Metcash Facility
Bungarribee Industrial Estate, Huntingwood, Sydney

Goodman
Level 10, 60 Castlereagh Street
Sydney NSW 2000

6 September 2010 | Final Issue | Report No s100643_FEB_02

Fire Engineering Brief

Metcash Facility

Bungarribee Industrial Estate, Huntingwood, Sydney

rawfire
razzi + weir FIRE SAFETY ENGINEERS

Report Details

Project: Metcash Facility, Bungarribee Industrial Estate, Huntingwood, Sydney

Document: Fire Engineering Brief

Report No.: s100643_FEB_02

Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY	VERIFIED BY
01	16th August 2010	Draft Issue for comment	**Alan Caulfield** Masters Degree in Fire Safety Engineering	**Sandro Razzi** Accredited Fire Engineer BPB 0501 MIEAust CPEng 2180287 (Fire Safety)	**Sandro Razzi** Accredited Fire Engineer BPB 0501 MIEAust CPEng 2180287 (Fire Safety)
02	6th September 2010	Draft Issue for comment	**Alan Caulfield** Masters Degree in Fire Safety Engineering	**Sandro Razzi** Accredited Fire Engineer BPB 0501 MIEAust CPEng 2180287 (Fire Safety)	**Sandro Razzi** Accredited Fire Engineer BPB 0501 MIEAust CPEng 2180287 (Fire Safety)

EXECUTIVE SUMMARY

RAW Fire has been engaged by Goodman to develop an Alternative Solution for the proposed warehouse facility for Metcash located at Bungarribee Industrial Estate, Huntingwood, Sydney.

For ease of reference the regulatory review by Blackett Maguire + Goldsmith has referred to the facility as consisting of three (3) buildings and a carpark building located as follows. The Class 7b warehouse components within each building have associated Class 5 offices. Note, the main office building is located at the northern end of Building 1 and is proposed to be five storeys.

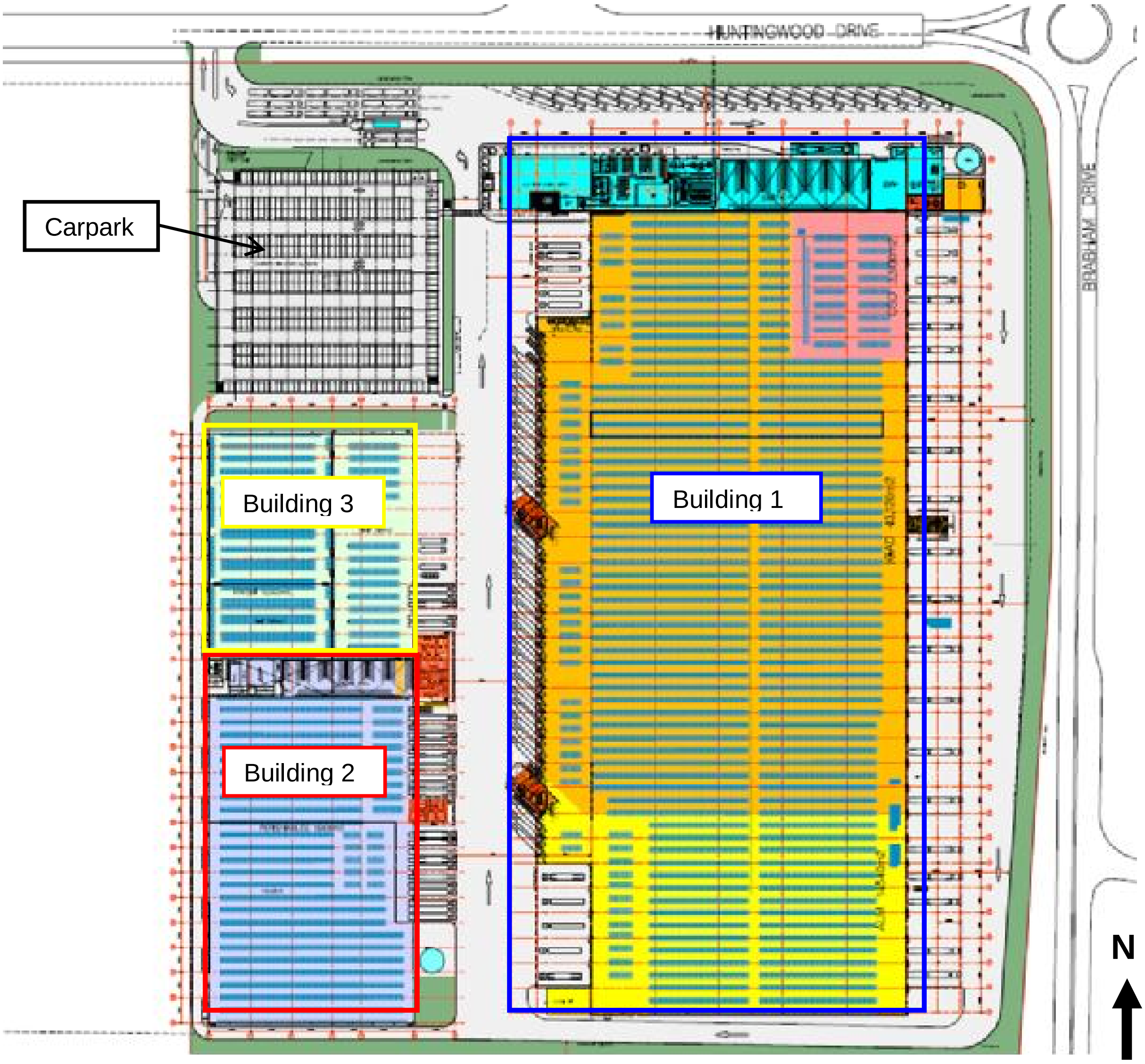


Figure 0-1: Site layout (stage 5)

The proposed facility consists of six stages described as follows;

Stage 1

- Construction of the IGAD and CSD warehouse (42,030 m^2) and two storeys of the five storey main office building (5,030 m^2) which are highlighted by the orange, pink and blue sections in the Figure above respectively (Building 1).
- Construction of the two storey open-deck carpark as highlighted in the Figure above.

Stage 2

- Construction of the Perishables warehouse (13,180 m^2) which is highlighted by the blue section in the southwest corner of Figure above (Building 2).
- Construction of the Fresh food warehouse (5,640m^2) which is highlighted by the light green section within Building 3 as shown in the Figure above (Building 3).

