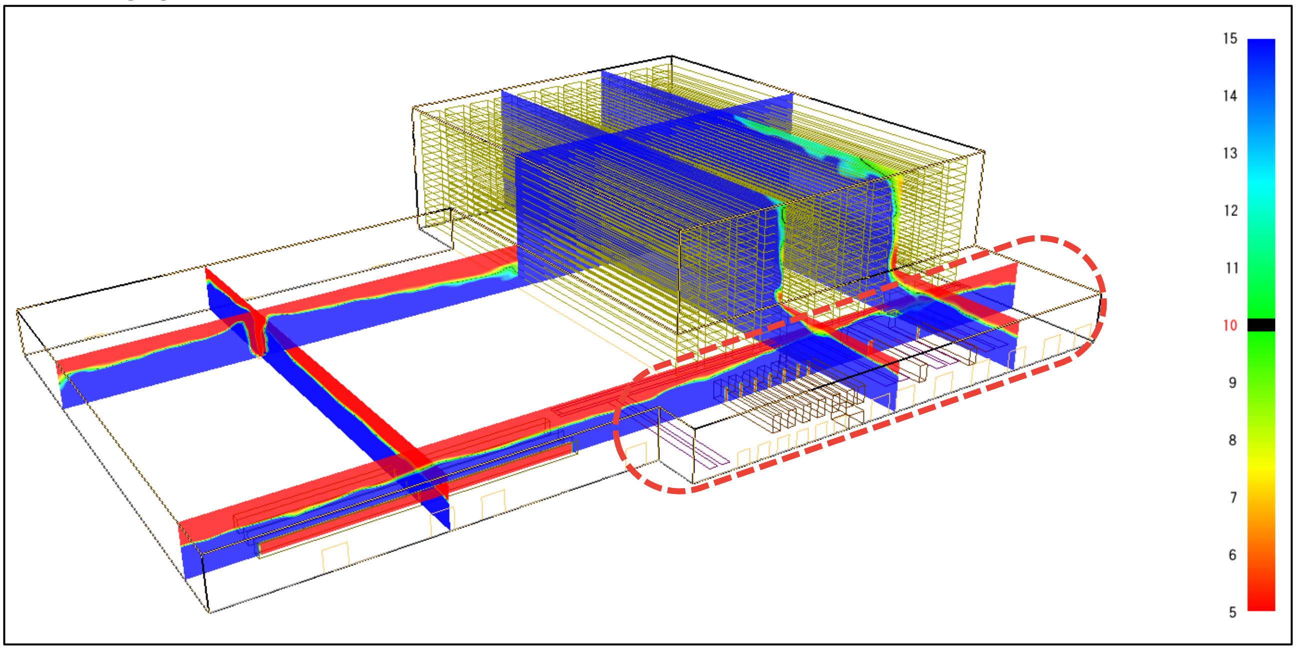


Figure D.11: Visibility Slice File at 497 seconds (RSET)

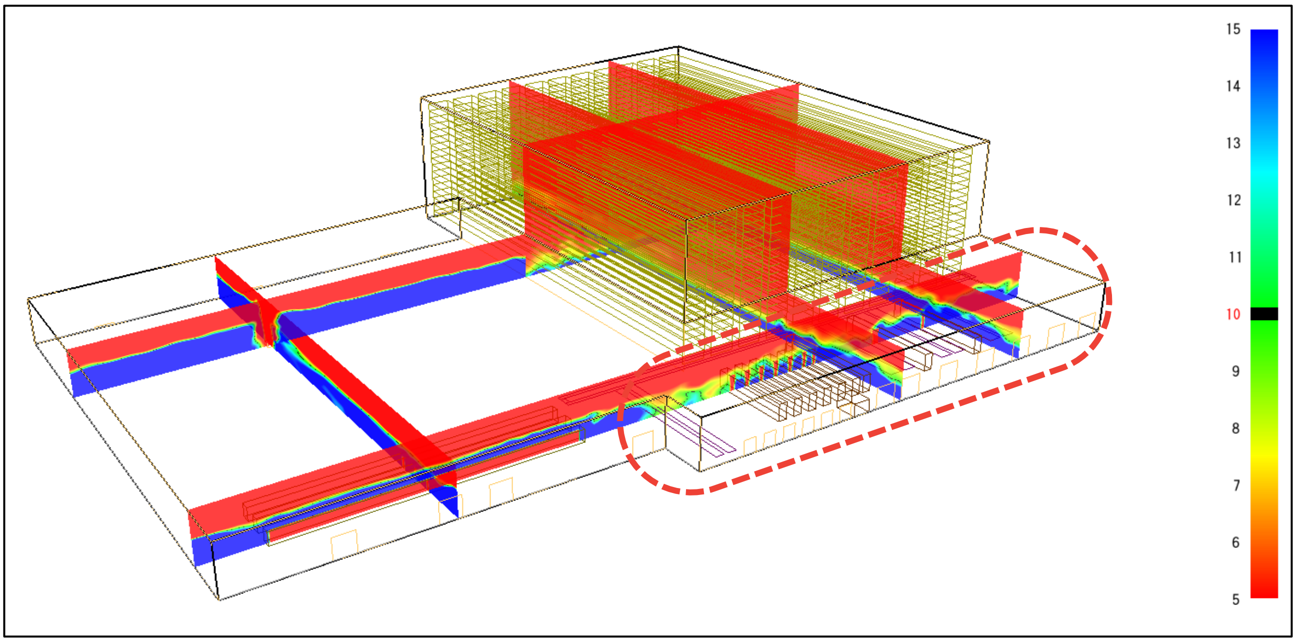


Figure D.12: Visibility Slice File at 1650 seconds (ASET)

D.4.3.2 Low Bay Warehouse

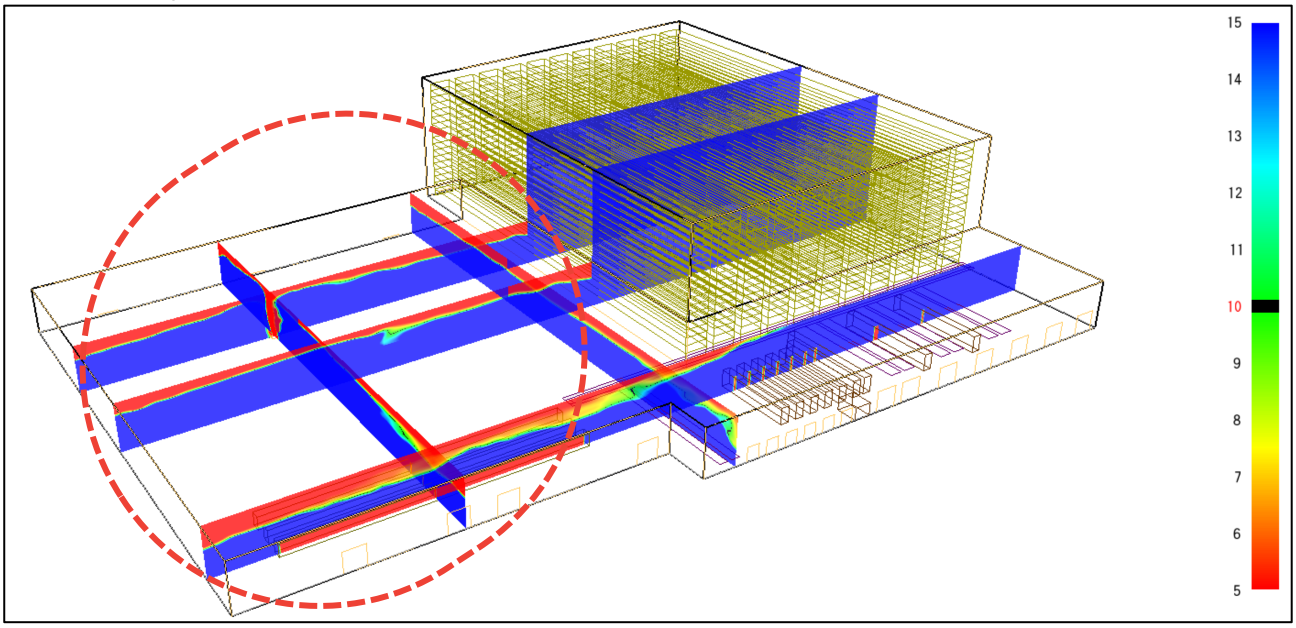


Figure D.13: Visibility Slice File at 315 seconds (RSET)

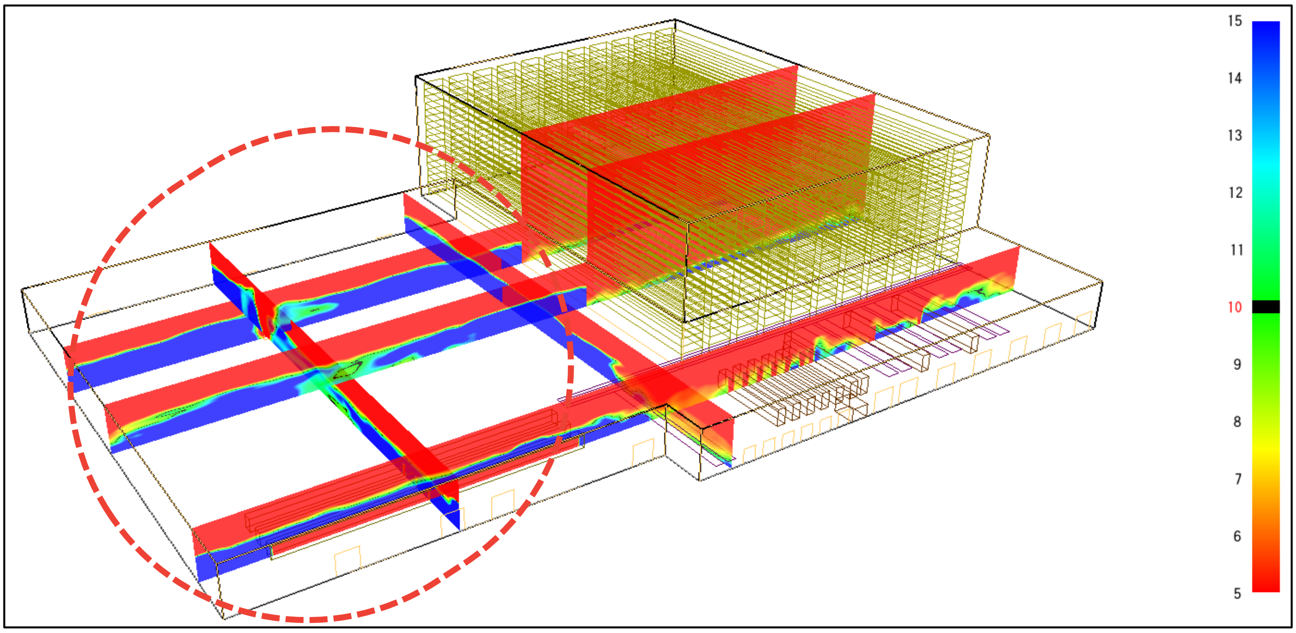


Figure D.14: Visibility Slice File at 1800 seconds (ASET)

D.4.3.3 High Bay Warehouse

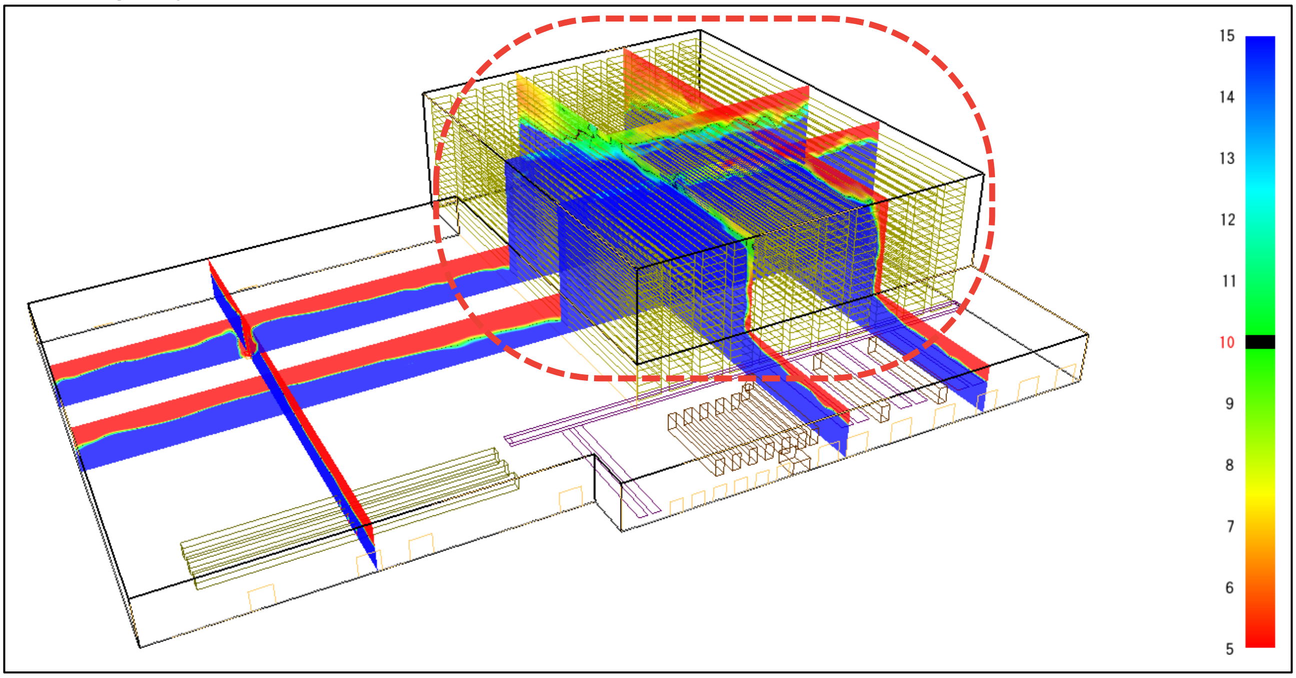


Figure D.15: Visibility Slice File at 685 seconds (RSET)

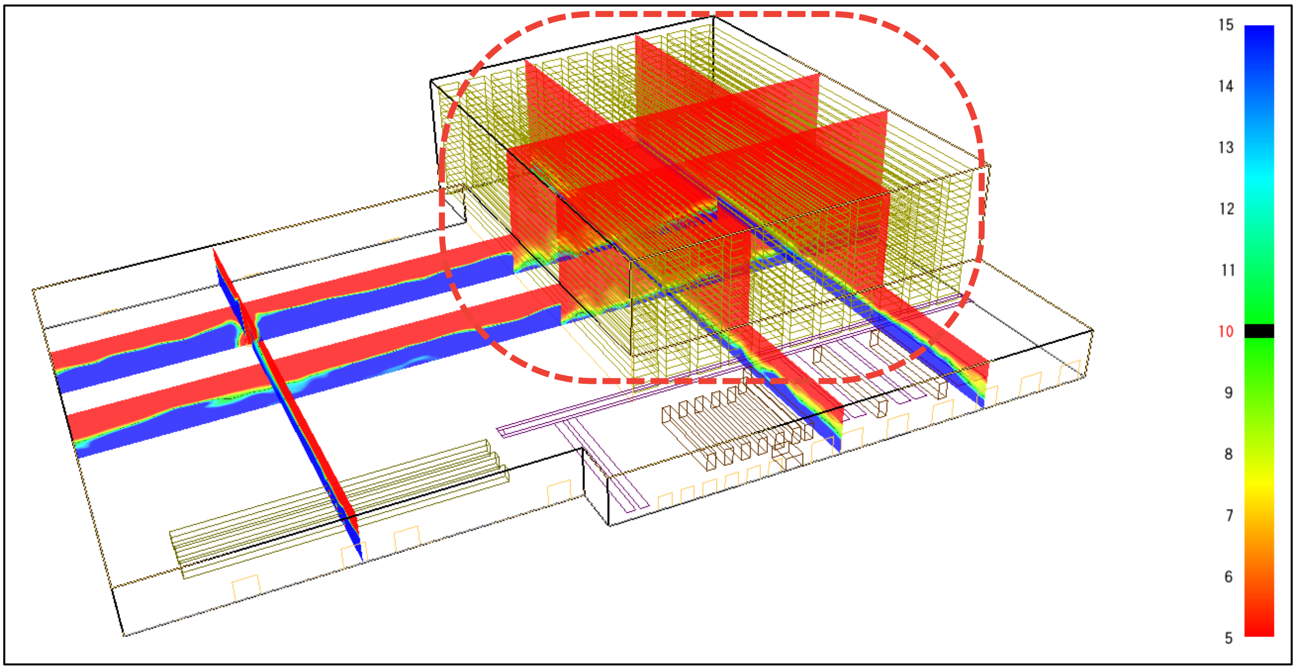


Figure D.16: Visibility Slice File at 1600 seconds (ASET)

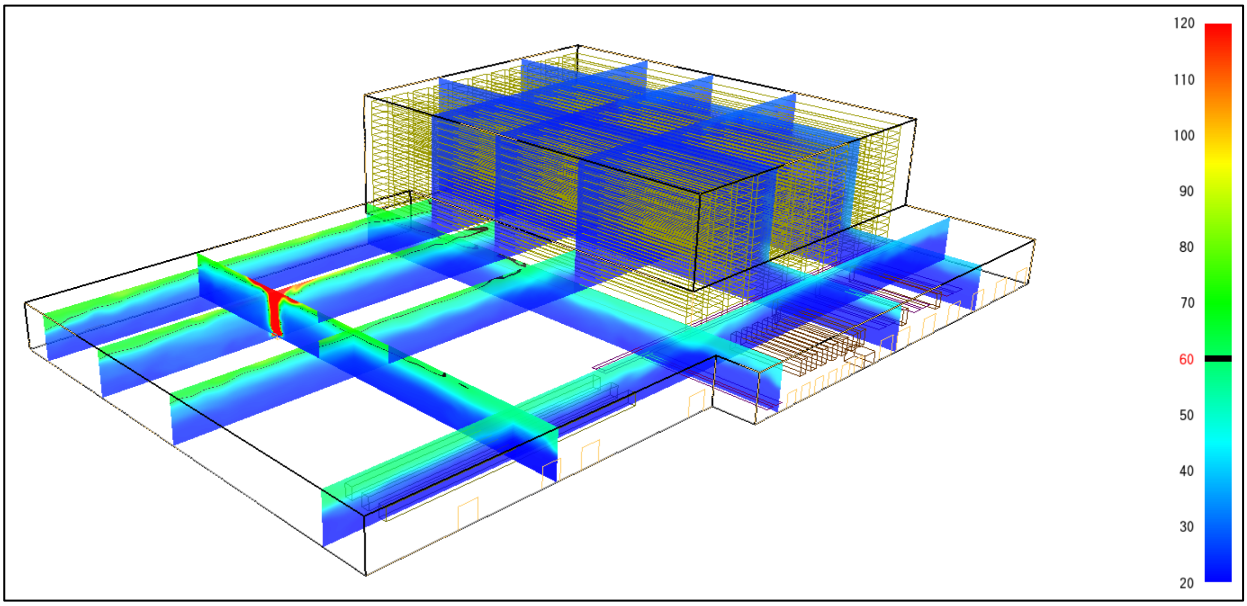


Figure D.17: Temperature Slice File at 1800 seconds

D.4.4 Sensitivity Fire Scenario: SB03C

D.4.4.1 Staging Area

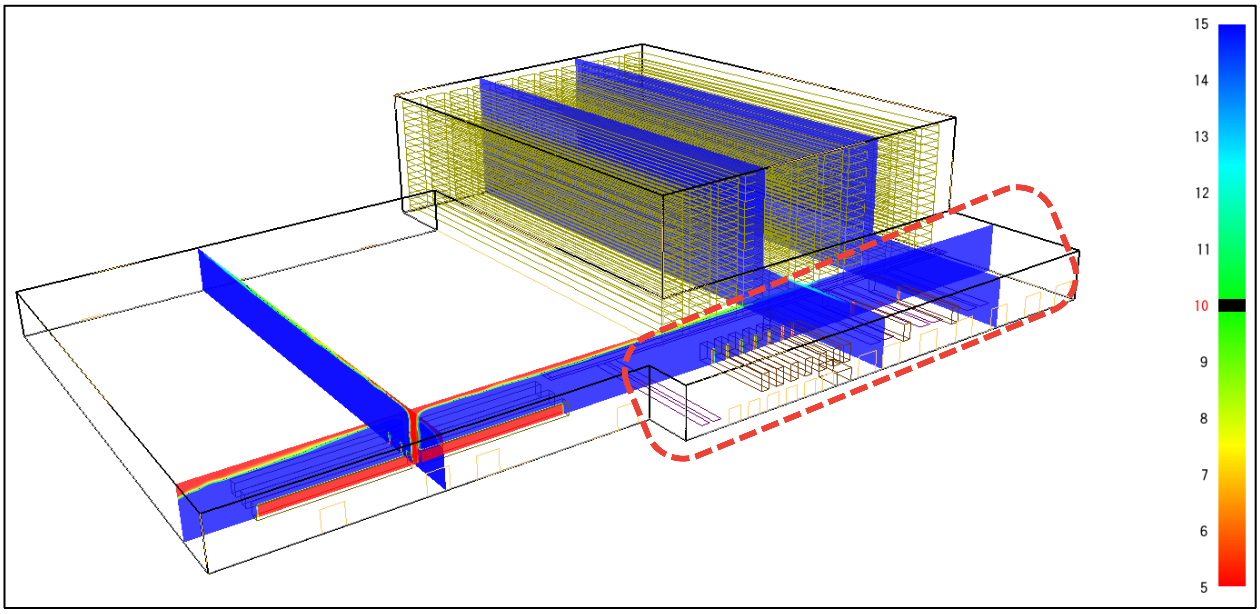


Figure D.18: Visibility Slice File at 527 seconds (RSET)

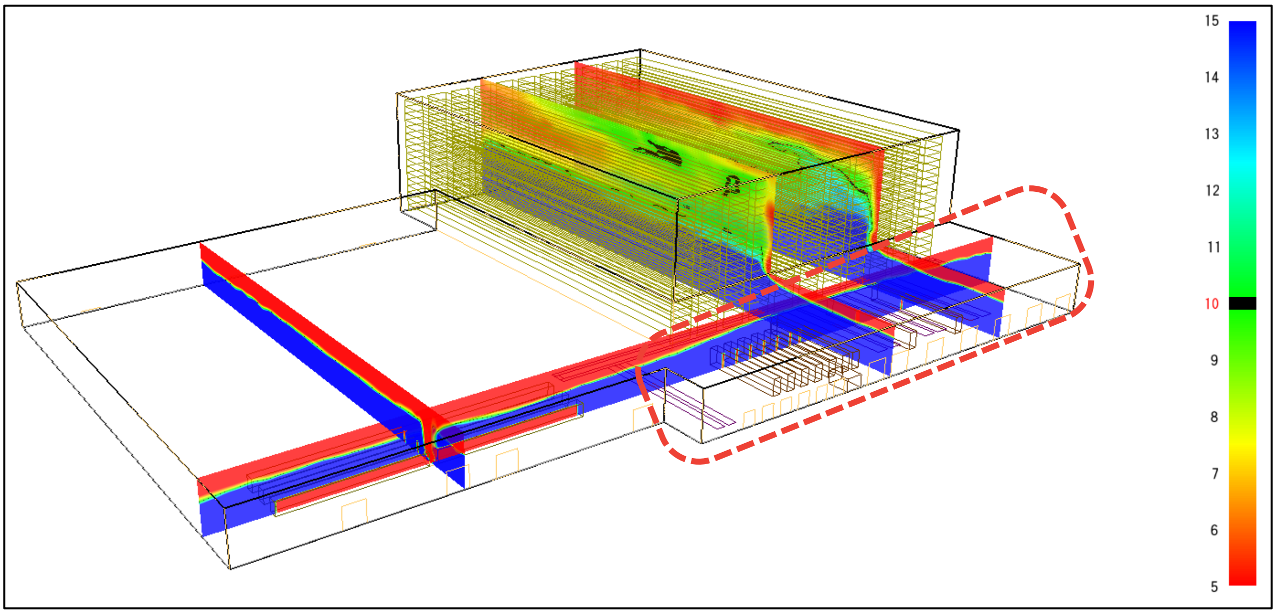


Figure D.19: Visibility Slice File at 1800 seconds (ASET)

D.4.4.2 Low Bay Warehouse

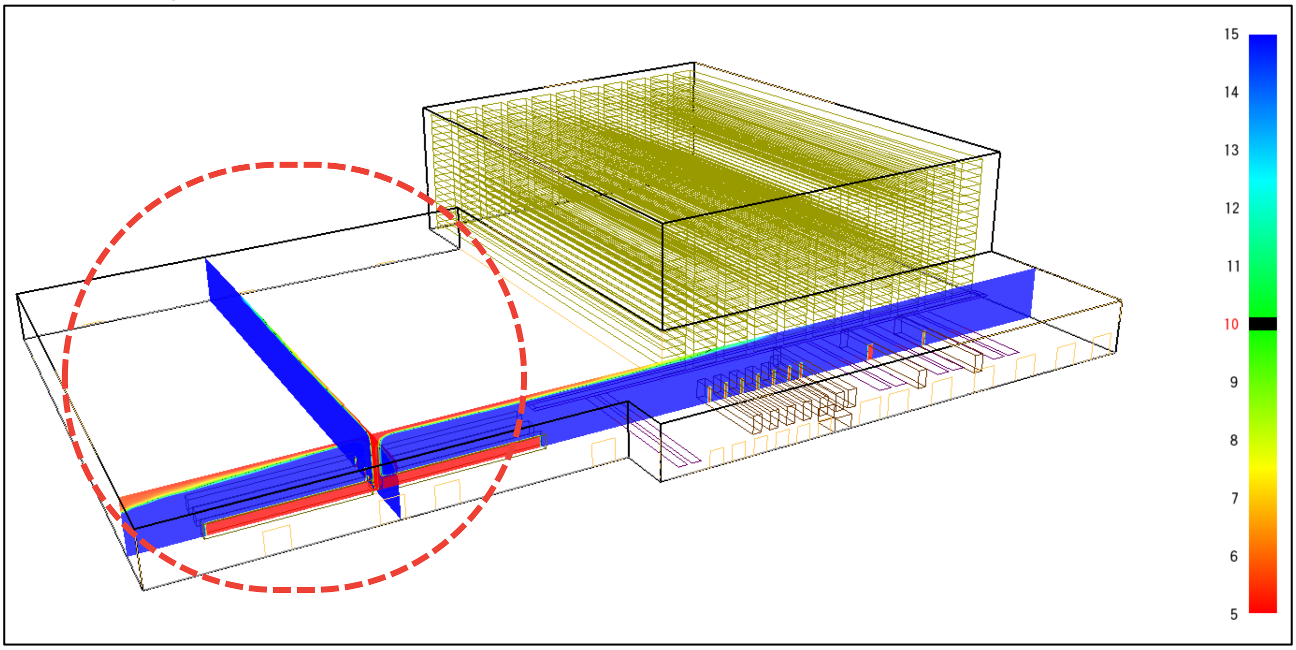


Figure D.20: Visibility Slice File at 465 seconds (RSET)

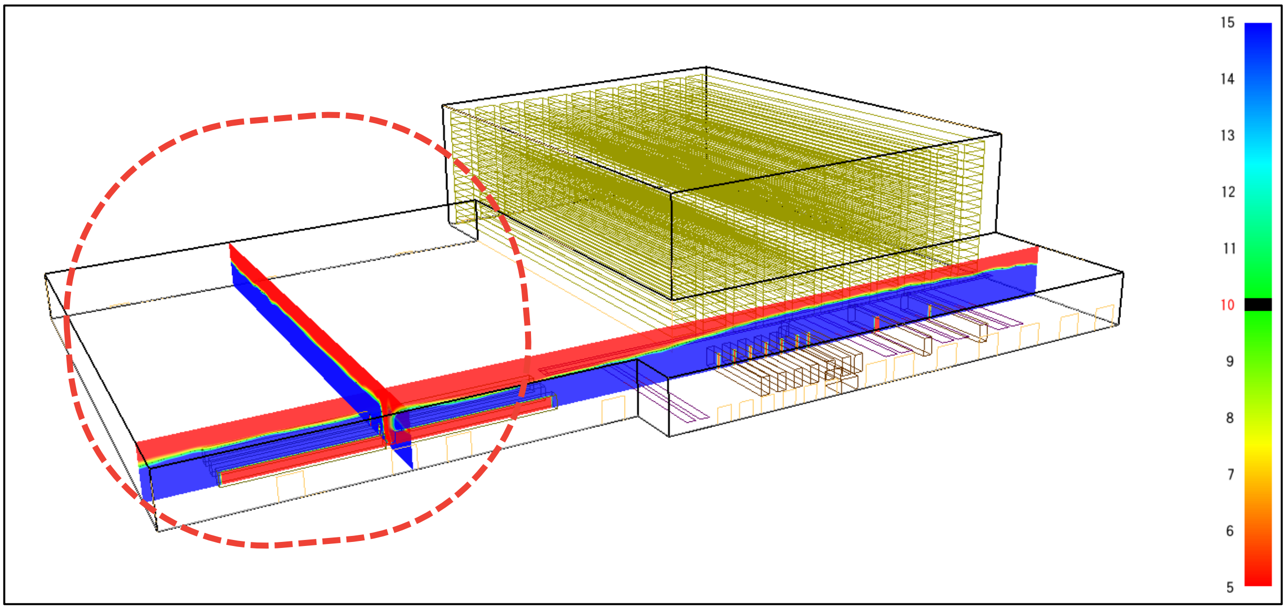


Figure D.21: Visibility Slice File at 1800 seconds (ASET)

D.4.4.3 High Bay Warehouse

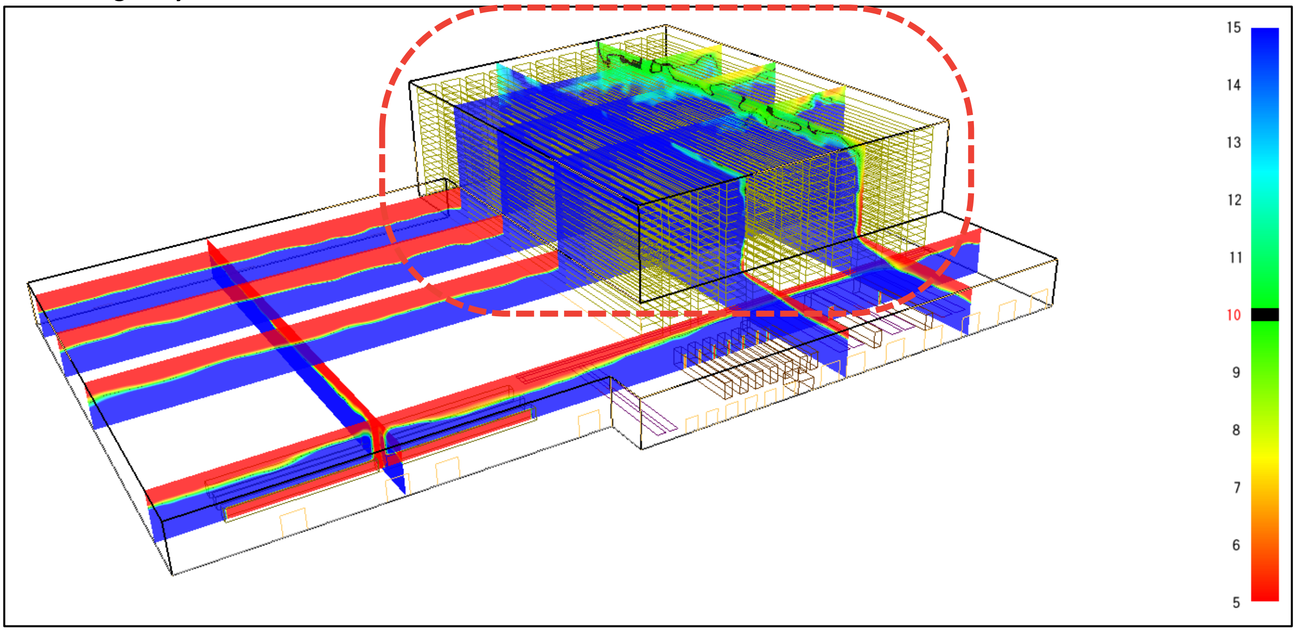


Figure D.22: Visibility Slice File at 1110 seconds (RSET)

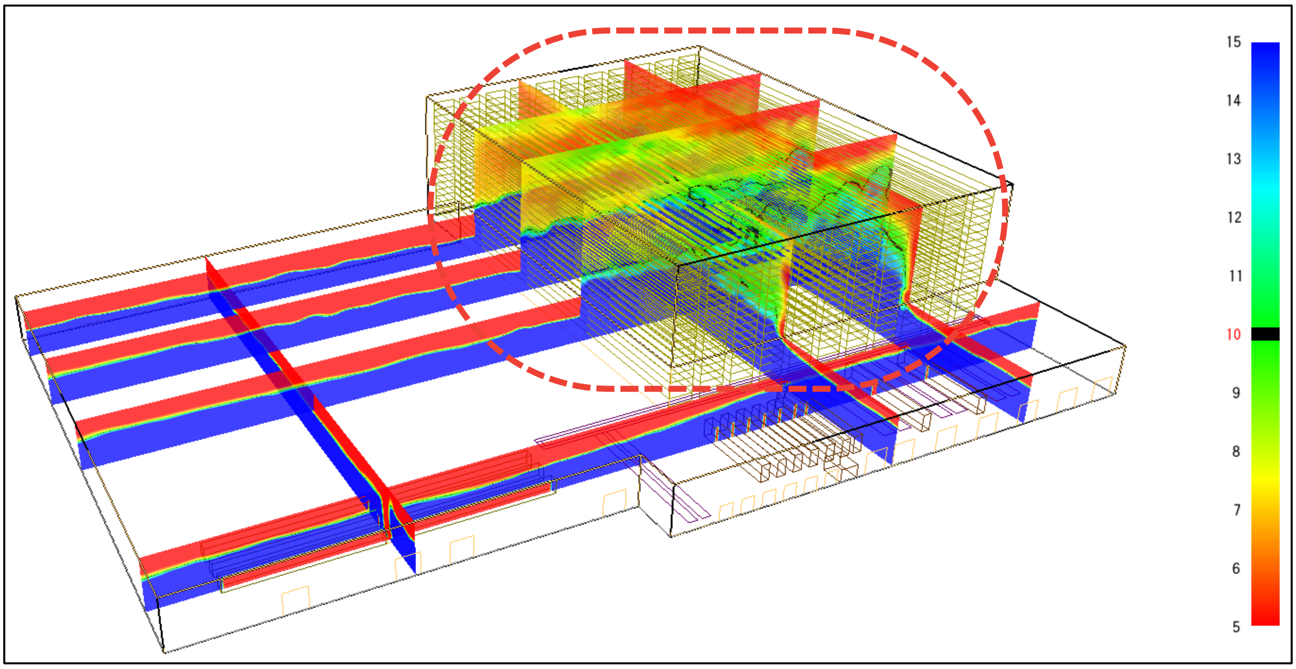


Figure D.23: Visibility Slice File at 1800 seconds (ASET)

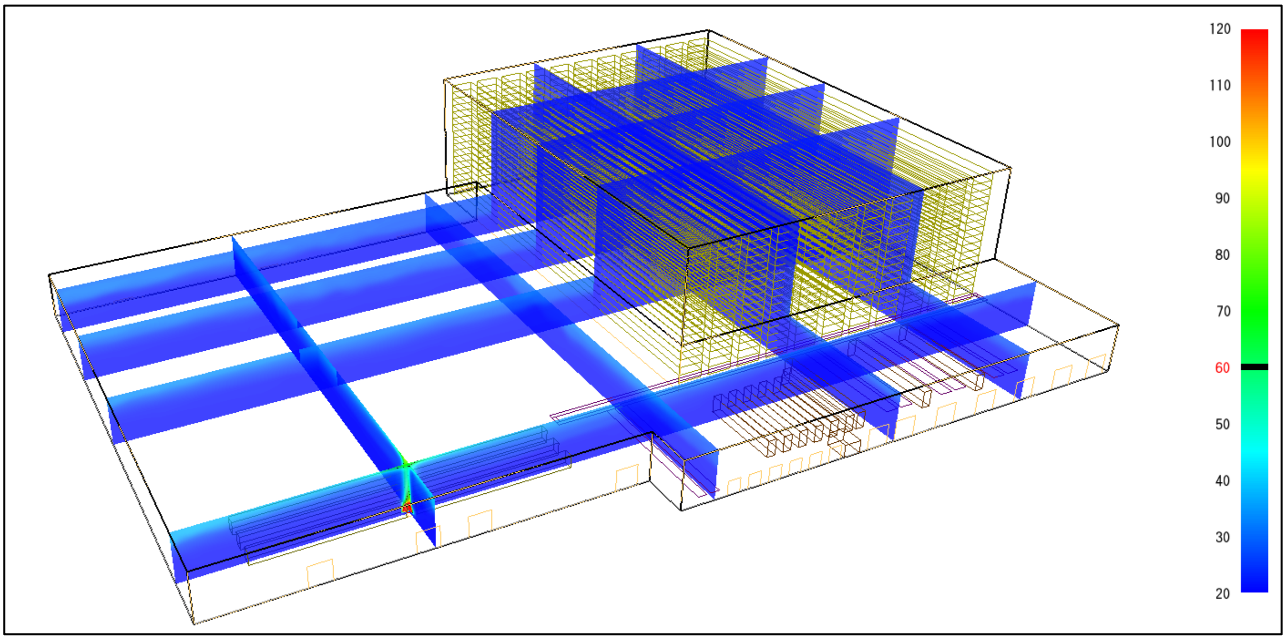


Figure D.24: Temperature Slice File at 1800 seconds

D.4.5 Sensitivity Fire Scenario: SB04C and SB05C

D.4.5.1 Staging Area

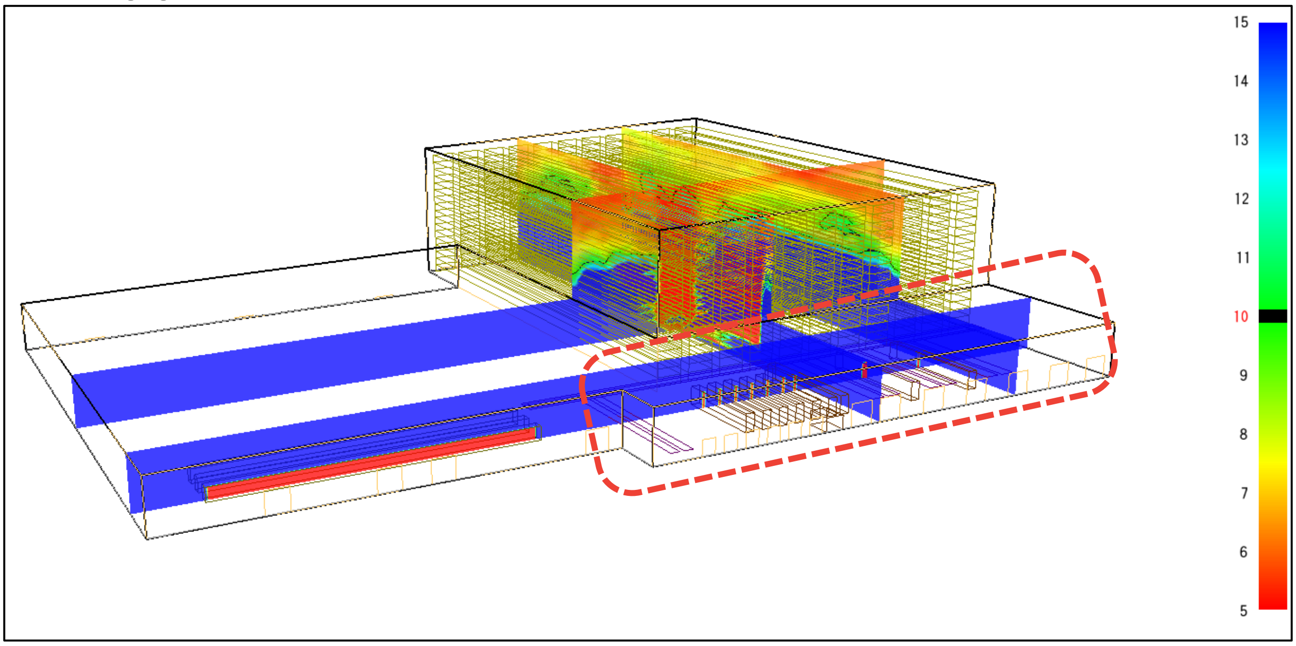


Figure D.25: Visibility Slice File at 556 seconds (RSET)

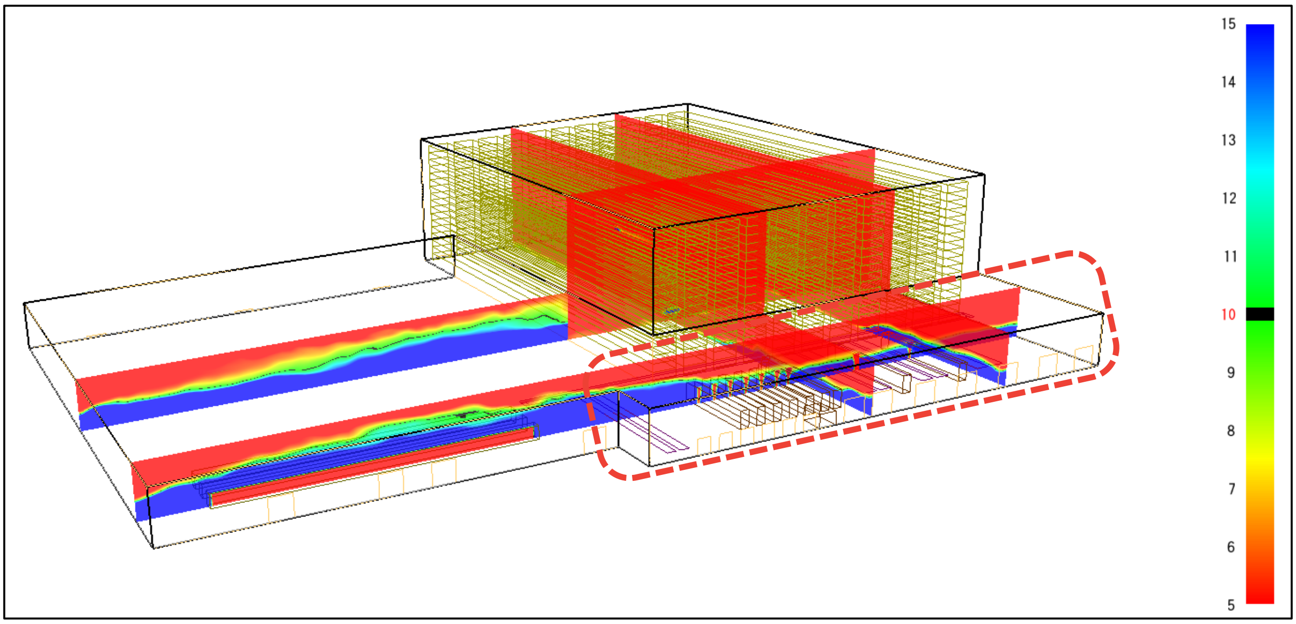


Figure D.26: Visibility Slice File at 3000 seconds (ASET)

D.4.5.2 Low Bay Warehouse

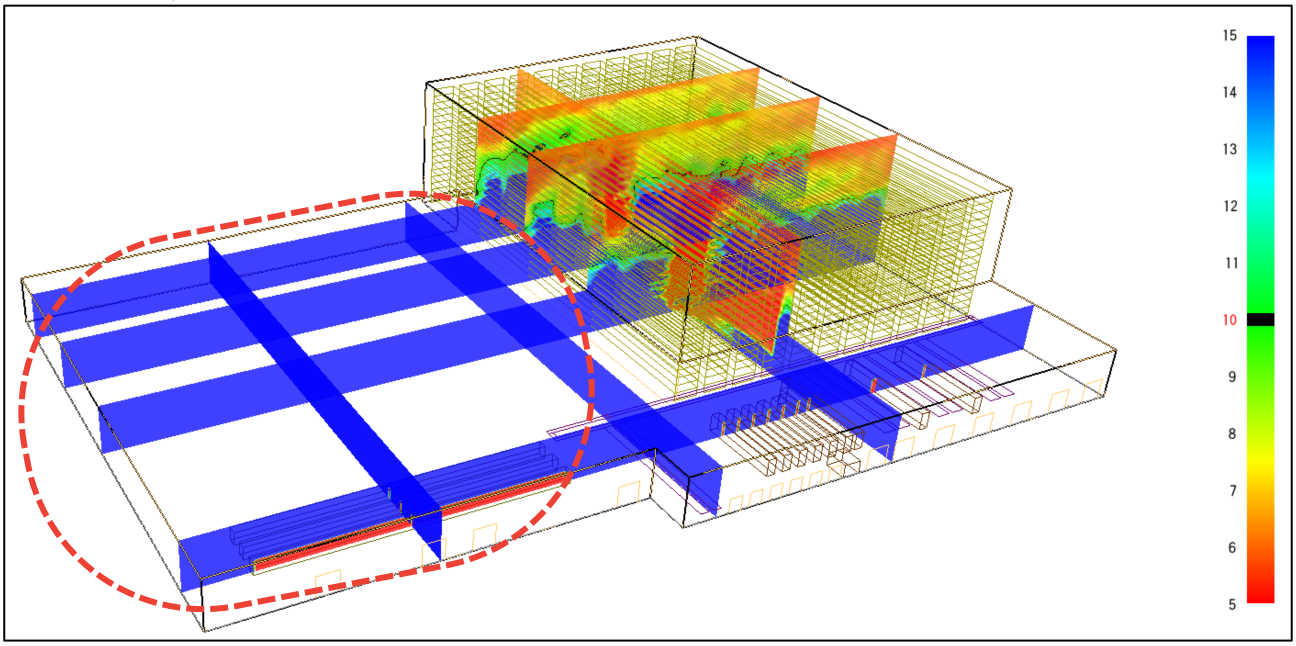


Figure D.27: Visibility Slice File at 596 seconds (RSET)

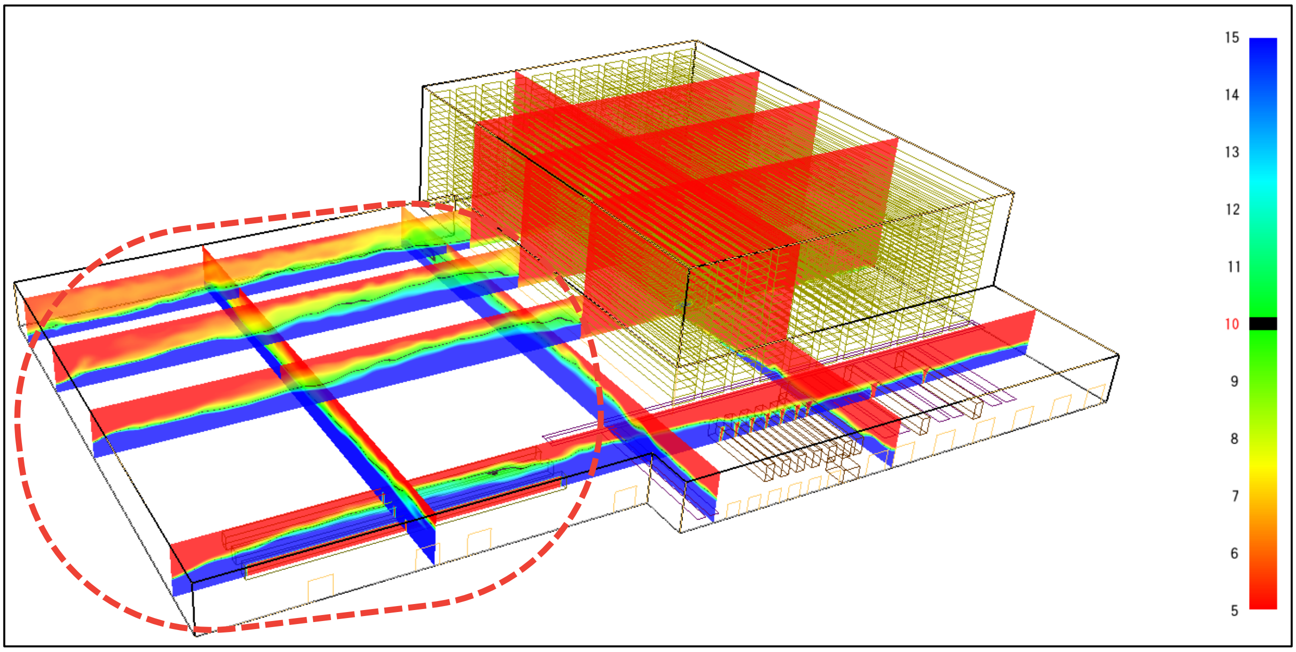


Figure D.28: Visibility Slice File at 3000 seconds (ASET)