Stage 3

- Extension of the ALM warehouse (14,110 m^2) which is highlighted by the yellow section located in the southeast corner of the proposed facility (Building 1).

Stage 4a

- Construction of the third storey (1,090 m^2) of the five storey main office building located at the northern end of Building 1.

Stage 4b

- Construction of the fourth and fifth storeys (4,450 m^2) of the five storey main office building located at the northern end of Building 1.

Stage 5

- Extension of the ALM warehouse which is highlighted by the yellow section located in the southeast corner of the proposed facility (Building 1).
- Extension of the Perishables warehouse located in the southwest corner of the proposed facility (Building 2).
- Extension of the Fresh food warehouse located in the northwest corner of the proposed facility (Building 3).

Refer to APPENDIX J for detailed staging drawings.

The fire compartment size of Buildings 1, 2 & 3 exceeds 18,000 m^2 and 108,000 m^3 and the maximum ceiling height is greater than 12 m, therefore according to the large-isolated building provisions under Clause C2.3(b) of the BCA, a fire sprinkler system in accordance with Specification E1.5 and a smoke exhaust system in accordance with Specification E2.2b is required to be installed within buildings 1, 2 & 3.

Note, Buildings 2 and 3 are interconnected by the common battery recharge areas and as such for the purposes of BCA Clause C2.3 they are considered as a single Large Isolated Building. Based on the above, the large-isolated building provisions as per Clause C2.3 of the BCA apply to both Buildings 1 and 2/3.

In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide (i) a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes <u>and/or</u> (ii) a natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis.

Further, given the floor area of this warehouse is approximately 57,600 m^2, part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to security issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this option may also lead to false alarms from the sway of racking. The intent of the above solutions (smoke detection, video detection and infra-red detection) is to provide an earlier level of occupant notification in a fire. It is important to note, adoption of these solutions is subject to further fire engineering analysis.

In addition to the above, we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas. Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required however is subject to further fire engineering analysis.

As per Clause C2.4 of the BCA, a minimum unobstructed width of 6 m is required around the building for fire brigade perimeter vehicular access with no part of its furthest boundary more than 18 m from the building. In this instance, the vehicular access path at the south-eastern corner of Building 2 is greater than 18 m from the eastern external wall its setback is non-compliant with the requirements of

C2.4. Further, temporary access roads may be required along the southern end of Building 1 during Stages 1 and 3, along with along the southern end of Building 2 and the northern end of Building 3 for Stage 2. As the future stages of these buildings are constructed these temporary access roads will need to be removed to facilitate the building works and hence for a period of time each of the building will not be provided with perimeter access to one side and as such will be non-compliant for a period of time. For example, during the construction phase of Stage 3, Building 1 will have non-compliant access to the southern side, similarly during Stage 5, Building 1 will have non-compliant access to the southern end and Building 2/3 will have non-complaint access to the southern and northern sides.

In addition to the above, the vehicular access path along the western side of the proposed facility is 4.5m in parts in lieu of the 6m clear access path. Previous discussions with the NSWFB suggested their in-principle support for the reduced access width along this side on the condition 6m wide points are provided every 50m (refer to APPENDIX I). Refer to Section 7.1 for vehicular access provisions during the three stages.

As per Clause C1.1 of the BCA, Building 1 is required to be constructed in accordance with Type A construction (due to the proposed five storey office), however Buildings 2 & 3, and the carpark building are to be constructed in accordance with Type C construction. Note, an alternative solution has been pursued to reduce the 4 hour FRL requirement to the warehouse area of Building 1 as per Type A construction for Class 7b and 5 adjoining parts. Refer to Table 0-1 for further details.

This Fire Engineering Brief (FEB) document highlights areas of non-compliance with the Building Code of Australia 2010 (BCA) [1] Deemed-to-Satisfy (DtS) provisions, outlines the scope of work for the Fire Engineering Analysis, sets down the basis on which the analysis will be undertaken (as agreed by the stakeholders), necessary acceptance criteria and proposes a trial Fire Safety Strategy and design for further evaluation.

This document will be revised throughout the Fire Engineering Brief process to keep an accurate account of the discussions and agreements between the design team and the relevant authorities.

The following table lists the departures from the DtS provisions of the BCA for the proposed works and those Fire Engineering requirements formulated as part of the trial concept design. The assessment methodology proposed for the Fire Engineering Assessment is in accordance with the International Fire Engineering Guidelines (IFEG) [3].

Table 0-1: Summary of Alternative Solutions

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
C2.3 – Large isolated buildings inter alia Specification E2.2b	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***EP2.2***	The fire compartment size of Buildings 1, 2 & 3 exceeds 18,000 m^2 and 108,000 m^3 and the maximum ceiling height is greater than 12 m, therefore according to the large-isolated building provisions under Clause C2.3(b) of the BCA, a fire sprinkler system in accordance with Specification E1.5 and a smoke exhaust system in accordance with Specification E2.2b is required to be installed within buildings 1, 2 & 3. Note, Buildings 2 and 3 are interconnected by the common battery recharge areas and as such for the purposes of BCA Clause C2.3 they are considered as a single Large Isolated Building. Based on the above, the large-isolated building provisions as per Clause C2.3 of the BCA apply to both Buildings 1 and 2/3. In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide (i) a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes and/or (ii) a natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis.

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
		Further, given the floor area of this warehouse is approximately 57,600 m^2, part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to theft issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this options may also lead to false alarms from the sway of racking. The intent of the above solutions (smoke detection, video detection and infra-red detection) is to provide an earlier level of occupant notification in a fire, however it should be noted adoption of these solutions is subject to further fire engineering analysis. In addition to the above, we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas. Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required, however is subject to further fire engineering analysis. It is understood a fire sprinkler shall be provided throughout Buildings 1, 2 & 3 in accordance with Specification E1.5 of the BCA. It shall be demonstrated that the oversize fire compartment area is not expected to affect occupant life safety, fire brigade intervention and fire spread within the building. Recommendations will be made in consultation with the NSWFB and the design team, and based on the outcomes of the fire engineering analysis.
C2.4 – Requirements for open spaces and vehicular access	- A0.5(b)(i) - A0.9(b)(ii) & (c) - A0.10 - ***CP9***	As per Clause C2.4 of the BCA, a minimum unobstructed width of 6 m is required around the building for fire brigade perimeter vehicular access with no part of its furthest boundary more than 18 m from the building. In this instance, the vehicular access path at the south-eastern corner of Building 2 is greater than 18 m from the eastern external wall its setback is non-compliant with the requirements of C2.4. Further, temporary access roads may be required along the southern end of Building 1 during Stages 1 and 3, along with along the southern end of Building 2 and the northern end of Building 3 for Stage 2. As the future stages of these buildings are constructed these temporary access roads will need to be removed to facilitate the building works and hence for a period of time each of the building will not be provided with perimeter access to one side and as such will be non-compliant for a period of time. For example, during the construction phase of Stage 3, Building 1 will have non-compliant access to the southern side, similarly during Stage 5, Building 1 will have non-compliant access to the southern end and Building 2/3 will have non-complaint access to the southern and northern sides. In addition to the above, the vehicular access path along the western side of the proposed facility is 4.5m in parts in lieu of the 6m clear access path. Previous discussions with the NSWFB

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
		suggested their in-principle support for the reduced access width along this side on the condition 6m wide points are provided every 50m (refer to APPENDIX I). Refer to Section 7.1 for vehicular access provisions during the three stages. Qualitative and quantitative analysis methods will be adopted to consider Fire Brigade Intervention capabilities to the available vehicular access. Fire risks, exposures and impact on fire operations will be assessed with consideration given to the effectiveness of the fire sprinkler system. Our recommendations will give due consideration to comments offered by the NSWFB.
C1.1 – Type of construction required inter alia Specification C1.1 – Fire resisting construction	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***CP1 & CP22***	Due to the proposed main office having a rise in storeys of five (5), Building 1 is required to adopt Type A construction. As such fire ratings in accordance with Table 3 of Specification C1.1 are required. Due to the Class 7b nature of the warehouse 4 hour fire ratings are required to be applied to the building structure. In this regard the following non-compliances will be addressed; • no fire rating to the internal columns in the warehouse (required to be 60/-/- FRL) • no fire rating to the columns incorporated in the external walls of the warehouse (required to be 240/-/-) • Reduction of FRL's to the office structure from 4 hours to 2 hours without the inclusion of a fire wall between the office are the warehouse areas. It is proposed to demonstrate that the oversize fire compartment area (main warehouse) is not expected to affect occupant life safety, fire brigade intervention and fire spread within the building. As such, although the warehouse is linked to the five storeys main office and vice versa, fire spread between these areas is not expected to be any greater than between the same warehouse to a two (2) storey office requiring Type C construction.

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
D1.4 – Exit Travel Distances	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***DP4 & EP2.2***	The distances of travel to an exit within the building are proposed to exceed the BCA DTS limit of 40m. Based on BM+G preliminary regulatory advice the following extended travel distances occur: < Building 1 (Stages 1, 3, & 5 - Warehouse) - Maximum exit travel distance measured from the central area of the Warehouse in each stage is approx. 110m. < Building 1 (Stage 1 - Forklift Recharge Area) – Maximum exit travel distance of 45m. < Building 1 (Stage 1 - Mens Locker Room) – Maximum exit travel distance of 44m. < Building 1 (Dispatch Offices x 2) – Level 1 maximum exit travel distances to a single exit of 24.5m < Building 1 (Stages 1, 4a & 4b - Main Office) – Complies on an open plan basis (on all 5 levels) – proposed fitout will require further assessment. < Carpark Building (Ground & Rooftop Levels - Stage 1) – Maximum worst case exit travel distances of 70m (dependant upon exact position of exits it may be reduced to approx. 55m). < Building 2 (Stage 2 - Warehouse) – Maximum exit travel distances of 70m in freezer. < Building 2 (Stage 2 – Perishables Offices Ground Floor) – Maximum exit travel distances of 53m and distance to a point of choice to alternative exits of 22m. < Building 2 (Stage 5) – Maximum exit travel distances of 70m in freezer. < Building 2 (Stage 2 – Forklift Recharge Area) – Maximum exit travel distances of 55m. < Building 3 (Stage 2 – Warehouse Fresh 0 to 4 degrees) – Maximum exit travel distances of 60m. < Building 3 (Stage 2 – Warehouse Fresh 10-14 degrees) – Maximum exit travel distances of 43m. < Building 3 (Stage 2 – Warehouse Fresh Staging Area) – Maximum exit travel distances of 57m. < Building 3 (Stage 2 – Fresh Offices Ground Floor Male Change Room) – maximum exit travel distances of 43m. < Building 3 (Stage 5) – Maximum exit travel distances of 60m. Note, the above maximum exit travel distances take into consideration the potential racking layout in the warehouse area of each building, however, a final assessment will be required upon confirmation of final racking layout. Both qualitative and quantitative analysis methods will be applied considering the effectiveness of the automatic fire sprinkler system including the additional smoke detection system (areas to be confirmed based on outcomes of the fire engineering analysis), building layout and configuration and occupant warning system in order to allow occupants to evacuate safely. Our analysis will assess, to the degree necessary, that the extended travel distances detailed herein are not expected to adversely affect the life safety of occupants whilst evacuating the building.

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
D1.5 – Distance between alternative exits	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***DP4 & EP2.2***	The distances of travel between alternative exits within the building are proposed to exceed the BCA DTS limit of 60m. Based on BM+G preliminary regulatory advice the following extended travel distances occur: < Building 1 (Stages 1, 3, & 5 - Warehouse) - Maximum distance between alternative exits in each stage is approx. 220m. < Building 1 (Stage 1 - Forklift Recharge Area) – Maximum distance between alternative exits of 80m. < Building 1 (Stage 1 - Mens Locker Room) – Maximum distance between alternative exits of 115m. < Building 1 (Stages 1, 4a & 4b - Main Office) – Complies on an open plan basis (on all 5 levels) – proposed fitout will require further assessment. < Carpark Building (Ground & Rooftop Levels - Stage 1) – Maximum distance between alternative exits of 95m (dependent upon exact position of exits it may be reduced on the ground level). < Building 2 (Stage 2 – Perishables Warehouse) – Maximum distance between alternative exits of 140m in freezer. < Building 2 (Stage 5) – Maximum distance between alternative exits of 140m in freezer. < Building 2 (Stage 2 – Forklift Recharge Area) – Maximum distance between alternative exits of 110m. < Building 3 (Stage 2 – Warehouse Fresh 0 to 4 degrees) – Maximum distance between alternative exits of 115m. < Building 3 (Stage 2 – Warehouse Fresh 10-14 degrees) – Maximum distance between alternative exits of 80m. < Building 3 (Stage 2 – Warehouse Fresh Staging Area) – Maximum distance between alternative exits of 95m. < Building 3 (Stage 5) – Maximum distance between alternative exits of 115m. Note, the above maximum distances take into consideration the potential racking layout in the warehouse area of each building, however, a final assessment will be required upon confirmation of final racking layout. Both qualitative and quantitative analysis methods will be applied considering the effectiveness of the automatic fire sprinkler system including the additional smoke detection system (areas to be confirmed based on outcomes of the fire engineering analysis), building layout and configuration and occupant warning system in order to allow occupants to evacuate safely. Our analysis will assess, to the degree necessary, that the extended travel distances detailed herein are not expected to adversely affect the life safety of occupants whilst evacuating the building.
D1.7 – Travel via fire-isolated exits	< A0.5(b)(i) & (ii) < A0.9(b)(ii) & (c) < A0.10 < ***DP5 & EP2.2***	The southern fire-isolated stair from the main office building discharges into an awning area and involves passing within 6m of glazed openings within the ground floor office in lieu of discharging directly to a road or open space. In this instance, it is proposed for the glazed openings within the ground floor office to be protected with wall-wetting sprinklers internally and as such equivalence with Clause C3.4 of the BCA can be argued. Further, it order to minimise the risk of exposing occupants to excessive radiant heat from a potential fire within the truck loading area/awning at the north-west corner of the main