D.4.5.3 High Bay Warehouse

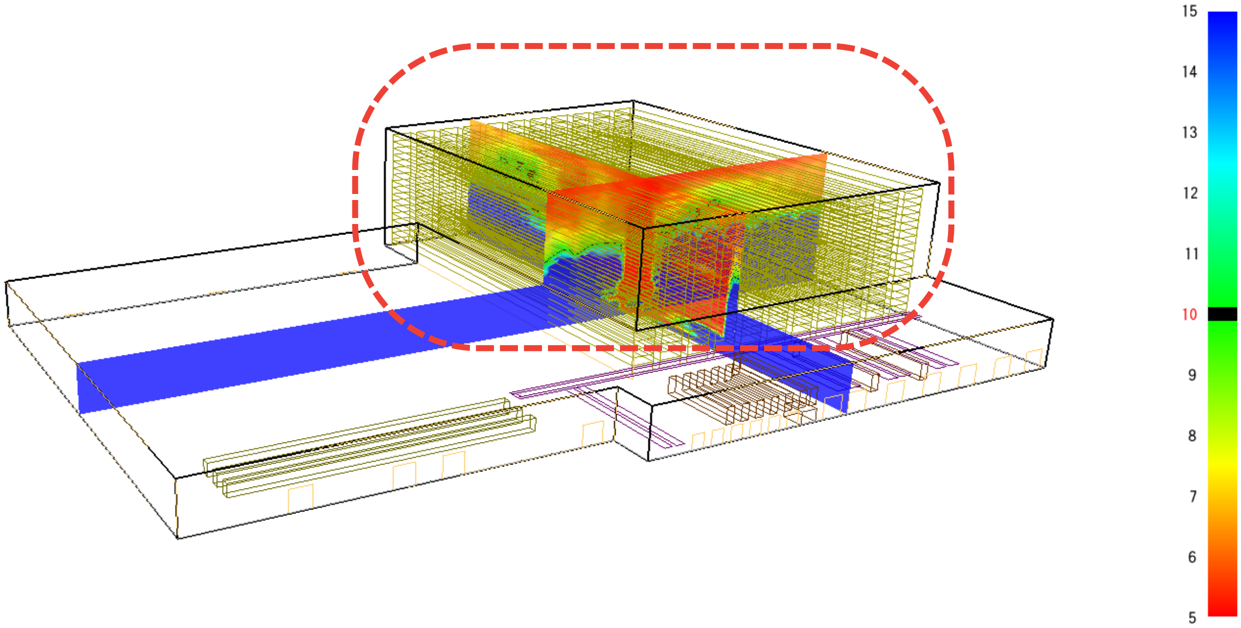


Figure D.29: Visibility Slice File at 571 seconds (RSET)

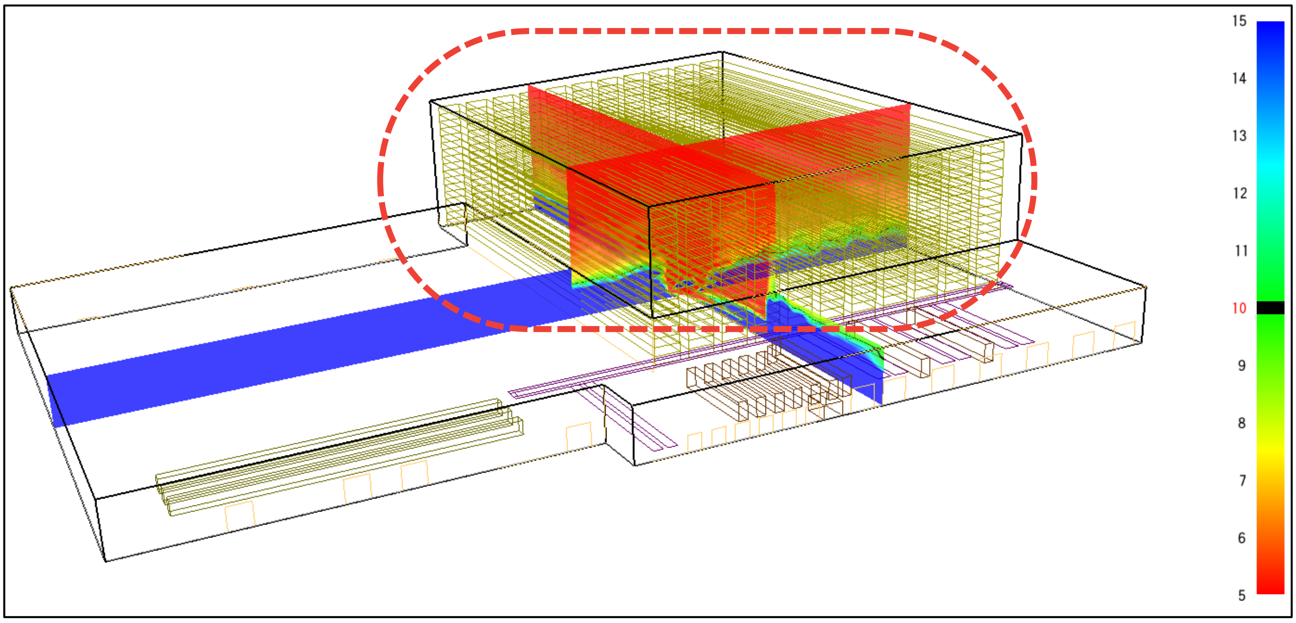


Figure D.30: Visibility Slice File at 1000 seconds (ASET)

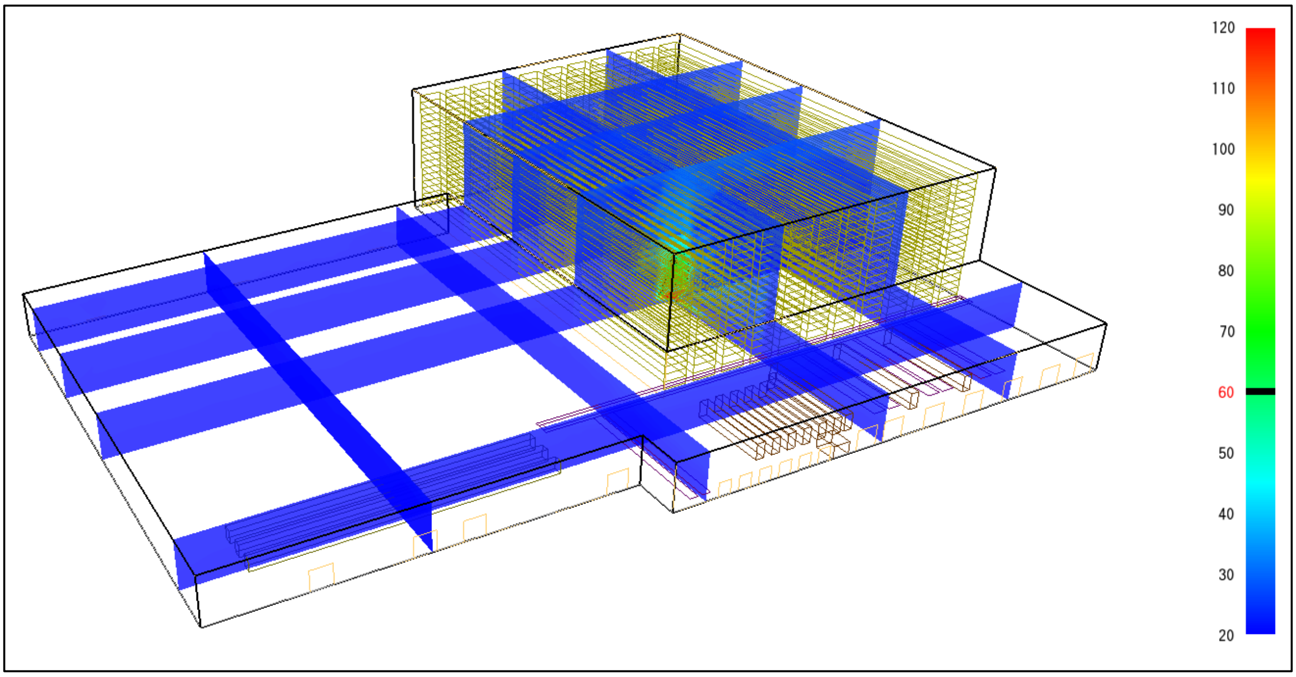


Figure D.31: Temperature Slice File at 3000 seconds

D.4.6 Core Fire Scenario SB05: SB01

D.4.6.1 Staging Area

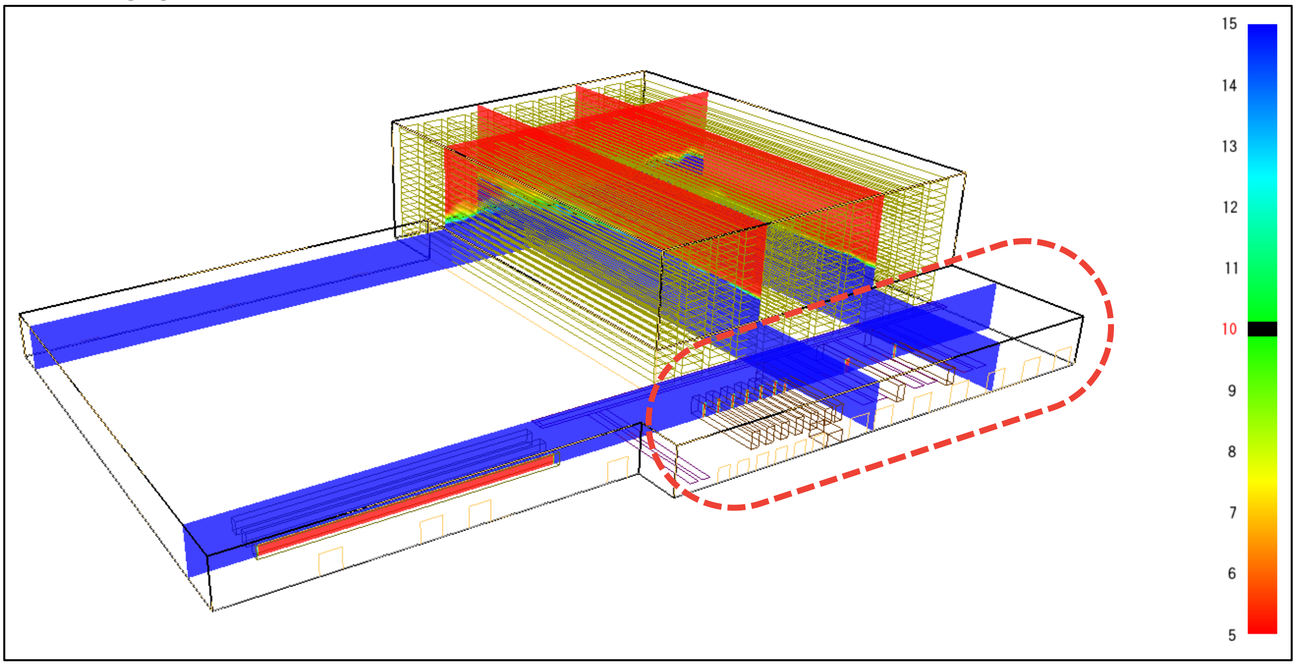


Figure D.32: Visibility Slice File at 654 seconds (RSET)

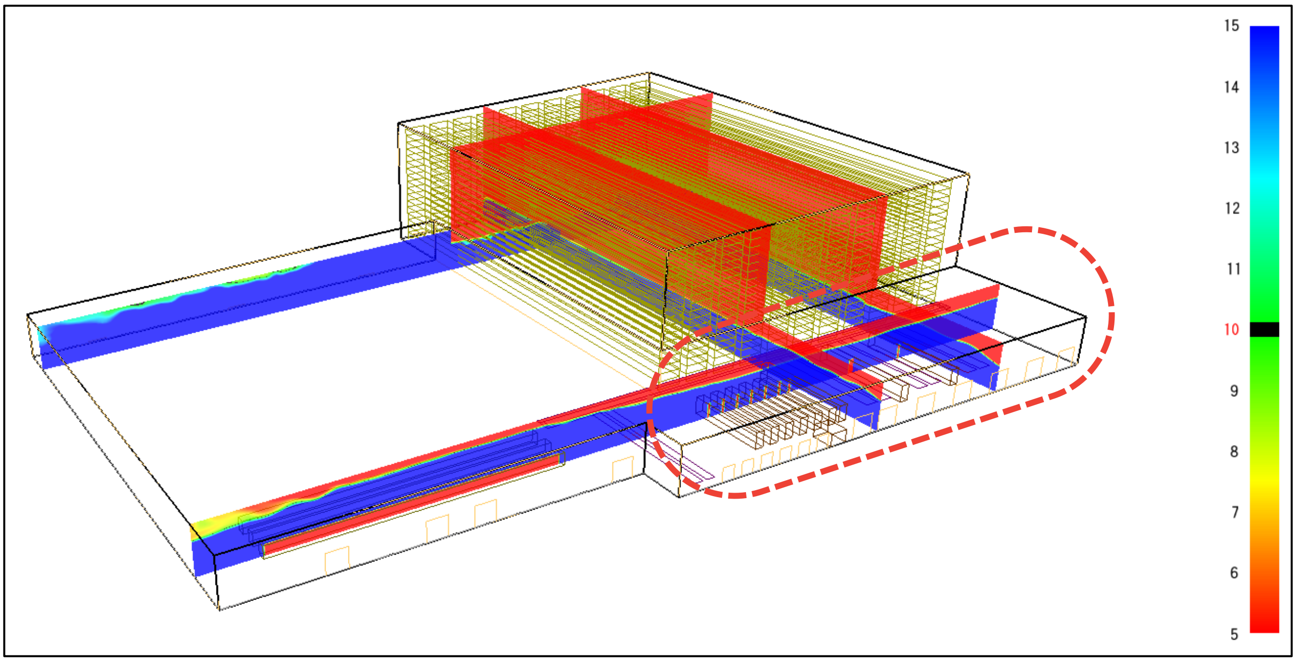


Figure D.33: Visibility Slice File at 3000 seconds (ASET)

D.4.6.2 Low Bay Warehouse

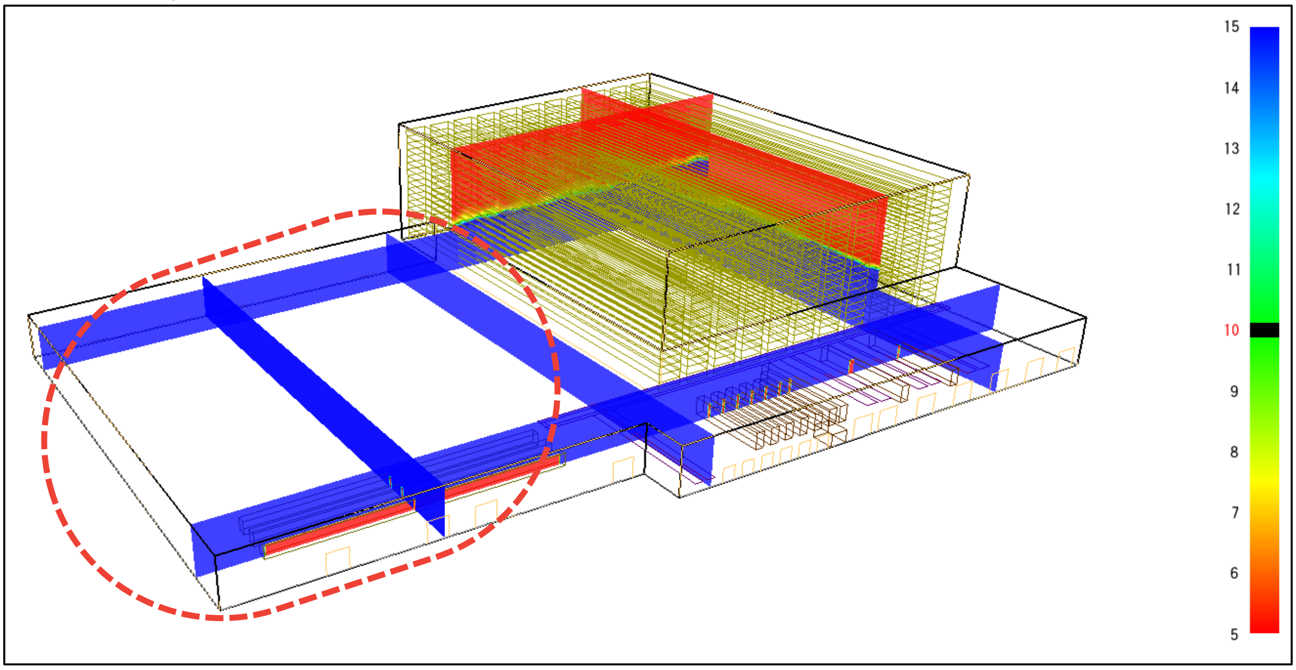


Figure D.34: Visibility Slice File at 694 seconds (RSET)

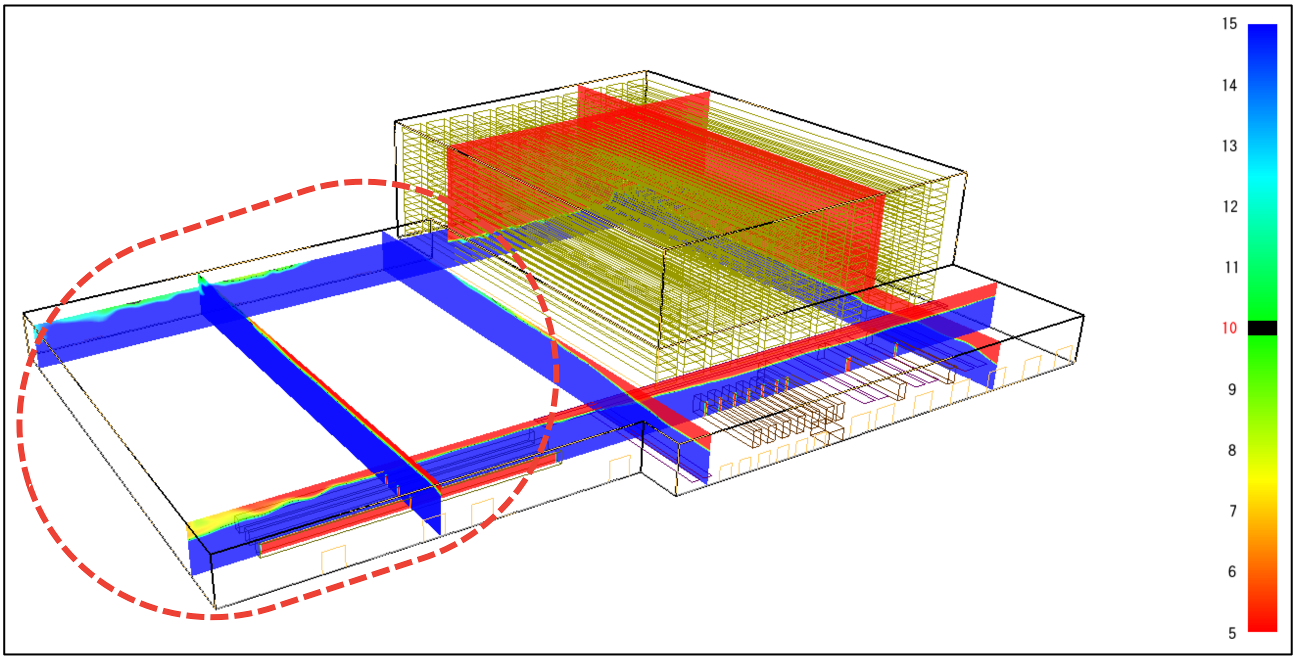


Figure D.35: Visibility Slice File at 3000 seconds (ASET)

D.4.6.3 High Bay Warehouse

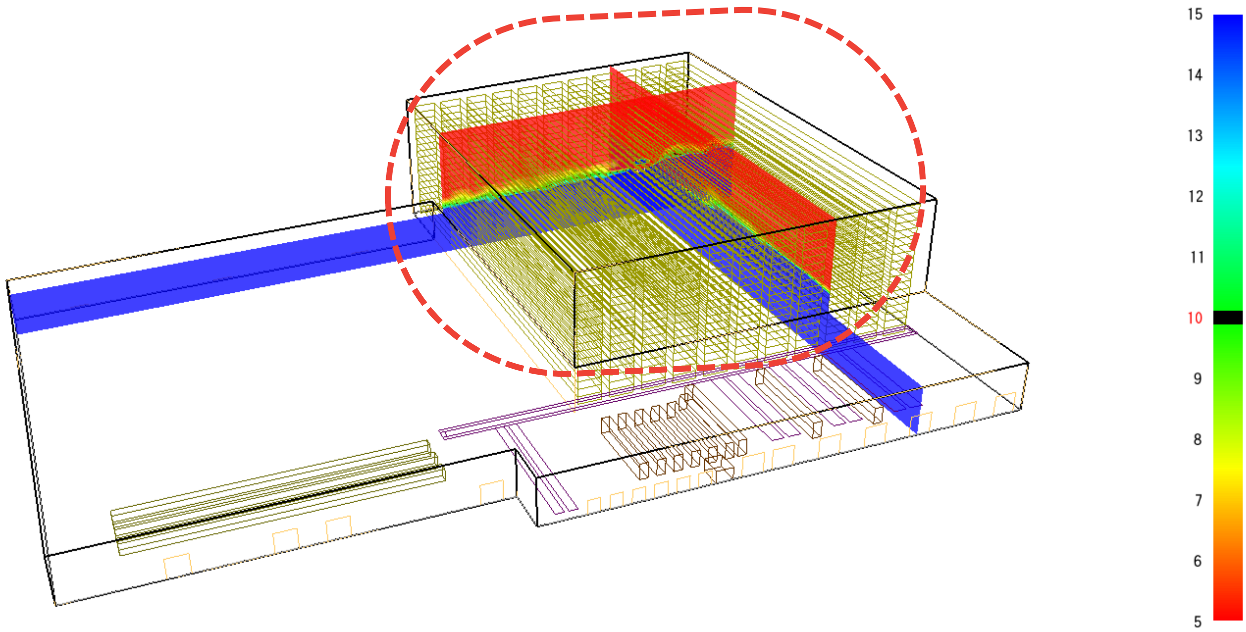


Figure D.36: Visibility Slice File at 669 seconds (RSET)

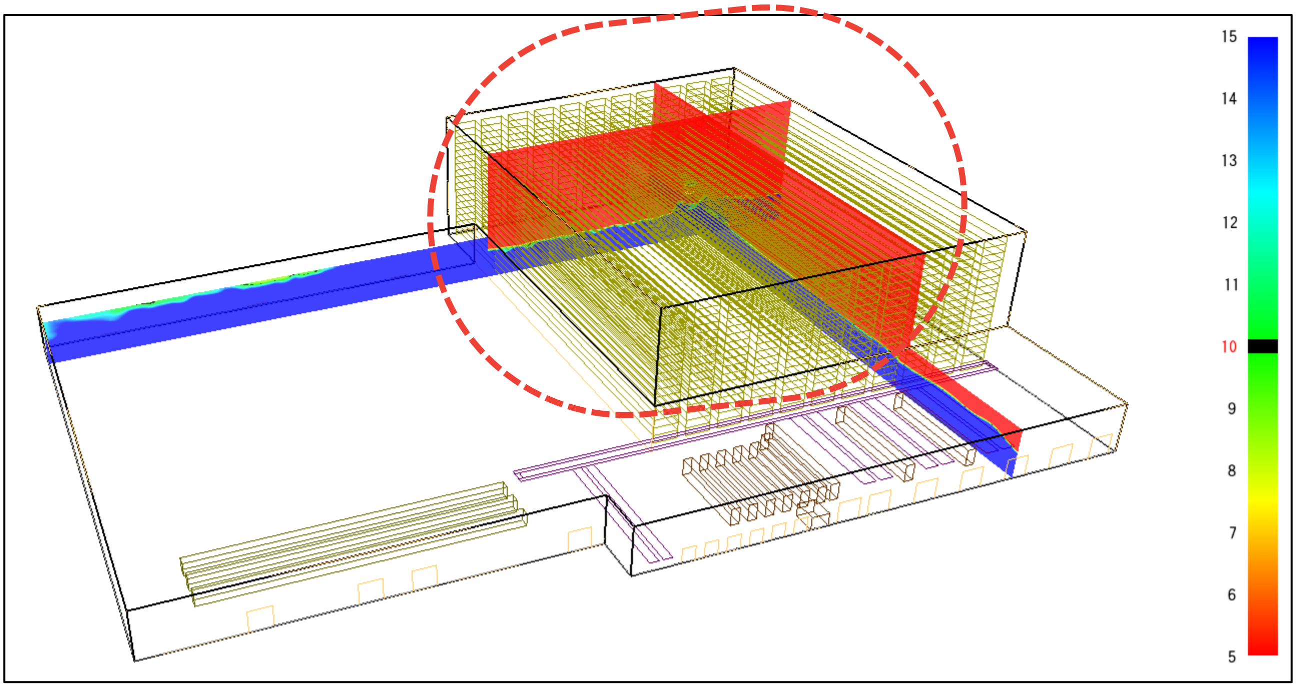


Figure D.37: Visibility Slice File at 3000 seconds (ASET)

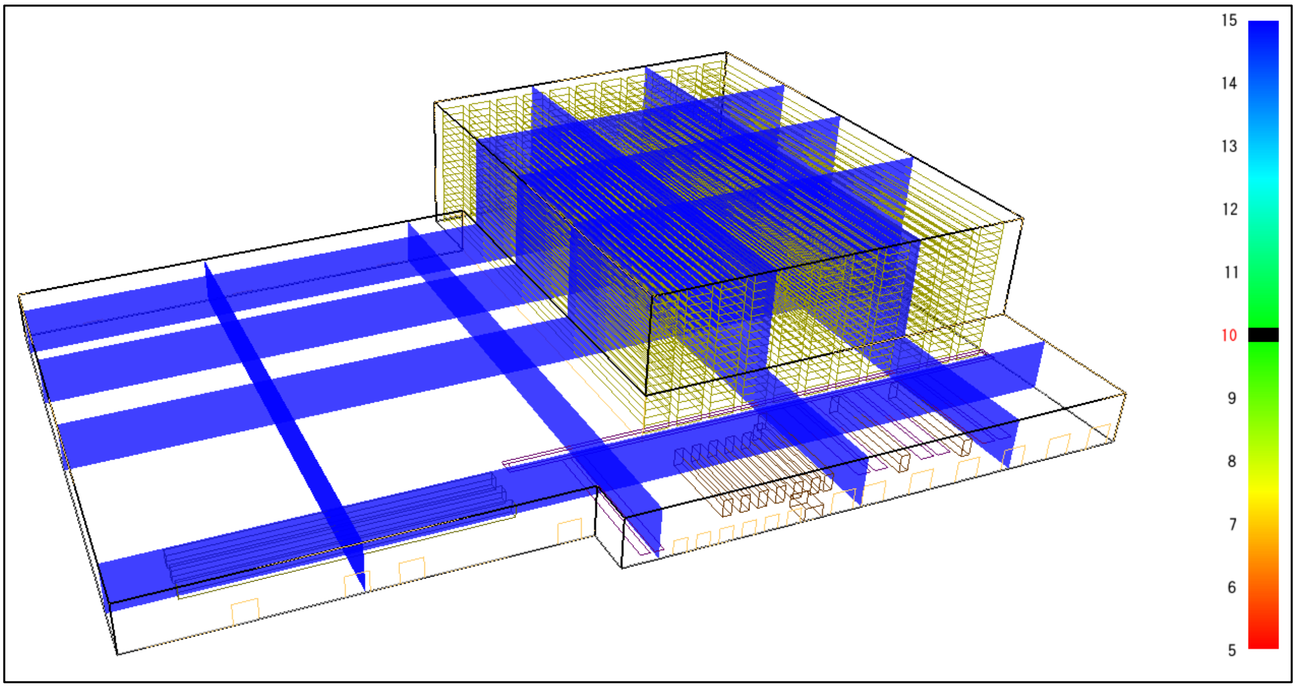


Figure D.38: Temperature Slice File at 3000 seconds

Appendix E. Occupant Movement Software (Pathfinder)

E.1 Pathfinder 3D Human Movement Simulation Model

The movement (or the floor clearing times) has been calculated using computer program Pathfinder. Pathfinder human movement simulation program is a validated and tested evacuation program. Pathfinder uses two primary options for occupant motion called SFPE mode and a steering mode. The SFPE mode implements the concepts in the SFPE Handbook of Fire Protection Engineering [Nelson and Mowrer, 2002]. This is a flow model, where walking speeds are determined by occupant density within each room and flow through doors is controlled by door width. The pathfinder computer program adopts the methodologies and principles outlined and based on actual research that has been conducted (IMO-Evacuation Analyses for New and Existing Passenger Ships). Pathfinder uses an occupant profile system to manage distributions of parameters across groups of occupants. This system helps you control the occupant speed, size, and visual distributions.

The alternate method in Pathfinder is the steering mode which is based on the idea of inverse steering behaviours. Steering behaviours were first presented in Craig Reynolds' paper "Steering Behaviours For Autonomous Characters" [Reynolds, 1999] and later refined into inverse steering behaviours in a paper by Heni Ben Amor [Amor et. al., 2006]. Pathfinder's steering mode allows more complex behaviour to naturally emerge as a by-product of the movement algorithms - eliminating the need for explicit door queues and density calculations. It is noted that in this instance the SFPE mode was incorporated in the Pathfinder simulation.

Pathfinder is an agent-based egress simulator that uses steering behaviours to model occupant motion throughout evacuation. It consists of three modules:

- The graphical user interface: and
- The simulator; and
- The 3D results viewer.
- **Current Pathfinder release version:** Pathfinder-2018-4-1210

E.2 Applications of the Pathfinder Software

In the Pathfinder evacuation modelling the occupants may be allocated profiles and behaviours. The profile defines characteristics of the occupants, such as speed, radius, avatar, and colour. The behaviour defines a sequence of actions the occupant will take throughout the simulation, such as moving to a refuge area, waiting or queuing at the exit, and then exiting.

Behaviours in Pathfinder represent a sequence of actions the occupant will take throughout the simulation. For each occupant behaviour in an evacuation model dedicated to agents there is an implicit action to move the occupant to an exit. This implicit action will always happen last. Additional intermediate actions may also be added in Pathfinder evacuation modelling can make the occupant wait or travel to a non-exit destination, such as a room or particular location on the floor plate. By default in the Pathfinder model the occupant behaviour is called “Go to Any Exit.” This behaviour type simply makes the occupant move from their starting position to any exit present in the model by the fastest route.

The SFPE mode uses the set of assumptions presented in the SFPE Handbook of Fire Protection Engineering and generally gives answers similar to hand calculations, depending on or if selected assumptions have been applied in the model. In SFPE simulations, the mechanism that controls simulation movement is the door queue, as queuing generally governs occupant evacuation. The Steering mode is more dependent on collision avoidance and occupant interaction for the final answer and often gives answers more similar to experimental data than the SFPE mode.

All occupants in Pathfinder use individual (or agent based) decision making algorithms. The model is a PC-based computer program capable of simulating the evacuation of large numbers of people through geometrically complex buildings.

E.3 Verification and Validation of the Pathfinder Software

Verification and Validation of the Pathfinder program have been documented by Thunderhead Engineering and Rolf Jensen & Associates Fire Protection Consultants (Document no: Pathfinder 2009.1.0417, Document Title: Verification and Validation). The aforementioned document has conducted the following:

- Verification tests: Synthetic test cases designed to ensure that the simulator is performing as specified by the Pathfinder Technical Reference. Usually these tests attempt to isolate specific simulated quantities or behaviours and may include only a small number of occupants. This type of test often has very specific pass/fail criteria. Verification tests ensure that the software is implements a particular model correctly –they are not designed to measure how accurately that model reflects reality.

- The document has documented eleven (11) IMO (International Maritime Organization) Tests which have demonstrated satisfactory results. These tests are listed below:
  - Movement speed, and
  - Stairway speed (Up), and
  - Stairway speed (Down), and
  - Door flow rates, and
  - Initial delay times, and
  - Concave geometry (Boundaries), and
  - Multiple movement speeds, and
  - Counter flow, and
  - Sensitivity to available doors, and
  - Exit assignments, and
  - Congestions.
- Validation tests – Designed to measure how well Pathfinder's implementation of simulation models captures real behaviour. Usually these tests will explore the interaction between multiple simulations elements and may have less specific pass/fail criteria. Validation tests are usually based on experimental data or experience.
- Comparisons – Pathfinder results alongside the results of other simulators. These tests are design to give the reader a sense of where Pathfinder "fits in" relative to other simulation software.

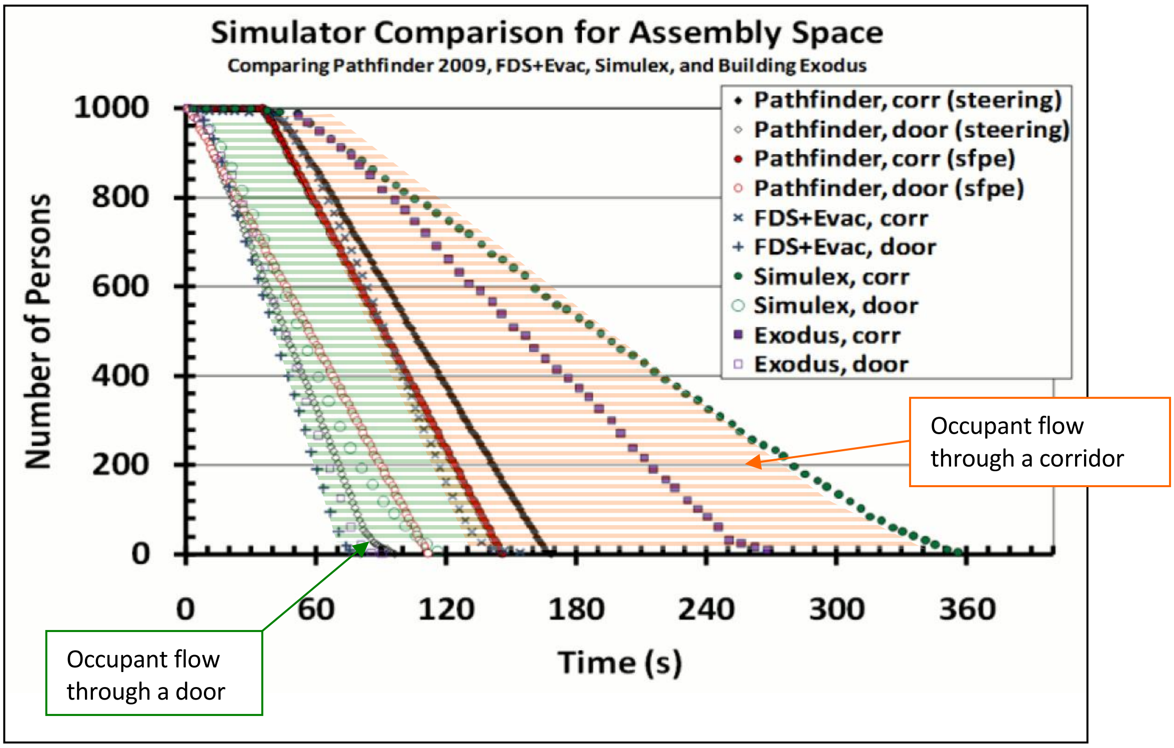


Figure E.1: Occupant movement simulator comparisons between different software.

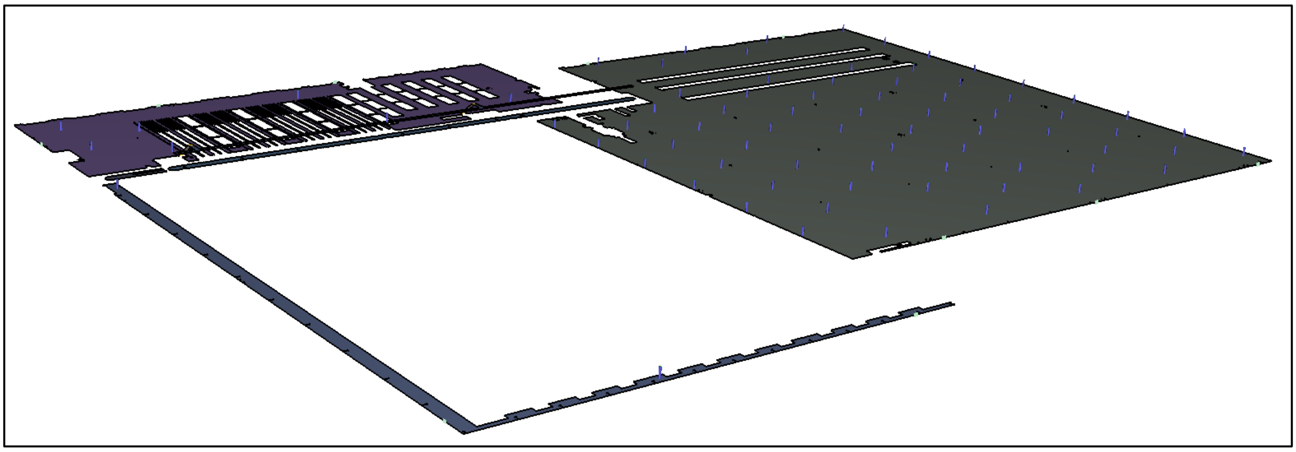
E.4 Occupant Risk Contour Approach

The risk contour approach is the concept methodology (Horasan, Kilmartin 2009) which has been adopted in this instance for the evacuation modelling. This concept has also been adopted and reflected by the New Zealand Department of Building and Housing as part of the Building Codes in the document titled "C/VM2 Verification Method: Framework for Fire Safety Design For New Zealand Building Code Clauses C1-C6 Protection from Fire".

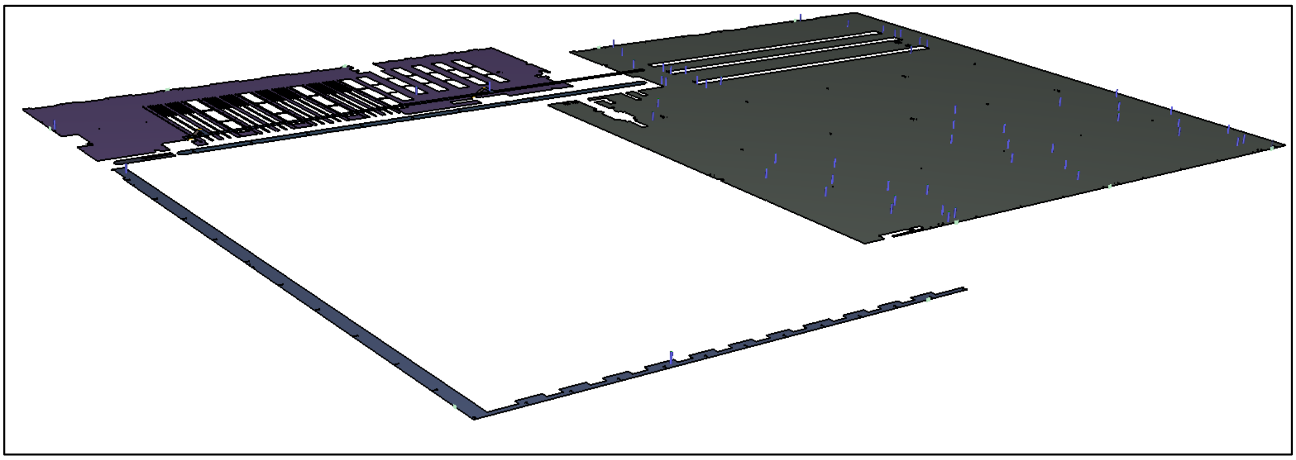
It is important to highlight that the evacuation modelling forming part of the overall Life Safety Analysis was performed utilising the 'Pathfinder' computer software program. The 'Pathfinder' computer software program was used to compute the cumulative time for both **pre-movement and movement times**. Verification and Validation of the Pathfinder program has been documented by Thunderhead Engineering and Rolf Jensen & Associates Fire Protection Consultants.

E.5 Pathfinder Graphical Results

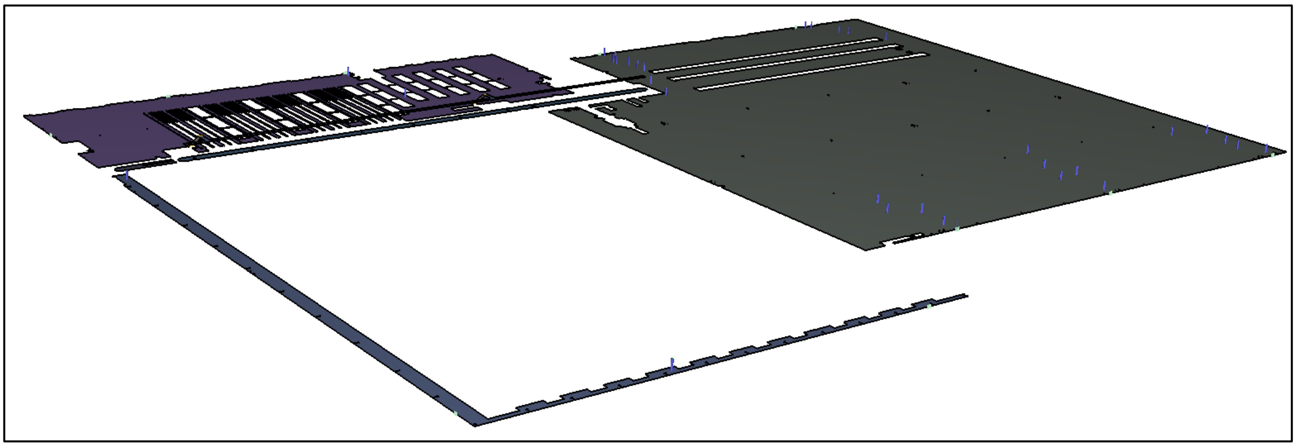
E.5.1 Core Evacuation Scenario (SB01C, SB02C, SB02C)



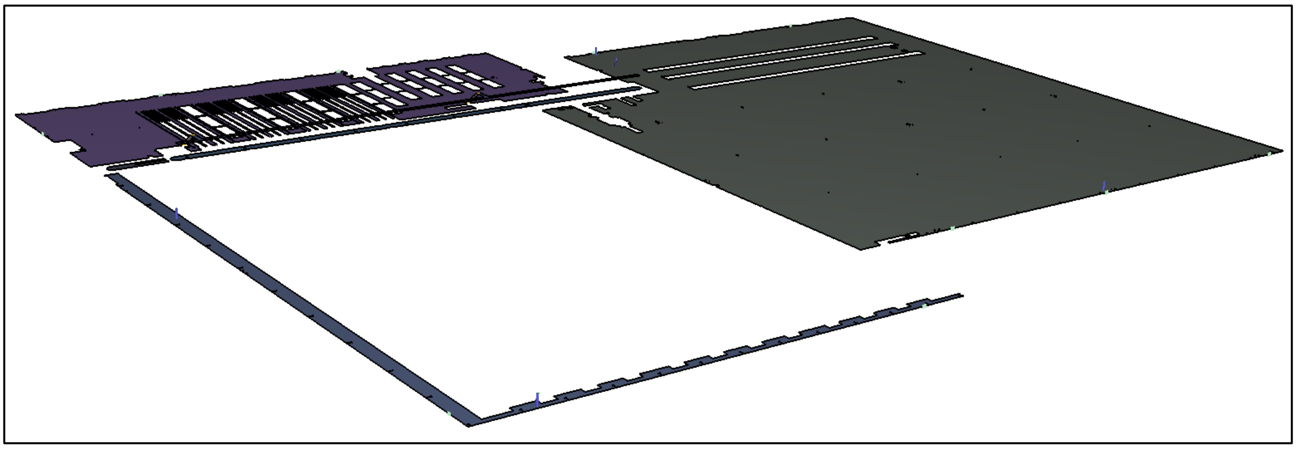
Snapshot at 0-60 seconds



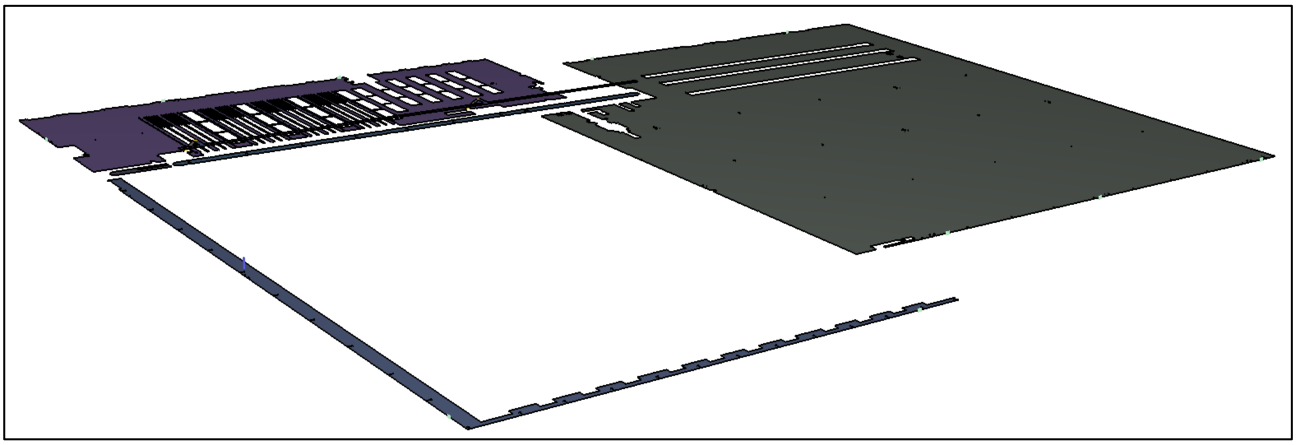
Snapshot at 90 seconds



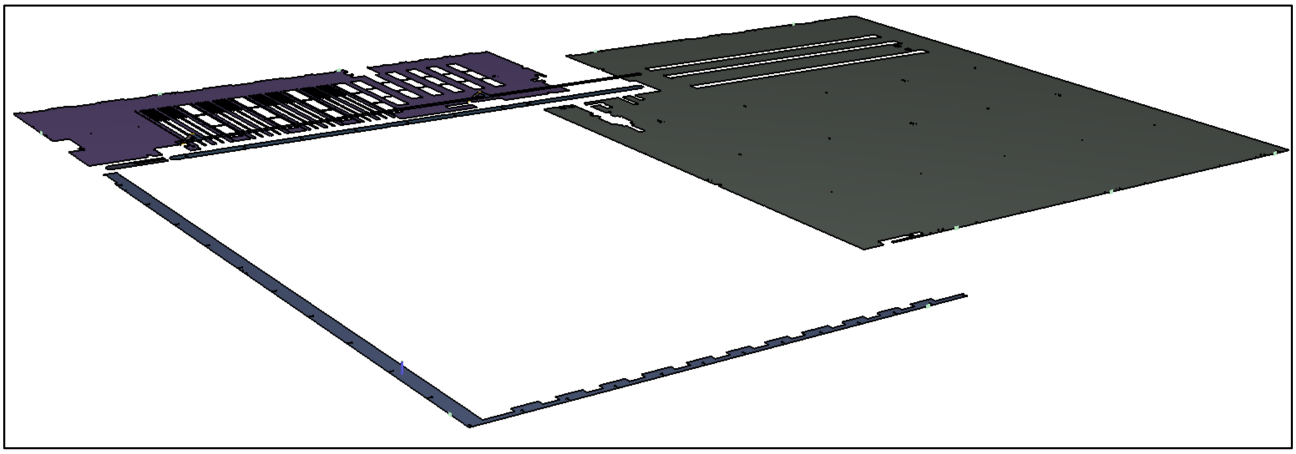
Snapshot at 120 seconds



Snapshot at 150 seconds



Snapshot at 180 seconds



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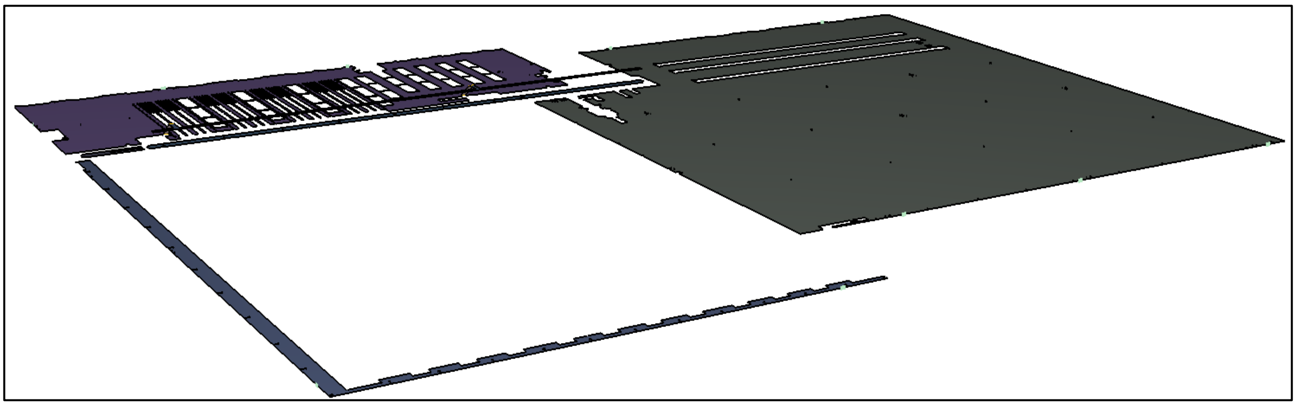
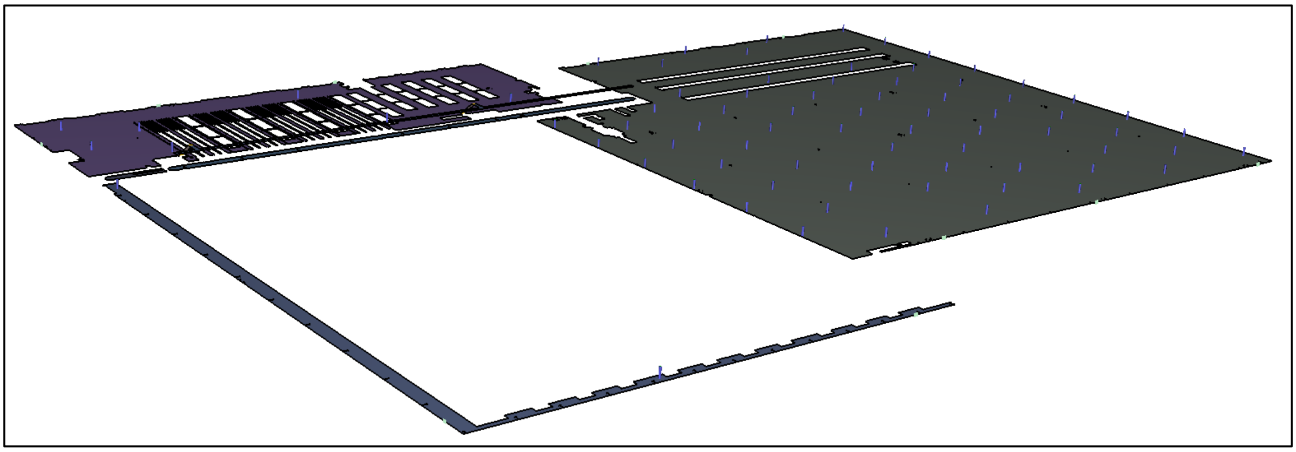
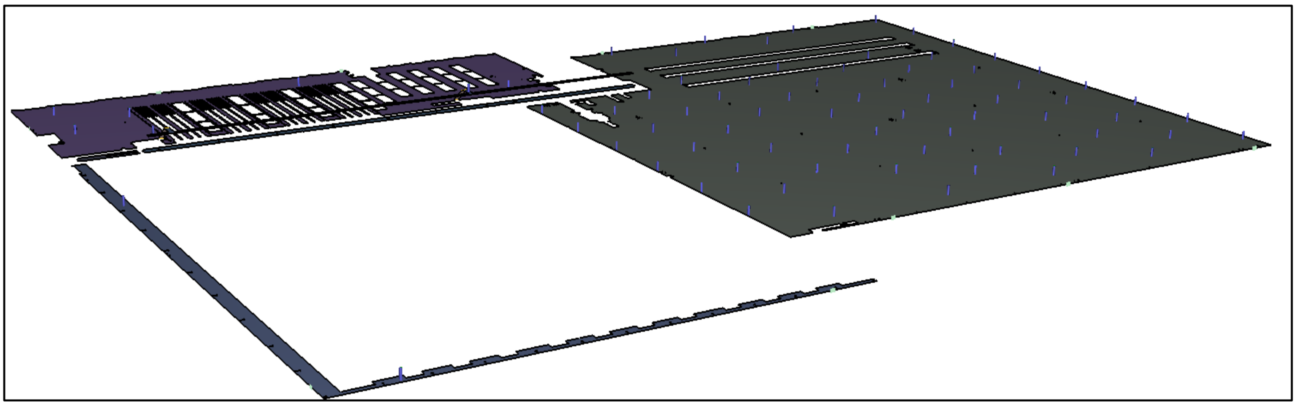


Snapshot at 260 seconds

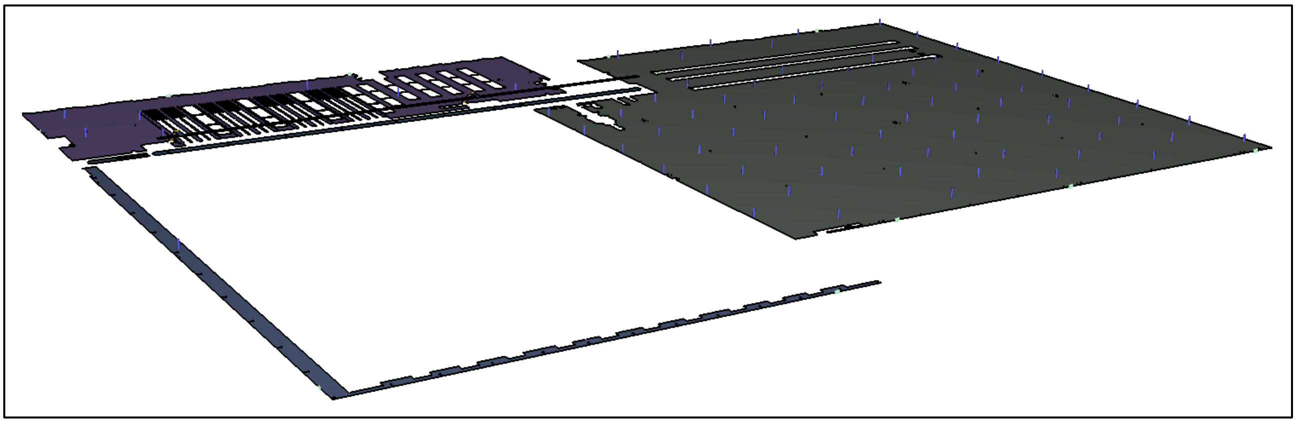
E.5.2 Core Evacuation Scenario (SB04C, SB05C)



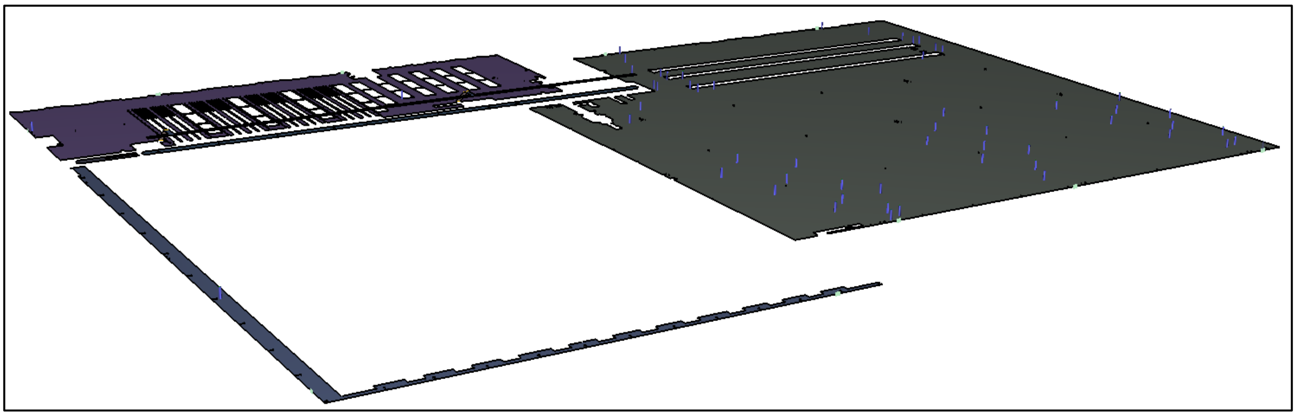
Snapshot at 0-60 seconds



Snapshot at 90 seconds



Snapshot at 120 seconds



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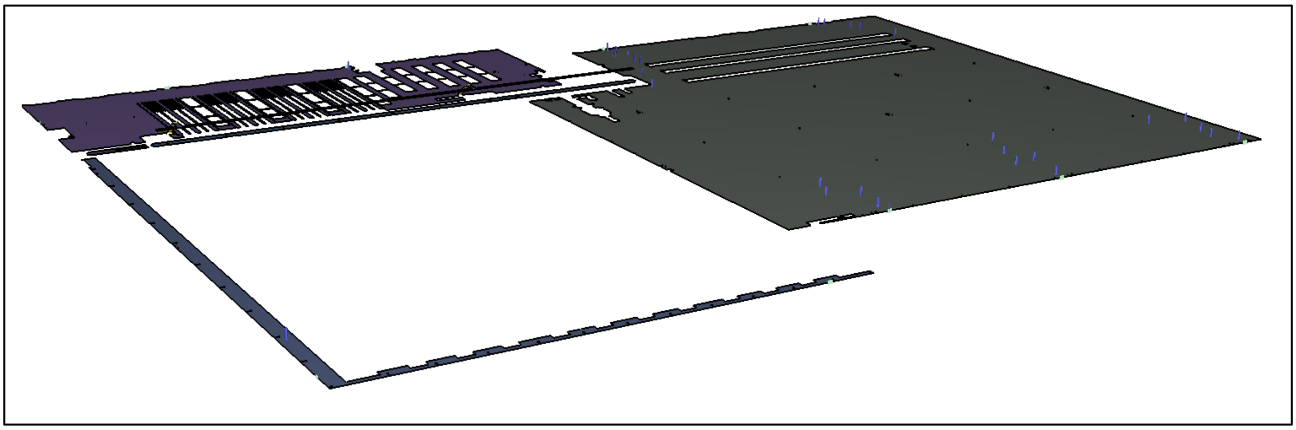
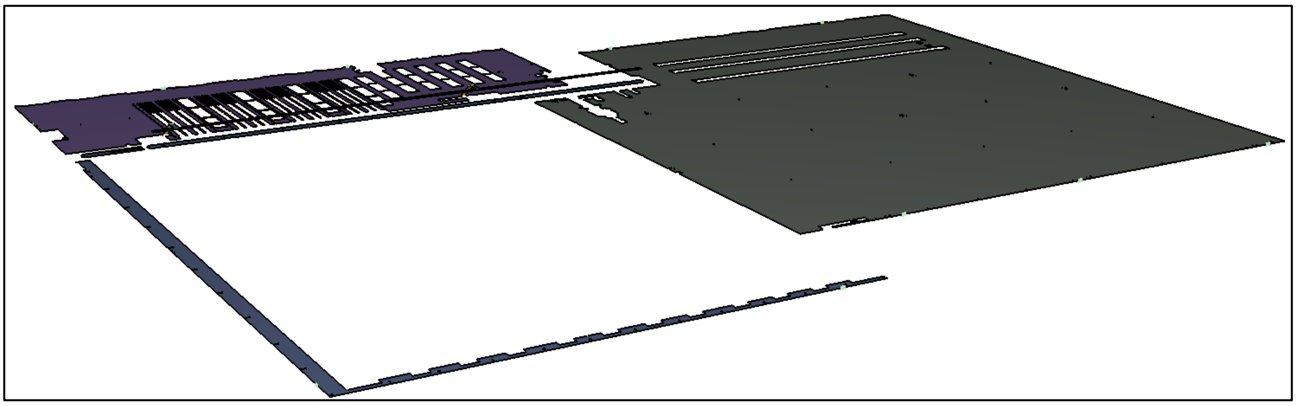
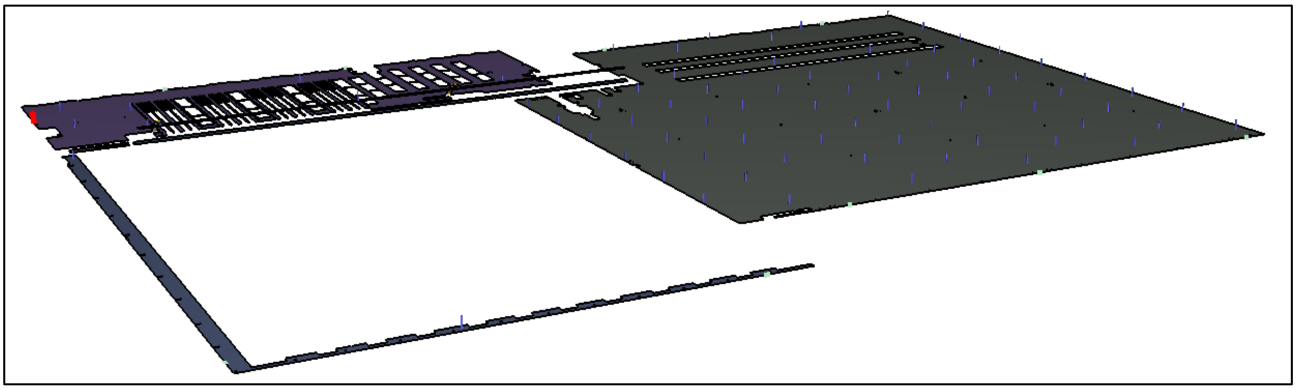


Snapshot at 180 seconds



Snapshot at 225 seconds

E.5.3 Sensitivity Evacuation Scenario (SB01S)



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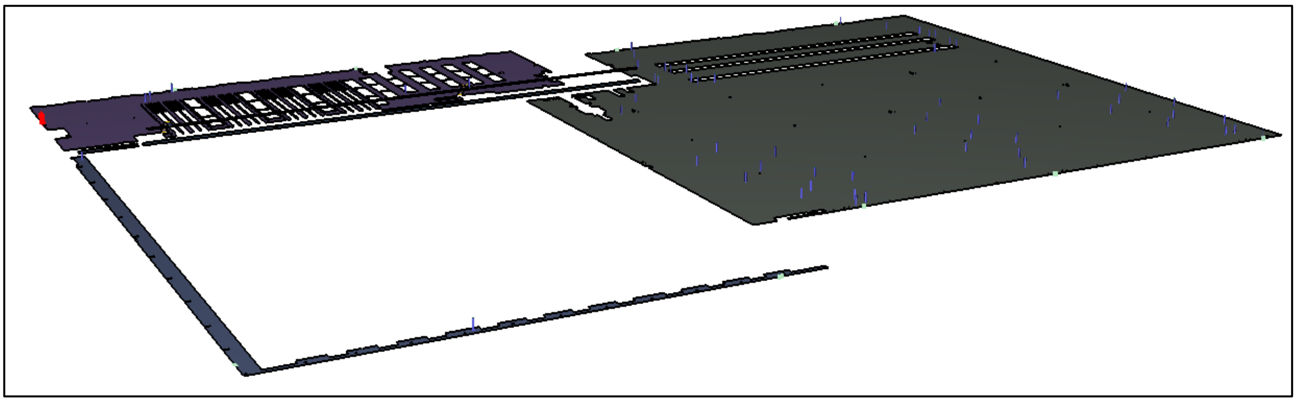

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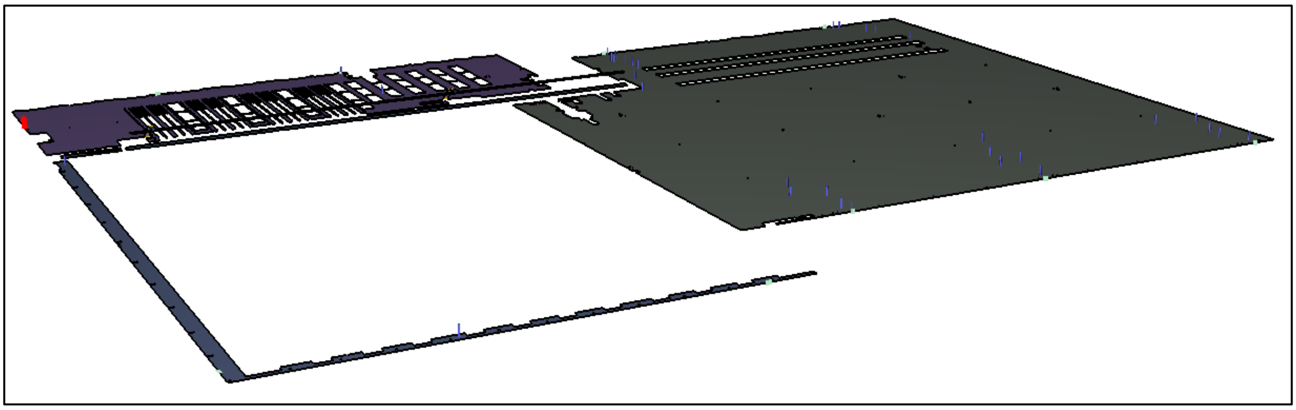
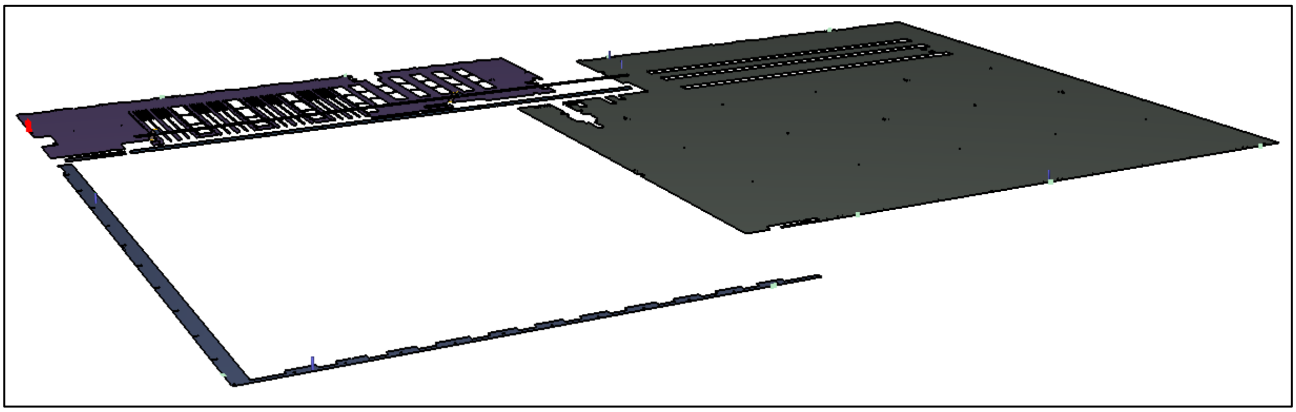


Snapshot at 120 seconds



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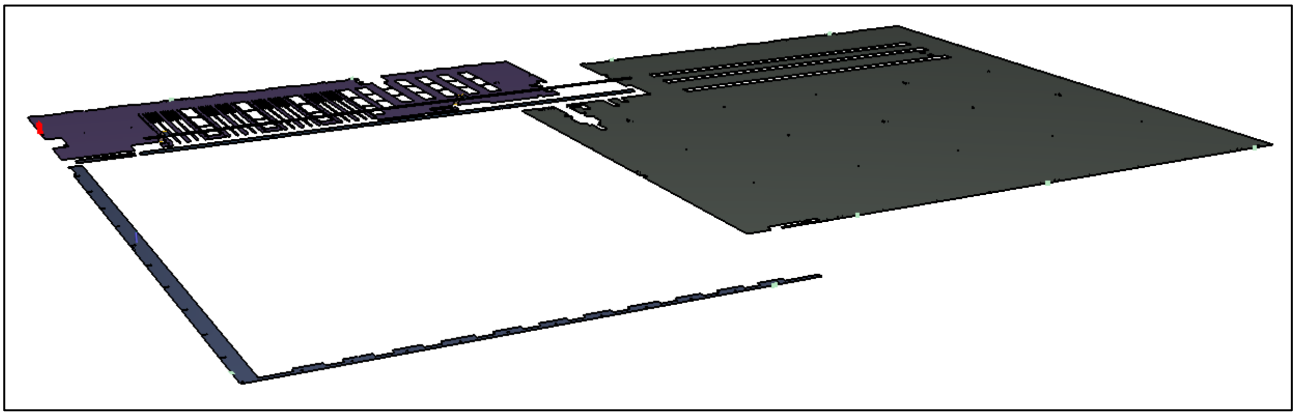
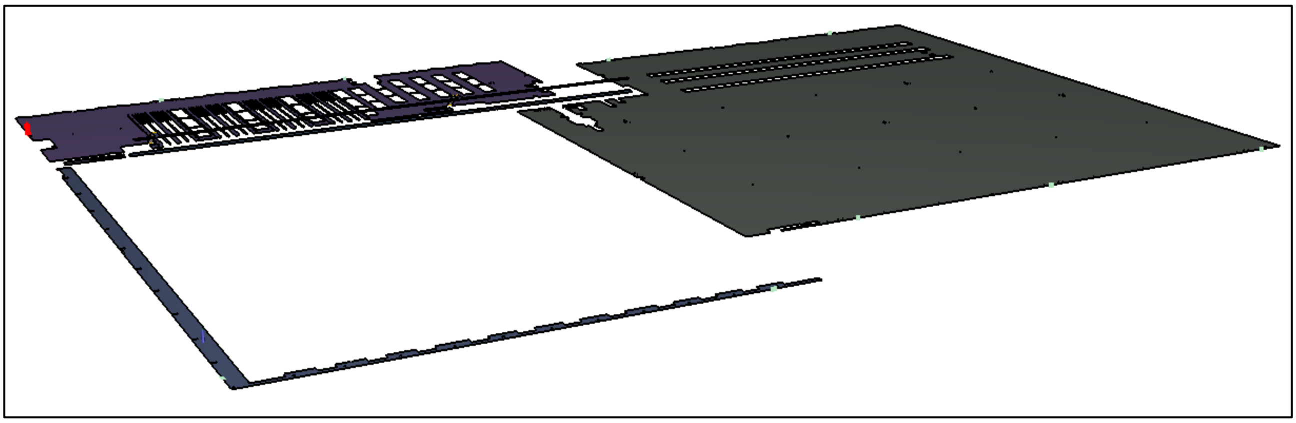
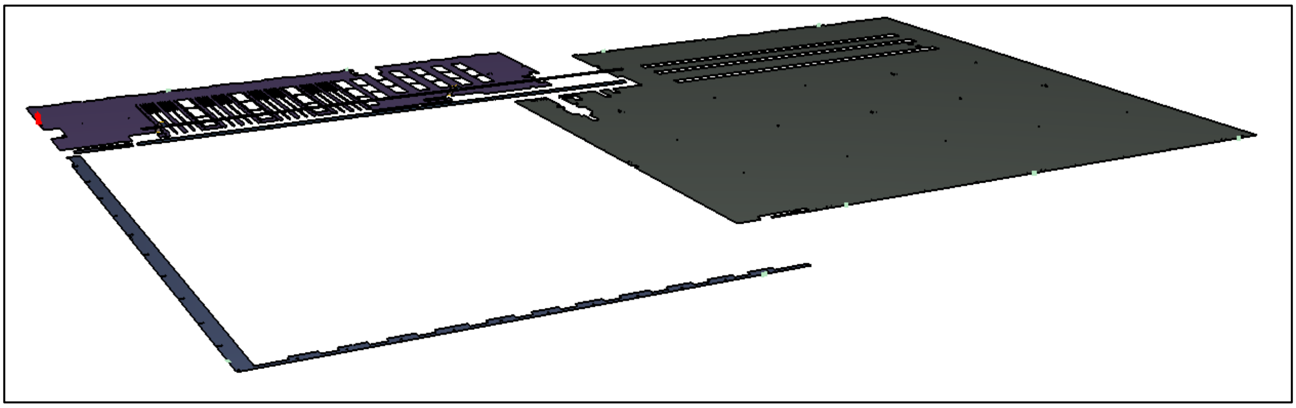


Snapshot at 180 seconds



Snapshot at 240 seconds



Snapshot at 260 seconds

Appendix F. Design Fire Documentation & Justification

F.1 General Overview

Design fires are to be adopted for each of the proposed fire scenarios that have been identified as most appropriate for the subject centre. Each design fire must have consideration for the fuel loads its orientation and the amount of ventilation. Fuel controlled fires represent the principal design fires for those areas not protected with automatic sprinklers (high ceiling level areas etc). The principal form of intervention considered in the fire and smoke modelling assessment is that of occupant or fire fighter suppression activities. It should be noted that the building is to be installed with a sprinkler system and therefore, it is more likely that within areas where sprinkler protection has been afforded the sprinklers will automatically operate and effectively control any potential fire. Extensive studies carried out by a number of experts (including Marryatt) covering the past century of sprinkler protected buildings have confirmed that these systems are inherently reliable if well maintained and managed.

It is unrealistic to adopt a single fire that represents the extreme worst case as the principal design fire and apply it to all fire scenarios required to be modelled. It is considered that systems appropriately design commissioned and maintained would work as designed and hence the worst-case design fire would be a fire that did not take into account such systems. For example, in a building with sprinklers, the principal design fire would not be that in which sprinkler system failure is assumed. This scenario would be considered but the tenability criteria adopted for the assessment of this scenario may be less conservative than that adopted for the sprinkler affected fires. Using the worst-case scenario as the controlling design fire would lead to unacceptable and extremely conservative designs. Assessments conducted to consider the potential impact of fires which are more severe than the principal design fire may be used to assess the sensitivity of the performance solutions applied.

The design fire for any location is therefore considered the *worst credible* fire size given the nature of the fuel type and disposition and elements being assessed. Whilst there is a large amount of information concerning the burning rate of items, rarely is this information sufficiently generic to be universally adopted and what may be representative of current fuel loadings may not be the case in years to come. In any event it would be a rare assessment in which the specific items forming the fuel load had been tested to provide fire rate of heat release data.

Much experimental work has been carried out on the burning rates of items. These have been closely examined and translated into a simplified mathematical expression relating heat release rate with time after commencement of the flaming stage of fire growth. The unpredictable incubation phase of fire development is not included. The basis of the mathematical simplification arises from the fact that the fire growth during the flaming stage can be approximated by a smooth curve which can be expressed mathematically.

It should be noted that this data is determined from test fires in which there is an adequate supply of air. The fire is not ventilation controlled and neither is there the radiant heat feedback into the burning item that occurs when a fire occurs in an enclosure with a ceiling. In this latter case, the hot smoke retained in the enclosure provides a radiant heat source to the fuel which may significantly change the burning rate from that determined during a test fire.

The growth rates of fires used in the modelling of smoke and fire spread can be conveniently defined by a quadratic equation of the form:

$$Q = (t/k)^2$$

where

Q = is the rate of heat release (MW)

k = is a constant, the fire growth parameter (MW/sec²)

t = is the time after ignition of the fire (seconds)

The continued growth of a fire defined by the above equation relies on a sufficient source of fuel and air and further assumes that flashover has not occurred within the fire compartment or that any suppression measures have been employed.

Studies of actual fire tests has led to the adoption of four standard fire growth rates covering a wide range of potential fire scenarios and fuel loads. The four standard fire growth rate models are those presented below:

‘Ultrafast' where k = 75

‘Fast' where k = 150

‘Medium' where k = 300

‘Slow' where k = 600

As noted, the times of the fire incubation period are not included in the use of the t^2 fire growth models to predict fire size over time. Figure F.1 illustrates typical fire growth rates.

The design fire curve represents the initial stages of a fire. For each scenario the design fire is modified to take into account either the action of fire suppression measures or the reduction of available fuel or lack of ventilation. These scenario fires are used in the computer models to determine the smoke spread between the enclosures or as the basis for assessing structural and barrier requirements.

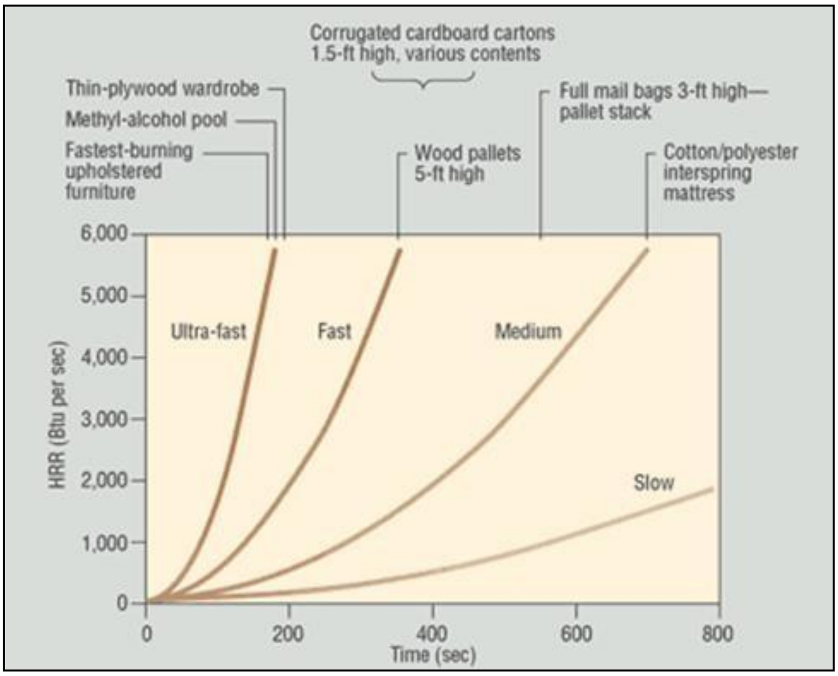


Figure F.1: Different t^2 Design Fires (based on test data)

F.2 Project Specific Design Fire Justification

It should be noted that the design fires were calculated using a number of calculations. The sprinkler activation times were found using an excel spread sheet model which incorporates formulas that have been referenced in R.L. Alpert Fire Technology 1972 pp181-195. The program computes the thermal response of a sprinkler head located near the ceiling where the ceiling is assumed to be unconfined.

The Storage Sprinkler head is based on the typical Viking Model K22 sprinkler (refer to Appendix G) which was calculated using a Response Time Index (RTI) of $50m^{-0.5}s^{-0.5}$ and an actuation temperature (for analysis purposes) of 100˚C. As per the example data sheet, Storage sprinkler heads can be supplied with temperature rating of 100ºC however as a conservative measure, 100ºC has been utilised as the actuation temperature. Storage sprinkler systems are designed for use with storage heights of up to 12.2m and maximum ceiling heights of 13.7m.

As the building is fitted with storage type sprinkles the core fire scenarios consist of fires that are controlled by the activation of sprinklers. In the scenario where sprinklers fail to activate or control the fire, the fire detection system becomes the means of automatic fire detection and furthermore, the fire growth rate continues to increase to represent fuel-controlled burning.

F.2.1 Project Specific Design Fires

The project specific design fires are based on the following incidents:

- Mechanical failure or malfunction of a forklift ignites the block storage within Low Bay Zone; and
- An electrical malfunction such as with the High Bay Zone is considered to ignite combustible contents within the sortation system.

F.3 SB01: Sprinkler Controlled Fire – Staging Area (Sortation System Fire (Core)

F.3.1 Ultra-Fast t^2 Fire Growth Rate

The adopted design fires within the sprinkler protected areas shall be based on the time at which the installed sprinkler system activates and hence impacts on the fire growth. The times adopted for sprinkler activation (time after ignition at which the fire would be controlled) within the subject warehouse shall be based upon the type of sprinkler heads installed, the location of the sprinkler heads above the finished floor level and the spacing of the sprinkler heads from each other.

For this fire scenario it is assumed that the storage sprinklers, as per their design specifications, would suppress and eventually extinguish the fire. The input to the sprinkler activation time model was based on the following specifications:

- Sprinkler Head Type:
  - Actuation Temp = 100°C, RTI = $50m^{0.5}s^{0.5}$
- Height Above the Finished Floor Level:
  - Maximum height above the finished floor level is 13.7m (to the ridge line)
- Sprinkler Head Spacing and distance of sprinkler from the axis of fire:
  - 3.1m x 3.1m grid ($9.6m^2$); R = 2.2m.
- Fire Growth Rate:
  - Ultra-Fast t^2 fire conservatively based on the presence of a wide range of goods stored within the storage racks.

The SB01 scenario shall assume that the first ring of sprinklers would activate, control and eventually extinguish the fire.

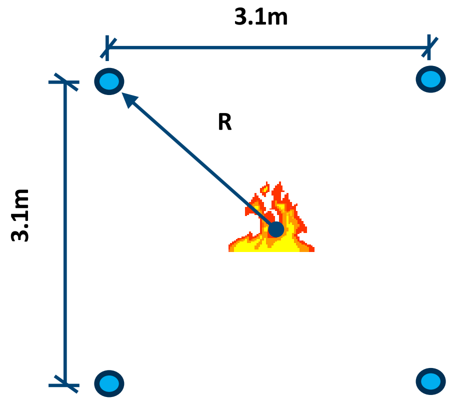


Figure F.2: First Ring of Sprinklers

The following illustrates the input to and the output from the sprinkler activation time calculations.

scientific fire services

Alpert's Correlation

Ambient Temperature, T =	20 (°C)
Fire Growth Rate =	Ultrafast
Time Step Interval =	20 (s)
Radial Distance of the Detector from the Fire, r =	2.20 (m)
The Height of the Ceiling above the fire, H =	13.7 (m)
The Response Time Index of the Detector, RTI =	50 ($m^{1/2}s^{1/2}$)
Sprinkler Density of Discharge =	5 mm / min
Sprinkler Activation Temperature =	100 (°C)
Calculated Quantites at Detector Activation	
The Gas Temperature at Sprinkler Activation, T =	108.83 (°C)
HRR at Sprinkler Activation =	8371.38 (kW)
The Gas Velocity, U =	7.60 (m/s)
Time at Sprinkler Activation =	218 (s)
Time to Reach 10% of peak HRR =	904 (s)
Ratio, r / H =	0.16

Illustration

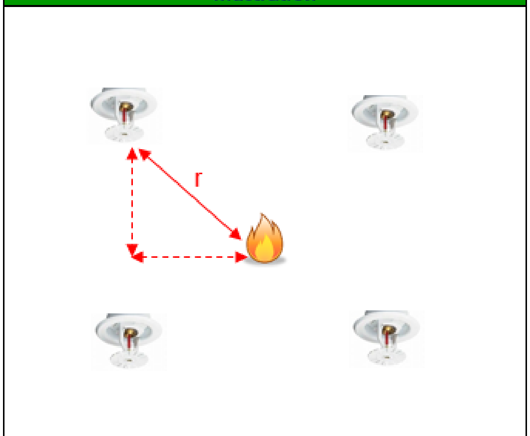


Figure F.3: Activation of sprinklers for SB01

The peak heat release rate has been calculated (at the time of sprinkler head activation) to be in the order of **8.5 MW**.

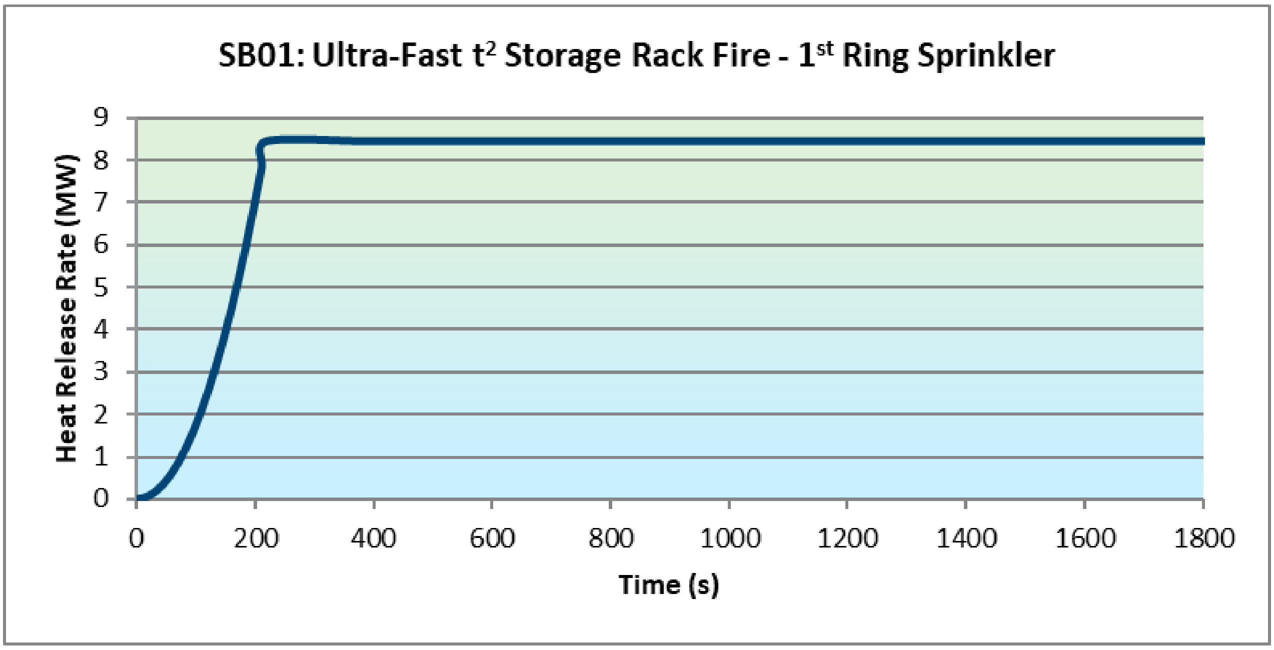


Figure F.4: SB01 Schematic design fire

F.4 SB02: Sprinkler Controlled Fire – Low Bay Area (Sortation System Fire (Sensitivity))

F.4.1 Ultra-fast t^2 Fire Growth Rate

The adopted design fire within the sprinkler protected storage area shall be based on the time at which the installed sprinkler system activates and hence impacts on the fire growth. The time adopted for sprinkler activation (time after ignition at which the fire would be controlled) within the subject warehouse shall be based on the type of sprinkler heads installed, the location of the sprinkler heads above the finished floor level and the spacing of the sprinkler heads from each other.

For this fire scenario it is assumed that the storage sprinklers, as per their design specifications, would suppress and eventually extinguish the fire. The input to the sprinkler activation time model was based on the following specifications:

- Sprinkler Head Type:
  - Actuation Temp = 100°C, RTI = $50m^{0.5}s^{0.5}$
- Height Above the Finished Floor Level:
  - Maximum height above the finished floor level is 13.7m (to the ridge line)
- Sprinkler Head Spacing and distance of sprinkler (second ring) from the axis of fire:
  - 3.1m x 3.1m grid ($9.6m^2$); R = 4.9m – based on second ring of sprinklers activate.
- Fire Growth Rate:
  - Ultra-Fast t^2 fire conservatively based on the presence of a wide range of goods stored with the storage racks.

The SB02 scenario shall assume that the second ring of sprinklers would activate and at least control the fire.

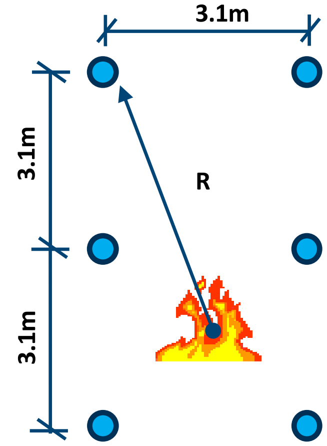


Figure F.5: Second ring sprinkler activation

The following illustrates the input to and the output from the sprinkler activation time calculations.

scientific fire services

Alpert's Correlation

Ambient Temperature, T =	20 (°C)
Fire Growth Rate =	Ultrafast
Time Step Interval =	20 (s)
Radial Distance of the Detector from the Fire, r =	4.90 (m)
The Height of the Ceiling above the fire, H =	13.7 (m)
The Response Time Index of the Detector, RTI =	50 ($m^{1/2}s^{1/2}$)
Sprinkler Density of Discharge =	5 mm / min
Sprinkler Activation Temperature =	100 (°C)
Calculated Quantites at Detector Activation	
The Gas Temperature at Sprinkler Activation, T =	107.97 (°C)
HRR at Sprinkler Activation =	16429.51 (kW)
The Gas Velocity, U =	4.88 (m/s)
Time at Sprinkler Activation =	305 (s)
Time to Reach 10% of peak HRR =	991 (s)
Ratio, r / H =	0.36

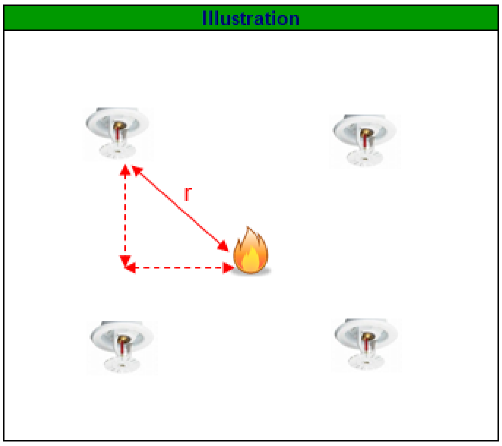


Figure F.6: Activation of sprinklers for SB02

The peak heat release rate has been calculated (at the time of sprinkler head activation) to be in the order of **16.6MW**.

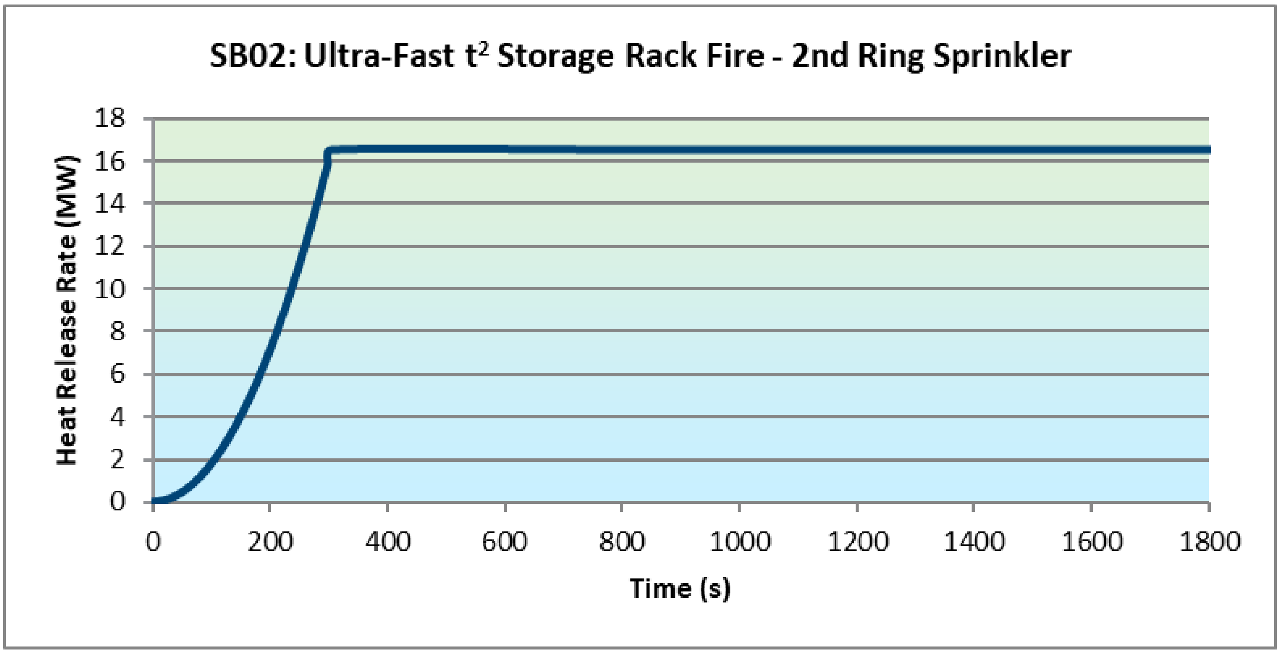


Figure F.7: SB02 Schematic design fire

F.5 SB03: Fuel Controlled Fire – Low Bay Area (Forklift & Storage Pallet Fire (Sensitivity))

F.5.1 Description of Fire Scenario

As part of the sortation and storage process within the warehouse facility a number of electrically powered forklifts are expected to be operating within this part of the building. Whilst it is unclear how many industrial fires are caused by forklift ignition sources and accidents, these fires are nonetheless well represented in the statistics and as such are relevant to the assessment for the subject premise. The forklifts are primarily used to transport goods. At times these goods may be stored on pallets (i.e. timber storage pallets). In this instance, a core fire scenario has been developed whereby a forklift fire shall initiate before spreading to a nearby storage/racking arrangement where additional combustibles are located. Published research material, a degree of engineering judgement and assumptions have been adopted to quantify the time when fire from the forklift is likely to spread to the stack of wooden pallet.

F.5.2 Fire Growth Rate – Forklift Fire

Rate of Heat Release (RHR) for a forklift can be similarly compared to a potentially small car fire. Free burn test data compiled by Lund University has been published with a small car fire being undertaken. The car used in the fire test was an ordinary sedan passenger vehicle and the RHR for the test is depicted as per the following:

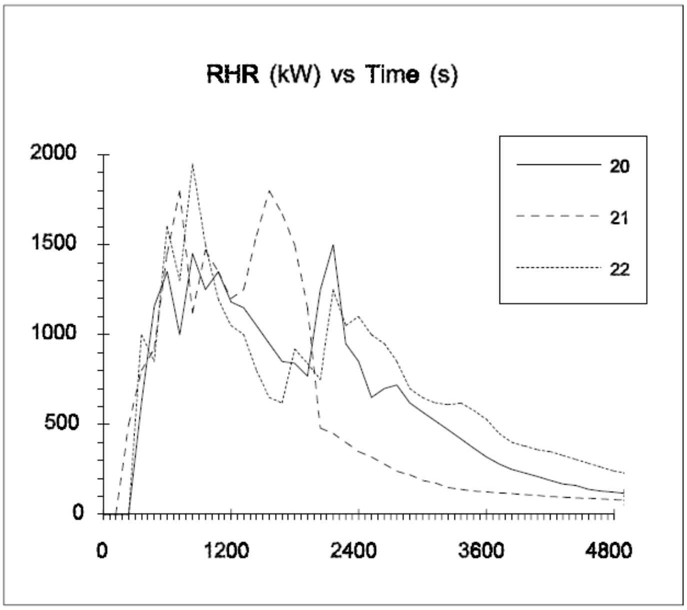


Figure F.8: RHR – Small car

As illustrated above, a total of three (3) tests were undertaken as denoted by Test 20, 21 & 22.

- Sample 20- Fuel burnt from the mouth of the filler pipe
- Sample 21- Fuel burnt from the mouth of the fuel tank and from a pool under the car, when the filler pipe and fuel hose melted
- Sample 22- Fuel burnt from the mouth of the fuel tank, when the filler pipe melted

As per the above, there is a considerable incubation period whereby the rate of heat release during the first 300-400 seconds is considered minimal. Based on the heat release rate curve results, 1MW is reached beyond 300 seconds and therefore, the fire growth curve is considered conservatively to be a medium t^2 fire growth rate.

Utilising the medium t^2 fire growth rate determined above, it can be assumed that the peak heat release rate for a credible vehicle (forklift) fire scenario can follow the medium fire growth rate however reach a peak heat release rate of **2.5MW (Q)** (fuel controlled) as per the PIARC recommendations.

F.5.3 Fire Growth Rate – Timber Storage Pallet Fire

According to the table below, it can be seen that the growth time (i.e. growth time to reach 1MW) is between 60-190 seconds for typical stacked combustible goods. Based on the data in the table below, timber pallets stacked 3.0m high may take up to 80-110 seconds to reach 1MW which is approximately representative of a fast to ultra-fast t^2 fire growth rate. Despite the mean k-factor, a conservative approach would be to consider an ultra-fast t2 fire growth rate which is calculated to reach 1MW in 75 seconds (being close to a k-factor of 80).

For the purposes of this analysis, an ultra-fast t^2 fire growth rate would conservatively be considered to be the minimum fire growth rate for an industrial/warehouse building reaching a peak heat release rate (PHRR) of 6.8MW.

Table F.1: Peak Heat Release Rate and Time data for Industrial Commodity obtained from Furniture Calorimeter Tests

Industrial Commodity	Growth Time (k value) (seconds)	Peak Heat Release Rate Density (MW/m^2)
Wood Pallets, stack, 0.45m high (6%-12% moisture)	150-310	1.2
Wood Pallets, stack, 1.5m high (6%-12% moisture)	90-190	3.7
Wood Pallets, stack, 3.0m high (6%-12% moisture)	80-110	6.8
Cartons, compartmented, stacked 3m high	60	2.3

Based on the data tabulated above, it can be expected that a timber pallet storage fire (i.e. up to 3.0m high) will achieve an ultra-fast t^2 fire growth rate whilst achieving a peak heat release rate (PHRR) of **6.8MW (Q)** (fuel controlled).

F.5.4 Stead State Condition – Forklift Fire

In this instance, the forklift is assumed to burn for a period of time reaching its peak heat release rate (PHRR) before decaying. Utilising the test data presented above, the result for Sample 22 shows an instant drop in heat release rate once the PHRR is achieved. For the purposes of this design fire, a 100 seconds steady state period has been adopted prior to fire spreading to the stack of timber storage pallets.

F.5.5 Steady State Condition – Timber Storage Pallet Fire

In this instance, the storage pallet is assumed to burn for a period of time reaching its peak heat release rate (PHRR) before decaying. Free burn test data compiled by Building and Fire Research Laboratory (American Institute of Aeronautics and Astronautics, 2000) has been published for a timber pallet fire as presented above. A free burn test is suitable in this instance due to the building having a large volume which is similar to a free burn environment.

The results show that the time between PHRR (i.e. t_{lo}) and the commencement of the decay phase (i.e. t_d) is approximately 30 seconds. For the purpose of this design fire, a conservative 100 seconds steady state period has been adopted.