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
		warehouse, it is proposed to construct a 2.4m high wall between the truck area and the discharge path. The alternative solution will assess to the degree necessary that the proposed solution will provide an adequate level of protection for occupants whilst evacuating the building.
E1.8 – Fire control centres	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***EP1.6***	Given the two large isolated buildings (Building 1 and Building 2/3) have a floor area greater than 18,000 m^2, a fire control centre is required to both of these buildings in accordance with Specification E1.8 of the BCA. In this instance, a single fire control centre for the site will be utilized in lieu of one for each of the two fire-isolated buildings.

Table 0-2: Summary of Fire Engineering Requirements

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
Fire Resistance Levels and Compartmentation	The two large-isolated buildings; Building 1 and Building 2/3 must have a minimum structural fire resistance level (FRL) in accordance with the BCA Type A and B fire resisting construction respectively with the exception of the items discussed within Table 0-1 above.	Table C1.1 and Specification C1.1 of the BCA.
	All materials and assemblies are to achieve early fire hazard indices.	BCA C1.10 and Specification C1.10.
	All dangerous goods shall be in accordance with the relevant dangerous goods legislation.	Dangerous goods consultant has been engaged and a detailed report will be provided for guidance.

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
Access and Egress	With the exception of the extended travel distances, as specified herein, all access and egress requirements of the BCA relevant to this building must be complied with.	Section D of the BCA DtS Provisions and via an alternative solution.
	Open spaces and vehicular access shall be in accordance with Clause C2.4 of the BCA DtS Provisions with the exception of the non-compliance as detailed within Table 0-1. Refer to Section 7.1 for vehicular access provisions during the six stages. It is understood the vehicular turning areas around the proposed facility shall comply with NSW FB Policy 4.	Assessed via an alternative solution. Our recommendations will give due consideration to comments offered by the NSWFB.
	Door hardware on all required exits, is to be in accordance with the current regulations such that all required exits shall be available for emergency egress.	Section D of the BCA 2010.
	Door swings to comply with Clause D2.20 of the DtS provisions of the BCA.	BCA Clause D2.20.
	All required emergency exit doors which may be locked due to security requirements shall unlock upon activation of the general fire alarm or power failure.	BCA Clause D2.21.
Services and Equipment	It is assumed the three buildings will be served by a single fire hydrant system with multiple ring mains. *Note, a combined fire sprinkler and fire hydrant system is considered unacceptable in this instance.*	BCA DtS Provision E1.3 and AS 2419.1
	Fire hose reels must be installed.	BCA DtS Provision E1.4 and AS 2441
	A fire sprinkler system is to be installed throughout the building. *Note, a combined fire sprinkler and fire hydrant system is considered unacceptable in this instance.*	- An ESFR sprinkler system shall be provided throughout the warehouse areas in accordance with Factory Mutual Guidelines FM2-2 and where applicable, BCA Specification E1.5 and AS 2118.1; and - The fire sprinkler system within the office areas shall be in accordance with AS 2118.1.

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
	As part of the alternative solution to address the non-complying discharge location of the southern fire-isolated stair from the main office, it is proposed to install wall-wetting sprinklers to the internal side of the glazed openings as per Figure 7-1. The design and maintenance of the drencher glass protected system is to be undertaken in accordance as follows: i. The glass windows must be minimum 6mm toughened glass. Glass side panels requiring drencher protection shall be fixed closed and non-openable. ii. The maximum dimensions of the glass panels should be compatible with the spray pattern of the Tyco WS Sprinkler System design criteria. iii. The maximum distance between two window sprinklers shall be no more than 2.44m in order to provide sufficient coverage to a window and frame. iv. Flexible seals are to be used between the top and bottom of the window frames to allow for the expansion of the glass. v. No horizontal mullions are to be installed within the drenchered side of the openings. Furthermore, at least one drencher head must be installed between every vertical mullion (if applicable). Where this is not achievable the drencher heads must be strategically located to ensure complete coverage of the glazed elements. vi. Sprinkler drencher system stop valve shall be locked in the open position and monitored, thus activating the local alarm should the status of the valve be change.	AS 2118.2. Tyco Technical Data Sheet or an approved alternate drencher head technical data sheet.

<table>
<tr><th>FIRE SAFETY SUB-SYSTEM</th><th>FIRE ENGINEERING REQUIREMENT</th><th>STANDARD OF INSTALLATION</th></tr>
<tr><td></td><td><u>Building 1</u>

In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide the following options;

<u>Option 1</u>

A smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes.

To conform with NSWFB operational requirements, smoke clearance fans should be provided with 1 air change per hour, however given the large size of the main warehouse, it is proposed to rationalise this extraction rate.

Further, the fans should be evenly distributed throughout the main warehouse with the following requirements:

(a) The smoke clearance fans shall be connected to the FIP which can be manually operated only by fire brigade personnel and authorised staff in the event of a fire; and

(b) Fans and fan cabling shall be fire-rated so that fans are capable of operating at 200 ^{O}C for 60 minutes; and

(c) Visible signage shall be provided in accordance with AS/NZS 1668.1-1998 clearly identifying the use and procedures of the fans.

<u>Option 2</u>

A natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis.

Further, given the floor area of this warehouse is approximately 57,600 m^2, part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to theft issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this options may also lead to false alarms from the sway of racking.</td><td>- AS 1668.1
- AS 1670.1
Assessed via an alternative solution.

Our recommendations will give due consideration to comments offered by the NSWFB.</td></tr>
</table>

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
	Building 2 As part of the alternative solution we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas. Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required however this requirement is subject to further fire engineering analysis.	Assessed via an alternative solution.
	Portable fire extinguishers must be provided throughout the building.	BCA DtS Provision E1.6 and AS 2444.
	An Occupant Warning System must be installed and connected to the fire sprinkler system and any form of detection system installed.	BCA Specification E2.2a Clause 6 and AS 1670.1.
	Emergency lighting must be installed.	BCA DtS Provision E4.2 and AS 2293.1.
	Exit signs and direction signs to exits must be installed.	BCA DtS Provision E4.6 and AS 2293.1.
	A fire indicator panel must be installed within the main entry. Further, given the size of this facility a mimic panel may also be required.	AS 1670.1.
Maintenance and Commissioning	The recommended fire safety systems must be replaced with equivalent systems in all future works and the recommended fire safety systems must be applied to any renovations or new works.	
	Periodic inspection, testing and maintenance of all fire safety systems, fire hydrants, fire hose reels (where provided), emergency lighting, exit signage, doors, fire resistance, portable fire extinguishers, etc. should be implemented.	AS 1851-2005.
	Under all circumstances it is important to keep as much of the system fully operational as is practical. Should any building works extend over a number of days, the system must be re-instated as far as practical at the end of each day.	
Building Management Requirements	No smoking policy throughout all public areas of the building.	
	Keep unnecessary combustible loads to a minimum in public areas via regular housekeeping, including the removal of random storage and accumulated debris.	
	Building Management Procedures provided in Section 8.10 shall be adopted.	

Table of Contents

1 INTRODUCTION

1.1 OVERVIEW

This Fire Engineering Brief has been undertaken to nominate proposed Alternative Solutions for assessing compliance with the nominated performance requirements of the BCA [1] in accordance with the methodologies defined in the IFEG [3].

In order to develop and assess the nominated non-compliances the following flowchart process is to be adopted.

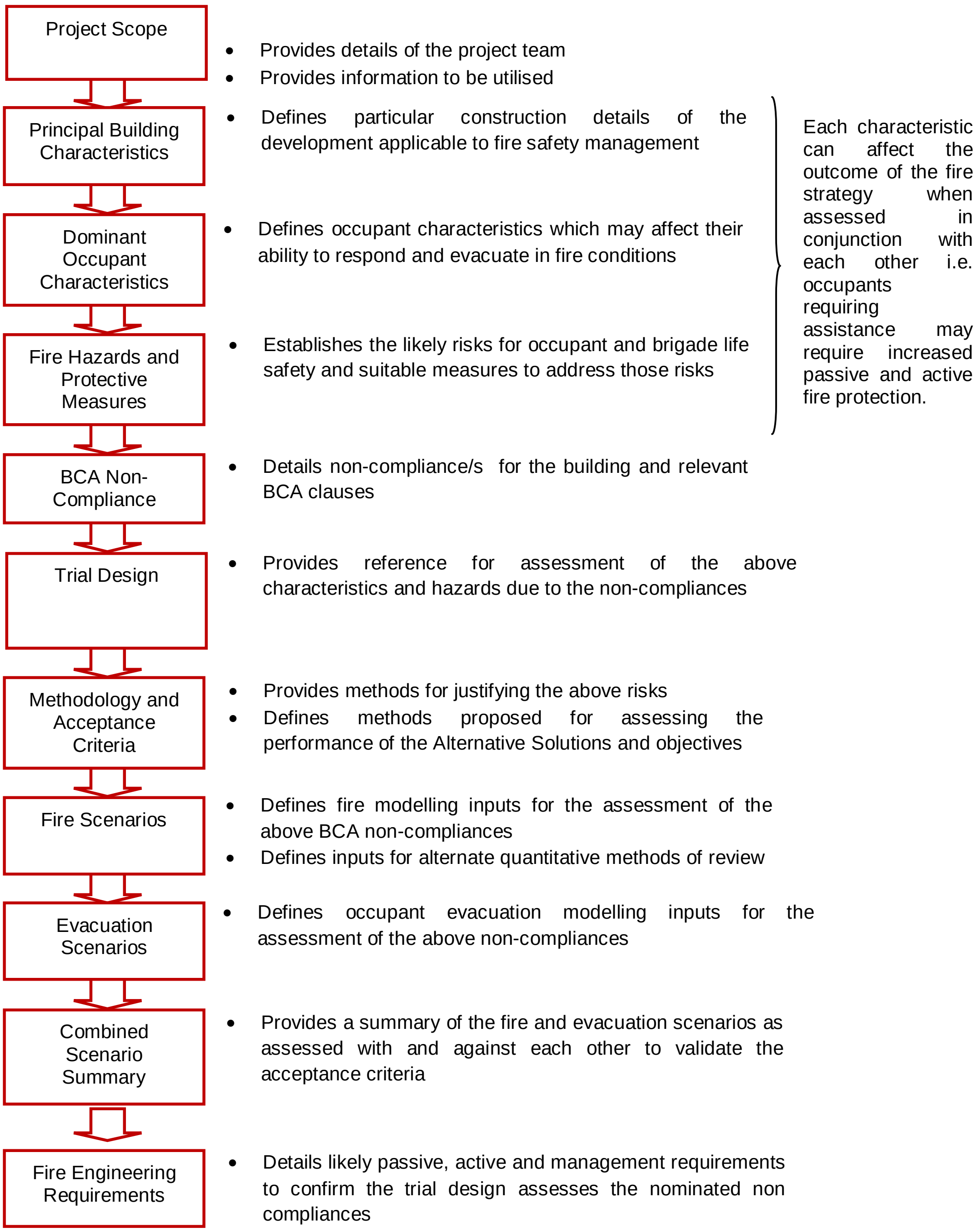


Figure 1-1: Fire Engineering Brief Process

The scope of the Fire Engineering Brief is to detail the nominated non-complying BCA DtS provisions with the performance requirements of the BCA and provide methodologies for establishing a workable and safe Fire Safety Strategy through a trial design.

1.2 FIRE SAFETY OBJECTIVES

The objective of a Fire Engineering Assessment is to develop a Fire Safety System, which satisfies the performance requirements of the BCA whilst maintaining an acceptable level of life safety, protection of adjacent property and adequate provisions for Fire Brigade intervention. At a community level, fire safety objectives are met if the relevant legislation and regulations are complied with. As stated in the BCA, "A Building Solution will comply with the BCA if it satisfies the Performance Requirements". In addition to this certain non-regulatory objectives exist as detailed below.