TABLE C. Heat Release Rate vs Time in t^2-fire Characterization of Building and Fire Research Laboratory Data

	CODE	DESCRIPTION	t_0	$t_{1\,MW}$	t_{lo}	t_d	t_{end}	$\dot{Q}_{max}$	t_g	α_g	α_d
Fig. C1.	Bunk Bed	BFRL* in February 1996.	186	211	240	240	445	4665.6	25	1.600000	0.111020
Fig. C2.	Koisk	Western Fire Center in the summer of 1995.	817	1129	1230	1230	3300	1752.2	312	0.010273	0.000409
Fig. C3.	Loveseat		48	222	350	371	866	3012.4	174	0.033029	0.012294
Fig. C4.	Mattress (Center)	BFRL in February 1996.	9	173	145	219	959	687.7	164	0.037180	0.001256
Fig. C5.	Mattress (Corner)	BFRL in February 1996.	85	294	295	321	484	1009.6	209	0.022893	0.037999
Fig. C6.	Small Dresser	BFRL in February 1996.	112	346	423	423	870	1766.4	234	0.018263	0.008840
Fig. C7.	Sofa		26	222	390	399	931	3449.0	196	0.026031	0.012186
Fig. C8.	Wooden Pallet	BFRL in February 1996.	0	467	634	664	1616	1843.1	467	0.004585	0.002034
Fig. C9.	Workstation (2 panels)	Sponsored by GSA** and performed at BFRL in 1991.	132	244	280	280	3276	1746.2	112	0.079719	0.000195
Fig. C10.	Workstation (3 panels)	Sponsored by GSA and performed at BFRL in 1991.	283	386	550	550	1142	6719.7	103	0.094260	0.019174

* BFRL – Building and Fire Research Laboratory
** GSA – General Services Administration

Figure F.9: Test results for Wooden Pallet (Building and Fire Research Laboratory)

F.5.6 Decay Phase – Forklift Fire

The decay phase for the forklift fire occurs following the steady state period. Utilising the test data presented above, the results show that the decay stage follows a parabolic nature for a period of time.

As the simulation of the design fire is for 2,700 seconds, the results show a considerable decrease from the peak heat release rate to the heat release rate at 2,700 seconds as all of the available fuel is consumed.

As a consequence and in order to add a layer of conservatism, the decay stage shall follow a sprinkler extinguishment relationship developed by NIST (1993) which has a longer decay phase when compared to the proposed vehicle fire.

$$\dot{Q}(t - t_{act}) = \dot{Q}(t_{act})\exp\left[\frac{-(t - t_{act})}{3.0(\dot{w}'')^{-1.85}}\right]$$

F.5.7 Decay Phase – Timber Storage Pallet Fire

The decay stage for the timber storage pallet fire occurs after the steady state period. Utilising the test data presented above and the heat release curve illustrated in the figure below, the results show that the decay stage follows a parabolic nature for a period of time. The results indicate that it takes approximately 1000 seconds prior to full extinguishment. In this instance, a similar rate of decay shall be considered however a linear relationship shall be adopted. This is a conservative approach as the parabolic relationship decays at a faster rate as opposed to the linear relationship.

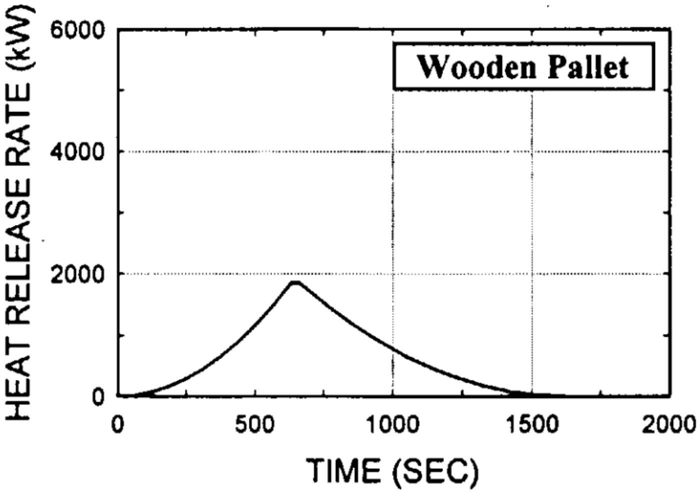


Figure F.10: Heat Release rate curve for Stack of Wooden Storage Pallets (Building and Fire Research Laboratory)

F.5.8 Fire Spread from Forklift to Timber Storage Pallet

In order to simulate fire spread from a forklift to a stack of wooden storage pallets, it is paramount to calculate the piloted ignition time for the stack of timber pallets. It should be noted that testing and literature reviews preformed and documented in codes around the world have concluded that timber is not readily ignited. There are a few recorded cases however where timber has been the first material to be ignited. Timber requires surface temperatures well in excess of 400°C if the material were to ignite in the medium to a short-term without the presence of a pilot flame. Even when a pilot flame is present, the surface temperature will need to be in the range of 270-300°C for a significant time before ignition occurs (et al Timber Structures). It was calculated via CFD modelling in a warehouse environment that the forklift fire produced temperatures of 300°C in approximately 375 seconds. To account for the timber storage pallets to undergo pyrolysis and combustion process, a further 100 seconds was added. Therefore, the time for fire spread to occur from a forklift fire to a stack of timber storage pallets is 475 seconds.

F.5.9 Design Fire

Utilising the information presented above the Heat Release Rate v Time Curve is presented in Figure F.11 for the overlapped forklift and storage pallet fire.

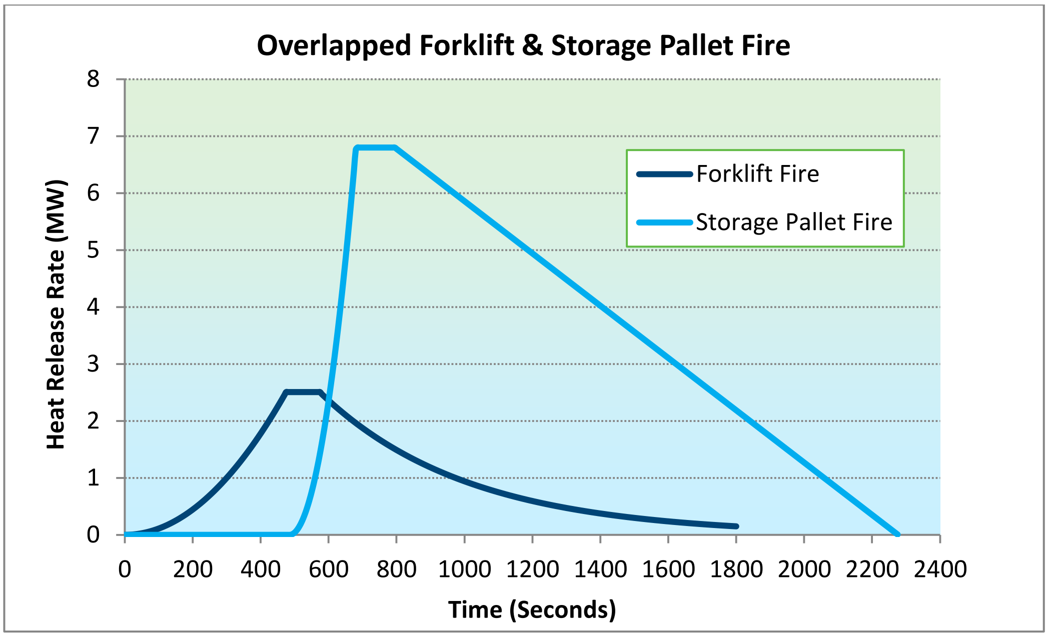


Figure F.11: Overlapped design fires for forklift and stack of wooden storage pallet

Utilising the information presented above, the Heat Release Rate v Time Curve is presented in Figure F.11 for the resultant combined forklift and storage pallet fire.

The subject warehouse is expected to have numerous types of electrically powered forklifts, pallet lifts and the like operating throughout the building. Whilst it is unclear how many industrial fires are caused by forklift ignition sources and accidents, these fires are nonetheless well represented in the statistics and as such are considered relevant to the assessment for the subject premise. The lifting equipment shall be used to transport the commercial goods to and from the sortation section of the building and stored on pallets or within the racking system. In this instance, the sensitivity fire scenario has been developed whereby a forklift fire shall initiate before spreading to the sortation equipment where the pallets and additional storage materials may be located as part of the sortation process. Published research material, a degree of engineering judgement and assumptions have been adopted to quantify the time when fire from the forklift is likely to spread to potential storage pallets and other combustible materials.

Referring to Figure F.12 a standard medium t^2 fire growth rate and a fast t^2 fire growth rate have been superimposed over a custom fire which shall be adopted in this instance due to the unique frozen goods stored within the building.

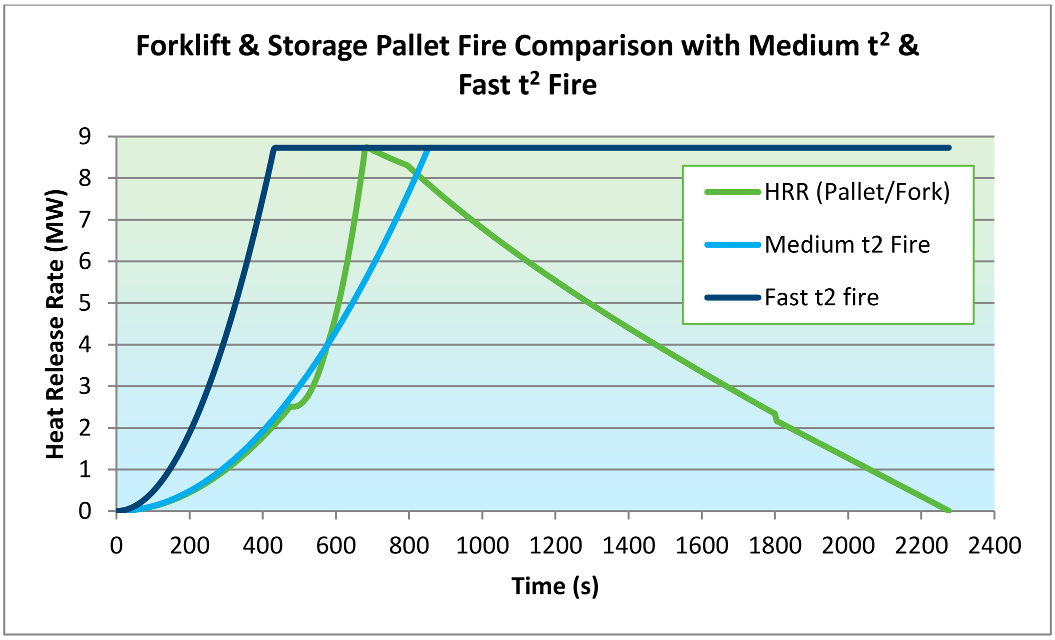


Figure F.12: Medium and fast t^2 Design Fire Growth Rates Comparison to the Custom Design Fire

F.5.10 Custom Design Fire Summary

A slower design fire curve may represent the initial stages of a fire. The purpose of a slower fire growth rate may be due to the initiating event being componentry within the forklift equipment having an incipient initial growth stage. The shielded nature of the forklift contributes to the fire growth rate. The fire eventually develops and spreads to the combustible pallet storage in close proximity. The storage/racking arrangement would be expected to be a combination of non-combustible metal and hard plastic, rubber materials and so on. The commodities being stored may not always be densely packaged whereby the fire is expected to be fuel controlled.

From a design perspective and in order to deviate from other sprinkler protected design fire scenarios already proposed as part of the overall assessment, a slightly slower growth rate fire scenario has been nominated in order to test the egress provisions and evacuation of the multitude of occupants within the warehouse. The non-sprinkler protected fire scenario will inevitably delay fire detection and notification, hence delaying the commencement of pre-movement and movement times. Occupants are most likely to rely on visual cues without the reliance on the automatic fire sprinkler system activating the BOWS. The scenario, in essence, is predominantly an 'evacuation' sensitivity scenario which considers maximum occupant numbers throughout the warehouse portion of the building.

A custom t^2 fire growth rate (which is appropriate to some of the credible fuel loads within this building) can be utilised which will (purposefully) generate initial lower temperatures during the growth phase of fire development coupled with the benefit of the automatic sprinkler system being ignored. Although the hot layer temperatures may not be a critical factor, occupants will be exposed to smoke conditions and visibility will be the tenability criteria most likely to be compromised.

F.6 SB04: Sprinkler Controlled Fire – High Bay Area (Sortation System Fire (Core))

F.6.1 Ultra-Fast t^2 Fire Growth Rate

The adopted design fires within the sprinkler protected areas shall be based on the time at which the installed sprinkler system activates and hence impacts on the fire growth. The times adopted for sprinkler activation (time after ignition at which the fire would be controlled) within the subject warehouse shall be based upon the type of sprinkler heads installed, the location of the sprinkler heads above the finished floor level and the spacing of the sprinkler heads from each other.

For this fire scenario it is assumed that the storage sprinklers, as per their design specifications, would suppress and eventually extinguish the fire. The input to the sprinkler activation time model was based on the following specifications:

- Sprinkler Head Type:
  - Actuation Temp = 100°C, RTI = 50m$^{0.5}$s$^{0.5}$
- Height Above the Finished Floor Level:
  - Maximum height above the finished floor level is 36.8m (to the ridge line) with in-rack sprinkler located at max 12m above floor level
- Sprinkler Head Spacing and distance of sprinkler from the axis of fire:
  - 3.1m x 3.1m grid (9.6m^2); R = 2.2m.
- Fire Growth Rate:
  - Ultra-Fast t^2 fire conservatively based on the presence of a wide range of goods stored within the storage racks.

The SB04 scenario shall assume that the first ring of sprinklers would activate, control and eventually extinguish the fire.

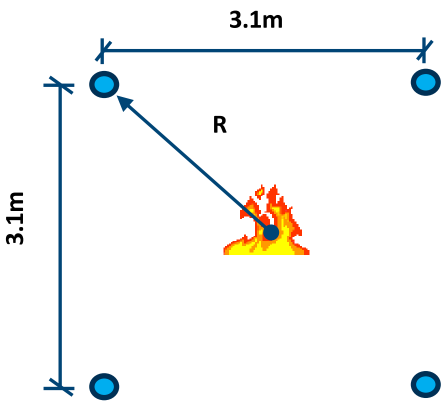
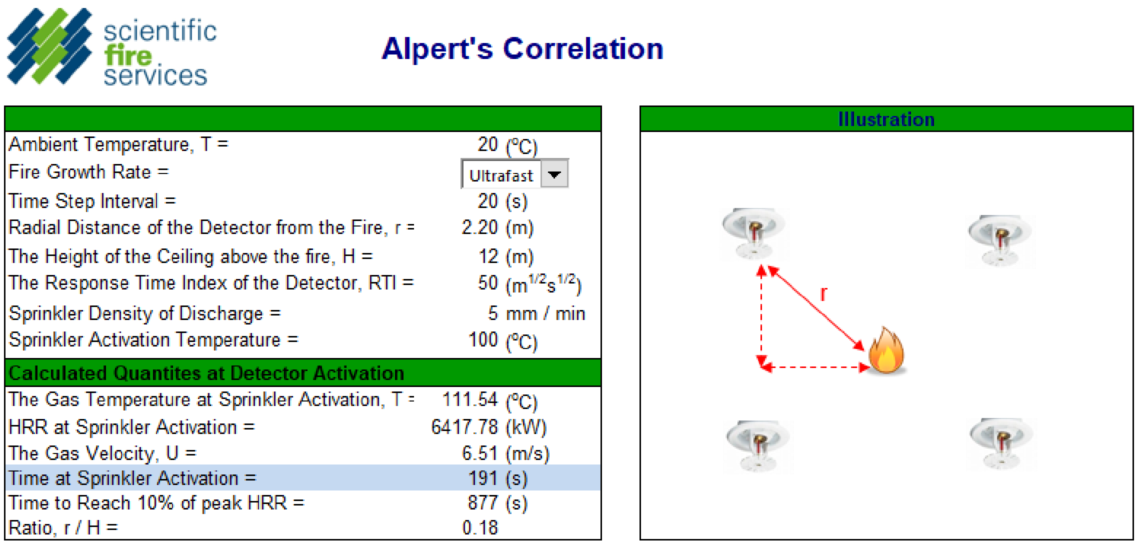


Figure F.13: First Ring of Sprinklers

The following illustrates the input to and the output from the sprinkler activation time calculations.



Ambient Temperature, T =	20	(°C)
Fire Growth Rate =	Ultrafast	
Time Step Interval =	20	(s)
Radial Distance of the Detector from the Fire, r =	2.20	(m)
The Height of the Ceiling above the fire, H =	12	(m)
The Response Time Index of the Detector, RTI =	50	(m$^{1/2}$s$^{1/2}$)
Sprinkler Density of Discharge =	5	mm / min
Sprinkler Activation Temperature =	100	(°C)
Calculated Quantites at Detector Activation		
The Gas Temperature at Sprinkler Activation, T =	111.54	(°C)
HRR at Sprinkler Activation =	6417.78	(kW)
The Gas Velocity, U =	6.51	(m/s)
Time at Sprinkler Activation =	191	(s)
Time to Reach 10% of peak HRR =	877	(s)
Ratio, r / H =	0.18	

Figure F.14: Activation of sprinklers for SB04

The peak heat release rate has been calculated (at the time of sprinkler head activation) to be in the order of **6.5 MW**.

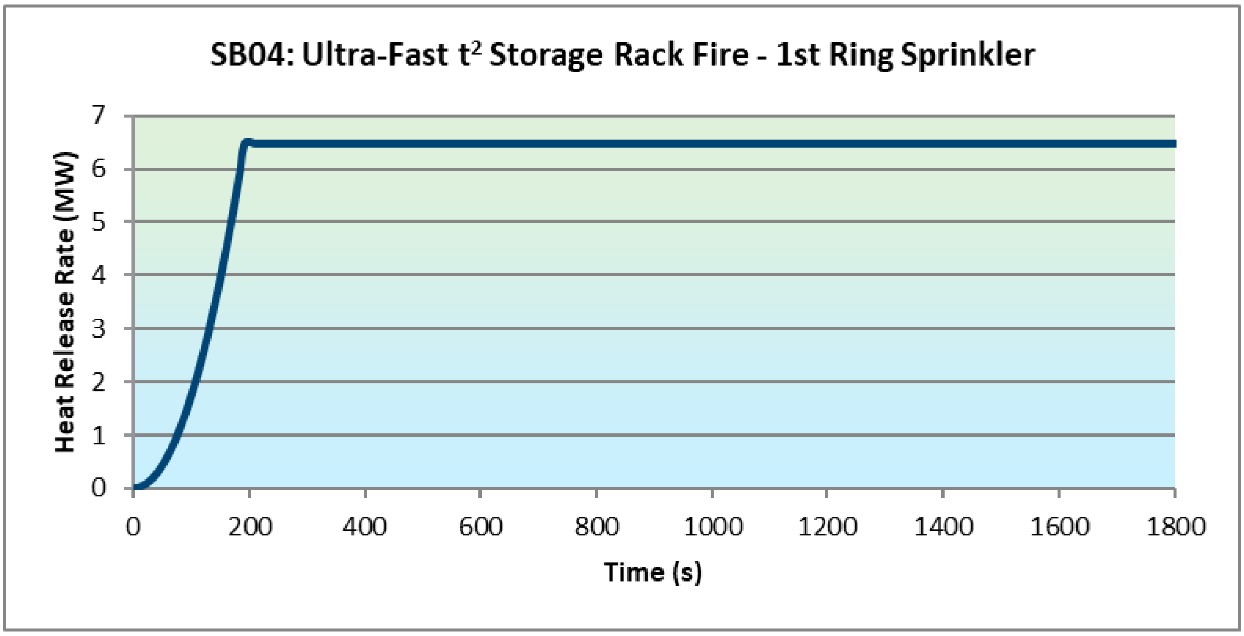


Figure F.15: SB04 Schematic design fire

F.7 SB05: Sprinkler Controlled Fire – High Bay Area (Sortation System Fire (Core))

F.7.1 Ultra-Fast t^2 Fire Growth Rate

The adopted design fires within the sprinkler protected areas shall be based on the time at which the installed sprinkler system activates and hence impacts on the fire growth. The times adopted for sprinkler activation (time after ignition at which the fire would be controlled) within the subject warehouse shall be based upon the type of sprinkler heads installed, the location of the sprinkler heads above the finished floor level and the spacing of the sprinkler heads from each other.

For this fire scenario it is assumed that the storage sprinklers, as per their design specifications, would suppress and eventually extinguish the fire. The input to the sprinkler activation time model was based on the following specifications:

- Sprinkler Head Type:
  - Actuation Temp = 100°C, RTI = $50m^{0.5}s^{0.5}$
- Height Above the Finished Floor Level:
  - Maximum height above the finished floor level is 36.8m (to the ridge line) with ceiling height sprinkler located at max 31.5m above floor level
  - An electrical malfunction such as hoist/automated lifts within the non-storage portions (AS/RS) of the High Bay Zone (14m above the floor, 17.5m from the ceiling sprinkler) is considered to ignite combustible contents within the sortation system.
- Sprinkler Head Spacing and distance of sprinkler from the axis of fire:
  - 3.1m x 3.1m grid ($9.6m^2$); R = 2.2m.
- Fire Growth Rate:
  - Ultra-Fast t^2 fire conservatively based on the presence of a wide range of goods stored within the storage racks.

The SB05 scenario shall assume that the first ring of sprinklers would activate, control and eventually extinguish the fire.

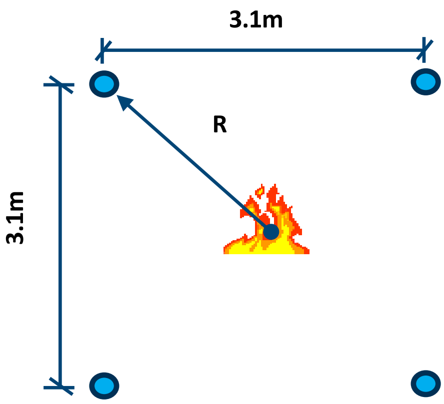


Figure F.16: First Ring of Sprinklers

The following illustrates the input to and the output from the sprinkler activation time calculations.

scientific fire services

Alpert's Correlation

Ambient Temperature, T =	20 (°C)
Fire Growth Rate =	Ultrafast
Time Step Interval =	20 (s)
Radial Distance of the Detector from the Fire, r =	2.20 (m)
The Height of the Ceiling above the fire, H =	17.5 (m)
The Response Time Index of the Detector, RTI =	50 ($m^{1/2}s^{1/2}$)
Sprinkler Density of Discharge =	5 mm / min
Sprinkler Activation Temperature =	100 (°C)
Calculated Quantities at Detector Activation	
The Gas Temperature at Sprinkler Activation, T =	106.15 (°C)
HRR at Sprinkler Activation =	14745.60 (kW)
The Gas Velocity, U =	9.07 (m/s)
Time at Sprinkler Activation =	289 (s)
Time to Reach 10% of peak HRR =	975 (s)
Ratio, r / H =	0.13

Illustration

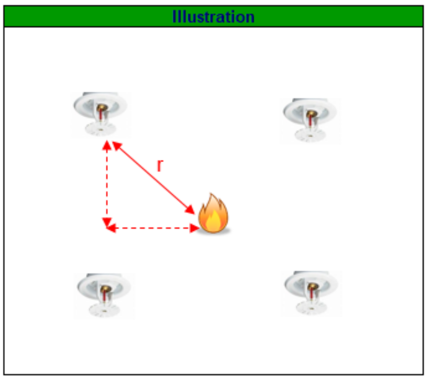


Figure F.17: Activation of sprinklers for SB05

The peak heat release rate has been calculated (at the time of sprinkler head activation) to be in the order of **14.9 MW**.

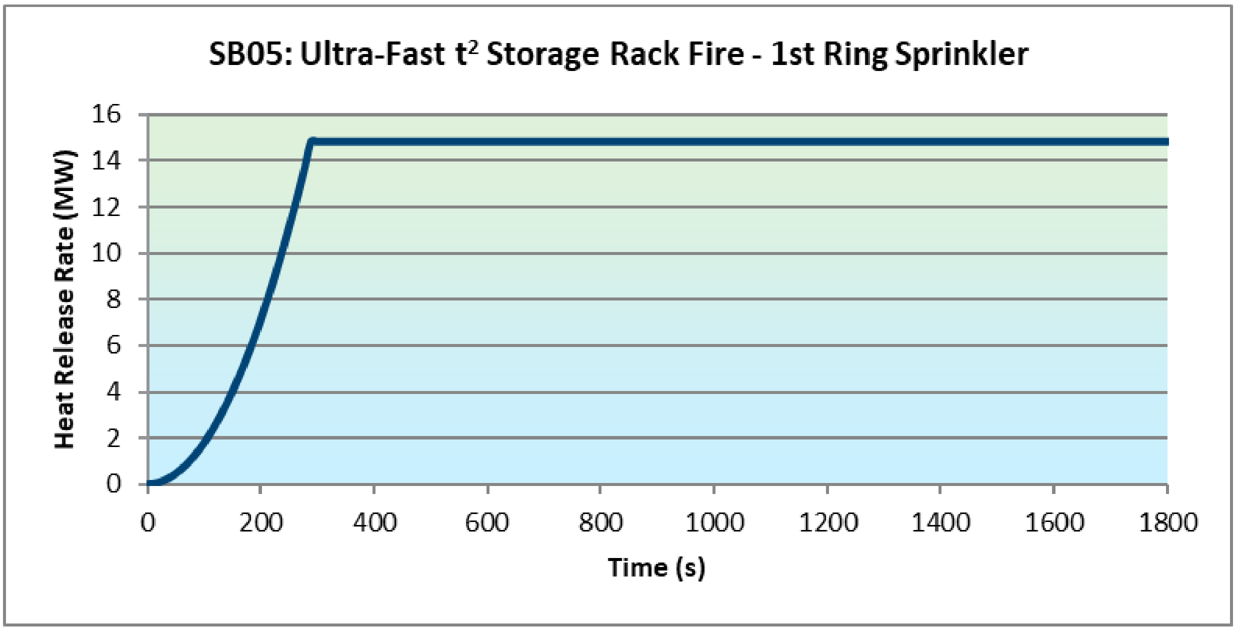


Figure F.18: SB05 Schematic design fire

Appendix G. Sprinkler properties

System Design	- High Hazard at roof level throughout Warehouse for protection of high-piled storage assumed suitable for K2 Suppression Mode (ESFR) sprinklers via 12 only operating at 350kPa based on a maximum building height of 14.6m to the Low Bay Warehouse Area of Stage 1. This will facilitate storage in unshelved racks, block-stacked or suitable bin-box storage fixtures of Class 1, 2, 3, 4 and cartoned unexpanded plastics as defined in FM Global Data Sheet 8-1, "Commodity Classification" providing that there is a minimum clearance of 914mm below sprinklers. - Ordinary Hazard 3 to majority of general rooms/areas above 4 Deg Celsius.no allowance has being made to change the existing high level ESFR to Ordinary Hazard sprinklers where they will be with the newly created void space above the sandwich panel ceilings. - High Hazard to the High Bay Warehouse Roof (Stage 1), Raw Materials Warehouse (Stage 2) for protection of high-piled storage assumed suitable for K22 Suppression Mode (ESFR) sprinklers via 12 only operating at 350kPa. - High Hazard to the High Bay Racking (Stage 1) utilising K22 In-rack sprinklers located at a maximum vertical height of 12m and 24m. This will allow for the protection of Class 1 to 4 Cartoned unexpanded Plastic based on 6 heads flowing at a minimum of 455 l/min each. This assumes that the racks can be classified as a Multi Row rack as defined in FM Data Sheet 8-9. o Multiple-row racks with butted storage can be treated as open-frame racks under the following conditions: ▪ The racks are void of solid shelves, and ▪ They have pallet loads butted in one direction, and ▪ Pallet loads are no wider than 5 ft (1.5 m), and ▪ Minimum 3 in. (75 mm) net clear width transverse flue spaces on each side of each butted row are provided, and ▪ A minimum net 6 in. (150 mm) wide longitudinal flue space is provided a maximum of every 16 ft (4.8 m) horizontally. o Multiple-row racks are racks greater than 12 ft (3.6 m) wide, or single-row or double-row racks separated by aisles 2 ft (0.6 m) wide or less having an overall width, including flues, greater than 12 ft (3.6 m). Multiple-row racks can be drive-in, drive-through, flow-through, push-back or double-deep standard racks. The rack depth is the determinant. - Light Hazard to Offices and Warehouse Amenities. - Ordinary Hazard to Ceiling Void Space above manufacturing sandwich panel ceiling.
	- Ordinary Hazard III to the manufacturing area (Below Ceiling Level only, no allowance for sprinkler protection to underside of plant, conveyors etc as there is insufficient information regarding the size and nature of these items). We make no allowance for sprinklers to the underside of ductwork/conveyors/raised platforms etc. • FM Global approved - Dual diesel Pumps - Full size modular metal fire water tank (powdercoated if on the street side of the building). • Manual call points located at every personnel exit door of the Warehouse. • Smoke exhaust being in accordance with the BCA and Australian Standards (or as per relevant fire engineering).
In Rack Sprinklers	The Developer is required to provide an in-rack fire sprinkler system service that is coordinated with the final racking design.

Appendix H. High Bay Area / Future Expansion

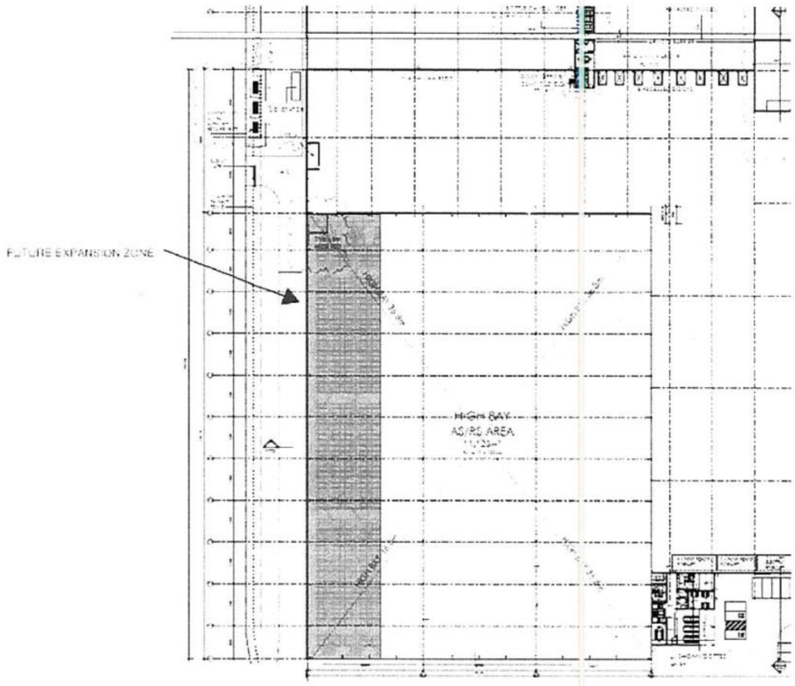
snackbrands
AUSTRALIA

13th November 2018

To Whom It May Concern

Dear Sir / Madam,

Snackbrands confirm that the future expansion area located within the Highbay area (highlighted below in purple) will not be used for storage or any operational activities.



If you, please require any additional information please don't hesitate to contact myself.

Regards

pp.

Sion Westcott - Lewis

Appendix I. Extracts from Project Brief

tm insight

    - Cleaners Store
    - Comms Room
    - Induction / Training Room
    - Outdoor area

- First Floor –
    - Open plan office of to accommodate up to 25 workstations
    - 16 single offices
    - 2 large meeting rooms
        - 1 x 6 persons
        - 1 x 4 persons
    - Kitchenet
    - Male & Female Amenities
    - Level 1 lift landing
    - One printing area within the open plan area
    - storage cupboards
    - Large glazing sections looking into warehouse and carpark
    - Disabled toilet

- Dispatch Office
    - The dispatch office areas shall include but not be limited to:
        - Ground Floor
            - Truck Drivers Break Room
            - Amenities
        - First floor
            - Open plan office to accommodate for 6 persons with viewing on all 4 facades
            - Utilities area
            - Kitchenette

1.5 Facility Operation

1.5.1 Hours of Operation

The normal working hours of operation of the facility are expected to be 24 hours per day, 7 days per week.

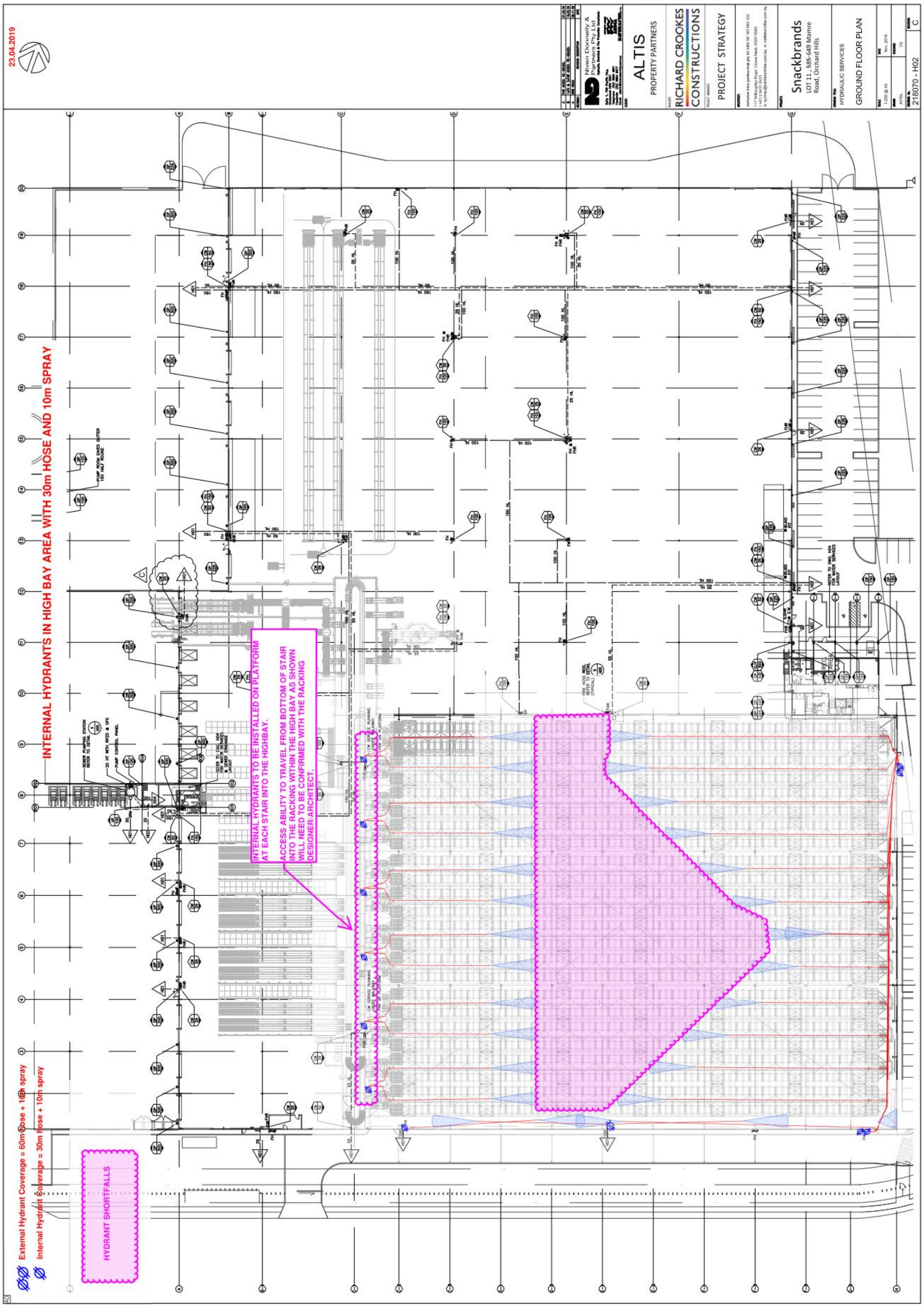
1.5.2 Employee Numbers

- Warehouse – 30 people 70% Male / 30 % Female
- Office/ Amenities – 25 people 50 % Male / 50% Female
-
- Dispatch Office
    - L1 Office – 6 People 70% / 30% Female
    - Drivers Breakroom – 15 People

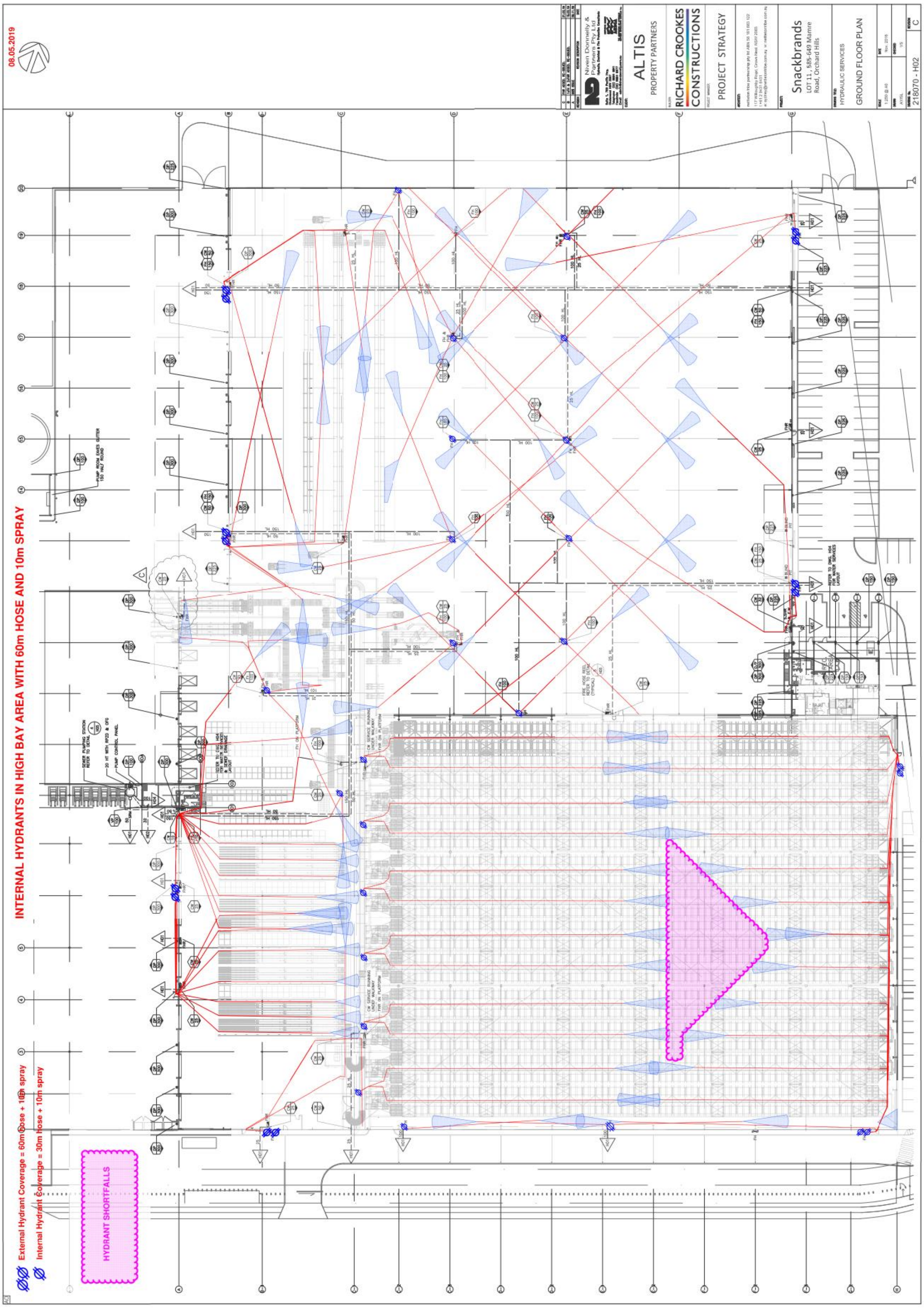
Snack Brands Distribution Breif Rev 5.docx Page 8

Appendix J. Fire Hydrants Coverage

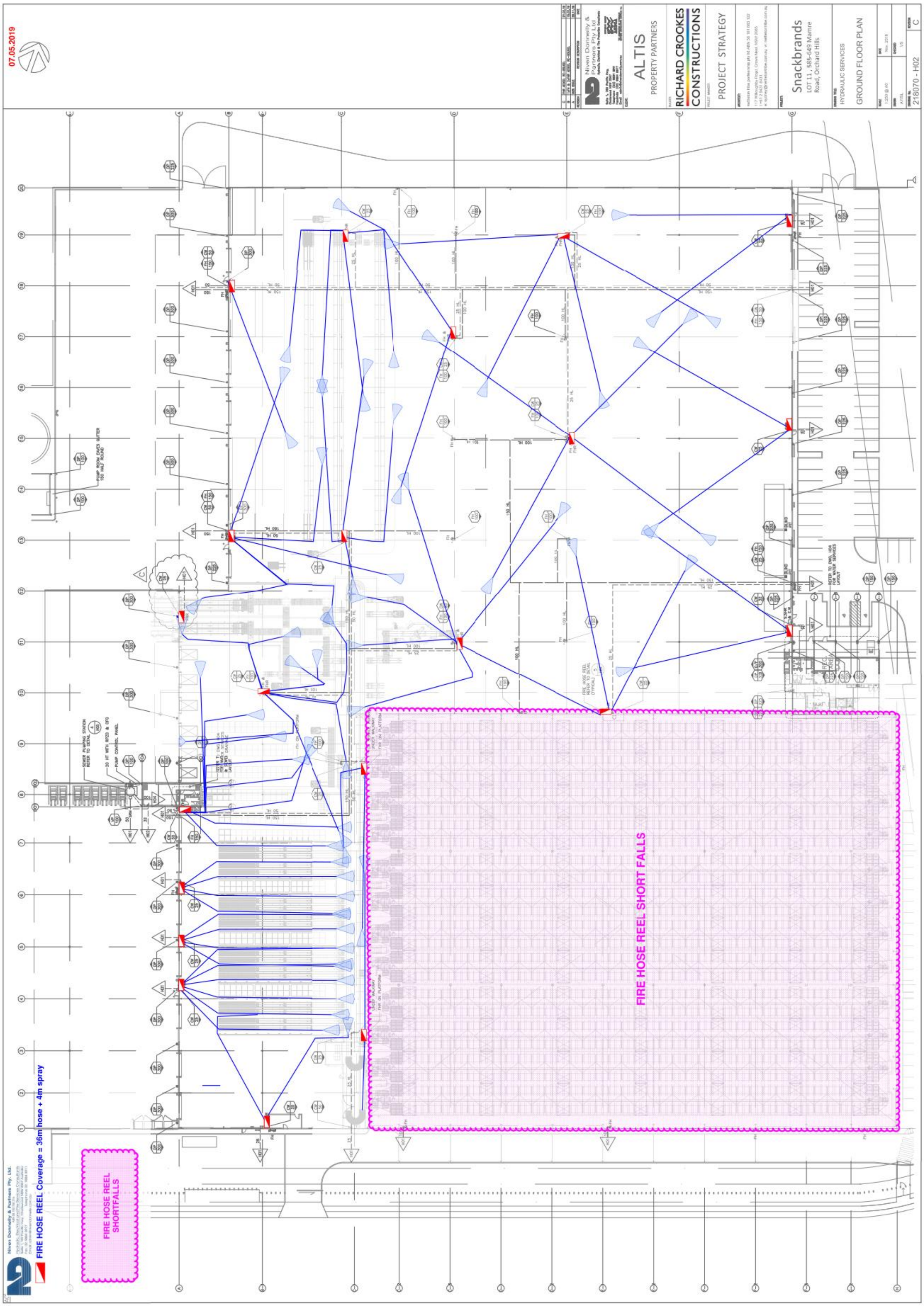
J.1 Coverage Shortfalls based on Internal fire hydrants based on 30m hose length



J.2 Coverage Shortfalls based on Internal fire hydrants based on 60m hose length



Appendix K. Fire Hose Reel Coverage Shortfalls



Appendix L. Relevant Extracts from BCA Report

REF: 075899-04BCA.docx

mckenzie group

BUILDING CODE OF AUSTRALIA REPORT

Revision: 4 18 December 2018

Snackbrands Australia – NSW Distribution Facility Stage 1
585-649 Mamre Road, Orchard Hills

Prepared for: Atlis Property C/- HB+B Property

Page 1 of 59

Date	Rev No	No. of Pages	Issue or Description of Amendment	Assessed By	Approved By	Date Approved
09.07.18	A	26	Draft for Project Application	Brigitte Thearle	Geoff Pearce	19.07.18
30.07.18	B	26	Final for Project Application	Brigitte Thearle		31.07.18
08.08.18	C	26		Geoff Pearce		10.08.18
05.12.18	D	26	Final for Project Application	Asic Regmi	Geoff Pearce	18.12.18

Date	Rev No	No. of Pages	Issue or Description of Amendment	Assessed By	Approved By	Date Approved
09.07.18	A	26	Draft for Project Application	Brigitte Thearle	Geoff Pearce	19.07.18

BCA ASSESSMENT REPORT
Snackbrands Australia – NSW Distribution Facility Stage 1
585-649 Mamre Road, Orchard Hills

Executive Summary

Development Overview

The proposed development is a new distribution facility that includes high bay and low bay storage areas, along with a staging area and a two storey office.

Compliance Summary

As Accredited Certifiers, we have reviewed architectural design documents prepared by Nettleton Tribe (refer appendix A) for compliance with the Building Code of Australia 2016 Amendment 1.

In this regard the following areas in particular require further review as the project develops:

No.	Items for review	Responsibility
1.	Please advise if there are any proposed alternative building solutions with regard to design of the building services for the project.	Services Consultants

The assessment of the design documentation has revealed that the following areas are required to be assessed against the relevant performance requirements of the BCA. The submission for Construction Certificate will need to include verification from a suitably accredited fire engineer: -

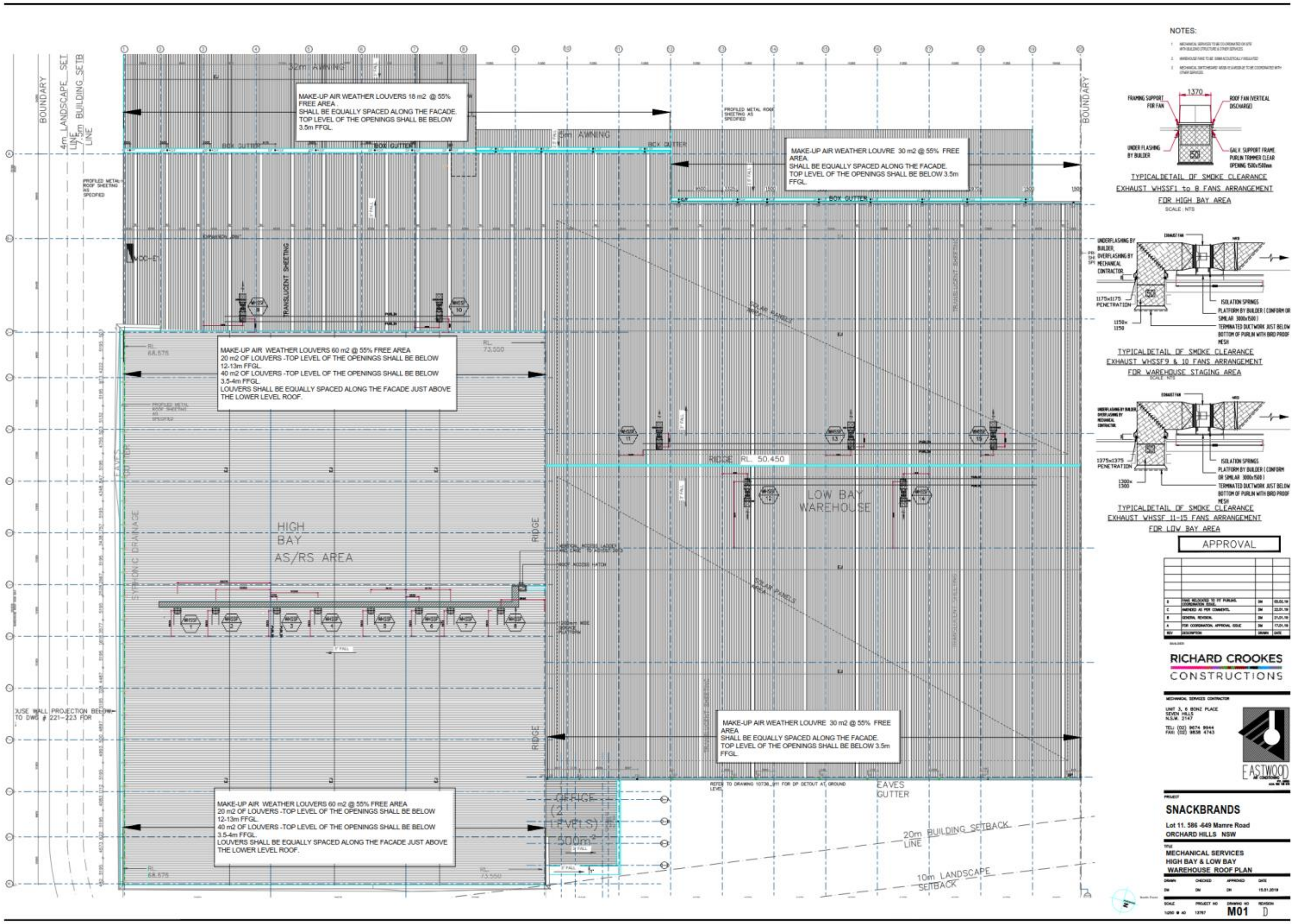
No.	Alternative Solution Description	DTS Clause	Performance Requirement
Fire Safety Items			
1.	**Perimeter Vehicular Access** The perimeter vehicular access provided to a portion of the southern façade is up to 26m away in lieu of 18m to the far side. Furthermore, the access provided to the north of the site is proposed to be on an adjoining allotment.	C2.3, C2.4	CP9
2.	**Exit Travel Distances** Following extended travel distance has been identified: ▪ Travel distance to one of the exit is 115m in lieu of 40m in high bay warehouse	D1.4, D1.5	DP4, DP5
3.	**Distance between alternative exits** Separation of exits does not comply in the following areas: ▪ Distance between alternative exits in high bay warehouse is 172m in lieu of 60m Where design amendments are not afforded, this will be required to be addressed through a fire engineered performance solution.	D1.5	DP4, DP5, EP2.2
4.	**Hydrant Coverage** It is anticipated that there will be some hydrants under awnings that will be considered as external hydrants for the purposes of coverage, and that there will be some areas of shortfall in coverage where additional hose lengths will be required.	E1.3	EP1.3

5.	**Fire Hose Reel Coverage** It is anticipated that there will be some areas within the warehouse that are not provided with compliant fire hose reel coverage.	E1.4	EP1.1
6.	**Smoke Hazard Management** The proposed smoke hazard management is to be rationalised based on smoke modelling	E2.2	EP2.2
7.	**Exit Sign Heights** The directional exit signs are proposed to be located more than 2.7m above the FFL	E4.5, E4.6	EP4.2
Non - Fire Safety Items			
8.	**Access – Level 1 Dock office & High Bay Racking** No access has been proposed up to the Level 1 Dock office and High Bay Racking. An Alternative Solution for access is required to be provided.	D3.1	DP1
9.	**Access Provisions** Provision need to be made for the access to building via existing principle public entry. Latch side cleareance not achited for door to the break room in ground floor dock office	D3.2, D3.3	DP1
10.	**Accessible sanitary and Ambulant sanitary facilities** An accessible sanitary facilities has not been proposed for the Level 1 office floor. At each bank of toilets where there are one or more toilets in addition to an accessible unisex sanitary compartment, a sanitary compartment suitable for a person with an ambulant disability in accordance with AS 1428.1-2009 must be provided for use by males and females. **Ambulent toilets 900*900 clearnace not in male sanitary fa ground floor office & male and female sanitary compartment in ground floor dock office**	F2.4	FP2.1

The fire engineered solution relating to CP9, EP1.3 and EP2.2 will be subject to consultation with the NSW Fire Brigade as part of the Construction Certificate process under Clause 144 of the Environmental Planning & Assessment Regulation 2000.