1.2.1 Building regulatory objectives

The following items are a summary of the fire and life safety objectives of the BCA:

- **Life safety of occupants -** the occupants must be able to leave the building (or remain in a safe refuge) without being subject to hazardous or untenable conditions. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of exposing building occupants to hazardous or untenable conditions in an event of a fire.
- **Life safety of fire fighters -** fire fighters must be given a reasonable time to rescue any remaining occupants before hazardous conditions or building collapse occurs. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would facilitate fire brigade intervention and minimise the risk of exposing fire fighters to hazardous or untenable conditions in an event of a fire.
- **Protection of adjoining buildings** - structures must not collapse onto adjacent property and fire spread by radiation should not occur. The objective of the Fire Engineering Assessment is to demonstrate that the proposed building design and fire safety systems would minimise the risk of fire spreading from one building to another.

1.2.2 Fire Brigade objectives

The overall philosophical Fire Brigade objectives throughout Australia is to protect life, property and the environment from fire according to the Fire Brigade Intervention Model (FBIM) [4] as per the Fire Services State and Territory Acts and Regulations.

Over and above the requirements of the BCA, the Fire Brigade has functions with regard to property and environmental protection and considerations regarding occupational health and safety for its employees.

1.2.3 Non-prescribed objectives

Fire Engineering has an overarching benefit to many facets of the built environment where non-prescribed objectives can have an influence on the Fire Safety Strategy adopted. Although not assessed within, the following can be considered if requested.

- **Business continuity -** will the loss of a particular facility due to fire / smoke damage result in excessive financial impact on the client? For example, is the facility critical to business continuity?
- **Public perception -** should a fire occur within the facility is there likely to be questionable public perception about the safety and operation of the facility?
- **Environmental protection –** fires of excessive sizes can have significant effects on the environment which may require a detailed risk assessment to minimise such outcomes.
- **Heritage salvation –** buildings can have a heritage value for both cultural and educational purposes which can be destroyed by insufficient fire protection.
- **Risk mitigation / insurance limitations -** are there specific limitations on insurance with respect to risk mitigation and fire safety design? i.e. Does the relevant insurer have concerns with respect to open atriums through the building?

- **Future proofing (isolation of systems) -** what flexibility is required in the overall design to allow for future development or changes in building layout?
- **OHS requirements -** buildings may have specific fire safety requirements pertaining to OHS requirements.

1.3 REGULATORY FRAMEWORK OF THE FIRE ENGINEERING ASSESSMENT

1.3.1 Building Code of Australia

One of the goals of the BCA is the achievement and maintenance of acceptable standards of safety from fire for the benefit of the community. This goal extends no further than is necessary in the public interest and is considered to be cost effective and not needlessly onerous in its application.

Section A0.5 of the BCA [1] outlines how compliance with the Performance Requirements can be achieved. These are as follows:

(a) complying with the Deemed-to-Satisfy Provisions; or

(b) formulating an Alternative Solution which –

(i) complies with the Performance Requirements; or

(ii) is shown to be at least equivalent to the Deemed-to-Satisfy Provisions or

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

Section A0.9 of the BCA provides several different methods for assessing that an Alternative Solution complies with the Performance Requirements. These methods are summarised as follows:

(a) Evidence to support that the use of a material, form of construction or design meets a Performance Requirement or a Deemed-to-Satisfy Provision.

(b) Verification Methods such as:

(i) the Verifications Methods in the BCA; or

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

(c) Comparison with the Deemed-to-Satisfy Provisions.

(d) Expert Judgment.

Section A0.10 of the BCA provides methods for complying with provisions A1.5 (to comply with Sections A to J of the BCA inclusive). The following method must be used to determine the Performance Requirements relevant to the Alternative Solution: These methods are summarised as follows:

(a) Identify the relevant Deemed-to-Satisfy Provision of each Section or Part that is to be the subject of the Alternative Solution.

(b) Identify the Performance Requirements from the same Section or Part that are relevant to the identified Deemed-to-Satisfy Provisions.

(c) Identify Performance Requirements from the other Sections and Parts that are relevant to any aspects of the Alternative Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions that are the subject of the Alternative Solution.

1.3.2 International Fire Engineering Guidelines

The IFEG [3] document has been developed for use in fire safety design and assessment of buildings and reflects world's best practice. The document is intended to provide guidance for fire engineers as they work to develop and access strategies that provide acceptable levels of safety.

The document is particularly useful in providing guidance in the design and assessment of Alternative Solutions against the Performance Requirements of the BCA. The prescribed methodology set out in the IFEG has been generally adopted in the Fire Engineering Brief.

2 PROJECT SCOPE

2.1 OVERVIEW

Project Scope

The proposed warehouse facility for Metcash located at Bungarribee Industrial Estate, Huntingwood, Sydney. It is proposed to store/distribute food, household goods and alcohol.

The fire compartment size of Buildings 1, 2 & 3 exceeds 18,000 m^2 and 108,000 m^3 and the maximum ceiling height is greater than 12 m, therefore according to the large-isolated building provisions under Clause C2.3(b) of the BCA, a fire sprinkler system in accordance with Specification E1.5 and a smoke exhaust system in accordance with Specification E2.2b is required to be installed within buildings 1, 2 & 3.

Note, Buildings 2 and 3 are interconnected by the common battery recharge areas and as such for the purposes of BCA Clause C2.3 they are considered as a single Large Isolated Building. Based on the above, the large-isolated building provisions as per Clause C2.3 of the BCA apply to both Buildings 1 and 2/3.

In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide (i) a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes and/or (ii) a natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis.

Further, given the floor area of this warehouse is approximately 57,600 m^2, part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to theft issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this option may also lead to false alarms from the sway of racking. The intent of the above solutions (smoke detection, video detection and infra-red detection) is to provide an earlier level of occupant notification in a fire. It is important to note, adoption of these solutions is subject to further fire engineering analysis.

In addition to the above, we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas. Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required, however is subject to further fire engineering analysis.