The application for Construction Certificate shall be assessed under the relevant provisions of the Environmental Planning & Assessment Act 1979 (As Amended) and the Environmental Planning & Assessment Regulation 2000.

Appendix M. Smoke Clearance System Schematic



Appendix N. FM Global Report

Plan Review

Sion Westcott-Lewis
URC Australia Holding Company Pty Ltd & URC New Zealand Holding Company Pty Ltd
585-649 Mamre Road
Orchard Hills, New South Wales 2748
Australia
Plans Submitted By: Stewart Johnson, Project Strategy

Index-Rec No: AUS644.00-02
Account No: 23-87639
Date of Review: August 23, 2018
Review No: 277165

Subject: Snack Brands Australia Warehousing Project – Orchard Hills

Executive Summary:

FM Global representatives Geoff Madden and Alex Hali attended an initial project consultant design meeting on 11 July 2018 at the offices of Altis Property Partners in Sydney. Following a review of preliminary documentation, a project report was issued by FM Global on 14 June 2018.

Subsequently, revised project documentation was provided by Mr. Stewart Johnson via Dropbox, which contained minor amendments to the original sprinkler protection design, as well as more detail about the warehouse construction and building materials, DG storage arrangement, and mechanical ventilation fan specification within the warehouse. In addition, specific information regarding storage arrangement of idle pallets within the low bay warehouse area were provided by Mr. Stewart Johnson via email.

This updated report has been generated by utilising extracts from updated drawings, which were reviewed by FM Global. A summary of FM Global property loss prevention recommendations pertaining to the above aspects of building design has been outlined in this report.

Scope of Review:

This confirms the receipt and review of project documentation relating to:

- Structural features of the warehouse
- Architectural features of the warehouse
- Automatic in-rack sprinkler design in the high bay warehouse
- Ventilation / smoke clearance fan specifications
- Idle pallet storage in the low bay warehouse

Review Comments:

1. Construction and Building Materials

1.1 Polycarbonate cladding, Lexan Thermoclear, is to be installed on the low bay warehouse east and west walls as shown in Figure 1.

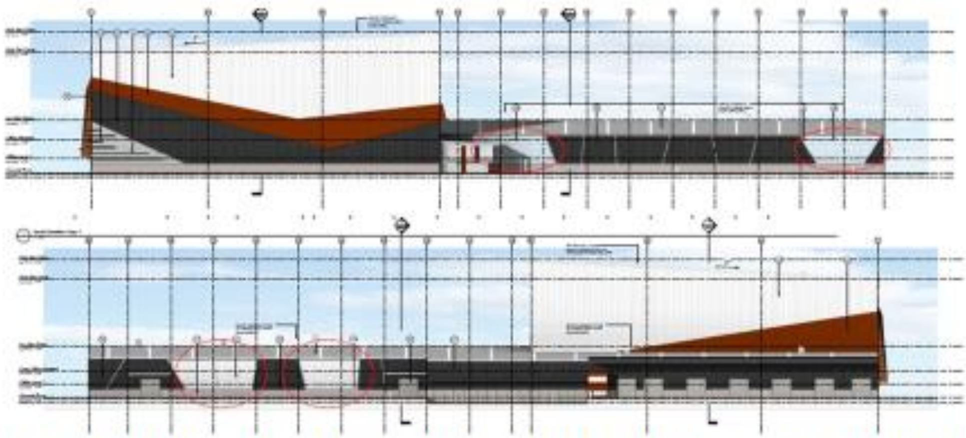


Figure 1 – Extent of Polycarbonate cladding on the east (top image) and west (bottom image) wall of the low bay warehouse.

1.2 The cladding comprises of twin wall insulated cladding with overall thickness (including air gap) of approximately 10 mm. The collective thickness of the 2 walls is <6 mm.

1.3 The details of this product have been previously reviewed by FM Global. Considering the material is to be located on the wall only, is limited in area, and adequate sprinkler protection is to be provided within the warehouse, **the proposed construction is acceptable to FM Global.**

2. Occupancy

2.1 The high bay warehouse will be used to store snack foods in plasticised aluminium bags in cartons in multi-row racks to a height of 30.5 m under a ceiling height ranging from 31.55 m at the eaves to 36.65 m at the ridge. No combustibles are to be stored in the lowest 780 mm of racking.

2.2 The low bay warehouse will be used for storage of idle pallets (see section 4 below for details) and snack foods in plasticised aluminium bags in cartons in open-frame racks. The extent and height of snack food storage in this area is not yet known.

2.3 In accordance with *FM Global Property Loss Prevention Data Sheet 8-1, Commodity Classification*, the snack food is classified as Cartoned Unexpanded Plastic for fire protection design purposes.

3. Fire Protection

3.A High Bay Warehouse

3.A.1 Updated drawings of open-frame rack storage arrangement and in-rack sprinkler design for the high bay warehouse were provided to FM Global for review. Refer to Figures 2 to 4 below.

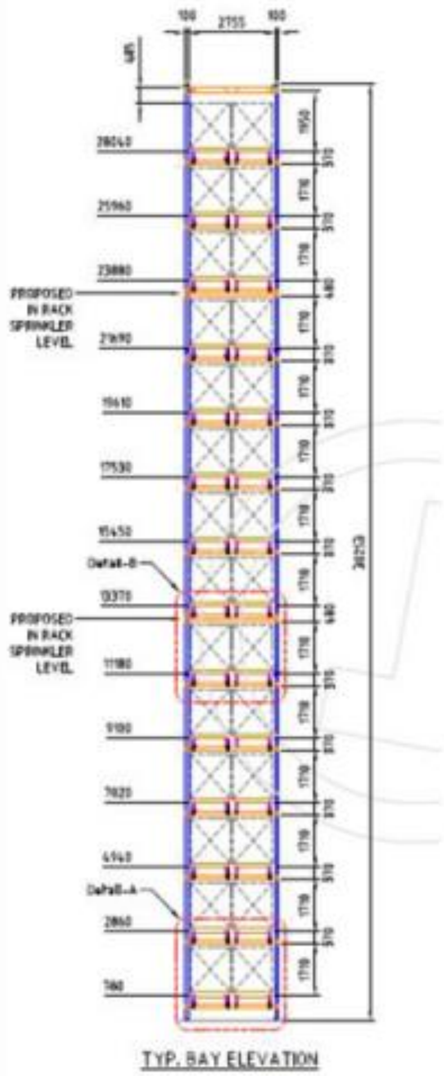


Figure 2 – Proposed in-rack sprinkler levels in the high bay warehouse.

3.A.2 Figure 2 demonstrates the in-rack sprinklers at u/s pallet level 7 at 13.37 m above the floor, and at u/s pallet level 12 at 23.88 m above the floor.

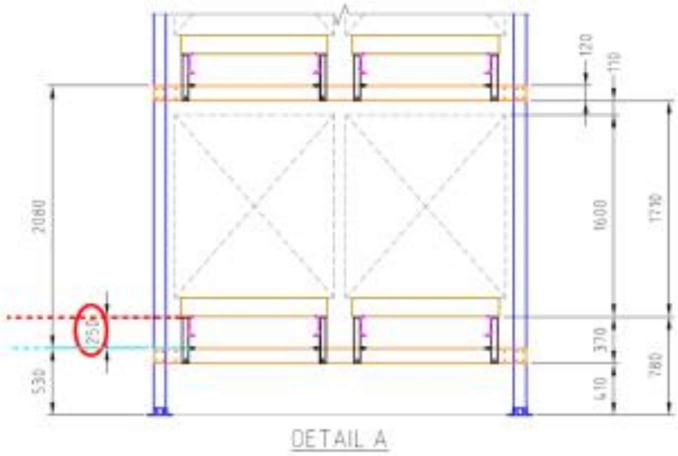


Figure 3 - Lowest level of combustibles (base of wood pallet) at 780 mm above floor level.

3.A.3 Figure 3 demonstrates that no combustibles are to be placed below 780 mm above the floor. This arrangement enables a favourable review of in-rack sprinkler protection as discussed below.

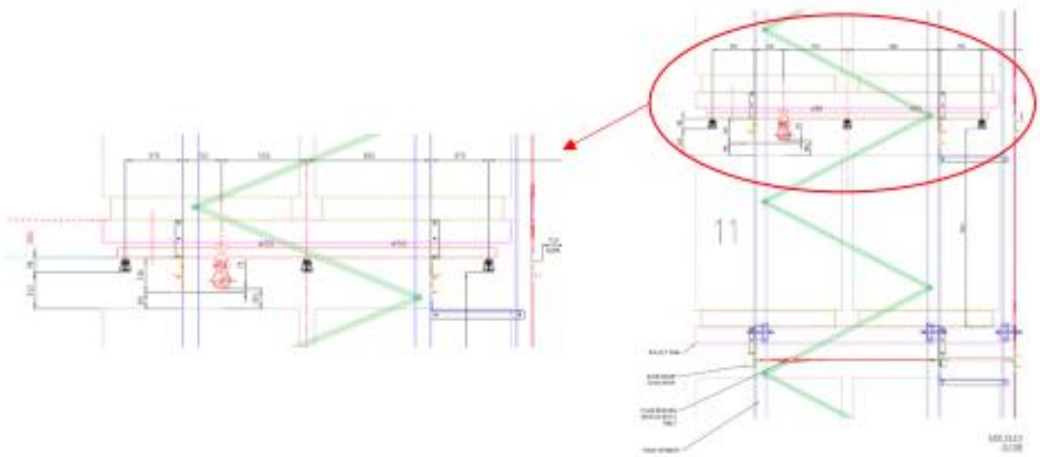


Figure 4 – In-rack sprinkler deflector position relative to the rack structural membrane.

3.A.4 Figure 4 demonstrates the exact vertical position of the in-rack sprinkler deflectors (less 250 mm and 98 mm) relative to the rack horizontal brace, resulting in height of 13.02 m and 23.53 m above floor level for the first and second level of in-rack sprinklers, respectively.

3.A.5 The above arrangement provides protection from 13.02 m down to 0.86 m above the floor by the first level of in-rack sprinklers, and coverage from 23.53 m down to 11.37 m by the second level of in-racks. The ceiling sprinklers at 36.65 m provide coverage down to 22.95 m. The lowest level of combustibles is at 0.78m, however considering the pallet height of 0.125 m, it is concluded that all combustible storage (including the pallet) is protected, with some vertical overlap at the two in-rack levels. **This design is acceptable to FM Global.**

3.B Low Bay Warehouse

3.B.1 The snack food products in the low bay warehouse stored in open-frame rack storage arrangement should be protected in accordance with FM Global *Data Sheet 8-9,* Table 8; and any palletised storage arrangement should be protected in accordance with *Data Sheet 8-9*, Table 3.

3.B.2 Sprinklers are to be standard coverage, quick response, pendent, with a nominal temperature rating of 70 ° C.

3.B.3 For a ceiling height up to 45 feet (13.72 m), the ceiling sprinkler design can be based on a demand area of 12 x K22.4 (K320 metric) heads operating at 3.5 bar.

3.B.4 The sprinkler pump should be sized to meet the individual demands of the in-rack sprinklers in the high bay warehouse, the ceiling sprinkler protection in the low bay warehouse, and that of indoor idle pallet storage specified in Section 4 below. The in-rack sprinkler demand does not have to be hydraulically balanced with the ceiling-level sprinkler system and does not have to be accounted for operating simultaneously with the ceiling-level sprinkler system.

3.B.5 A hose stream demand of 950 L/min for a duration of 60 minutes is also required for manual firefighting purposes, unless the hydrant system demand is to be supplied by a separate hydrant pump.

4. Idle Pallet Storage

4.1 The storage of idle pallets is to be located on the floor within the low bay warehouse adjacent to the warehouse west wall as shown in Figure 5.

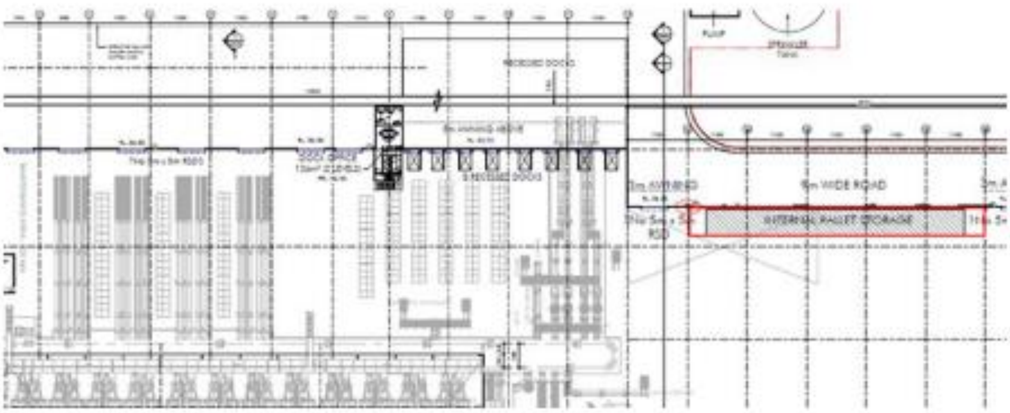


Figure 5 - Proposed storage arrangement of idle pallets within the low bay warehouse.

This report has been developed for insurance underwriting purposes. It is provided to you for informational purposes only to reduce the possibility of loss to insured property by bringing to your attention certain potential hazards or conditions. Life, safety, or health issues are not addressed. You must make the decision whether to take any action. The company undertakes no duty to you or any other party by providing this report or the activities on which it is based. The liability of the company is limited to that contained in its insurance policies.

7281E (05/2018)

4.2 A total capacity of 1,000 to 2,000 pallets is required with storage to be arranged per the following:

- Across 5 grids long (~55 m)
- 4 rows deep (off the wall) (~4.8 m)
- 13 pallets (1.7 m) high
- Edge of pallet storage (4.8m from edge of building) is 10.65 m to u/s of roof sheet

4.3 Indoor storage of idle pallets on the warehouse floor should be protected in accordance with *Data Sheet 8-9*, Table 5.

4.4 Sprinklers are to be standard coverage, quick response, pendent, with a nominal temperature rating of 70 $^{\circ}$ C.

4.5 For the proposed storage arrangement, the ceiling sprinkler design can be based on a demand area of 12 x K22.4 (K320 metric) heads operating at 3.5 bar. This protection design is acceptable for a maximum ceiling height of 40 feet (12.19 m) directly above the pallet storage area.

4.6 A hose stream demand of 950 L/min for a duration of 60 minutes is also required for manual firefighting purposes, unless the hydrant system demand is to be supplied by a separate hydrant pump.

5. Storage of Flammable Gases

5.1 Storage of flammable gases should be in accordance with *FM Global Loss Prevention Data Sheet 7-50, Compressed Gases in Portable Cylinders*.

5.2 It is recommended to store flammable gases outside the main building and maintain a separation distance of 50 feet (15 m) between the cylinder storage cage and the warehouse building.

6. Mechanical Ventilation / Smoke Clearance Fans

6.1 Roof mounted ventilation fans are to be installed in the high bay warehouse and the warehouse staging area. The proposed fan specifications are shown in Figure 6.

4.1 Fans – High Bay Warehouse ventilation & smoke clearance systems

FAN ID No. / SWITCHBOARD No.	**WHSSF-1 to 08 (8 off units) /MSSB-1E**	
LOCATION/SERVING	Roof /Warehouse	
TYPE/MOTOR TYPE CLASS	Ducted axial roof unit / smoke spill- Class H	
AIR FLOW L/S	13,100	
EST. EXTERNAL STATIC Pa	100	
POWER SUPPLY (V/PHASE/HZ)	415/3/50	
MOTOR SIZE kW (min) / Rev/s	4.0/16	
FULL LOAD AMPS	8.8	
Sound Level @ 3m	75	
Selected make/model	Fantech – RSI1256CA6/19	
Ancillaries	Back draft shutter	

4.2 Fans – Warehouse staging area ventilation & smoke clearance systems

FAN ID No. / SWITCHBOARD No.	**WHSSF- 9/10 (2 off units) /MSSB-2E**	**WHSSF- 11-15 (5 off units) /MSSB-2E**
LOCATION/SERVING	Roof /Warehouse staging area	Roof /Low bay Warehouse area
TYPE/MOTOR TYPE CLASS	Roof mounted ducted inline axial / Smoke spill –Class H	Roof mounted ducted inline axial / Smoke spill –Class H
AIR FLOW L/S	7,500	10,000
EST. EXTERNAL STATIC Pa	120	120
POWER SUPPLY (V/PHASE/HZ)	415/3/50	415/3/50
MOTOR SIZE kW (min) / Rev/s	2.2	3.0
FULL LOAD AMPS	5.2	7.2
Sound Level @ 3m	65	67
Selected make/model	Fantech – APS1006CA3/31	Fantech – APS1006CA6/27
Ancillaries	Back draft shutter	Back draft shutter

Figure 6 - Roof mounted ventilation fan specifications as submitted.

6.2 The proposed fire mode operation for the ventilation fans consists of:

- Fans automatically cease to operate in ventilation mode on fire trip
- Smoke clearance fans will be provided with controls at fire indicator panel (FIP) for fire brigade operation
- Smoke clearance fans will be manually operated by intervention of fire brigade from control facility at FIP

6.3 The above parameters were reviewed in accordance with *FM Global Property Loss Prevention Data Sheet 2-0, Installation Guidelines for Automatic Sprinklers*, Section 2.2.1.7.1; and *Data Sheet 1-10 Interaction of Sprinklers, Smoke and Heat vents, and Draft Curtains*. **The proposed ventilation fan fire mode operation is acceptable to FM Global.**

Please do not hesitate to contact me for further clarification. I look forward to assisting you further with this project.
This review is for property insurance purposes only in accordance with FM Global standards and guidelines. Nothing should be inferred from this review regarding compliance with any rules, regulations or requirements of government agencies, state or local codes or any other jurisdictional authority. We are retaining the copy of your submitted plans for our files.

Sincerely,

Alexander Hali
Consultant Engineer
+61 422 091 645
alexander.hali@fmglobal.com

Distribution:

Mr. Damian Winzer, AFM
Ms. Elise Smith, FM Global
Mr. Geoff Madden, FM Global
Mr. Nick Ingleby, TMINSIGHT
Mr. Craig Cims, Hansen Huncken
Mr. Dan Malone, Altis Property Partners
Mr. Darryl Malton, Snack Brands Australia
Mr. Stewart Johnson, Project Strategy

Appendix O. BCA Letter of Support (Special Hazards)

25 January 2019

Ref: 075899-06L.doc

mckenzie group
A Bureau Veritas Group Company
McKenzie Group Consulting (NSW) Pty Ltd
ACN: 093 211 995
Level 6, 189 Kent Street, Sydney NSW 2000
Tel: 02 8298 6800 Fax: 02 8298 6899
sydney@mckenzie-group.com.au

Project Strategy
PO Box 271,
Sutherland NSW 1499

Attention: Stewart Johnson

Dear Stewart,

Re: Snackbrands Devleopment – Orchard Hills (SSD 9429)
NSW Fire and Rescue commentary Ref No.BFS18/2762 (4931)

Further to our conversations and receipt of email correspondence regarding the aforementioned matter, please see below our response with respect to all items raised by NSW Fire and Rescue as part of the planning and approvals process for the site:-

1. Based on the proposed content to be stored within subject warehouse as confirmed to date, we note that the requirements of Clause E1.10 of the BCA will not apply in this instance.

   We confirm that additional fire safety measures have already been provided for within the design to cater for the height and storage content within the building.

   Furthermore we also note that compliant provision of water for firefighting purposes has been allowed for and will achieve compliance with the requirements of the current applicable Australian Standards for Hydrant and Hose Reel coverage, and Sprinkler coverage/peformance.

2. We note that as part of the construction approval process for the development, consultation with NSW Fire and Rescue will be required to occur, as prescribed within Section 144 of the Environmental Planning and Assessment Regulations 2000.

3. We note that details of the fire services to be provided throughout the development, and in particular to the area of high bay racking has already been communicated and presented to NSW Fire and Rescue, within the FEBQ process. We note that this was issued to NSW Fire and Rescue on the 30 November 2018.

4. As per item 1 above.

5. We note that Fire Hose Reel and Fire Hydrant coverage to the Warehouse has already been considered and addressed within the developments Fire Engineered Solution. Furthermore as note in item 3 of this letter, the performance of the Fire Hose Reels and Fire Hydrants throughout the development have been presented to NSW Fire and Rescue through the FEBQ (Fire Engineering Brief Questionnaire)

If you have any further questions, or require any additional information, please contact me to discuss.

Yours faithfully,

Geoffrey Pearce
Accredited Certifier A1
McKenzie Group Consulting (NSW) Pty Ltd
ACN 093 211 995

Appendix P. Emergency Management Procedures (EMP)

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SNACKBRANDS AUSTRALIA

NSW DISTRIBUTION FACILITY – STAGE 1

EMERGENCY MANAGEMENT PLAN

585-649 Mamre Road, Orchard Hills NSW 2748

CONTENTS

1. Facility Operational Information

The proposed manufacturing and Distribution Centre will be an ambient facility providing product storage within the Automated Storage and Retrieval System (ASRS) serving the high bay area, recessed and on-grade docks with potential for operating hours to be 24 hours a day, 7 days a week without limitation.

2. Purpose of Facility

Snackbrands Australia primary business activities to be supported by this facility include: The proposed distribution facility will receive Snackbrands Fast Moving Consumer Goods from a nearby off-site manufacturing plant and will have an integrated Automated Storage and Retrieval System (ASRS) for the handling of palletised goods. The pallet handling system comprises a double deep storage model with 10 aisles, equipped with a single extractor providing sufficient capacity to accommodate storage and throughput requirements. The system further strategically utilizes Sorting Transfer Vehicles (STV) in place of pallet handling conveyor

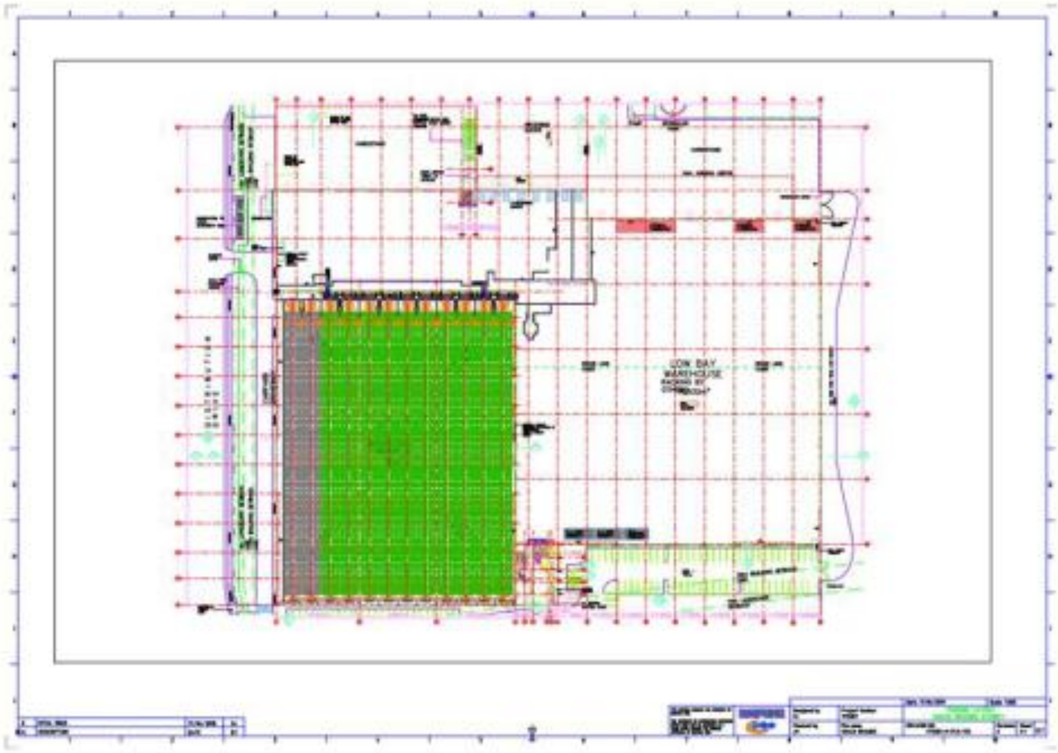
3. Normal operational process/procedure:

- This facility will be Snackbrands distribution facility only. Snackbrands will manufacture their potato chips in an offsite manufacturing plant and shuttle the finished / packaged goods to this facility.
- Once the truck arrived it will enter through the truck designated entry gates and reverse up to the recessed docks to be unloaded.
- The chips will be unloaded from the truck and placed onto the internal conveyor system which will palletise the produce and then store automatically into the ASRS highbay.
- The pallet of chips will be stored there until the order is ready and the truck is onsite.
- The pallet will then be retrieved from the ASRS and automatically conveyed to the outbound lanes.
- The last process will be for a forklift to load the trucks.

4. Restricted access provisions to the high bay zone:

As the highbay is fully automated there will be no access to personnel during operation. The only reason someone would enter the highbay would be to fix a fault with the automation or general maintenance of the equipment. The only people who can enter the highbay will be trained staff. Please note access into the highbay is restricted by fencing and interlocked gates. If an entry gate is opened then the automation will automatically stop working.

The high bay area is to be isolated from the low bay areas by either full height fence or pedestrian fence and not accessible to any personnel under normal operating circumstances.


LOW BAY
WAREHOUSE

snackbrands AUSTRALIA

5. Maintenance Schedule:

a. The maintenance schedule shall include the following activities:
   i. Preventative Maintenance Activity …. (Weekly)
   ii. Emergency Maintenance … only in the event of a breakdown/malfunction
   iii. Operational maintenance … trouble with products etc (pending quality of products …may be daily).

6. High bay area shut down procedures whilst trained occupants are located with the ASRS/high bay zone:

- If maintenance is required within the highbay the appropriately trained technician will enter the highbay via the raised walkway.
- The technician will unlock the safety gate which is located at every highbay aisle
- As soon as the gate has been unlocked the crane in that aisle will automatically shutdown
- The technician will conduct the required maintenance and will remove the key from the crane insert into the gate and close the gate behind
- Once the key has been returned to the gate the crane will begin its duties again.

7. CCTV coverage and highbay area monitored via CCTV at a control point/location:

A CCTV system is provided to monitor the following areas

- 100% coverage of internal warehouse
- 100% coverage all external staging areas & coverage under all external canopy areas
- 100% coverage of all handstand areas
- Truck entry & exit lanes
- Internal main office reception area
- Visitor car parks.

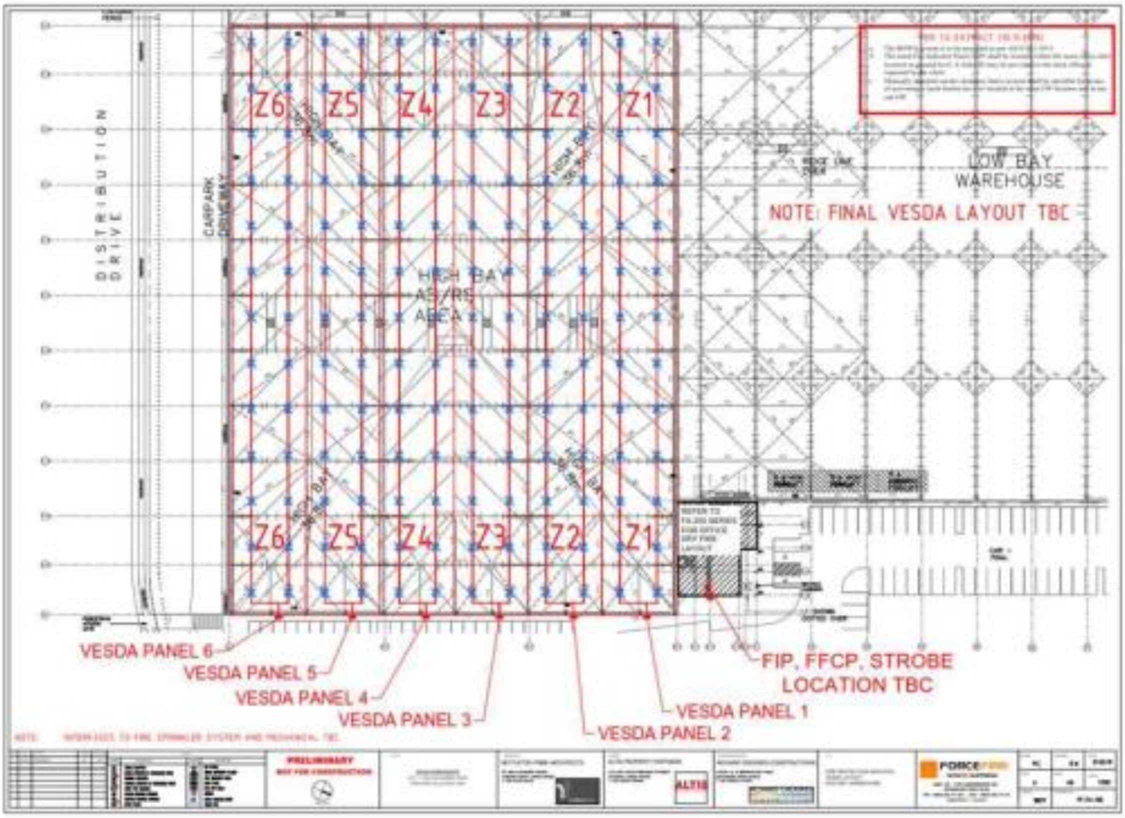
Give the above nearly all areas of the internal and external of the building will be monitored with CCTV.

8. Building access details:

- All staff entry to the site will be via the main office.
- All truck entry and exit will be via the truck entry / exit

9. Fire Safety Measures:

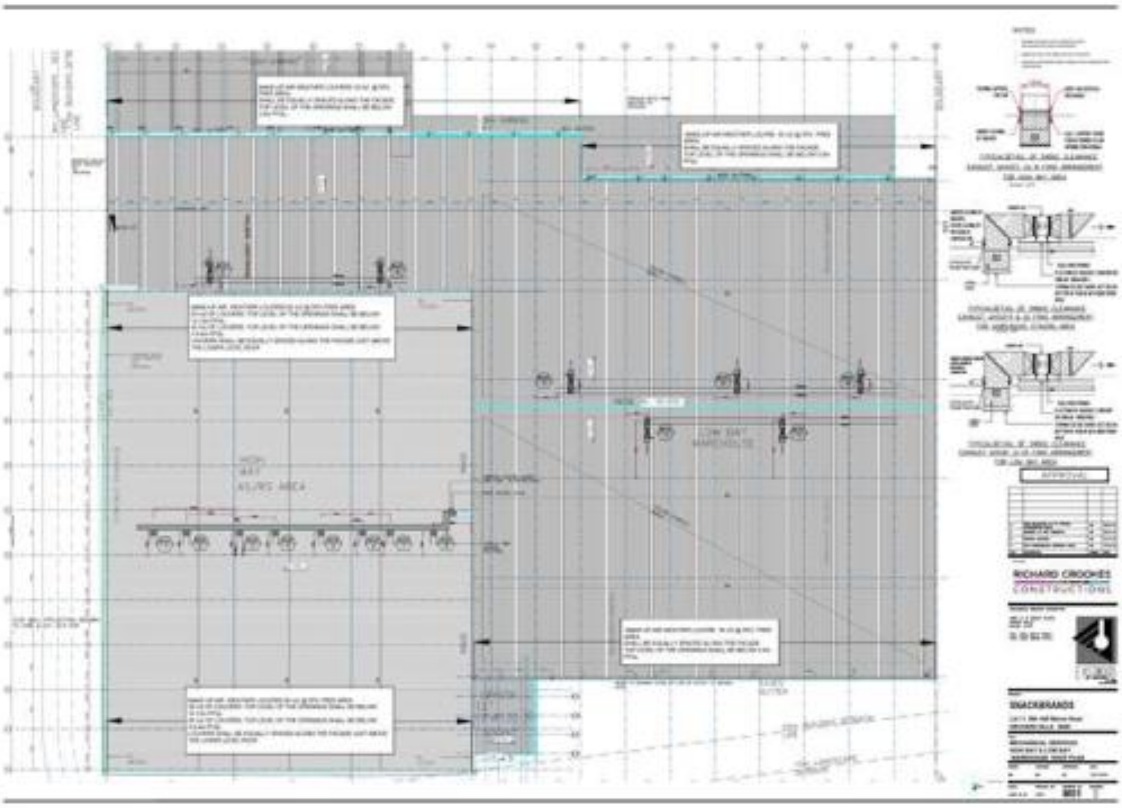
- The entire building is provided with automatic fire sprinkler protection in accordance with AS 2118.1:2017. The sprinkler system shall be as follows:
  a. The warehouse portion of the subject building is to be sprinkler protected with the installation of Storage Sprinklers incorporating K22 'fast response' sprinkler heads. The activation temperature of K22 storage sprinkler heads shall be no more than 100°C; and
  b. In-rack sprinklers are provided within parts of the storage areas (i.e. K22 sprinkler heads) in accordance with AS2118.1:2017, FM Global Guidelines and as per the fire protection services requirements and specifications; and
  c. All other storage and/or manufacturing areas not protected with Storage Sprinklers (i.e. K22 "fast response" sprinkler heads) in accordance with the hazard classification strictly commensurate with AS2118.1:2017, FM Global Guidelines and as per the fire protection services requirements and specifications; and
  d. Covered awnings forming part of the Class 7b warehouse portion of the subject building are sprinkler protected as per Specification E1.5 from Volume One of the NCC and AS2118.1:2017 to 'Ordinary Hazard 3' classification; and
  e. The Class 5 office portion of the subject building are sprinkler protected as per Specification E1.5 from Volume One of the NCC and AS2118.1:2017 appropriate to 'Light Hazard' classification and fitted with fast response sprinkler heads.
- An aspirating fire detection and alarm system (i.e. VESDA) is provided within the high bay area (only) in accordance with AS1670.1:2015.



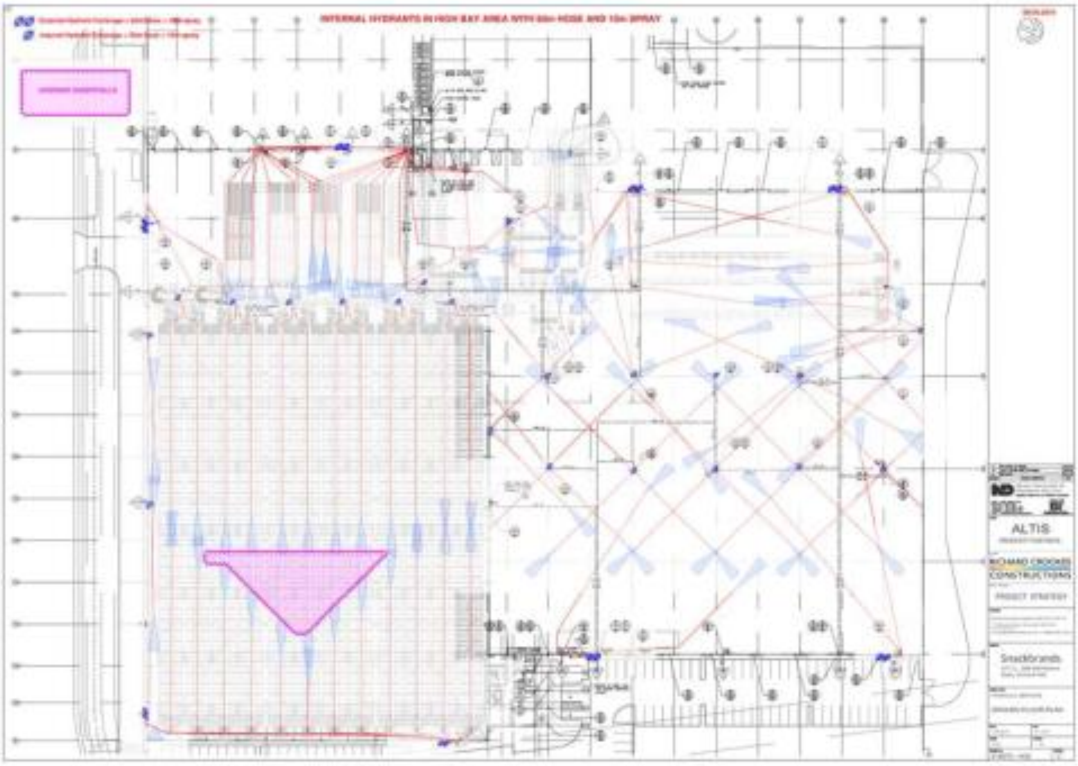
- The automatic fire sprinkler system and fire detection system (including VESDA) must be interconnected to the Building Occupant Warning System (BOWS).
- The Building Occupant Warning System (BOWS) shall actuate upon activation of the automatic sprinkler system and/or the automatic fire detection system. The BOWS shall initiate a General Fire Alarm (GFA) throughout the building and hence achieve sound pressure levels in accord with AS1670.1:2015.
- The main Fire Indicator Panel (FIP) is located within the main office entry location at ground level.
- Installations activating the BOWS are connected to a fire alarm monitoring system connected to a fire station or fire station despatch centre in accordance with AS1670.3:2004.
- The warehouse portions of the building (only) are provided with a smoke clearance system/s to allow a degree of smoke and hot gas venting from the warehouse portions of

the building. In this instance, the smoke clearance system shall can be achieved via a manually operated smoke clearance fan system as per the following:

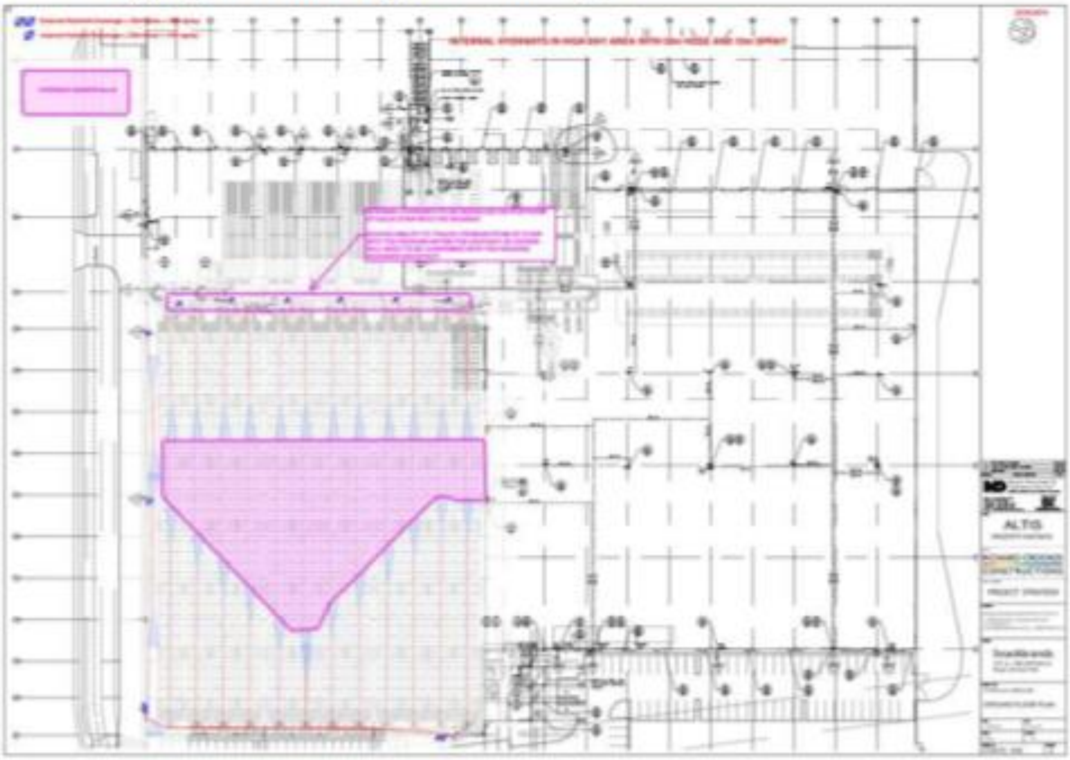
a. Manual Operation (dedicated fire mode system for smoke clearance – **fire brigade use only**); and
   i. Manually operated smoke clearance fan(s) system shall be operable by means of activating a 'push button devices' located at the main FIP location and at any sub FIP; and
   ii. The warehouse portion shall have the capacity to vent a minimum of one (1) air change per hour throughout the respective warehouse portions; and
   iii. Designed and installed in accordance with Specification E2.2b with regards to the componentry such as control gear, wiring and operation temperature (i.e. 200°C for a period of 1 hour); and
   iv. Designed and installed with power supply wiring to the smoke clearance fan infrastructure must comply with AS1668.1:2015.



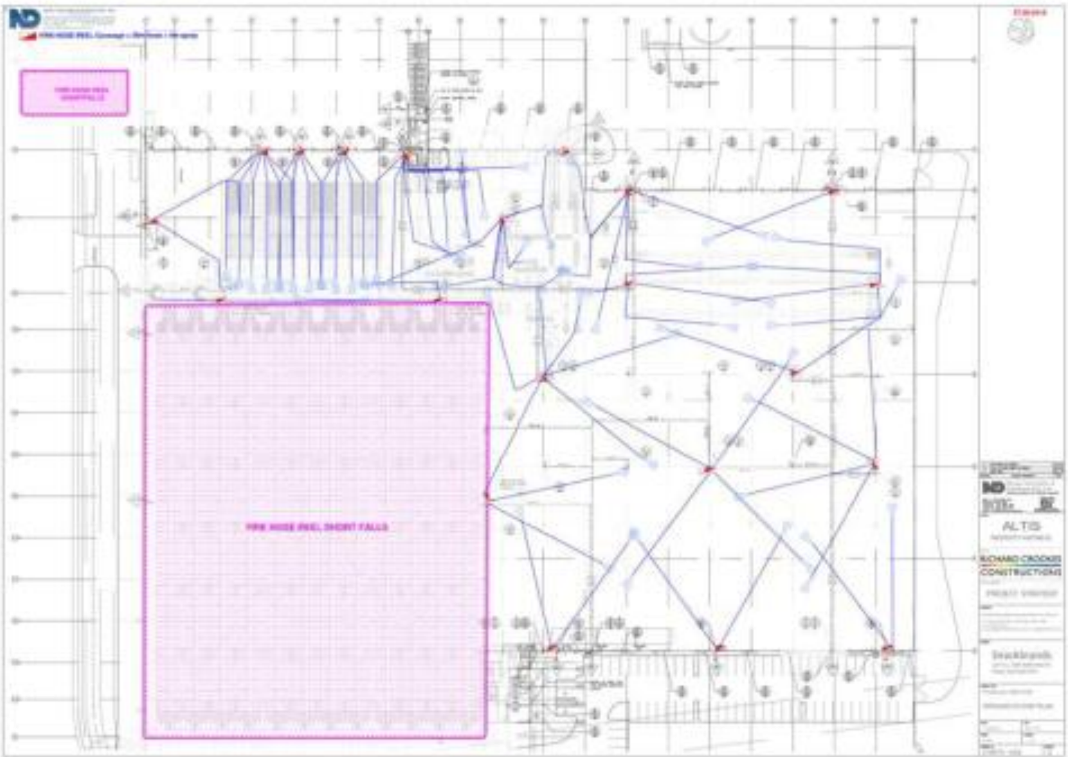
- Fire hydrants are to be located and installed in accordance with Clause E1.3 from Volume One of the NCC and AS2419.1:2005 with the exception of the following:
  a. Permit external fire hydrants to be located beneath the covered awnings whilst utilising two (2) lengths of 30m fire hose for the purposes of achieving fire hydrant coverage; and
     i. Provide additional external 'fall back' hydrant(s) to facilitate operations such that fire-fighters are able to utilise the fire hydrants located beneath the covered awnings. The external 'fall back' fire hydrants are to be located within 60m if the fire hydrants located beneath the covered awnings, be located as close as possible to the perimeter vehicular access location and furthermore are to be design and installed to achieve attack fire hydrant performance. Finally, fire hydrant coverage from the 'fall back' hydrant(s) must provide coverage to all fire hydrants located beneath the awning structures.
- Fire hydrant coverage shortfalls occur to the high bay area only:
  a. Two (2) lengths of internal fire hydrant hose coverage


ALTIS
RICHARD CROOKES
CONSTRUCTIONS
Snackbrands

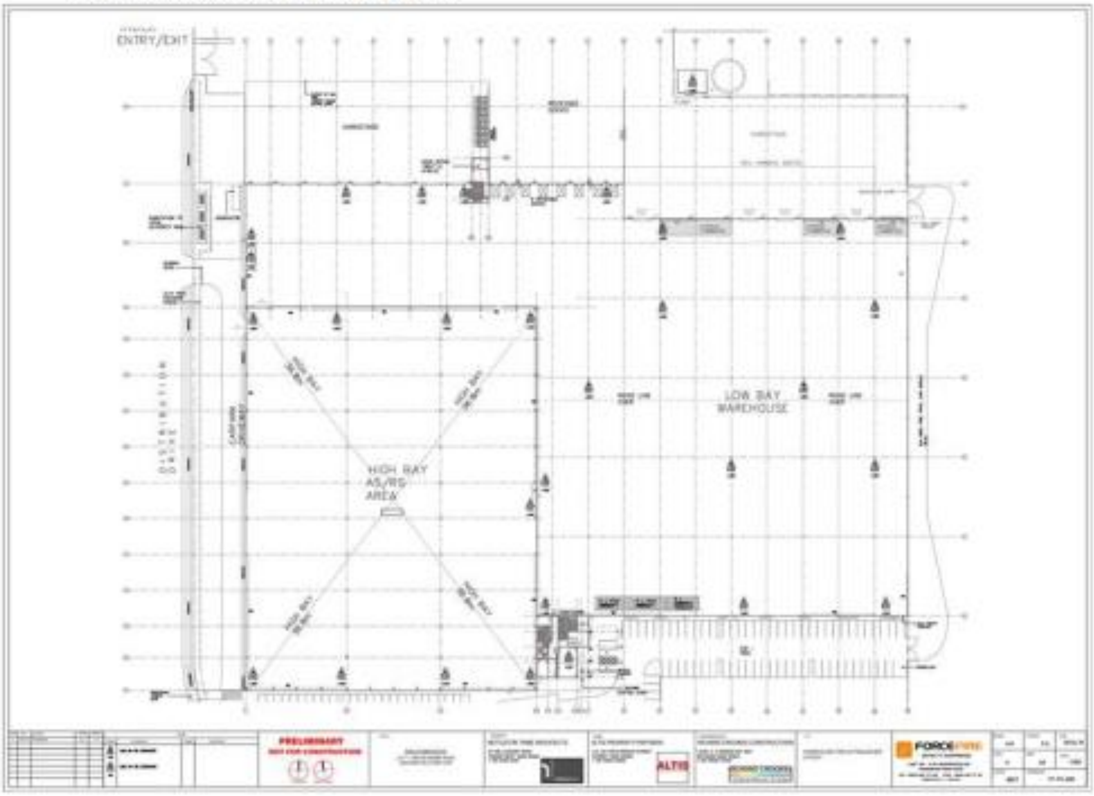
b. One (1) length of internal fire hydrant hose coverage.



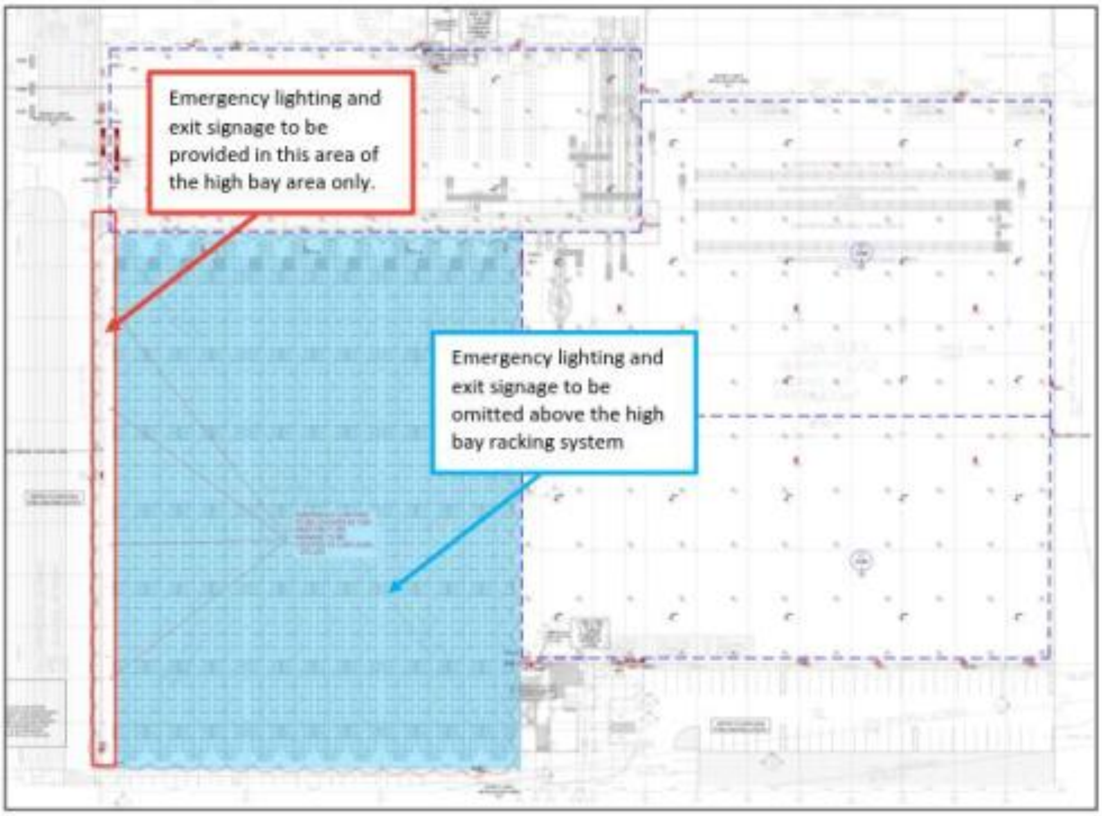
- Internal fire hydrants are required for coverage purposes. The internal fire hydrants are to be located in the building such as to allow progressive movements of fire fighters towards central parts of the building:
  a. When working from an external hydrant, the next additional hydrant is located within the building not more than 50m from the external hydrant; and
  b. When working from an internal hydrant (either within 4 metres of an exit or another additional fire hydrant), the next additional hydrant is located not more than 25m from that hydrant; and
  c. Where additional hydrants are provided, a localised block plan is provided at every fire hydrant pictorially and numerically illustrating the location of the next available additional hydrant; and
- A fire hydrant ring main is provided; and
- Block plans are provided at the main Fire Indicator Panel (FIP) and at the fire hydrant booster assembly connection; and
- The fire hose reel system are provided accordance with AS2441.1:2005 with the exception of the following:
  a. Nil fire hose reel coverage to the storage (i.e. racking portions) within the high bay zone.



- Portable fire extinguishers are provided in accordance with AS2444:2001; and
  a. Additional portable fire extinguishers are provided in strategic locations within the storage portions of the high bay zone;



- Emergency lighting in accordance with AS2293.1:2005, with the exemption of the following:
  a. Nil emergency lighting above the high bay racking system located within the high bay area.
  b. Exit signs and directional exit signs are installed throughout the building in accordance with Clauses E4.5, E4.6 and E4.8 from Volume One of the NCC and AS2293.1:2005 excluding the high bay areas.



  a. The high bay area shall be installed with low level LED Emergency spitfire lighting to the small maintenance corridor (only) located along the southern edge of the high bay area; and
  b. Jumbo Emergency Exit signage shall be provided over the doorways exiting the building.

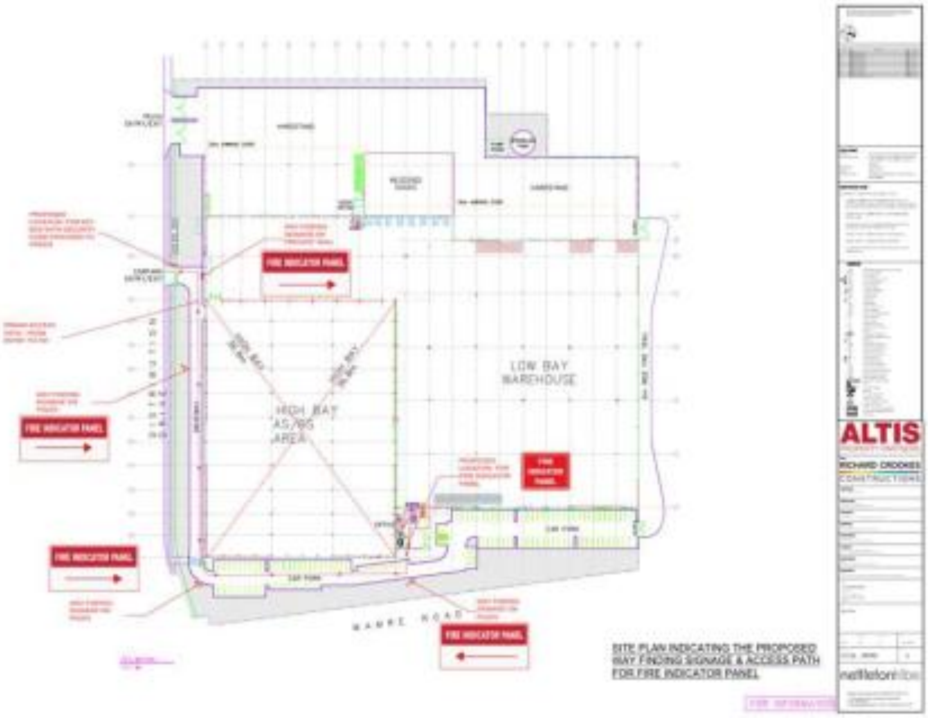
  Note: There is no requirement for general lighting or emergency lighting throughout the high bay racking system as it is automated.

- The high bay area that consists of the following electrical supplies; (DB:7, PPD-01, PPD-02, PPD-03, PPD-04, PPD-05, MCP-01 (Future), MCP-02 & PPD-06 (Future).
  a. All of these electrical supplies are fed directly from one of the three Mains Switchboards that are all located together in the Main Switch room.

b. Each independent submain supply shall be labelled at each respective MCCB on the relevant MSB. Furthermore, drawings shall be provided within the MSB Room showing each of the noted electrical supplies for clarity should FRNSW require to de energise these DB's.

10. Vehicular Access and Open Space Provisions:

- The perimeter vehicular access serving the development is continuous around the site.
- To further assist the attending fire brigades, additional signage are provided (externally along the building) from the vehicular entry location and along the perimeter access road directing fire crews to the location of the FIP which is situated within the building's main entrance.
- Any gates forming part of the perimeter vehicular access road that are proposed to be locked are fitted with suitable conventional 003 padlocks or alternatively, the FNRSW has been provided with building keys to enable fire-fighter access.
- A secure key box is located at the front gate to house the building/site keys for the attending fire crew. The security code to the secure key box has been provided to the FRNSW.
- The vehicular access is designed to accommodate turning arcs for General Appliance Access.



11. Storage and Handling of Goods:

There are no dangerous goods stored or handled throughout the site.

A supply of full and empty 9kg gas bottles will be required for running gas forklifts. The gas bottles will be stored in Australian Standard gas bottle cages located external to the building under the awning. The number of gas bottles to be located on site at any one time as follows:

- 20 x 9kg full bottles; and
- 10 x 9kg full bottles

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12. Dangerous Goods Letter:

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Altis Property Partners

Level 14,
60 Castlereagh Street
Sydney NSW 2000

Snack Brands Stage 1 Warehouse Development

RE: Dangerous Goods

Further to your query regarding the Dangerous Goods requirement for the project we confirm the following:

No Dangerous goods will be stored within the building. A supply of full and empty 9kg gas bottles will be required for running gas forklifts

These will be stored in Australian Standard compliant gas bottle cages located external to the building under the awning. We estimate we will have the following number of gas bottles onsite at once.

20 9Kg full bottles
10 9KG empty bottles

Please advise if you require any additional information.

Regards

Sion Westcott-Lewis

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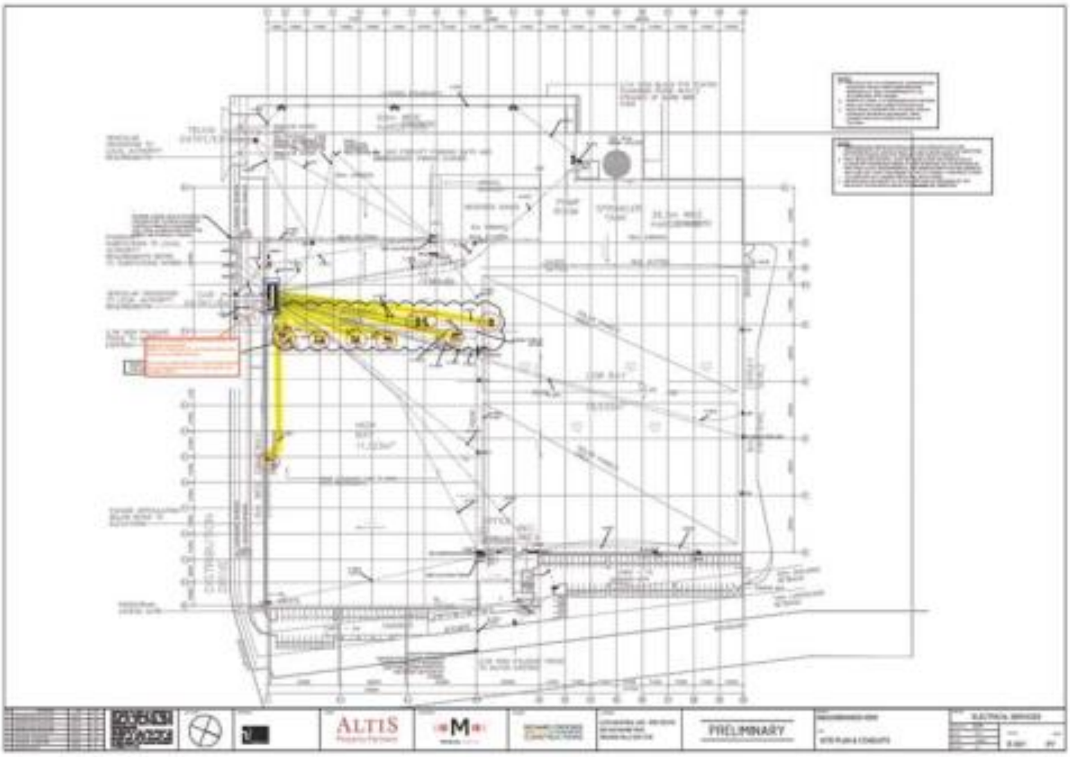
13. Power Isolation Procedure to High bay Area:

The following power isolation procedures are provided including the availability of trained persons to assist the FRNSW with isolating the power in the event that the FRNSW arrive and are required to intervene and undertake firefighting operations.

As illustrated below, low level LED Emergency spitfire lighting is provided to the small maintenance corridor located along the southern edge of the high bay area. These are accompanied with Jumbo Emergency Exit signage over the doorways exiting the building. THERE IS NO GENERAL LIGHTING OR EMERGENCY LIGHITNG THROUGHOUT THE HIGH BAY AREA



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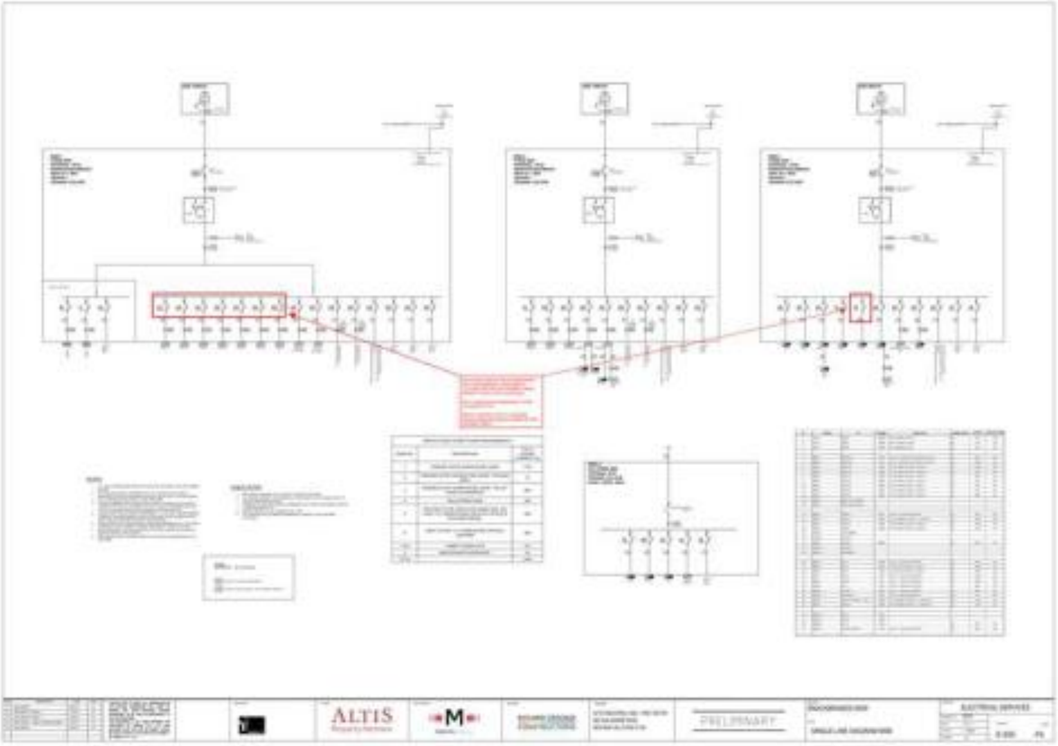


The High bay area consists of the electrical supplies; (DB:7, PPD-01, PPD-02, PPD-03, PPD-04, PPD-05, MCP-01 (Future), MCP-02 & PPD-06 (Future). All of these electrical supplies are fed directly from one of the three Mains Switchboards that are all located together in the Main Switch room. Each independent submain supplies are labelled at each respective MCCB on the relevant MSB.

The following diagram is provided in the MSB Room (and at the FIP for information) showing each of the noted electrical supplies above for clarity should FRNSW require to de energise these DB's.

14. Snackbrands site access person(s) contact details (during business hours and after hours):

In case of an emergency, at least one (1) trained personnel per shift (i.e. Snackbrands employee) on site will be available to support FRNSW intervention including the non-business hours.

- Darryl Malton will be the site distribution Manager 040 0557 462
- Sion Westcott-lewis is the logistic manager 0419 747 805
- Jackie Vrljucak will be head of OH&S 0427 003 513

Appendix Q. Exit Signage and Main Switchboards

From: Luke Nichols <Luke.Nichols@modcol.com.au>
Sent: Monday, 25 February 2019 5:14 PM
To: 'Damien Silva' <SilvaD@richardcrookes.com.au>
Cc: John Stathis <John.Stathis@modcol.com.au>; Ben Kilby <KilbyB@richardcrookes.com.au>; Grant Johnson <Grant.Johnson@modcol.com.au>; Parkan Behayeddin <Parkan.Behayeddin@scifire.com.au>
Subject: RE: Snackbrands - Fire brigade comments

Hi Damien,

As discussed with Parkan (Scientific Fire Services) this afternoon, we have proposed to supply & install low level LED Emergency spitfire lighting to the small maintenance corridor located along the southern edge of the high bay area. They will be accompanied with Jumbo Emergency Exit signage over the doorways exiting the building. There is no requirement for general lighting or emergency lighting throughout the high bay racking system as it is automated. (Please refer to the attached mark up and tech data sheet)

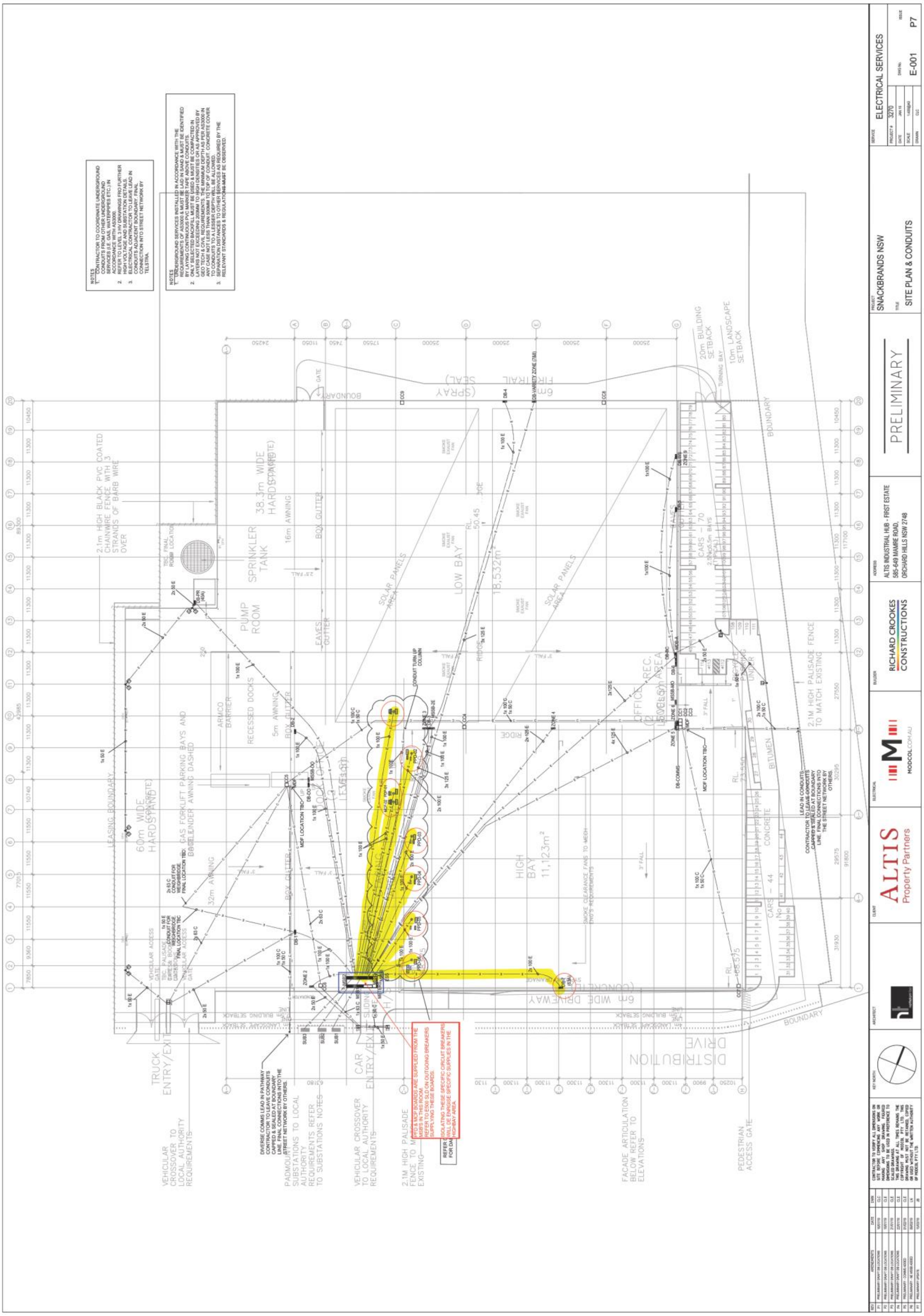
Regarding the Highbay area that consists of the following electrical supplies; (DB:7, PPD-01, PPD-02, PPD-03, PPD-04, PPD-05, MCP-01 (Future), MCP-02 & PPD-06 (Future). All of these electrical supplies are fed directly from one of the three Mains Switchboards that are all located together in the Main Switch room. Each independent submain supply shall be labelled at each respective MCCB on the relevant MSB. To assist, we can supply the attached drawing in the MSB Room showing each of the noted electrical supplies above for clarity should FRNSW require to de energise these DB's. We can also have the same plan located at the FIP.

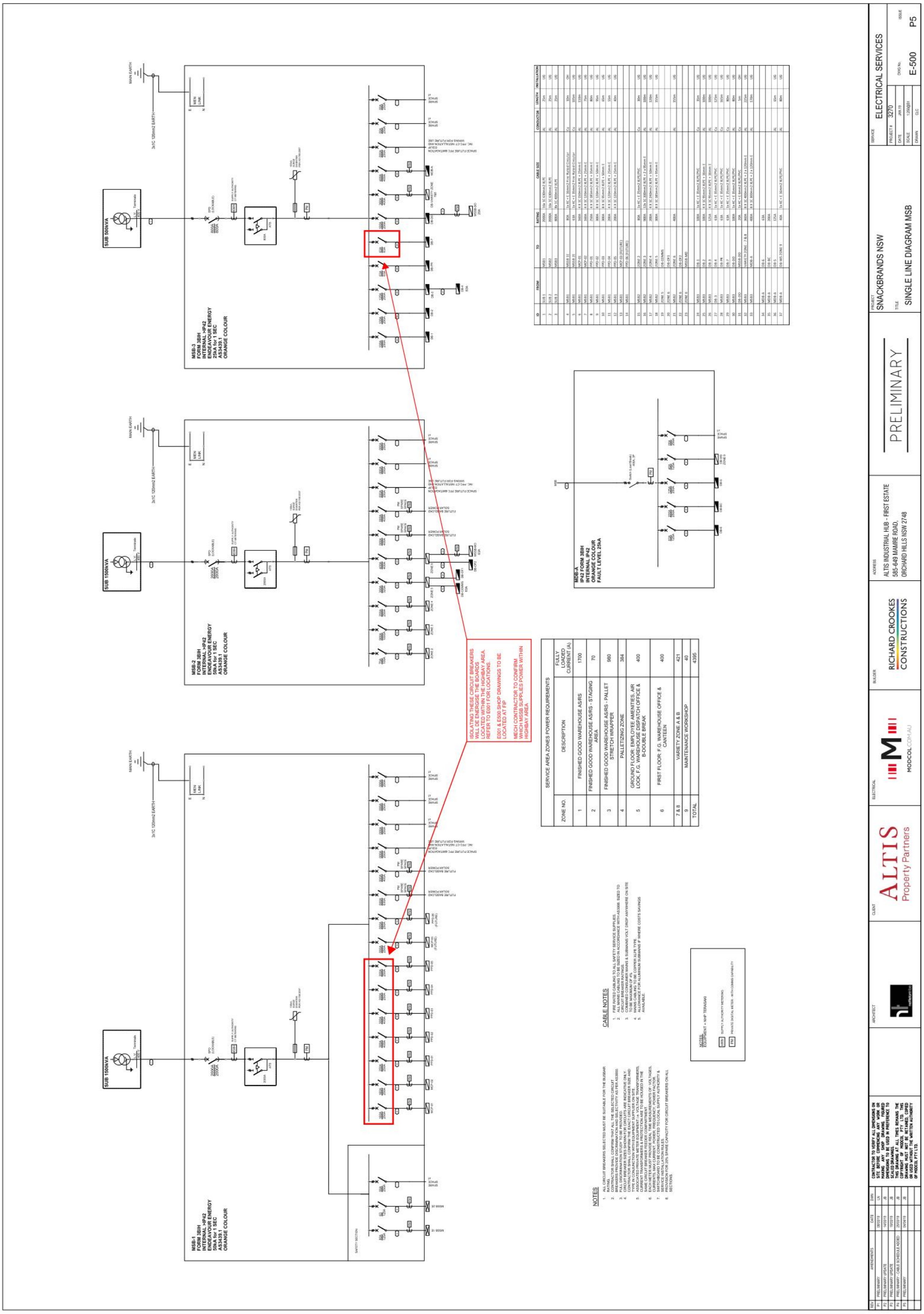
Can you please advise if you require any further documentation in order to close this out ?
I have also cc'd in Parkan for reference.

Thanks

Regards,

Luke Nichols
M. 0412 854 778 | luke.nichols@modcol.com.au


ELECTRICAL SERVICES
E-001
P7
SNACKBRANDS NSW
SITE PLAN & CONDUITS
ALTIS INDUSTRIAL HUB - FIRST ESTATE
585-649 MAMRE ROAD,
ORCHARD HILLS NSW 2748
RICHARD CROOKES CONSTRUCTIONS
ALTIS
Property Partners
PRELIMINARY



Appendix R. Clevertronics Economy LED Supalite

EFLLED

CLEVERTRONICS ECONOMY LED SUPALITE

PRODUCT INFORMATION	
Catalogue Number	EFLLED
Description	Economy LED Supalite Flood Unit, surface mount emergency light
Operating Mode	Non-Maintained
Enclosure	Polycarbonate
Mounting	Surface Wall Mount & supplied with flex and plug (the flex and plug can be removed to allow for a hard wired connection)
Testing System	Manual Test Switch
Charging Method	NiCd Pulse Charge
Dimensions W x H x D	Main enclosure - 282mm (W) x 137mm (H) x 64mm (D) Total height including LED Heads 225mm.
Lamp(s)	2 x LED
Operating Voltage	240V AC
Power Consumption	2.0W standby (3.3W Max during the first 16 hours charge)
Operating Temperature	1°C to 40°C (Ambient)
IP Rating	IP20
AS2293 Classification	N/A

REPLACEMENT PARTS

PART NUMBER	DESCRIPTION
1510170	Battery, 5SubC Cell, NiCad Battery Pk 6V 1.8AH, SBS, Bracket
8002080	PCA: LED Driver/Charger PCA
1100955	LED Eco Lamp Head Ass, Cable & Connector

Version: September 2015-1

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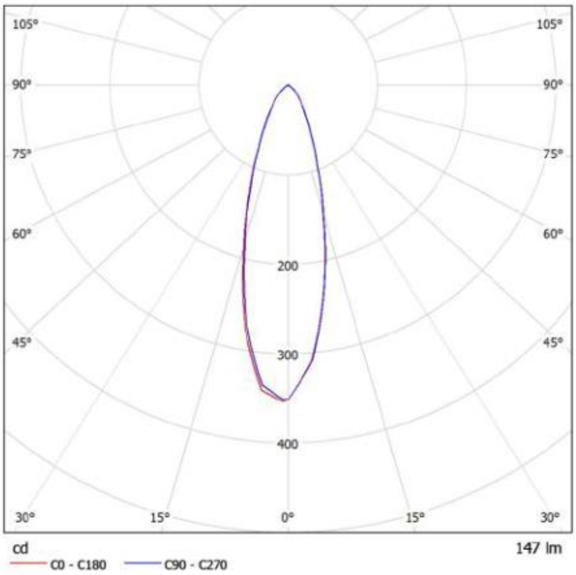
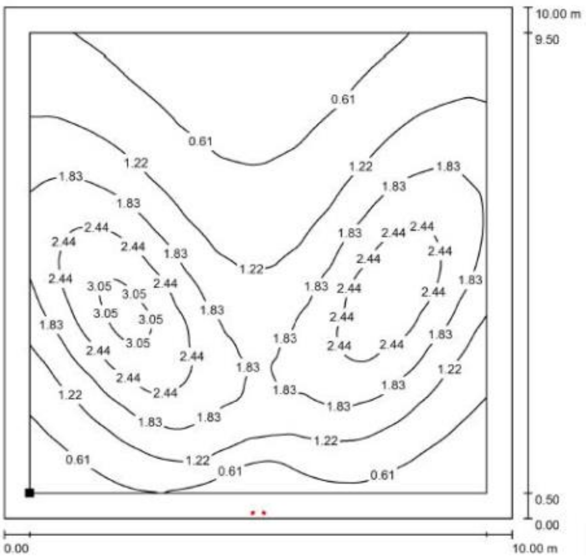
Spacing Guidance

Polar curve for a single LED lamp head



Isolux plot and value table for a 10m x 10m area serviced by an EFLLED with each LED lamp head tilted down 30°, rolled out 30°. EFLLED mounted on the wall at a height of 3m (values in lux).



0.65	0.56	0.46	0.37	0.32	0.29	0.28	0.31	0.34	0.41	0.54	0.67	0.78	0.84
0.77	0.67	0.54	0.43	0.37	0.33	0.32	0.35	0.40	0.49	0.63	0.79	0.91	0.98
0.91	0.80	0.63	0.51	0.42	0.38	0.36	0.41	0.46	0.58	0.75	0.95	1.07	1.14
1.08	0.96	0.77	0.60	0.49	0.43	0.42	0.46	0.54	0.69	0.89	1.12	1.24	1.28
1.28	1.15	0.93	0.72	0.58	0.50	0.48	0.53	0.62	0.82	1.07	1.33	1.44	1.43
1.52	1.38	1.13	0.86	0.67	0.58	0.56	0.61	0.73	0.97	1.27	1.55	1.66	1.58
1.78	1.64	1.37	1.04	0.79	0.68	0.64	0.70	0.85	1.15	1.51	1.80	1.89	1.73
2.04	1.94	1.65	1.25	0.95	0.78	0.74	0.82	1.00	1.36	1.78	2.06	2.10	1.90
2.29	2.25	1.97	1.50	1.12	0.92	0.86	0.95	1.17	1.60	2.07	2.33	2.27	1.96
2.49	2.57	2.31	1.79	1.32	1.07	0.99	1.10	1.36	1.86	2.35	2.56	2.39	1.97
2.63	2.86	2.64	2.10	1.54	1.23	1.14	1.26	1.56	2.12	2.60	2.72	2.44	1.91
2.65	3.02	2.92	2.38	1.76	1.40	1.30	1.41	1.75	2.33	2.77	2.77	2.40	1.79
2.53	3.05	3.11	2.65	2.00	1.59	1.44	1.58	1.94	2.49	2.82	2.69	2.22	1.58
2.33	2.92	3.21	2.79	2.19	1.75	1.59	1.73	2.06	2.50	2.80	2.50	1.99	1.38
1.99	2.62	3.06	2.88	2.33	1.90	1.73	1.87	2.18	2.54	2.54	2.20	1.66	1.14
1.69	2.26	2.78	2.76	2.37	2.00	1.77	1.92	2.15	2.34	2.31	1.90	1.42	0.95
1.37	1.85	2.36	2.55	2.27	1.98	1.80	1.87	2.00	2.15	1.97	1.56	1.15	0.77
1.07	1.47	1.92	2.21	2.03	1.77	1.68	1.62	1.71	1.81	1.61	1.25	0.91	0.62
0.82	1.13	1.51	1.79	1.72	1.53	1.41	1.28	1.35	1.43	1.24	0.95	0.69	0.48
0.62	0.86	1.14	1.38	1.37	1.17	0.82	0.96	1.04	1.05	0.91	0.69	0.50	0.35
0.46	0.61	0.83	0.98	0.98	0.64	0.41	0.49	0.74	0.76	0.64	0.49	0.36	0.25

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Appendix S. Dangerous Goods Letter

Altis Property Partners

Level 14,
60 Castlereagh Street
Sydney NSW 2000

Snack Brands Stage 1 Warehouse Development

RE: Dangerous Goods

Further to your query regarding the Dangerous Goods requirement for the project we confirm the following:

No Dangerous goods will be stored within the building. A supply of full and empty 9kg gas bottles will be required for running gas forklifts

These will be stored in Australian Standard compliant gas bottle cages located external to the building under the awning. We estimate we will have the following number of gas bottles onsite at once.

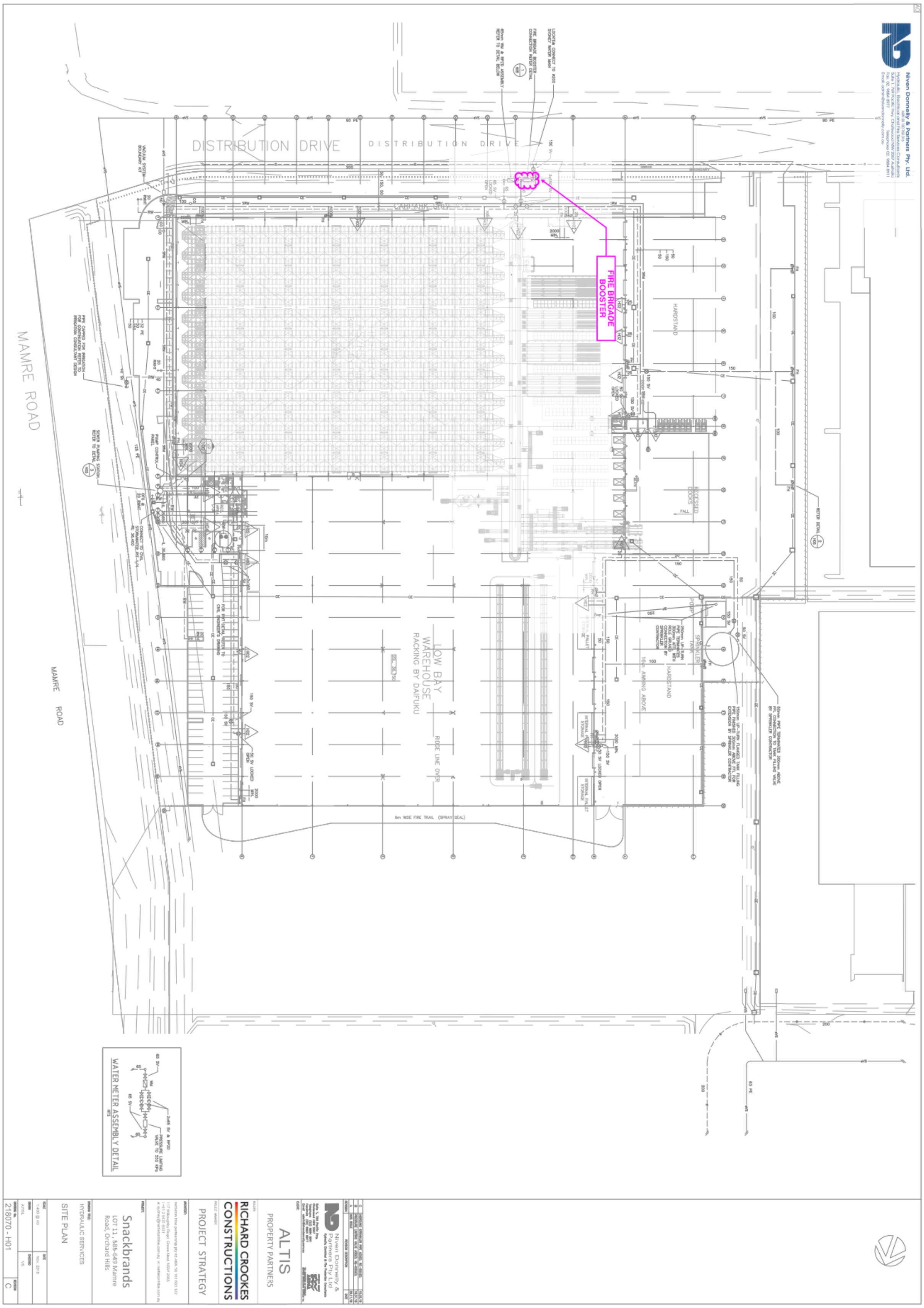
20 9Kg full bottles
10 9KG empty bottles

Please advise if you require any additional information.

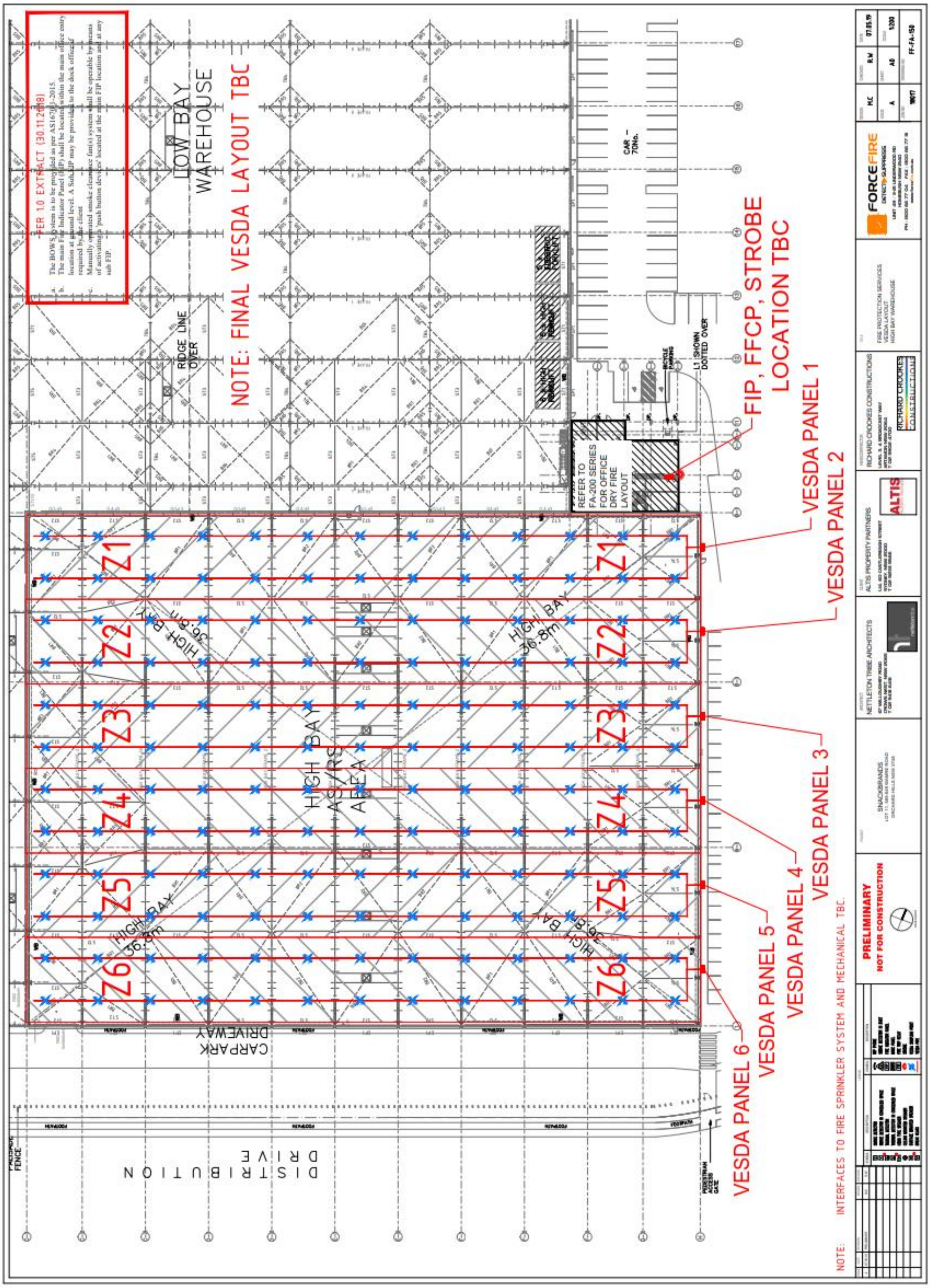
Regards

pp Sion Westcott-Lewis

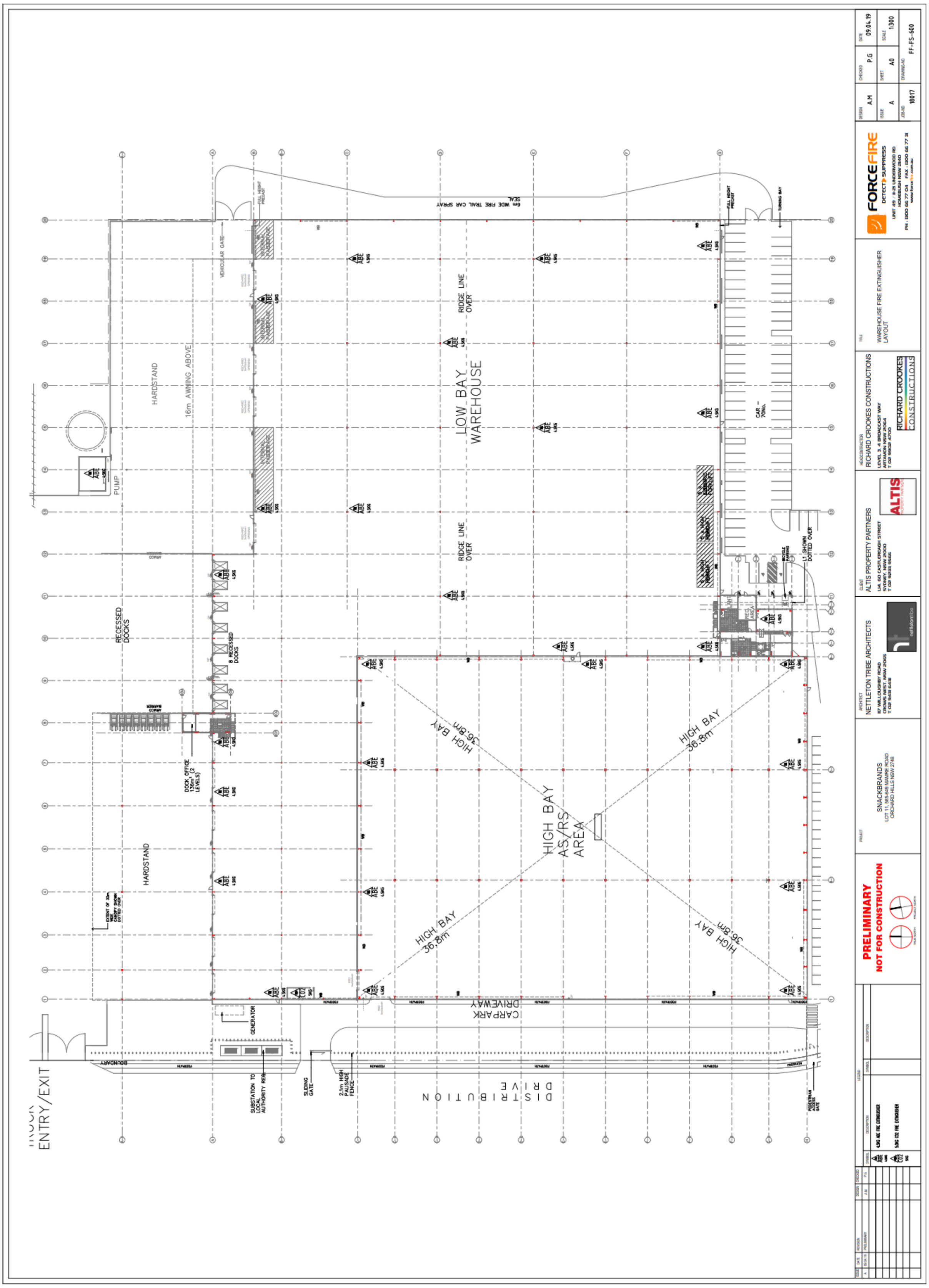
Appendix T. Fire Brigade Booster Assembly Location



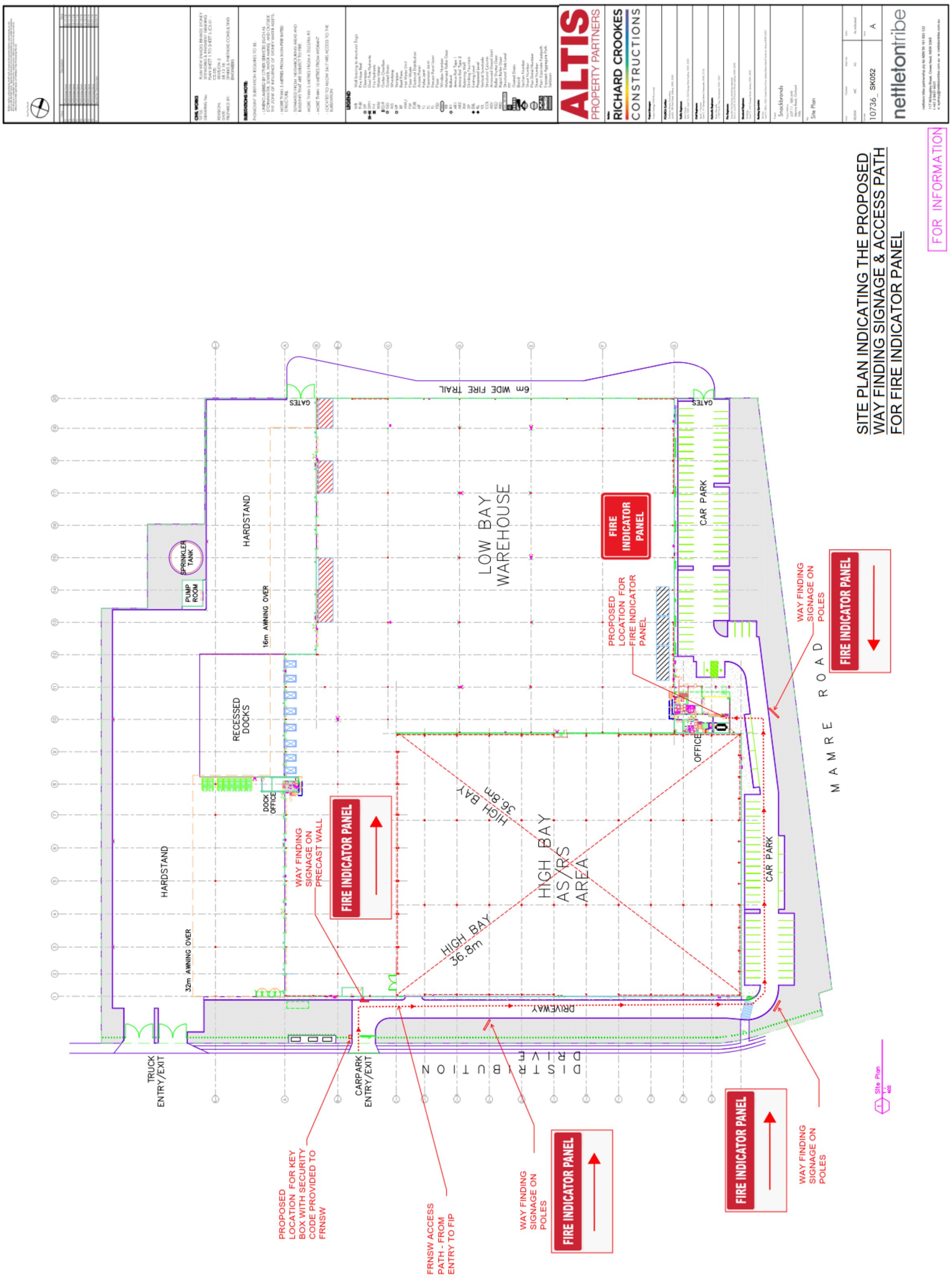
Appendix U. VESDA Layout



Appendix V. Fire Extinguisher Layout



Appendix W. Location of Secure Key Box and Wayfinding Signage to the FIP



Appendix X. Fencing and Gate Details (High Bay Area)

Annexure C FRNSW Guideline

Fire safety guideline

Access for fire brigade vehicles and firefighters

Version 05
Issued 4 October 2019

Fire Safety Branch
Community Safety Directorate

Published by
Fire and Rescue NSW
Community Safety Directorate
Fire Safety Branch

Document control

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Document ID: D15/6224
Version: Version 05
Release Date: 4 October 2019

Document history

Version	Date	Authorised by:
01	17 Jul 2007	Director Risk Management
02	21 Oct 2010	Director Risk Management
03	29 Jul 2011	Director Risk Management
04	24 May 2019	Interim approval by Chief Superintendent Fire Safety
05	4 Oct 2019	Assistant Commissioner Community Safety

Contents

1 Purpose

The purpose of this document is to provide safe, efficient and effective access for *fire brigade vehicles* (i.e. a *fire appliance*) to any *premises* and allow firefighters to rapidly intervene when fire or other *emergency incident* occurs.