As per Clause C2.4 of the BCA, a minimum unobstructed width of 6 m is required around the building for fire brigade perimeter vehicular access with no part of its furthest boundary more than 18 m from the building. In this instance, the vehicular access path at the south-eastern corner of Building 2 is greater than 18 m from the eastern external wall its setback is non-compliant with the requirements of C2.4. Further, temporary access roads may be required along the southern end of Building 1 during Stages 1 and 3, along with along the southern end of Building 2 and the northern end of Building 3 for Stage 2. As the future stages of these buildings are constructed these temporary access roads will need to be removed to facilitate the building works and hence for a period of time each of the building will not be provided with perimeter access to one side and as such will be non-compliant for a period of time. For example, during the construction phase of Stage 3, Building 1 will have non-compliant access to the southern side, similarly during Stage 5, Building 1 will have non-compliant access to the southern end and Building 2/3 will have non-complaint access to the southern and northern sides. Refer to Section 7.1 for vehicular access provisions during the six stages.

As per Clause C1.1 of the BCA, Building 1 is required to be constructed in accordance with Type A construction (due to the proposed five storey office), however Buildings 2 & 3, and the carpark building are to be constructed in accordance with Type C construction. Note, an alternative solution has been pursued to reduce the 4 hour FRL requirement to the office areas as per Type A construction for Class 7b and 5 adjoining parts. Refer to Table 0-1 for further details.

The proposed facility consists of six stages described as follows;

Stage 1

- Construction of the IGAD and CSD warehouse (42,030 m^2) and two storeys of the five storey main office building (5,030 m^2) which are highlighted by the orange, pink and blue sections in the Figure above respectively (Building 1).
- Construction of the two storey open-deck carpark as highlighted in the Figure above.

Stage 2

- Construction of the Perishables warehouse (13,180 m^2) which is highlighted by the blue section in the southwest corner of Figure above (Building 2).
- Construction of the Fresh food warehouse (5,640m^2) which is highlighted by the light green section within Building 3 as shown in the Figure above (Building 3).

Stage 3

- Extension of the ALM warehouse (14,110 m^2) which is highlighted by the yellow section located in the southeast corner of the proposed facility (Building 1).

Stage 4a

- Construction of the third storey (1,090 m^2) of the five storey main office building located at the northern end of Building 1.

Stage 4b

- Construction of the fourth and fifth storeys (4,450 m^2) of the five storey main office building located at the northern end of Building 1.

Stage 5

- Extension of the ALM warehouse which is highlighted by the yellow section located in the southeast corner of the proposed facility (Building 1).
- Extension of the Perishables warehouse located in the southwest corner of the proposed facility (Building 2).
- Extension of the Fresh food warehouse located in the northwest corner of the proposed facility (Building 3).

Refer to APPENDIX J for detailed staging drawings.

The layout of the various buildings at stage 5 works is shown in the Figure below.

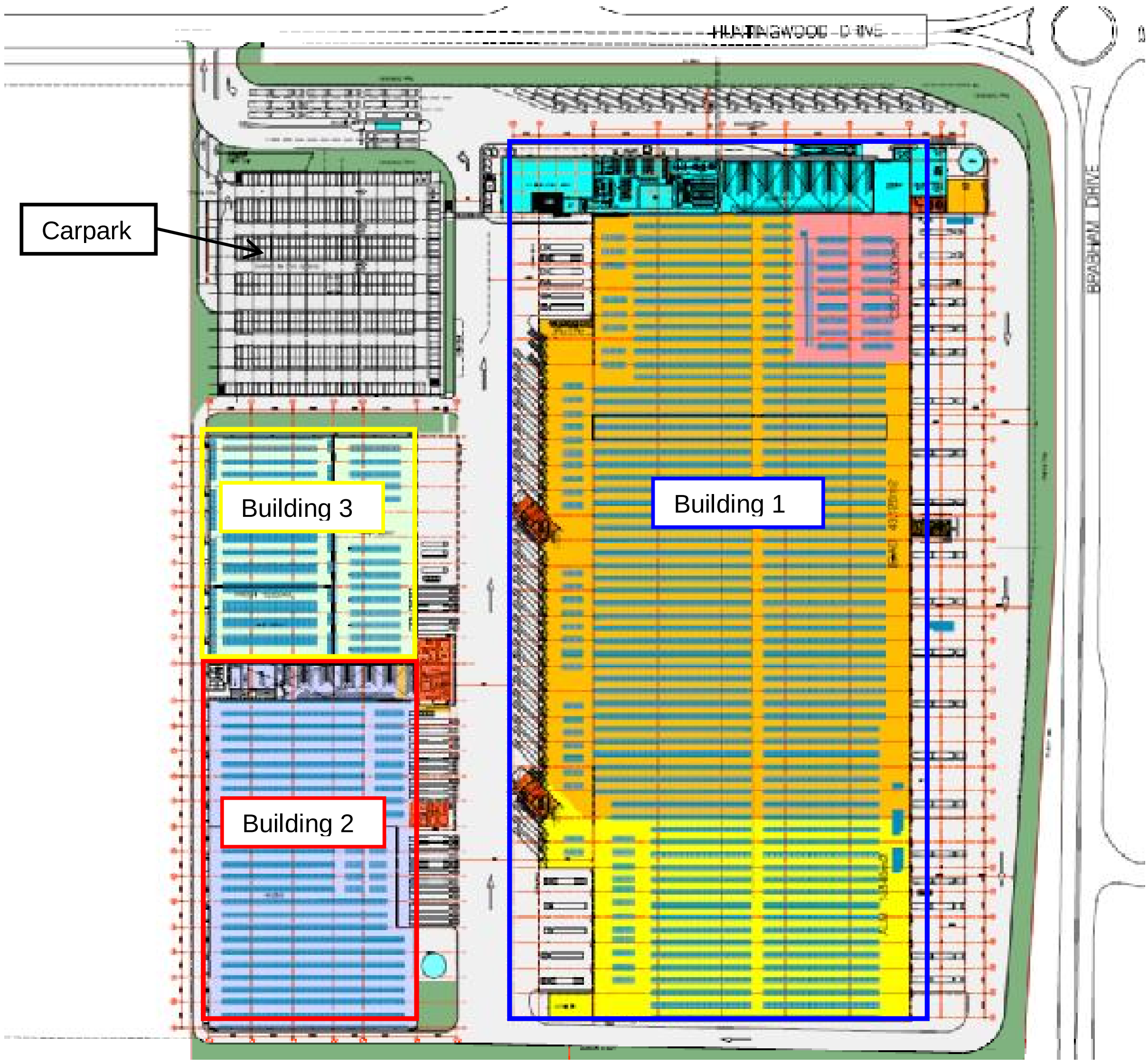


Figure 2-1: Site layout (stage 5)