2 Scope

This guideline details the requirements of Fire and Rescue NSW (FRNSW) for:

a) identifying areas within NSW that are protected by the diverse types of *fire appliances* used by *fire brigades* within NSW

b) providing access for *fire brigade vehicles* to any *premises* using public roads

c) providing access for *fire brigade vehicles* to any building, structure or site using a privately-owned road system

d) providing *hardstand* areas that are suitable for firefighting operations

e) roads and structures to support the weights and loads of *fire appliances*

f) consideration of operational limitations when planning *fire brigade vehicles* access for any proposed development

g) *fire brigade vehicle* access on land that is designated as bush fire prone land, and

h) planning and implementing local area traffic management.

When this guideline is followed, the *fire brigade* will be able to undertake their statutory duty and function to protect and save life and property during an emergency in the speediest and most efficient manner.

3 Application

This guideline applies to any land subdivision, proposed development, change of building use, or building construction that is intended to meet the *National Construction Code* (*NCC*[1]), and which is located within NSW.

Note: Performance requirement CP9 of the *NCC* requires *fire brigade vehicle* access be provided to the degree necessary (this guideline) to facilitate *fire brigade* intervention.

This guideline is intended to be used by owners, developers, designers, engineers, urban planners, regulatory and consent authorities when planning, assessing or determining any application pertaining to any applicable land or *premises*.

Access for *fire brigade vehicles* and firefighters is relevant to all *premises* and is to be commensurate to the potential level of risk; it should be considered even when not specifically identified by any planning instrument, regulation or Act.

Note: The relevant consent authority can impose conditions on development or issue orders when provision for access is inadequate.

[1] *National Construction Code 2019, Building Code of Australia Volume One*

Developers, designers, engineers and planners are to ensure that adequate access is given to an *aerial appliance* when appropriate to the development (e.g. multiple-storeys and located within the coverage area of an *aerial appliance*).

This guideline has been developed in the public interest and is intended to be used by any consent authority considering any proposed development (refer to *Section 4.15(1)(e)* of the *Environmental Planning and Assessment Act 1979*).

Note: Under *Section 4.17* of the *EP&A Act*, the consent authority may impose requirements from this guideline (in part or full) as a condition on the development consent.

This guideline is to be used for any land or development within NSW as deemed applicable by the consent authority. Access requirements are generally consistent across all emergency services, but reference should be made to other guidelines where appropriate (e.g. NSW Rural Fire Service (RFS) *Planning for Bush Fire Protection* in bush fire prone land).

4 Definitions

The following definitions apply in this guideline:

aerial appliance — means a specialised type of *fire appliance* fitted with an *aerial apparatus* which elevates to given heights to provide fire suppression and rescue capabilities.

aerial apparatus — means a purpose-built device which can elevate, extend, articulate and slew within a field of operations to provide operational functions at elevated height (e.g. water stream, cage rescue, stairway rescue, observation, gear lift, water supply, work platform).

alternative solution (or performance solution) – means a method of complying with the *NCC* performance requirements other than by a ‘deemed-to-satisfy’ solution.

carriageway – means any public road, *private road*, shared traffic zone, laneway, access way or the like, whether having a sealed surface layer or not, that is intended for the carriage of vehicles. A carriageway may comprise one or more vehicle lanes.

complex development – means any development comprising one or more buildings or structures of higher than normal risk (e.g. infrastructure, podiums, precincts and shared zone or a *major facility*).

designated building entry point (DBEP) – means the entry point into a building providing firefighter access when fire or other *emergency incident* occurs.

Note: Typically, the *DBEP* will be the main building entrance. The *DBEP* is identified when the building has a fire detection, warning, control and intercom system installed.

designated site entry point (DSEP) – means the entry point into a site that provides access to emergency vehicle when fire or other *emergency incident* occurs.

effective height – means the same as in the *National Construction Code*.

emergency incident – means any abnormal and dangerous situation that has caused, or threatens to cause, harm persons, property or the environment, and requires a response by an emergency service to manage back to safe and normal condition.

fire appliance – means any vehicle that forms part of the equipment of a *fire brigade* and that is equipped with an audible warning device and flashing lights.

fire brigade – means a statutory authority constituted under an Act of Parliament having as one of its functions, protect life and property from fire and other emergencies.

fire brigade vehicle – means any *fire appliance* being used by firefighters from a *fire brigade*.

fire brigade station – means a state government operated premises which is a station for a *fire brigade* (i.e. FRNSW fire brigade station or NSW RFS fire brigade station).

fire district – means an area which the *Fire and Rescue NSW Act 1989* applies in relation to fires and contributions of costs.

Note: Fire districts are constituted by the Governor under *Section 5* of the *Fire and Rescue NSW Act 1989* by order published in the NSW Gazette.

hardstand – means an apron or section of *carriageway* specifically designated for use by a stationary *fire appliance* (e.g. for a *fire appliance* at the fire hydrant booster assembly).

local area traffic management (LATM) – means the analysis of traffic characteristics and the implementation of *traffic control devices* within a local area.

national construction code (NCC) – means the *National Construction Code (NCC) 2019, Building Code of Australia Volume One*, as amended.

major facility – means any large building or complex of related buildings on any given site and having multiple designated site or building entry points for emergency response. Any facility having a network of *private roads* providing building access may be considered major.

premises – means any building, facility or site (land).

private road – means a *carriageway* located within the boundary of privately-owned *premises* and not under the care and management of a council or public authority.

rural fire district – means an area which the *Rural Fires Act 1997* applies in relation to the area of the responsible local authority or authorities (e.g. Councils).

Note: Rural fire districts are constituted under *Section 6* of the *Rural Fires Act 1997* and published in the NSW Gazette.

stabiliser – means a hydraulic operated stabilising jack fitted to an *aerial appliance* to provide stability when the vehicle's centre of gravity shifts during operation of the *aerial apparatus*.

suction-connection outlet – means a connection outlet for suction hose that draws water from a static water supply (e.g. tank, reservoir, dam, lake, river).

traffic control device – means any sign, signal, pavement markings or other installation placed or erected by an authority having jurisdiction, for the purpose of regulating, warning or guiding road users.

turning circle radius – means the minimum arc radius that provides wall-to-wall clearance of a fire appliance turning at full steering lock (e.g. to negotiate corners or turnaround areas).

wheelbase – means the distance between the centre-point of the front steer axle (or group) and rear drive axle (or group).

5 Background

Under *Section 5A* of the *Fire and Rescue NSW Act 1989* and *Section 9* of the *Rural Fires Act 1997, fire brigades* in NSW have the duty to protect persons from injury or death and property from damage from fires and other emergencies. A fundamental factor to achieving this is the ability of firefighters to respond and undertake intervention activities as quickly as possible.

During an emergency, firefighters require efficient and effective access for a rapid and unhindered response. Poor or inadequate access to any *premises* will result in delays to response and intervention and may directly impact on the life safety of occupants.

Access to a given *premises* is primarily provided by a public road network in accordance with *Austroads Guide to Road Design*. On the given *premises*, vehicular access around buildings and structures may be provided by way of *private roads*.

Planners and designers sometimes only consider local traffic (i.e. minor vehicles) and typically exclude the carriage of heavy vehicles. *Fire brigade vehicles* are larger and heavier types of vehicles that may require access to any given *premises* at any time, without notice.

Note: When designing for local traffic, access for *fire appliances* should not be prohibited.

Owners of existing *premises* must ensure *fire brigade vehicle* access provisions are maintained at all times (e.g. access is not obstructed by parked vehicles or stored goods).

6 Fire appliances

6.1 Types of fire appliance

6.1.1 Both FRNSW and NSW RFS have several types of *fire appliances*, each specifically designed to perform a different range of functions at any given emergency.

6.1.2 Most general *fire appliances* comprise a purpose-built body fitted on a two axle truck chassis. Depending on the primary function, various levels of firefighting, rescue and hazardous materials equipment will be carried (see Figure 1).

Note: While the core function of a 'general' *fire appliance* is firefighting, some may provide only rescue or hazardous materials capability.

Figure 1 General fire appliances: tanker, pumper and rescue (from l to r)

6.1.3 FRNSW operates a fleet of *fire appliances* that are fitted with an *aerial apparatus* that elevates, rotates and extends to a given height to access an emergency in a building or structure. In this guideline, an *aerial appliance* is a 'specialist' fire appliance.

Note: An *aerial appliance* is commonly, even though incorrectly, referred to as a 'cherry picker' by the media and public.

6.1.4 Both FRNSW and NSW RFS operate specialist *fire appliances* to undertake specific functions at a given incident. These *fire appliances* are larger and heavier and may be on either a two, three or four axle truck chassis (see Figure 2).

Note: Specialist fire appliances are strategically located across NSW to protect key assets and community places as required.

Figure 2 Specialist fire appliances: bulk water, command and aerial appliance (from l to r)

6.1.5 Both FRNSW and NSW RFS operate articulated heavy vehicles (e.g. prime mover with trailer) which are excluded from the scope of this guideline.

6.2 Overall parameters for design

6.2.1 While specifications vary between *fire appliances*, for the purpose of design overall parameters are broadly categorised into two distinct *fire appliance* types as follows:

General fire appliance	
Gross vehicle mass	15 000 kg
Overall length	10.0 m
Overall width (incl. mirrors)	3.0 m
Body width (excl. mirrors)	2.5 m
Overall height	3.7 m

Specialist fire appliance	
Gross vehicle mass	29 300 kg
Overall length	12.5 m
Overall width (incl. mirrors)	3.0 m
Body width (excl. mirrors)	2.5 m
Overall height	4.3 m

Table 1 Overall parameters of fire appliances

Note: A medium rigid (MR) licence or higher is required for a general *fire appliance*, while a heavy rigid (HR) licence is required for a specialist *fire appliance*.

6.3 Coverage area by types of fire appliance

6.3.1 A general *fire appliance* will offer fire protection to any *premises* located within a *fire district* or *rural fire district*; *fire brigade vehicle* access commensurate to parameters given for ‘general’ *fire appliance* is to be provided for all *premises* in NSW.

Note: The fire may be attended by FRNSW, NSW RFS or both (e.g. mutual aid) and may also be supported by other emergency vehicles.

6.3.2 Any *complex development* may be attended by a specialist *fire appliance*; *fire brigade vehicle* access commensurate to parameters given for ‘specialist’ *fire appliance* is to be provided as appropriate to the risk.

Note: A non-fire emergency may require attendance of a specialist *fire appliance* (e.g. for rescue, aerial access or hazardous materials incident).

6.3.3 Any building having an *effective height* greater than 9 m (e.g. more than three storeys above ground) and located within the coverage area of an *aerial appliance* should be provided with *fire brigade vehicle* access commensurate to the parameters given for 'specialist' *fire appliance* as appropriate to the risk (refer to section 10.4).

Note: The portable extension ladder carried on a fire appliance can only reach 10 m high. An *aerial appliance* can provide a means of emergency escape in any building that only has a single required exit.

6.3.4 *Aerial appliances* are strategically located within *fire districts* for optimum response in areas of greatest fire risk, and cover the greater metropolitan regions of Sydney, Newcastle and Wollongong, and the regional cities of Albury and Wagga Wagga.

Note: FRNSW can be consulted to identify when development is located within the coverage area of an *aerial appliance* and 'specialist' access applies.

6.3.5 Clause E1.3 of the *NCC* requires a fire hydrant system (e.g. *AS 2419.1–2005*) be provided only when a *fire brigade station* is no more than 50 km away and is equipped to utilise the fire hydrant. The fire hydrant system is only required when the *fire brigade station* has a *fire appliance* not less than shown in Table 2.

Note: The *fire appliance* must have appropriate personnel available (i.e. crew cabin) and carry self-contained breathing apparatus. Refer to Appendix A for typical pump performance of *fire appliances*.

No. of hydrants required to flow simultaneously	Min. system design flow rate	Operating pressure	Available fire brigade station	Type of fire appliance available (as stationed within 50 km)
1	10 L/s (600 L/min.)	900 kPa	FRNSW	Any Pumper or Tanker
			NSW RFS	Any Category 1, 3, 10 or 11
2	10 L/s (1,200 L/min.)	1,000 kPa	FRNSW	Any Pumper or Tanker
			NSW RFS	Any Category 10 or 11
3	10 L/s (1,800 L/min.)	1,000 kPa	FRNSW	Any Class 2, 3 or Aerial pumper
			NSW RFS	Any Category 10 or 11
4	10 L/s (2,400 L/min.)	1,000 kPa	FRNSW	Any Class 2, 3 or Aerial pumper
			NSW RFS	None (FRNSW mutual aid only)
5 or more	≥50 L/s (≥3,000 L/min.)	1,000 kPa	FRNSW	Two or more pumpers
			NSW RFS	None (FRNSW mutual aid only)

Table 2 Types of fire appliance suitable to operate a fire hydrant system

7 Vehicle access requirements

7.1 Carriageway width

7.1.1 A *carriageway* is to be wide enough to allow easy negotiating by the *fire appliance* and provide room around the vehicle to allow firefighters to exit and work with equipment.

Note: During an *emergency incident*, the *fire appliance* will be positioned (i.e. parked) in the most tactically advantageous position.

7.1.2 Along any straight *carriageway* section, the minimum width is 4.5 m for general *fire appliance* access, or 6 m for specialist *fire appliance* access (see Figure 3).

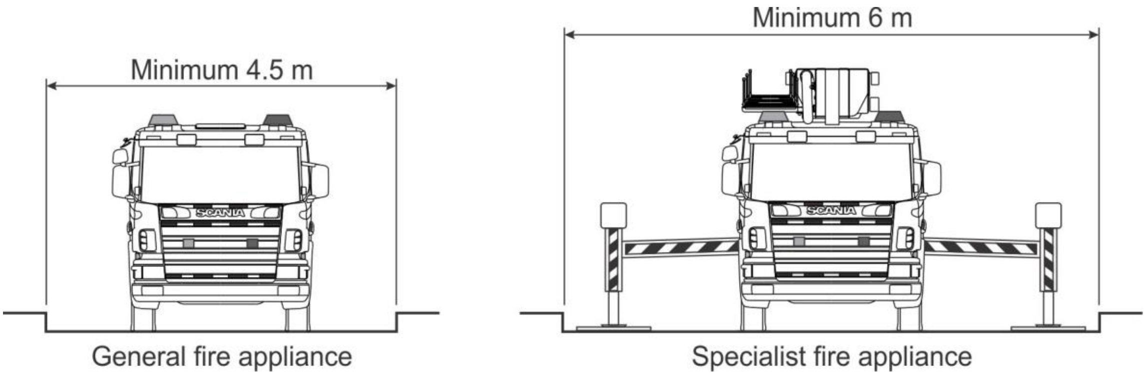


Figure 3 Minimum carriageway width (straight section)

Note: An *aerial appliance* requires additional width to extend *stabilisers* and operate. A designated *aerial appliance hardstand* area may be considered if continuous minimum width clearance cannot be achieved (see Figure 13).

7.1.3 When the *carriageway* is curved, including a corner around a building or structure, consideration is to be given to the *turning circle radius* and the minimum wall to wall clearances from both inner and outer body sections (including overhangs).

7.1.4 The minimum *turning circle radius* of any curved *carriageway* section is to be 6.5 m (inner) and 11.5 m (outer) for general *fire appliance* access, or 7.5 m (inner) and 14.6 m (outer) for specialist *fire appliance* access (see Figure 4).

Note: These turning circles provide wall to wall clearance from the vehicle body and overhangs. They are not the turning circles for the vehicle's wheel tracks.

7.1.5 The distance between inner and outer *turning circle radius* is to provide body swing clearance (i.e. vehicle swept path), and not be less than 5 m for general *fire appliance* access and 7.5 m for specialist *fire appliance* access (see Figure 4).

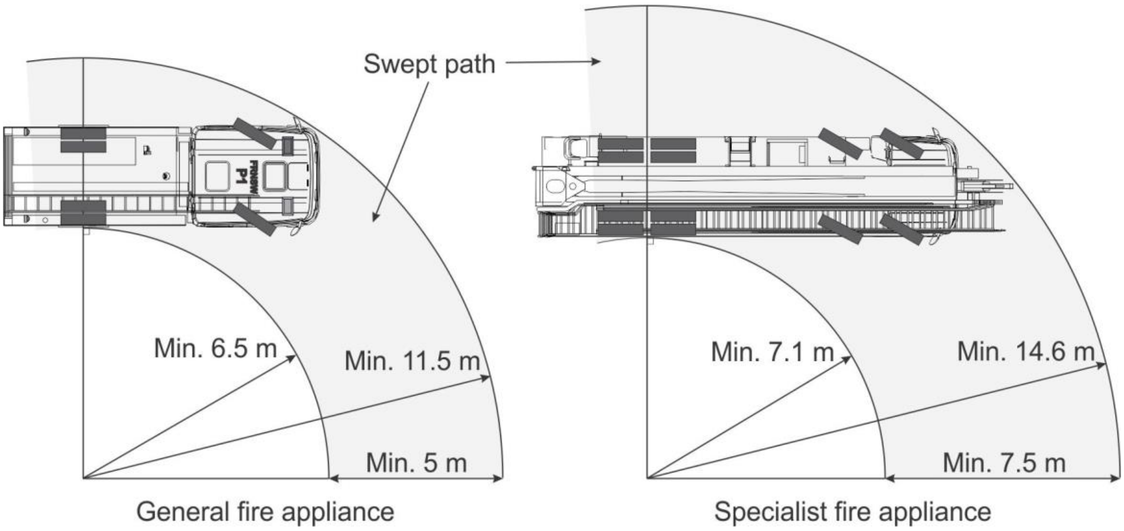


Figure 4 Minimum turning circle radius (curved section)

7.1.6 Body swing on turn entry and exit is to be considered, particularly when going around a building (see Figure 5). The pivot is tangential to the centre of the drive axle/s.

Note: The body swing arc changes with forward travel to full steering lock and back and arc created by the front opposite corner needs to clear any obstructions.

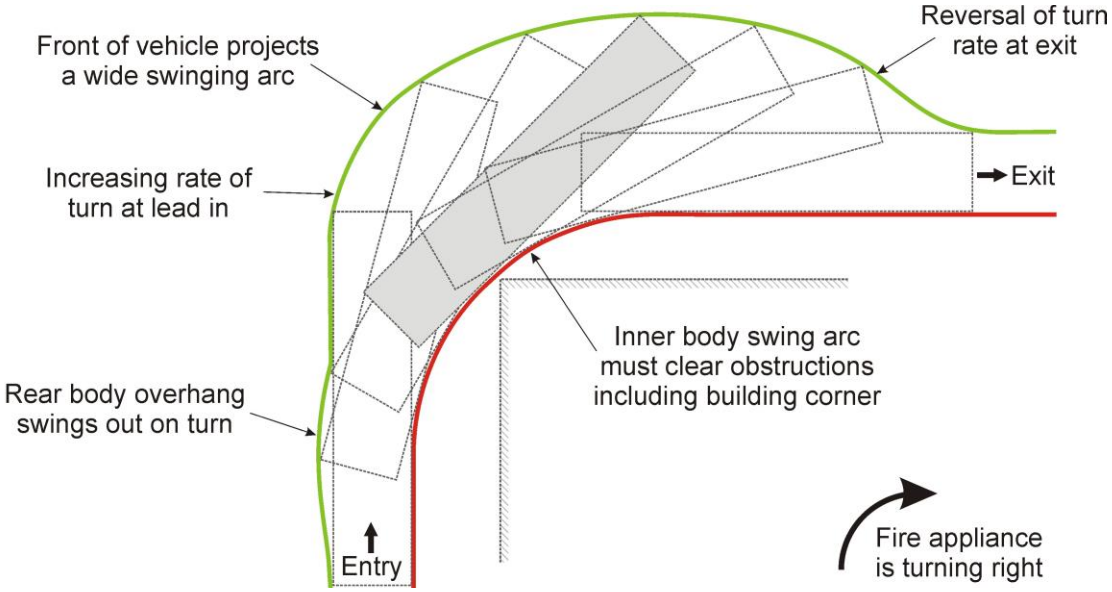


Figure 5 Typical body swing on entry and exit of turn

7.1.7 The design vehicle from *AS 2890.2:2018 Parking facilities Off-street commercial vehicle facilities* should be used for swept path analysis, with 'medium rigid vehicle' used for a general *fire appliance* and 'heavy rigid vehicle' for specialist *fire appliance*.

Note: The front overhang of some *aerial appliances* results in an increased swept circle diameter of 29.2 m instead of 27.8 m for the design heavy rigid vehicle.

7.2 Turnaround area

7.2.1 Any carriageway that extends longer than 120 m from an intersection and does not lead directly to an exit or connecting *carriageway* (i.e. dead end) is to have a suitable turnaround area so that a *fire appliance* does not need to reverse out (see Figure 6).

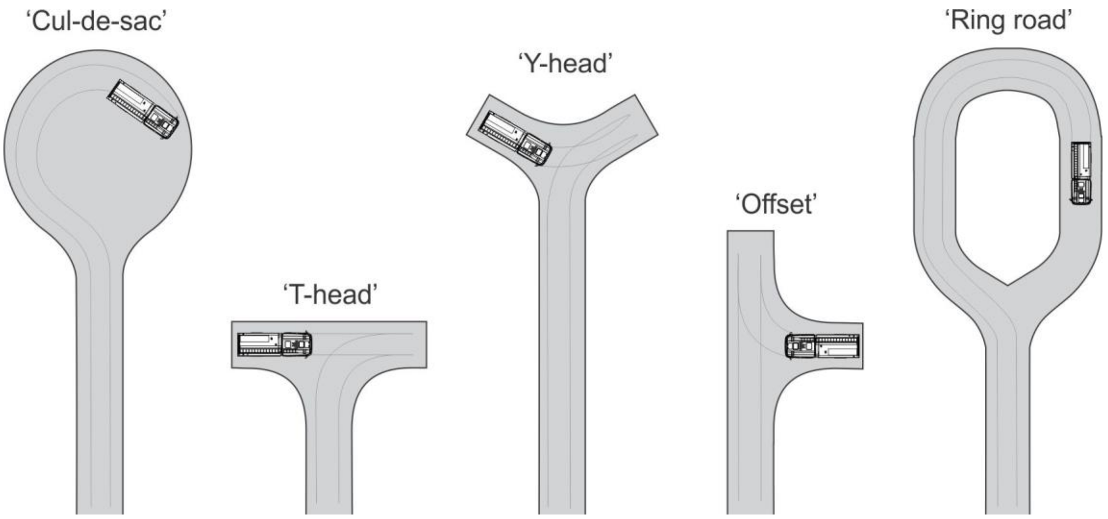


Figure 6 Examples of typical turnaround area configurations

7.2.2 The turnaround area must allow for body swing bias to the front of the *fire appliance*. If a multiple-point turn is required due to space restriction, the turning area is to be large enough to not require more than three points of turn (see Figure 7).

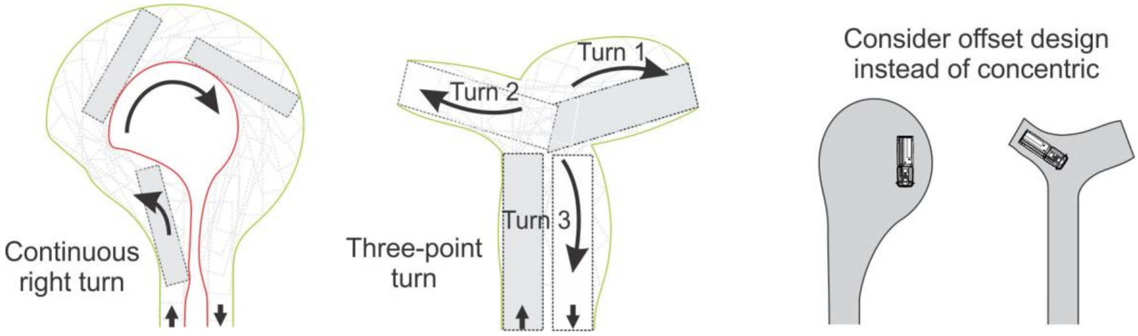


Figure 7 Turnaround body swing; continuous (left) or multiple point (right)

7.3 Constricted access (i.e. pinch point)

7.3.1 Constricted access is any narrow pinch point around an immovable object (e.g. building, structure, bridge, bollard, pylon, gate, vehicle barrier, *traffic control device*, utility pole, drain, fence, tree etc.) that provides less than 4.5 m width.

Note: A pinch point has insufficient width for firefighters to exit the *fire appliance* and work with equipment. A *fire appliance* is not able to stop at any pinch point.

7.3.2 The carriageway is not to have any constricted access providing less than 3.2 m width (see Figure 8).

Note: A *fire appliance* is unable to negotiate past a pinch point less than 3.2 m wide.

7.3.3 Any constricted access along a straight *carriageway* section is not to be longer than 50 m (see Figure 8).

Note: A 50 m long pinch point allows two lengths of fire hose.

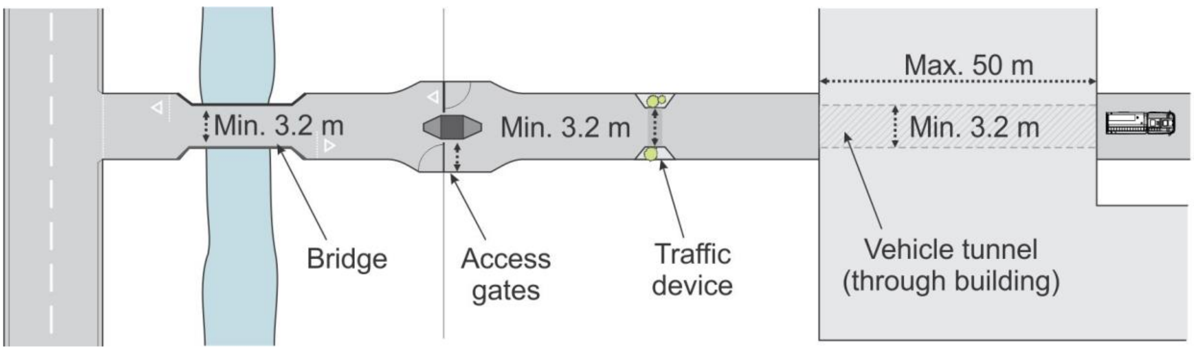


Figure 8 Examples of constricted access (typical pinch points)

7.3.4 Site managers are to ensure *fire brigade vehicle* access is not blocked by non-permanent obstructions including by parked vehicles, freight containers, pallets, stored goods, stored waste, bins, temporary structures etc.

7.4 Underbody clearance

7.4.1 All raised kerbs along the edge of a *carriageway* are to be no higher than 200 mm and be free of vertical obstructions at least 300 mm back from the kerb face, to allow clearance from and body overhang when turning (see Figure 9).

7.4.2 Kerbs in the centre of a *carriageway* (e.g. splitter islands and median strips) should be no higher than 200 mm and no wider than 500 mm, and be free of obstruction along their length, to allow the *fire appliance* to drive over the kerb (see Figure 9).

Note: A *fire appliance* responding to an *emergency incident* may need to manoeuvre onto opposing traffic lanes to get past stationary built up traffic.

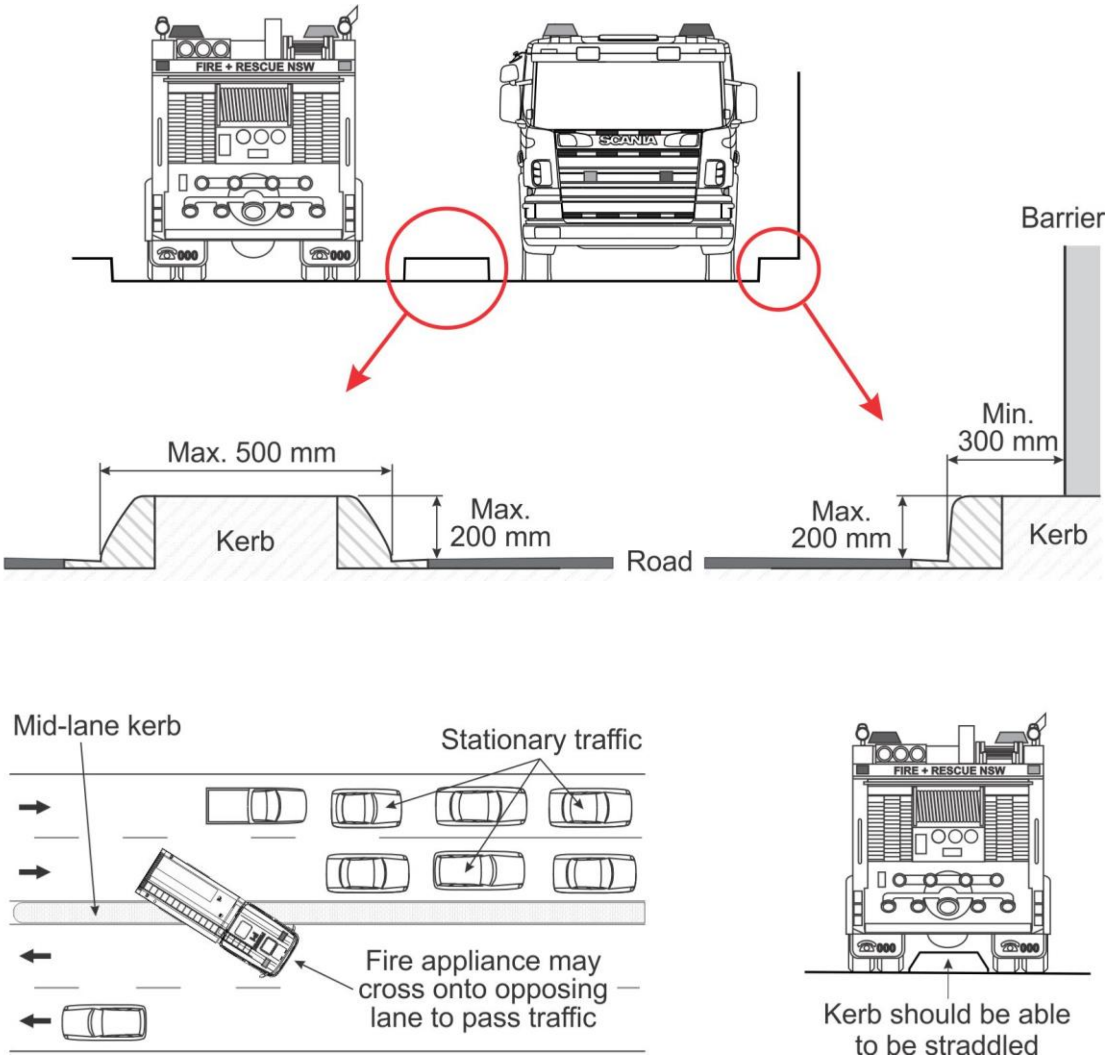


Figure 9 Kerb clearance dimensions

7.4.3 *Traffic control devices* that have integrated kerbs to slow traffic (e.g. speed hump, chicane slow point, small roundabout) are to have low profile mountable kerbing with 40 mm bull nose edge to allow easy negotiation by a *fire appliance*.

7.5 Overhead clearance

7.5.1 The *carriageway* is to have a minimum overhead clearance height of 4 m for general *fire appliance* access or 4.5 m for specialist *fire appliance* access (see Figure 10).

Note: The maximum vehicle height under the *Road Transport (Vehicle Registration) Regulation 2017* is 4.3 m. *AS 2890.2:2018 Parking facilities, Part 2: Off-street commercial vehicle facilities* prescribes a clearance height of 4.5 m.

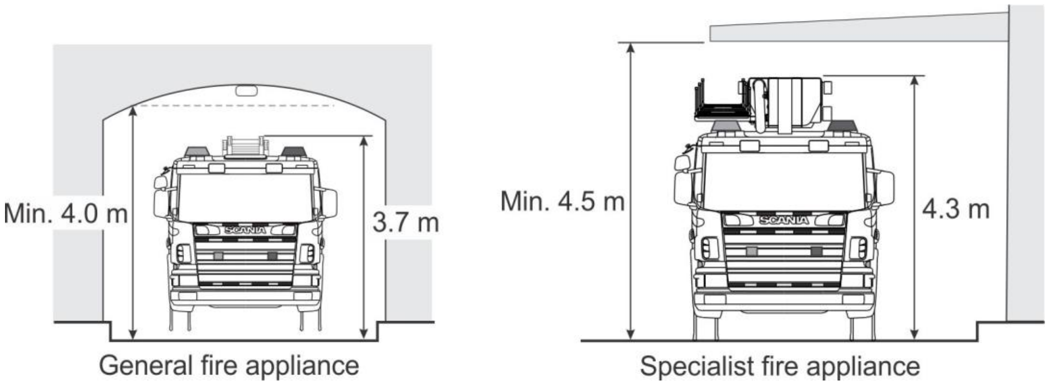


Figure 10 Minimum clearance height

7.5.2 Overhead clearance is to be free of any obstructions including building element (e.g. ceiling, beam, truss) bridge, archway, tunnel, walkway, barrier and any ceiling or overhanging fixtures such as lights, signs, poles, pipes, ducts, sprinkler heads etc.

7.5.3 Any restricted height clearance due to unavoidable overhead obstacle (e.g. low bridge) is to be clearly signed and indicate the actual maximum height clearance.

7.6 Grades and ramps

7.6.1 The grade of a *carriageway* or ramp is to be no steeper than 1:6 (16.6%).

Note: A grade of 1:8 (12.5%) or less is preferred for easier access. *AS 2890.2:2018* prescribes a maximum roadway/ramp grade of 1:6.5 (15.4%).

7.6.2 If the *carriageway* or ramp follows a curved or circular path, the maximum grade is to be no greater than 1:8 (12.5%) as measured along the centre line.

Note: The vehicle's chassis and body will twist and flex when negotiating a circular path, increasing with vehicles that have a longer *wheelbase*.

7.6.3 Ramps are to have transition grades between entry and exit which have a maximum rate of change of 1:16 (6.25%) for every 7 m of travel (see Figure 11 below).

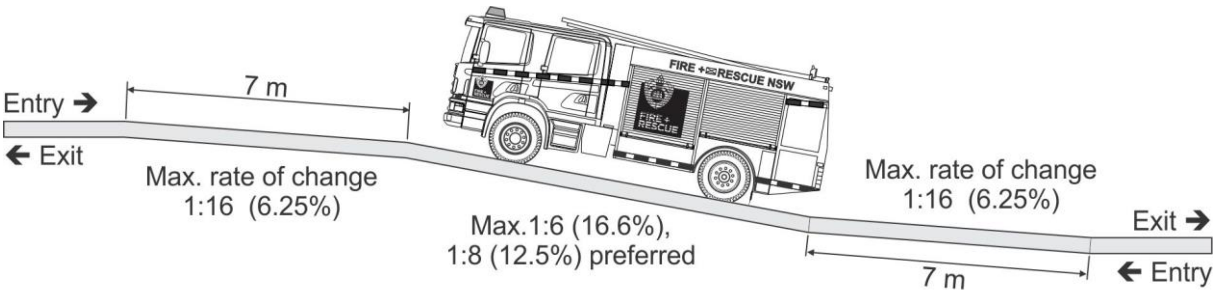


Figure 11 Maximum gradients of access ramps

7.6.4 Ramps that do not have a transition grade of at least 7 m are to have an approach and departure angle not exceeding 8° to ensure front and rear body overhang of a *fire appliance* does not contact the ground when negotiating the gradient change.

7.6.5 If any gradient change incorporates a recessed threshold (e.g. gutter or drain at site entrance driveway), the design should consider any reduced entry and exit clearance for the *fire appliance* (see Figure 12).

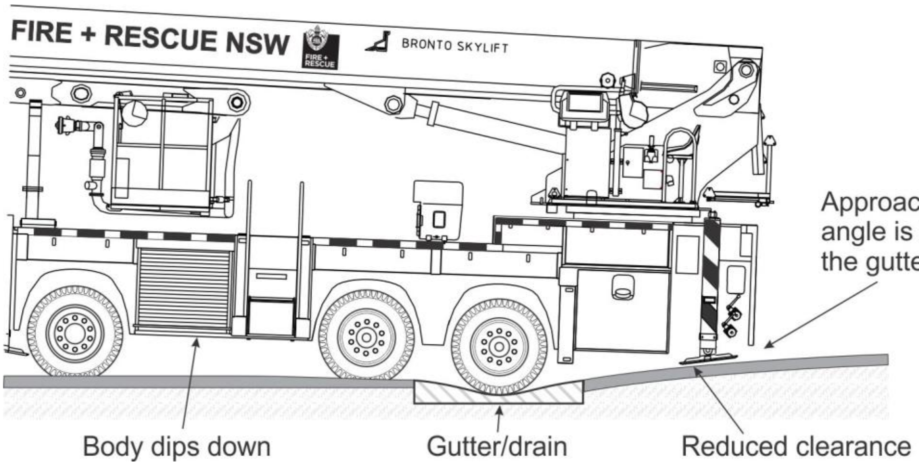


Figure 12 Reduced gradient clearance from recessed gutter

Note: Wheels will recede into any gutter or drain and reduce the effective approach and departure angle. Clearance is impacted most on *fire appliances* having long front and rear overhanging body sections (e.g. specialist *fire appliance*).

7.7 Security points and barriers

7.7.1 Gates, barriers and bollards installed to inhibit vehicle access for security purposes are to be either removeable, retractable or foldable so that a *fire appliance* can gain access to the site during an *emergency incident*, including access after-hours.

Note: A bypass should be provided for any weighbridge, vehicle station, loading bay or the like, if likely to be obstructed by a vehicle during normal operations.

7.7.2 Any vehicle access gate that is required to be locked, including any alternate vehicle access gate, should be secured with a non-hardened metal chain and lock (e.g. galvanised mild steel).

Note: Firefighters may need to force entry through the vehicle access gate using standard bolt cutters on the chain or lock.

7.7.3 All locks fitted to vehicle access gates and security devices are to be keyed alike, and a copy of the key deposited with the two nearest FRNSW *fire brigade stations* or kept with the site security if 24/7 security is provided for the site.

Note: *Premises* keys can be deposited directly with the local FRNSW *fire brigade stations* (see clause 10.5.5).

7.7.4 Any electrically operated vehicle access gate or security device should incorporate either mechanical override, fail-safe open mode, or activation by site security so that fire appliances can access the site in the event of fire.

8 Hardstand area

8.1 Design requirements

8.1.1 Designated *hardstand* areas are to provide a safe working space for firefighters to exit the vehicle and move around the fire appliance to remove and use equipment, including connecting fire hoses to the *fire appliance* (see Figure 13).

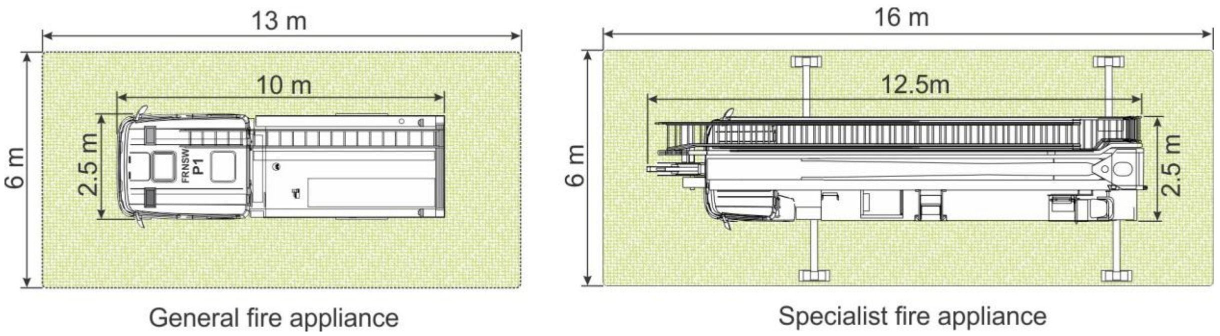


Figure 13 Minimum working space for hardstand area

8.1.2 The designated *hardstand* area is to be flat and level all weather surface which is clear of any obstructions that could be hazardous during operations (e.g. bollard, railing, fencing, sign, kerb, gutter, fixed structure, parked vehicle, storage, rubbish).

8.1.3 The designated *hardstand* area is to provide easy manoeuvring for the *fire appliance* to be positioned onto the *hardstand* from the *carriageway*.

8.1.4 Any section of *carriageway* may be used as a designated *hardstand* area only when the passing traffic flow will not be blocked by the positioned *fire appliance*.

Note: A minimum clearance of 3.5 m should be provided. A turnaround area may be used as a hardstand only when another fire appliance can safely turn around.

8.1.5 Any *hardstand* serving a *suction-connection outlet* is to have a working space which extends a minimum of 18 m from the point of connection to allow semi-rigid suction hose to be connected to the rear of the *fire appliance* (see Figure 14).

Note: *Fire appliances* typically use three x 2.4 m or two x 3.6 m long suction hoses (i.e. combined length of 7.2 m). Some FRNSW ‘aerial pumpers’ have a mid-mounted pump where the suction hose is connected to the side of the vehicle.

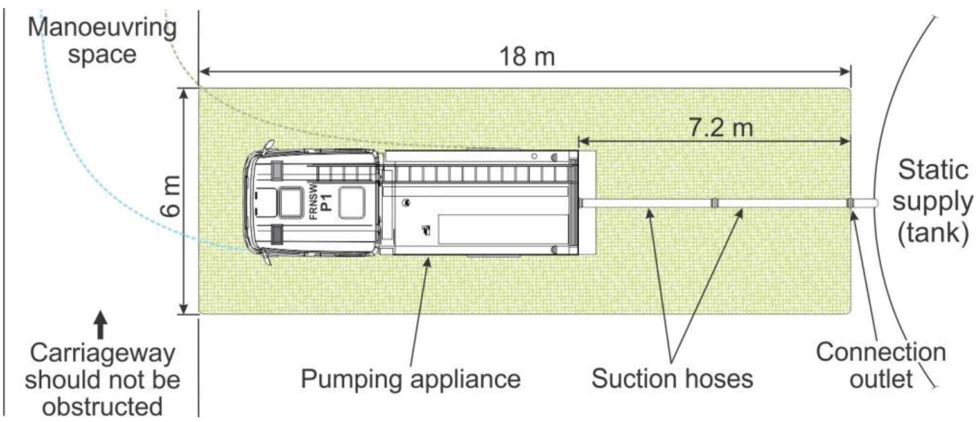


Figure 14 Hardstand area serving a suction-connection outlet

8.1.6 Any designated *hardstand* area serving a pumping *fire appliance* for firefighting operations (e.g. pumper using a feed fire hydrant) is to have appropriate guttering and drainage to remove any continuous water discharge from the *fire appliance*.

8.2 Hardstand locations

8.2.1 A *hardstand* is to be provided as required by *AS 2419.1—2005 Fire hydrant installations – System design, installation and commissioning*, and as otherwise nominated by the relevant authority having jurisdiction, including:

- within 20 m of any feed fire hydrant
- within 8 m of any fire hydrant booster assembly
- within 50 m of an external attack fire hydrant
- within 20 m of the access door to any external fire pumproom
- in front of any *suction-connection outlet* (e.g. tank, river, lake, dam, sea).

Note: The location must also consider other required factors such as firefighter access to the building and maximum hose coverage requirements.

8.2.2 Any *hardstand* area serving a *suction-connection outlet* is to be positioned at an angle not greater than 45º from the outlet's longitudinal direction (see Figure 15).

Note: Suction hoses are semi-rigid and only allow slight bending, therefore the *fire appliance* must be positioned relative to the connection outlet. The working space must be kept unobstructed at all times.

8.2.3 If multiple *fire appliances* are required to connect to *suction-connection outlets*, the *hardstand* areas should allow each *fire appliance* to operate independently without encroaching onto the other's working space (see Figure 15).

Note: *Suction-connection outlets* are not be located within 5 m of each other.

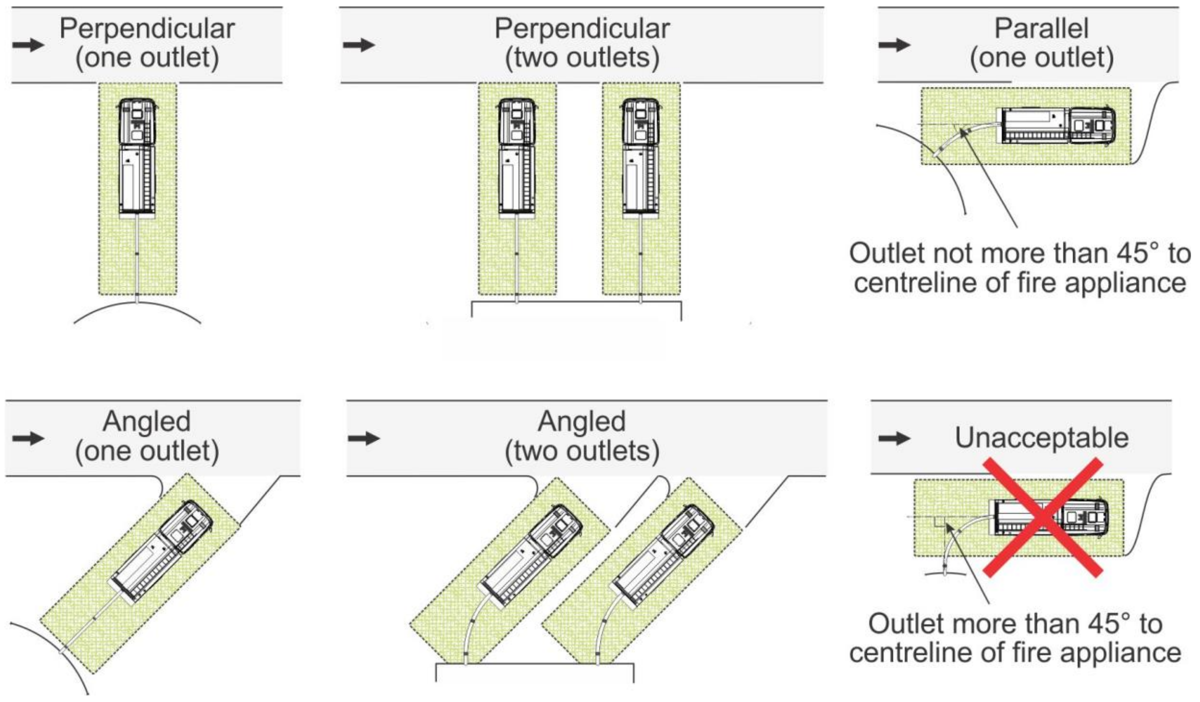


Figure 15 Example of orientation of hardstand area for suction-connection outlets

9 Weights and loads

9.1 Design requirements

9.1.1 All *carriageways* and *hardstand* areas are to be suitably formed and constructed having an all-weather sealed surface capable of supporting the *fire appliance*.

Note: Refer to the *Austroads Guide to Road Design* for best practice *carriageway* design and construction.

9.1.2 All *carriageways* and *hardstand* areas are required to maintain structural adequacy under load from a *fire appliance*, including when supported, elevated or reinforced by structural members (e.g. bridge, ramp, apron, suspended floor, wharf etc.).

Note: Load limited bridges unable to support a *fire appliance* should be avoided, particularly when alternate routes involve much longer distances.

9.2 Weight (static load)

9.2.1 The maximum weight of a general *fire appliance* is 15 tonnes, and 28 tonnes for a specialist *fire appliance*. The static load should be used when determining forces acting through load bearing structures and surfaces (see Figure 16).

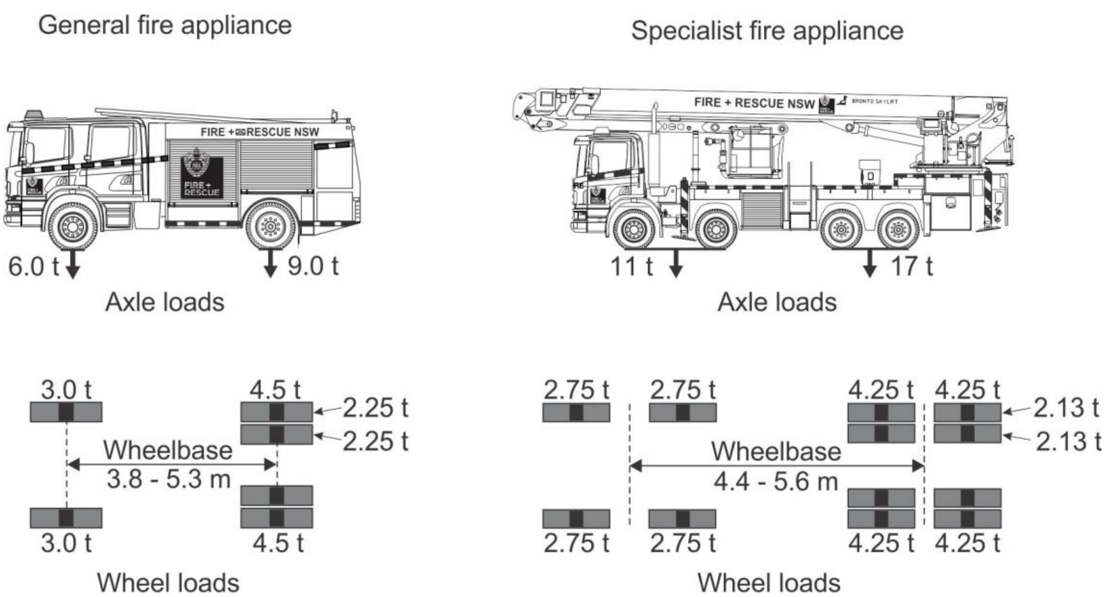


Figure 16 Static loads from fire appliances

9.2.2 The *Bronto Skylift F44 RLX* *aerial appliance* is the heaviest *fire appliance* in the FRNSW fleet and exceeds legal mass limits (i.e. operates by special permit).

9.2.3 The surface of any *carriageway* and *hardstand* area is to have enough binding and hardness to withstand point loads exerted thought each tyre (i.e. tyre pressure contact point as represented by black squares in Figure 16).

Note: Tyres are typically inflated around 850 kPa pressure. If the *carriageway* or *hardstand* has insufficient surface integrity, the point load will result in localised damage to the road surface (i.e. cracking of surface layer).

9.3 Dynamic load (of an aerial appliance)

9.3.1 An *aerial appliance* is fitted with hydraulically actuated *stabilisers* to support the vehicle when the *aerial apparatus* is operating and will either have two stabilisers at both the front and rear or just two *stabilisers* at the rear only (see Figure 17).

Note: *Stabilisers* extend out and lift the *fire appliance* to provide a stable operating base and prevent overbalancing. If any *stabiliser* cannot be fully extended the field of operations of the *aerial apparatus* will be restricted accordingly.

9.3.2 Movement of the *aerial apparatus* results in changing weight distribution and dynamic forces being exerted through the *stabilisers* (e.g. momentum from rotation, torsion from elevation/extension, weight from rescued persons, water stream reaction).

9.3.3 A bearing plate is positioned under each *stabiliser* to increase ground contact surface area and lower the pressure exerted on the ground. A *stabiliser* will only be deployed without a bearing plate when it is opposite to the intended working side.

Note: The lower pressure assists maintain surface integrity and minimises the likelihood of the *stabiliser* being pushed through the ground surface.

9.3.4 Bearing plates do not reduce the point load from each *stabiliser*. Designers need to consider the foundation and structural support under the *carriageway* surface, particularly when supported, elevated or reinforced by structural members (e.g. bridges, ramps, aprons, suspended floors, wharfs etc.).

Note: Consideration should be given to relocating or reinforcing underground services that may be damaged from high point loads (see Figure 17).

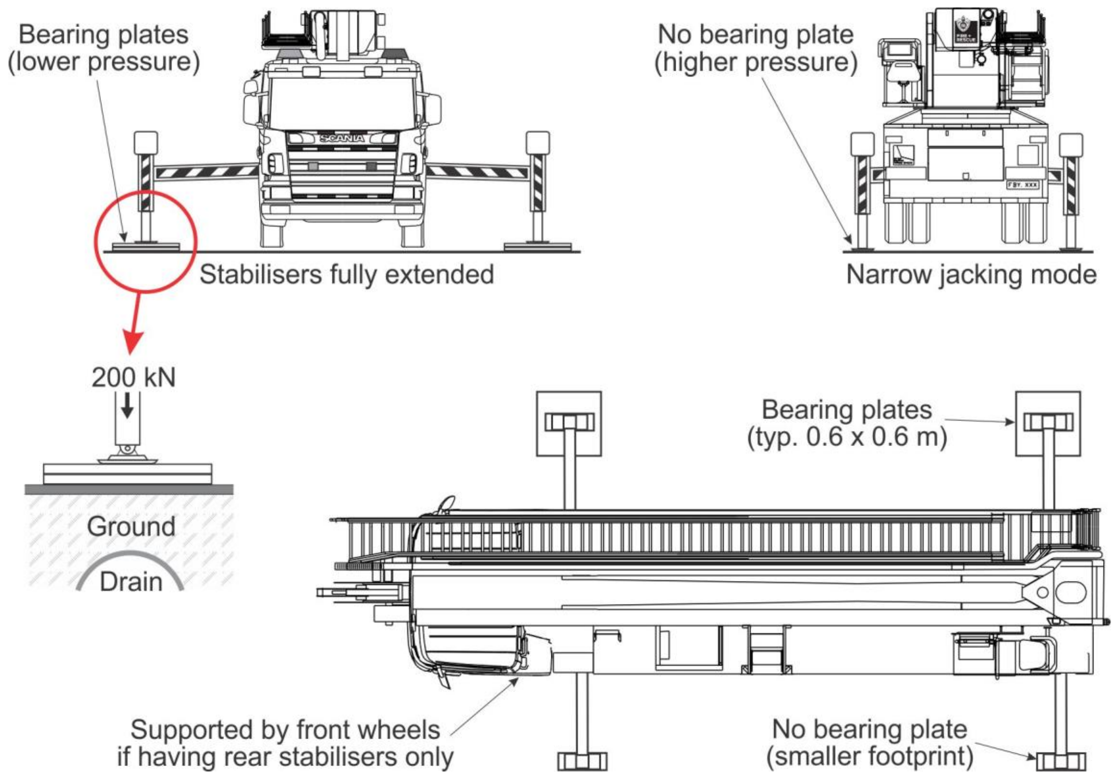


Figure 17 Typical operation of stabilisers and bearing plates

9.3.5 When the *Bronto Skylift F44 RLX* *aerial appliance* has a fully loaded cage (500 kg) at maximum extension and worst-case rotation angle (I.e. over a rear *stabiliser*), the maximum load exerted though a single *stabiliser* is shown in Table 3 (see Figure 18).

Maximum load through single stabiliser	
Force	200 kN
Mass	20,400 kg
Percentage of vehicle mass	70% of gross
Footplate pressure	11 kg/cm² (1080 kPa)
Bearing plate pressure	2.8 kg/cm² (275 kPa)

Table 3 Maximum dynamic loads of an aerial appliance

Note: Dynamic loads should be considered when determining forces acting through load bearing surfaces and structures, particularly when being supported, elevated or reinforced by structural members.

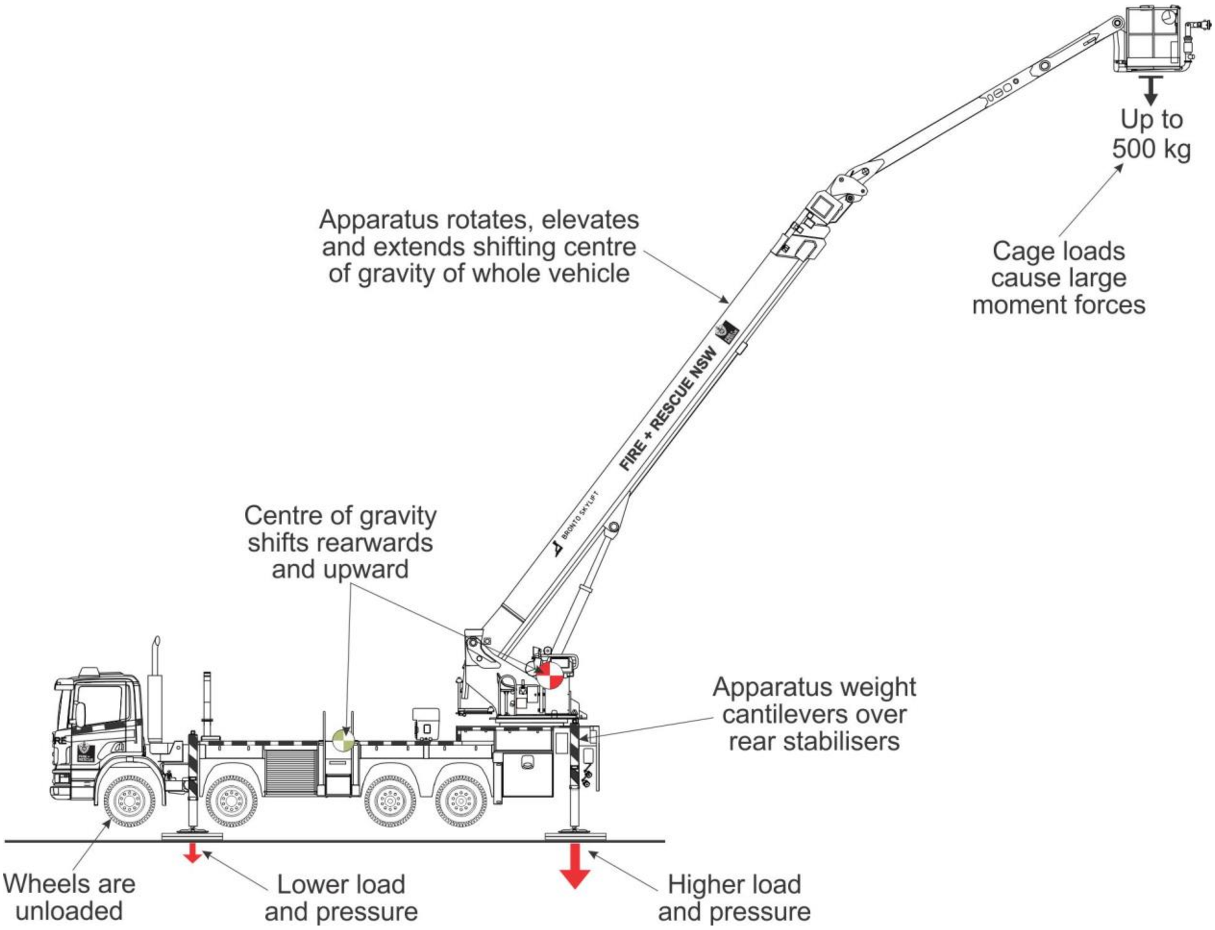


Figure 18 Dynamic loads exerted during aerial appliance operation

10 Considerations for development

10.1 NCC requirements

10.1.1 Performance requirement CP9 of the *NCC* states:

Access must be provided to and around a building, to the degree necessary, for fire brigade ***vehicles*** *and* ***personnel*** *to facilitate fire brigade intervention appropriate to –*
a) the function or use of the building; and
b) the fire load; and
c) the potential fire intensity; and
d) the fire hazard; and
e) any active fire safety systems installed in the building; and
f) the size of any fire compartment.

10.1.2 *Fire brigade vehicle* access is critical to *fire brigade* intervention. Performance requirement CP9 is to be considered in any performance-based design (i.e. *alternative solution*) where *fire brigade* intervention is to be verified.

Note: When identifying relevant performance requirements under clause A2.2(3)(b) of the *NCC*, CP1, CP2, CP9, DP5, EP1.3, EP1.5, EP1.6, EP2.2 and GP4.4 all require verification of *fire brigade* intervention and/or firefighting operations.

10.1.3 Except for Clause C2.3 of the *NCC*, there are no deemed-to-satisfy provisions directly applicable to the provision of *fire brigade vehicle* access to comply with performance requirement CP9.

Note: The *NCC* deemed-to-satisfy provisions deal with general firefighter access.

10.1.4 Design and planning of development should holistically consider *fire brigade vehicle* access for any type of major *emergency incident* (e.g. fire, explosion, accident, gas leak, hazardous material, structural damage or collapse, bomb threat, terrorism etc.).

Note: A major *emergency incident* will require a multiple alarm response; good *fire brigade vehicle* access will assist *fire brigades* and other emergency services to manage the incident and treat casualties.

10.2 Large isolated building

10.2.1 Clause C2.3 of the *NCC* allows the size of a fire compartment in a building to exceed that specified in Table C2.2 when the building is provided with perimeter vehicular access complying with Clause C2.4(b) of the *NCC*.

10.2.2 Clause C2.4(b) of the *NCC* requires the vehicular access to:

- provide continuous forward direction vehicular access around the building
- have a minimum unobstructed width of 6 m, with no part being more than 18 m from the building
- provide reasonable pedestrian access to the building
- have a load bearing capacity and unobstructed height suitable to permit the operation and passage of *fire brigade vehicles*, and
- be wholly within the allotment, except when a complying public road is used.

10.2.3 Any external panel walls must be designed to minimise the likelihood of external collapse onto the vehicular access *carriageway*, with emphasis on Clause 3(g) of Specification C1.11 of the *NCC*.

10.2.4 The unobstructed width of a *carriageway* may be less than 6 m only when:

a) the development is in an area where a specialist *fire appliance* is unlikely to attend (i.e. outside of major metropolitan areas)

b) the unobstructed width is not less than 4.5 m and the external wall adjacent the *carriageway* is a fire wall having a suitable fire resistance level (see Figure 19)

c) a performance-based design (i.e. *alternative solution*) has been undertaken and agreed to by FRNSW

d) openings in the fire wall are passenger doors only and suitably protected to maintain the required fire rating.

Note: A carriageway having a reduced unobstructed width will impact on *fire brigade* intervention, accessibility and safety.

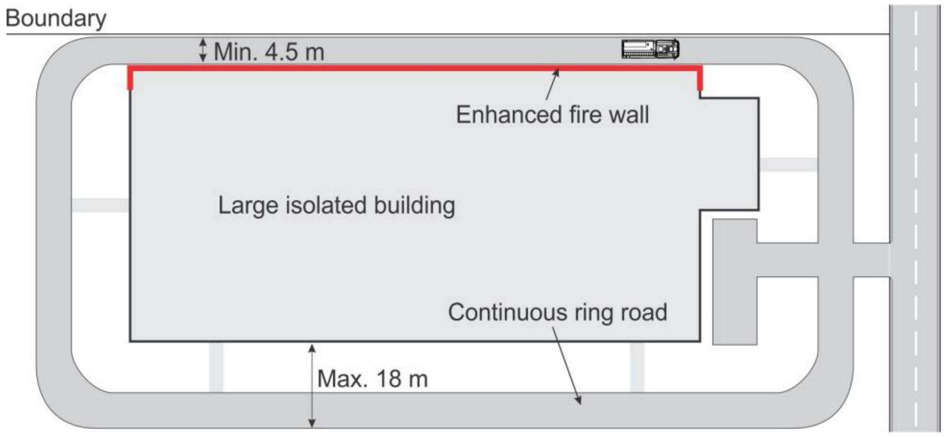


Figure 19 Large isolated building with reduced carriageway width

10.2.5 If the building is protected by an automatic fire sprinkler system, any awning over the *carriageway* is to also be protected by sprinkler system (see Figure 20).

Note: The sprinkler system is to be appropriate to the hazard and minimum clearance is to be maintained under the awning for *fire appliance* access.

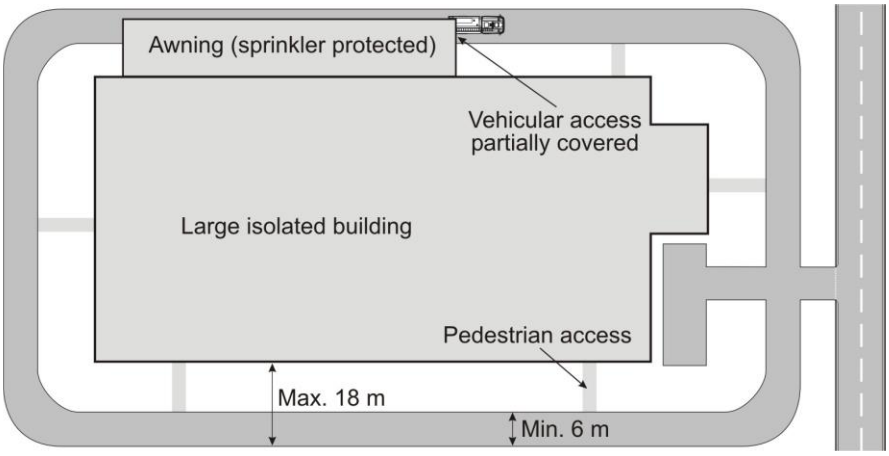


Figure 20 Large isolated building with awning over carriageway

10.2.6 If continuous forward travel around the building is not possible, a performance-based design (i.e. *alternative solution*) should be undertaken and agreed to by FRNSW.

10.3 Complex development

10.3.1 Development typically has a building adjacent to a public road providing easy access; modern development may be complex in design and require firefighters to negotiate a complicated route through the premises to undertake *fire brigade* intervention.

10.3.2 *Complex development* may involve several buildings which may be united (e.g. podium), clustered (e.g. urban precinct), or be a *major facility*. Such development is likely to have higher than normal occupation levels and/or risks.

10.3.3 *Complex development* may not require any specific *fire brigade vehicle* access other than to a designated entry point. However, this can have a significant adverse impact on operations during any *emergency incident*, including:

- increased *fire brigade* intervention times
- congestion of emergency vehicles and personnel at the designated entry
- not being able to position an *aerial appliance* within its field of operations
- confusion and delay from complicated routes through building, facility or site
- the need to carry equipment over greater distance to/from *fire appliances*
- greater dispersal of evacuees at multiple building evacuation points
- the need to move casualties over more distance to triage areas or ambulances

Note: A holistic assessment of *fire brigade vehicle* access for possible or likely major emergencies should be considered during the design phase, including provision of accessible *private roads* and *hardstand* areas as appropriate.

10.4 Buildings under 25 m effective height

10.4.1 Performance requirement CP9 of the *NCC* requires access be provided for *fire brigade vehicles* to facilitate *fire brigade* intervention. The *Guide to NCC Volume One* also states ‘access for the *fire brigade* must be appropriate to their needs and the type of vehicles and equipment to be used’.

10.4.2 In regard to the 25 m *effective height*, Clause D1.2(b)(i) of the *Guide to NCC Volume One* states that 25 m is ‘the effective operating height of *fire brigade* ladders and other firefighting and rescue equipment’.

Note: The *Guide to NCC Volume One* further identifies the role of the *fire brigade* ‘to undertake external rescue or firefighting from ladders’ in clauses D1.2(d)(i), D1.8 and E1.8(a), performance requirement EP1.4, and Table E1.5.

10.4.3 All buildings should have suitable ‘provision for escape’ from each storey, such as multiple required exits (e.g. building over 25 m) or a single required exit with an alternate means of emergency escape (e.g. fire brigade ladders).

Note: During *fire brigade* intervention, a portable extension ladder can only reach up to 10 m and an *aerial appliance* up to 25 m (see Figure 21).

10.4.4 Any non-sprinklered building more than three storeys above ground, and having a single stairway serving each storey (i.e. under 25 m building), should demonstrate that an *aerial appliance* can be positioned to provide means of emergency escape.

Note: If an *aerial appliance* cannot be suitably positioned to provide means of emergency escape, an *alternative solution* should be sought to demonstrate compliance with performance requirement CP9 of the *NCC*.

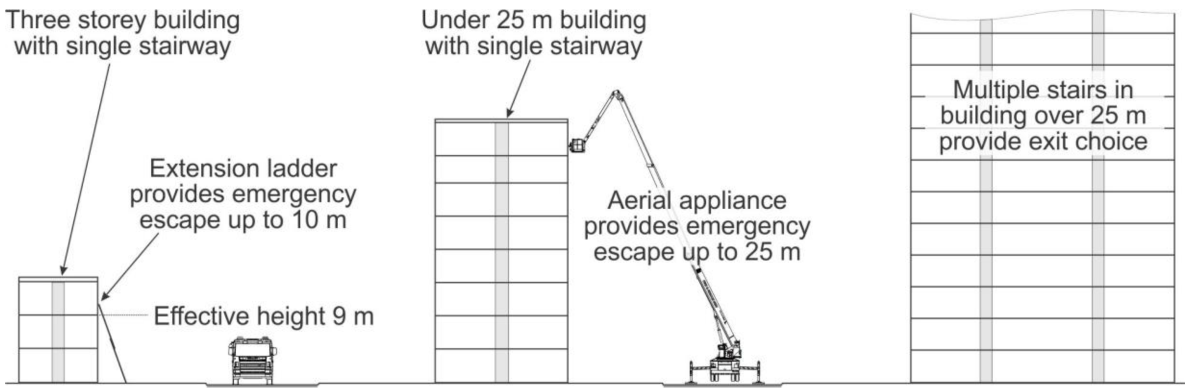


Figure 21 Using fire brigade ladders to provide emergency escape

10.4.5 An *aerial appliance* has a limited field of operations that requires it to be positioned adjacent to and near the building; any part of a building that is set back from the *carriageway* may be outside the reach of the *aerial appliance* (see Figure 22).

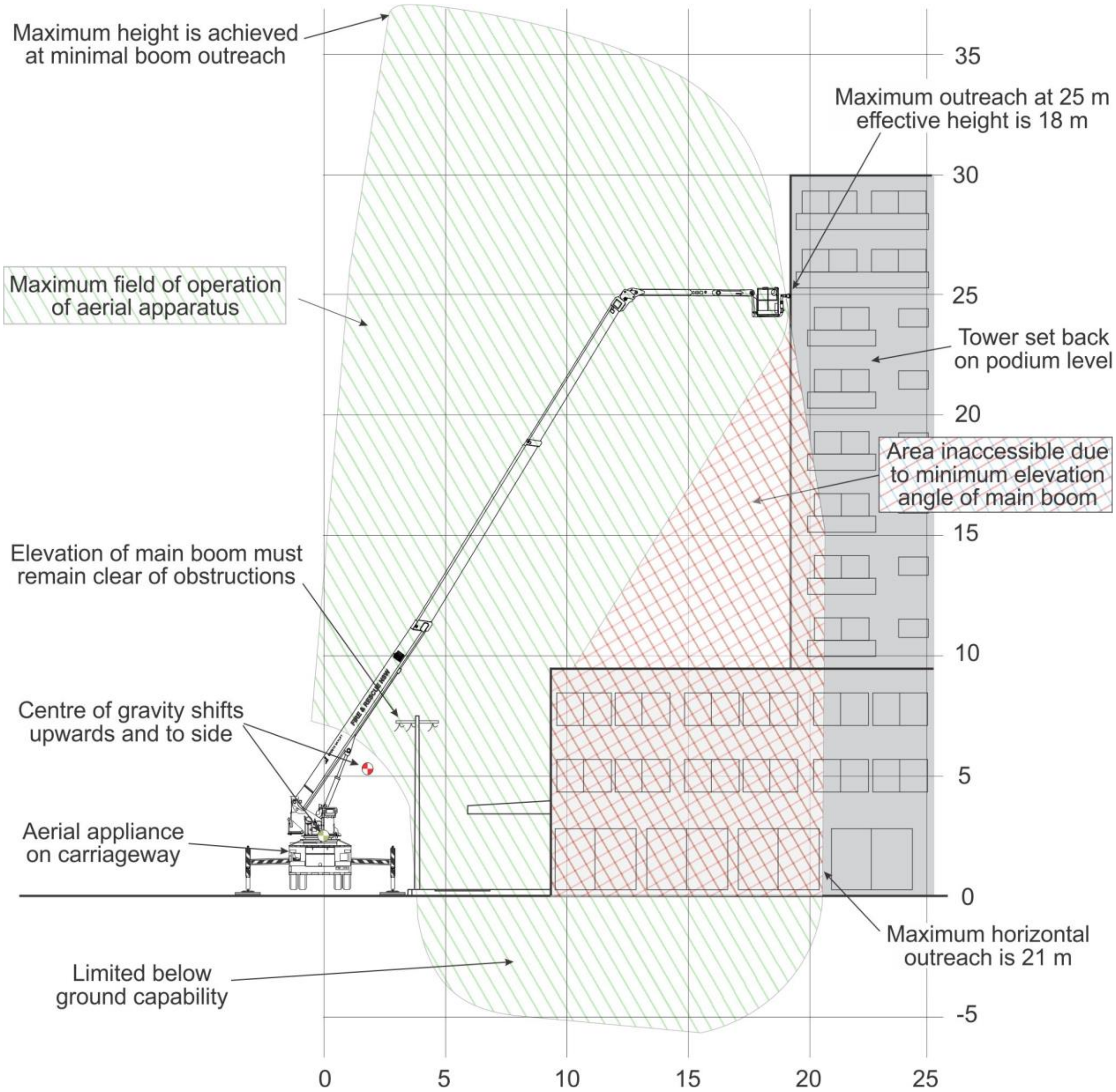


Figure 22 Typical field of operations of an aerial appliance

10.5 Building access

10.5.1 Buildings with a monitored automatic fire alarm system are to provide firefighters access into the *DBEP* and to the fire control centre (e.g. if located within a room off the main entrance) including after-hours.

Note: Any delay in gaining access during an *emergency incident* may be life critical.

10.5.2 When building access through an emergency exit door is necessary in an emergency (e.g. to enter a fire isolated stairway to access upper storeys), the emergency exit door is to be openable from the outside using either a key, fob or security passcode.

10.5.3 Doors to essential services and systems including pump room, sprinkler control valve room, fire control room, facility emergency control centre etc. are to be kept unlocked or accessible using either a key, fob or security passcode.

10.5.4 If the building has an emergency lift, a copy of the fire service lift key is to be kept at the fire control centre and clearly identified.

10.5.5 A copy of all *premises* keys, fire service lift keys, electronic access fob or security passcode should be deposited with the two nearest FRNSW *fire brigade stations*.

Note: Keys are kept in a wire sealed bag within a locked cabinet until needed during notification of alarm. The owner may apply their own seal if they wish.

10.5.6 When multiple *premises* keys are being kept or deposited, individual keys are to be readily identifiable (e.g. engraved, numbered or colour coded).

10.6 Signage and wayfinding

10.6.1 Clear signage should be provided at the *DSEP* to direct *fire brigade vehicles* around the site (e.g. buildings, structures, roadways, access points, fire safety systems, *hardstand* areas, assembly areas, storage areas, hazardous chemicals etc.).

10.6.2 Clear signage should be provided at the *DBEP* to direct emergency service personnel around the building (e.g. access/egress points, emergency lifts, refuge areas, fire safety systems, control rooms, utilities and services etc.).

10.6.3 A block plan located at the fire control centre is to clearly indicate how and where firefighters are to access different areas of the building including upper storeys, especially when exiting the *DBEP* to enter via an emergency exit.

10.6.4 When multiple exits discharge at a common point, each exit door should have signage identifying the area/floors the exit will provide access to (see Figure 23).

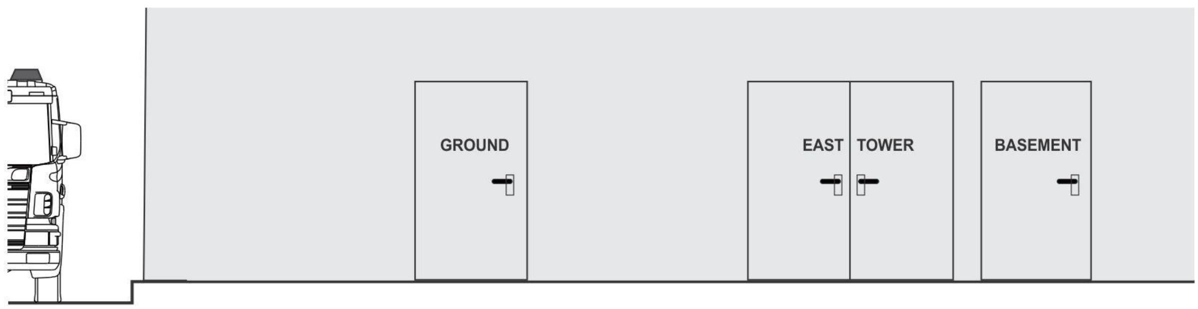


Figure 23 Example of exit door signage to assist firefighters

10.6.5 All buildings, towers, areas and floors are to be adequately labelled to assist with wayfinding, including corresponding identification provided on the safety side of emergency exit doors (e.g. 'East Tower – Level 3' sign being in the lift lobby as well as on the reverse side of all emergency exit doors on the same storey).

Note: Firefighters ascending fire stairs must be able to readily identify their actual location (e.g. floor level).

10.6.6 Signage is to be permanently affixed, weather resistant if external, high contrasting (e.g. black on white), clearly visible and readable at the expected viewing distance.

Note: Font height of signage is to be not less than 10 mm per metre of viewing distance as per *AS 1319–1994 Safety signs for the occupational environment*.

10.7 Other operational issues

10.7.1 The scale of response by *fire brigades* and other emergency services is proportional to the nature of the emergency. A major *emergency incident* will require a multiple alarm response by multiple combat and support agencies.

10.7.2 Any *complex development* having multiple site access points to deal with an *emergency incident* is to have all *DSEPs* clearly identified with signage to ensure it does not get obstructed (e.g. 'Emergency vehicle access – do not block').

10.7.3 Additional *fire brigade vehicles* may be responded to provide extra personnel for the *emergency incident*. These vehicles will likely be staged at an assembly area nearby.

Note: *Fire appliances* generally have a crew of four to six firefighters. At a large fire, many *fire appliances* will respond to provide additional firefighters.

10.7.4 An *aerial appliance* will be positioned in the most operationally advantageous position having clear overhead working space to safely operate within its field of operation.

10.7.5 When fire occurs in a building not having a fire-resisting roof, the risk of roof collapse may require firefighters to not enter the building and fight the fire externally.

10.7.6 When fire occurs in a building not having Type C construction, the risk of wall collapse may require firefighters to fight the fire defensively outside collapse zones.

Note: When external walls are tilt-slab panels, the collapse zone is 1.5 time the height of the wall. *Fire appliances* will be strategically positioned at corners.

10.7.7 When significant firefighting operations is being undertaken *carriageways* and *hardstand* areas may be partly or fully obstructed by fire hose running between *fire appliances*, water sources and buildings.

Note: If fire hose is required to cross the carriageway (e.g. to access a street fire hydrant), passing road traffic may be stopped for safety reasons

10.7.8 Development comprising multiple privately-owned dwellings, where not all dwellings have direct frontage onto a public road, is to have *fire brigade vehicle* access as outlined within *Firefighting access and water for minor residential development*.

11 Bush fire prone land

11.1 The NSW RFS *Planning for Bush Fire Protection – A guide for councils, planners, fire authorities and developers* (PBP) applies to all development on 'bush fire prone land' within NSW.

Note: Bush fire prone land is mapped by each respective council under *section 146* of the *Environmental Planning and Assessment Act 1979*.

11.2 As all general *fire appliances* have comparable specifications, complying with the requirements of this guideline will ensure PBP requirements are also satisfied.

11.3 Suitable *fire brigade vehicle* access is to be provided to within 4 m of a static water supply if no reticulated water supply is available (e.g. 10,000 L tank).

11.4 Perimeter roads on a bush fire interface are to provide not less than 8 m clear width (i.e. exclusive of parking) so that firefighters can safely operate when heavy smoke reduces visibility across the road.

11.5 Access roads are to allow traffic to pass by having passing bays at least 20 m long by 2 m wide provided every 200 m if the *carriageway* does not allow traffic to freely pass (see Figure 24).

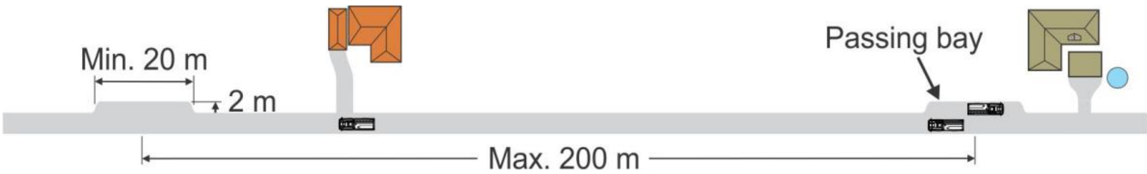


Figure 24 Example of passing bays on road in bush fire prone land

12 Local area traffic management (LATM)

12.1 Design requirements

12.1.1 *LATM* is the installation of *traffic control devices* to purposely modify speed, volume and composition of traffic in a local area. LATM devices will slow or restrict all traffic including *fire appliances* that are responding with speed to an *emergency incident*.

12.1.2 Traffic engineers and planners should consider the effects of *LATM* on *fire brigade* response. *LATM* should be implemented strategically to achieve optimum balance of managing traffic without detrimentally delaying response times.

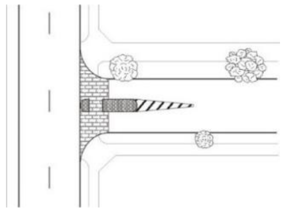
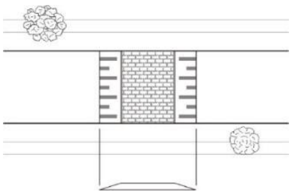
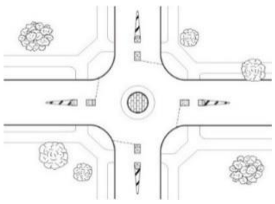
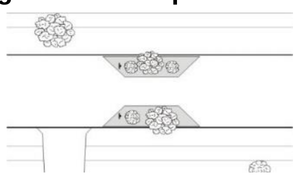
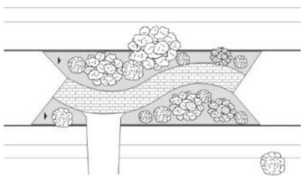
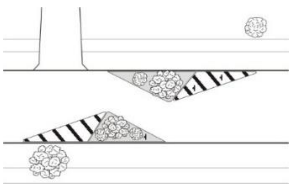
12.1.3 *LATM* impact on both public and *private roads*. Roads that prohibit heavy vehicles (i.e. trucks) still need to be accessible by *fire brigade vehicles*, including by a specialist *fire appliance*, that is responding to an *emergency incident*.

Note: Improper *LATM* design may delay or terminate the response of a *fire appliance* and potentially result in loss of life and/or property.

12.2 LATM devices

12.2.1 *LATM* devices are to comply with *AS 1742.13 Manual of uniform traffic control devices - Local area traffic management*.

12.2.2 *Fire brigades* prefer *LATM* device that are easily negotiated by a *fire appliance*. The impact on *fire appliance* access by each *LATM* device is provided in Table 3 below.

LATM device	Impact to fire appliance access
Perimeter treatment 	• Street entry is at very low speed as extra caution is required. • The treatment should not reduce entry/departure angles. • Any island should allow negotiation by turning fire appliances. • Any island should not exceed kerb clearance dimensions. • Non-mountable islands may impede fire appliance response. • Traffic bank up may occur on street exit, impeding response. • Landscaping should not restrict visibility at intersection.
Road hump 	• Actual design will greatly impact on negotiating speed. • Flat top hump (shown) preferred over Watts profile hump. • Shallow entrance/exit allow better negotiating and reduce delays. • Short humps require slow negotiating and results in delays. • Humps will strain vehicle suspension and increase wear and tear. • Should be installed strategically; significant delays to response times will result if many are installed locally.
Roundabout 	• Design should allow negotiation by turning fire appliances. • Roundabout should not exceed kerb clearance dimensions. • Approach islands should not exceed kerb clearance dimensions. • Non-mountable roundabouts and/or approach islands may impede fire appliance response. • Traffic bank up may occur if through traffic is constant. • Landscaping should not restrict visibility at intersection.
Single-lane slow point 	• Minimum width of 3.2 m required. Width of 4.0 m preferred to allow easier and speedier negotiating by fire appliance. • Conflict with opposing traffic may occur if road is dual direction. • Should not be used with another *LATM* device (e.g. road hump) • Landscaping should not adversely restrict visibility past device.
Driveway link 	• Design should allow easy negotiation and constant line of sight. • Negotiation speed very slow because of manoeuvring required. • If negotiation is not possible for a specialist appliance an alternative route is needed significantly delaying response times. • Surfaces must be suitable for loads from fire appliances. • Conflicts with opposing traffic may occur. • Landscaping should not adversely restrict visibility past device.
Single-lane angled slow point 	• Design should allow easy manoeuvring on approach and exit, especially for a specialist fire appliance. • Any kerbs should not exceed kerb clearance dimensions. • Should be installed strategically; significant delays to response times will result if many are installed locally. • Access may be restricted by improperly parked vehicles. • Conflicts with opposing traffic may occur. • Landscaping should not adversely restrict visibility past device.

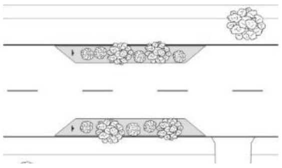
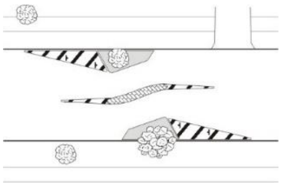
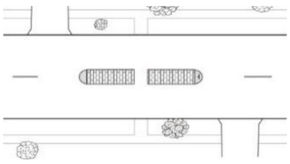
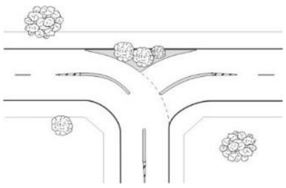
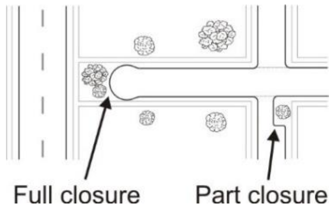
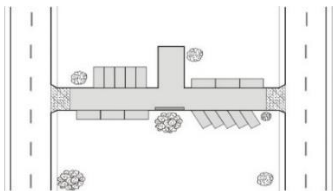
LATM device	Impact to fire appliance access
Two-lane slow point 	• Preferred method of speed reduction (i.e. over road humps). • Should not be used with another LATM device (e.g. mid-block island, road hump). • Landscaping should not adversely restrict visibility past device.
Two-lane angled slow point 	• Design should allow easy manoeuvring on approach and exit, especially for a specialist fire appliance. • Kerbs or islands should not exceed kerb clearance dimensions. • Non-mountable islands may impede fire appliance response. • Should be installed strategically; significant delays to response times will result if many are installed locally. • Access may be restricted by improperly parked vehicles. • Landscaping should not adversely restrict visibility past device.
Mid-block island 	• Preferred method of speed reduction (i.e. over road humps). • Island is generally used for pedestrian refuge. • Any island should not exceed kerb clearance dimensions. • Non-mountable islands may impede fire appliance response. • Landscaping should not restrict visibility; pedestrians require unobstructed view of traffic and vice-versa.
Modified intersection 	• Design should allow easy manoeuvring through intersection • Intersection priority can be confusing when responding emergency vehicles are encountered. • Any island should allow negotiation by turning fire appliances. • Any island should not exceed kerb clearance dimensions. • Non-mountable islands may impede fire appliance response. • Traffic bank up may occur, impeding response. • Landscaping should not restrict visibility at intersection.
Road closure 	• Diverts traffic onto adjacent roads which may increase congestion and result in delays to response times. • Detour and alternative route required when full road closure. • Suitable turnaround area for fire appliance should be provided if full road closure is used. • Minimum width of 3.2 m required if part road closure is used. • Landscaping should not restrict visibility at intersection when part road closure is used.
Shared zone 	• Careful design required to ensure negotiation by fire appliances. • Negotiation speed very slow due to conflicts with pedestrians, traffic and parked vehicles being encountered. • Access may be restricted by improperly parked vehicles. • Surfaces must be suitable for loads from fire appliances. • Generally avoided unless *emergency incident* is in shared zone. • Local traffic bank up may occur, impeding response.

Table 4 Impact of LATM on fire appliance access and response

13 References

Australian Building Codes Board, *National Construction Code 2019, Building Code of Australia Volume One*, 2019, Canberra ACT, Australia.

Austroads, *Guide to Road Design* (document set), 2014, CanPrint Communications, Fyshwick ACT, Australia.

National Heavy Vehicle Regulator, *National heavy vehicle mass and dimension limits*, 2016, Fortitude Valley QLD, Australia.

National Heavy Vehicle Regulator, *National heavy vehicle inspection manual Version 2.3*, 2018, Fortitude Valley QLD, Australia.

NSW Rural Fire Service, *Planning for bush fire protection – A guide for councils, planners, fire authorities and developers*, 2017, Lidcombe NSW, Australia.

Standards Association of Australia, *AS 2419.1–2005 Fire hydrant installations. Part 1: System design, installation and commissioning*, Standards Australia, 2005, Sydney NSW, Australia.

Standards Association of Australia, *AS 1319–1994 (R2018) Safety signs for the occupational environment*, Standards Australia, 1994, Sydney NSW, Australia.

Standards Association of Australia, *AS 1742.13–2009 Manual of uniform traffic control devices - Local area traffic management*, Standards Australia, 2009, Sydney NSW, Australia.

Standards Association of Australia, *AS 2890.2:2018 Parking facilities, Part 2: Off-street commercial vehicle facilities*, Standards Australia, 2018, Sydney NSW, Australia.

Appendix A – Pump performance of fire appliances

A1 General

Most *fire appliances* are fitted with a fire pump that have varying pumping capacity depending on the type of pump, installation, connections and efficiency (i.e. condition) of the fire pump. When boosting a fire hydrant and/or sprinkler system, the highest capacity pump available at the scene will be typically be used.

A standard urban *fire appliance* has a maximum of four 65 mm inlets and outlets, so fire brigade booster inlets are grouped into a maximum of four per *fire appliance*. Under *AS 2419.1–2005*, fire brigade booster inlets are calculated to flow at 10 L/sec per inlet.

Note: If the required fire hydrant and/or sprinkler system performance exceeds 40 L/sec, then a second *fire appliance* will be required to boost the additional inlets.

A standard urban *fire appliance* also has a single large bore suction inlet to take water from a static water source (e.g. on-site storage tank). A *suction-connection outlet* is required for each *fire appliance* required to boost the system.

Under *AS 2419.1–2005*, if more than eight fire brigade booster inlets are required for the system (i.e. exceeds 80 L/sec), then a separate fire brigade booster assembly and third *fire appliance* is required.

A standard urban *fire appliance*, being an FRNSW Class 3 pumper, is capable of delivering 50 L/sec through four fire hydrant booster inlets. A performance-based design (i.e. *alternative solution*) may be sought to increase the flow rate per booster inlet to 12.5 L/sec.

Note: If the required fire hydrant and/or sprinkler system performance is 50 L/sec (normally five booster inlets), an alternative solution can remove the need for the fifth booster inlet, second *fire appliance* and second *suction-connection outlet*.

A performance-based design (may also be sought for increased flow rate per booster inlet (at 12.5 L/sec) to remove the need for a separate fire brigade booster assembly.

Note: If the required fire hydrant and/or sprinkler system performance is 100 L/sec (i.e. ten booster inlets), an alternative solution can remove the need for a third *fire appliance*, third *suction-connection outlet* and second fire brigade booster assembly.

Any performance-based design proposing an alternative solution as discussed in this Appendix should be referred to FRNSW for consultation.

A2 FRNSW fire appliances

Class 1 Tanker

- Min. 1,500 L/min at 1,000 kPa
- Min. 2,200 L water
- Two 65 mm outlets
- Two 65 mm inlets
- One 100 mm inlet (at rear)
- 4x4 crew-cab chassis

Maximum hydrant design

- 20 L/sec (1,200 L/min)
- 2 inlet/outlet design
- One large bore *suction-connection* (using a 150-100 mm Storz reducer)

Note: Light tankers used for hazard reduction role are excepted.

Class 2 Pumper

- Min. 2,900 L/min at 1,000 kPa
- Min. 2,000 L water
- Four 65 mm outlets
- Four 65 mm inlets
- One 125 mm inlet (at rear)
- 4x2 crew-cab chassis

Maximum hydrant design

- 40 L/sec (2,400 l/min)
- 4 inlet/outlet design
- One large bore *suction-connection* (using a 150-125 mm Storz reducer)

Class 3 Pumper

- Min. 3,500 L/min at 1,000 kPa
- Min. 1,800 L water
- Four 65 mm outlets
- Four 65 mm inlets
- One 150 mm inlet (at rear)
- 4x2 crew-cab chassis

Maximum hydrant design

- 40 L/sec (2400 l/min)
- 4 inlet/outlet design
- One large bore *suction-connection*
- Up to 50 L/sec possible (via *alternative solution* of 12.5 L/sec per inlet/outlet)

Aerial Pumper

- Min. 5,000 L/min at 1,000 kPa
- or 2,500 L/min at 2,000 kPa
- 2,000 L water
- Four 65 mm outlets
- Four 65 mm inlets
- 150 mm inlets (side or rear)
- 6x4 crew-cab chassis

Maximum hydrant design

- 40 L/sec (2400 l/min)
- 4 inlet/outlet design
- One large bore *suction-connection*
- Up to 50 L/sec possible (via *alternative solution* of 12.5 L/sec per inlet/outlet)

A3 NSW RFS fire appliances

Category 1 or 3

- Min. 1,100 L/min at 1,000 kPa
- 3,500 L water
- One 65 mm outlet, and
- two 38 mm outlets
- One 75 mm inlet (at rear)
- 4x4 crew-cab chassis (Cat 1)
- 4x2 crew-cab chassis (Cat 3)

Maximum hydrant design

- 10 L/sec (600 L/min)
- 1 inlet/outlet design
- One small bore *suction-connection* (using a 75-65 mm Storz reducer)

Category 10

- Min. 2,100 L/min at 1,000 kPa
- 1,800 L - 2,400 L water
- Two 65 mm outlets, and one 38 mm outlet
- Two 65 mm inlets
- One 100 mm inlet (at rear)
- 4x2 crew-cab chassis

Maximum hydrant design

- 20 L/sec (1,200 L/min)
- 2 inlet/outlet design
- One large bore *suction-connection* (using a 150-100 mm Storz reducer)

Category 11

- Min. 2,000 L/min at 1,000 kPa
- 1,800 L water
- Two 65 mm outlets, and one 38 mm outlet
- Two 65 mm inlets
- One 100 mm inlet (at rear)
- 4x4 crew-cab chassis

Maximum hydrant design

- 20 L/sec (1,200 L/min)
- 2 inlet/outlet design
- One large bore *suction-connection* (using a 150-100 mm Storz reducer)

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Annexure D Correspondence

Vikrant Gorasia

From:	Alexandra Ceccato
Sent:	Tuesday, 6 July 2021 2:20 PM
To:	Vikrant Gorasia
Subject:	FW: Level 2 Mezzanine deletion - Project Horizon.

FYI

ALEXANDRA CECCATO
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From: Vanessa Hinge <vhinge@mckenzie-group.com.au>
Sent: Tuesday, 6 July 2021 2:18 PM
To: Hong Lau <hlau@hlarchitects.com.au>; Nick Ingleby <Nick.Ingleby@tmx.global>
Cc: Hansika Morin <hansika.morin@omnii.com.au>; Andrew Martin <andrew.martin@omnii.com.au>; Alexandra Ceccato <alexandra.ceccato@omnii.com.au>; Viorica Steinhaus <Viorica@sparksandpartners.com.au>; Alex Troyak <Alex.Troyak@jhaengineers.com.au>; Barry Martin <Barry.Martin@jhaengineers.com.au>; Willy Gabut <willy@hlarchitects.com.au>; Legen Li <LLi@northrop.com.au>; Filip Milic <filip.milic@snackbrands.com.au>; Mark Harrison <Mark.Harrison@snackbrands.com.au>
Subject: RE: Level 2 Mezzanine deletion - Project Horizon.

We can drop back to Type C.

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From: Hong Lau <hlau@hlarchitects.com.au>
Sent: Tuesday, 6 July 2021 2:08 PM
To: Nick Ingleby <Nick.Ingleby@tmx.global>
Cc: Hansika Morin <hansika.morin@omnii.com.au>; Vanessa Hinge <vhinge@mckenzie-group.com.au>; Andrew Martin <andrew.martin@omnii.com.au>; Alexandra Ceccato <alexandra.ceccato@omnii.com.au>; Viorica Steinhaus <Viorica@sparksandpartners.com.au>; Alex Troyak <Alex.Troyak@jhaengineers.com.au>; Barry Martin <Barry.Martin@jhaengineers.com.au>; Willy Gabut <willy@hlarchitects.com.au>; Legen Li <LLi@northrop.com.au>; Filip Milic <filip.milic@snackbrands.com.au>; Mark Harrison <Mark.Harrison@snackbrands.com.au>
Subject: Re: Level 2 Mezzanine deletion - Project Horizon.

Nick,
Note that the development table in the SSDA set will be updated as well, showing a reduction in development area.

Vanessa,
Does that mean we revert back to Type C Construction?

Thanks

Regards,

Hong Lau
Principal

Level 1, 5 George Street, North Strathfield, NSW 2137
02 9166 9942 | 0424 160 365 | hlau@hlarchitects.com.au
Nominated architect: Kok Hong Lau *RAIA* (NSW ARB#7559, QLD ARB#5003, TAS ARB#1101)

On Tue, 6 Jul 2021 at 13:27, Nick Ingleby <Nick.Ingleby@tmx.global> wrote:

> Hi All,

Please note over the last 24 hours Snackbrands have made the decision to delete level 2 of the mezzanine all together. We understand this deletion may impact several services drawings and reports however it is a good outcome for the project.

Hong & Willy will need to update their drawings to remove level 2 and once uploaded onto Procore I will notify all other services.

Any questions please let me know.

Nick Ingleby
Project Director

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