2.2 RELEVANT STAKEHOLDERS

This Alternative Solution has been developed collaboratively with the relevant stakeholders as identified below:

Table 2-1: Relevant Stakeholders

ROLE	NAME	ORGANISATION
Client representative/Construction Manager	Brendon Quinn Richard Seddon	Goodman
Metcash Project Manager	Sean Wildblood	Property Integration
Architect	Paul Rudolph	ARC Architects
Architect	Scott Moylan	Gray Puksand
Principal Certifying Authority	Dean Goldsmith	Blackett Maguire + Goldsmith
Fire Safety Engineer	Sandro Razzi	RAWFire Safety Engineering
Fire Safety Consultant	Alan Caulfield	RAWFire Safety Engineering

It should be noted that at times some parties may have a vested interest in the outcome of the Fire Engineering assessment. Such parties can include local fire brigades, insurers, EPA, project control groups, end users and community representatives. Although not always a legislative requirement, the design team should give due consideration to their inclusion in the Fire Engineering process. Where not required by legislation it is the client's decision to involve such parties, especially local fire brigade, to ensure a transparent and adequate fire safety solution for all. Where we are not notified of the inclusion of such parties it is assumed the client / representative has given due consideration to the above.

2.3 SOURCES OF INFORMATION

The following sources of information have been provided by the design team:

- BCA Assessment Report prepared by Blackett Maguire + Goldsmith dated 03/09/10; and
- Architectural Plans prepared by ARC Architects as indicated in Table 2-2 below and in APPENDIX J.

Table 2-2: Drawings

DRAWING NO.	DESCRIPTION	DATE
BIE-SITE-A000	SITE PLAN-STAGE 3	July 2010
BIE-SITE-A001	SITE PLAN-STAGE 2	July 2010
BIE-SITE-A002	SITE PLAN-STAGE 1	July 2010
BIE-SITE-A011	DECK CARPARK PLAN	July 2010
BIE-SITE-A012	UPPER DECK CARPARK PLAN	July 2010
BIE-WH1-A001	WH1-FLOOR PLAN-STAGE2	July 2010
BIE-WH1-A003	PERSIHABLES/FRESH OFFICES	July 2010
BIE-WH1-A004	WH1 EAST ELEVATION	July 2010
BIE-WH1-A005	WH1 WEST ELEVATION	July 2010
BIE-WH1-A006	WH1 SECTIONS 1-3	July 2010
BIE-WH2-A001	DRY WAREHOUSE FLOOR PLAN STAGE 2	July 2010
BIE-WH2-A004	WH2 SOUTH ELEVATION	July 2010
BIE-WH2-A005	WH2 NORTH ELEVATION	July 2010
BIE-WH2-A006	WH2 EAST ELEVATION	July 2010
BIE-WH2-A007	WH2 WEST ELEVATION	July 2010
BIE-WH2-A008	WH2 SECTIONS 123	July 2010

2.4 LIMITATIONS AND ASSUMPTIONS

In this instance the Fire Engineering Brief is developed based on applicable limitations and assumptions for the redevelopment which are listed as follows:

- The report is specifically limited to the project described in Section 2.1.
- The report is based on the information provided by the team as listed above in Section 2.3.
- Building and occupant characteristics are as per Section 3 and 4 respectively of this brief. Variations to these assumptions may affect the Fire Engineering Strategy and therefore they should be reviewed by a suitably qualified Fire Engineer should they differ.
- As per any building design, DtS or otherwise, the report is limited to the fire hazards and fuel loads as prescribed in Section 6. The report does not provide guidance in respect of areas, which are used for bulk storage, processing of flammable liquids, explosive materials, multiple fire ignitions or sabotage of fire safety systems.
- The development complies with the DtS provisions of the BCA [1] with all aspects unless otherwise specifically stated in this report. Where not specifically mentioned, the design is expected to meet the BCA DtS requirements of all relevant codes and legislation at the time of construction and / or at the time of issue of this report.

- The assessment is limited to the objectives of the BCA and does not consider property damage such as building and contents damage caused by fire, potential increased insurance liability and loss of business continuity.
- Malicious acts or arson with respect to fire ignition and safety systems are limited in nature and are outside the objectives of the BCA. Such acts can potentially overwhelm fire safety systems and therefore further strategies such as security, housekeeping and management procedures may better mitigate such risks.
- This report is prepared in good faith and with due care for information purposes only, and should not be relied upon as providing any warranty or guarantee that ignition or a fire will not occur.
- The Fire Engineering Brief is only applicable to the completed building. This brief is not suitable, unless approved otherwise, to the building in a staged handover.
- Where parties nominated in Section 2.2 have not been consulted or legislatively are not required to be, this report does not take into account, nor warrant, that fire safety requirements specific to their needs have been complied with.

3 PRINCIPAL BUILDING CHARACTERISTICS

3.1 OVERVIEW

Principal Building Characteristics

Building characteristics are assessed as part of the Fire Engineering Review due the following:

1. The location can affect the time for fire brigade intervention and potential external fire exposure issues.
2. The structure will impact on the ability to resist a developing fire and support condition to allow occupants to escape the building and the fire brigade to undertake fire fighting to the degree necessary.
3. The floor area determines the potential fire size and area required to be evacuated in the event of a fire.
4. BCA details such as Type of Construction, Class and Height will dictate passive and active fire safety systems.

The fire compartment size of Buildings 1, 2 & 3 exceeds 18,000 m^2 and 108,000 m^3 and the maximum ceiling height is greater than 12 m, therefore according to the large-isolated building provisions under Clause C2.3(b) of the BCA, a fire sprinkler system in accordance with Specification E1.5 and a smoke exhaust system in accordance with Specification E2.2b is required to be installed within buildings 1, 2 & 3.

Note, Buildings 2 and 3 are interconnected by the common battery recharge areas and as such for the purposes of BCA Clause C2.3 they are considered as a single Large Isolated Building. Based on the above, the large-isolated building provisions as per Clause C2.3 of the BCA apply to both Buildings 1 and 2/3.

As per Clause C2.4 of the BCA, a minimum unobstructed width of 6 m is required around the building for fire brigade perimeter vehicular access with no part of its furthest boundary more than 18 m from the building. In this instance, the vehicular access path at the south-eastern corner of Building 2 is greater than 18 m from the eastern external wall its setback is non-compliant with the requirements of C2.4. Further, temporary access roads may be required along the southern end of Building 1 during Stages 1 and 3, along with along the southern end of Building 2 and the northern end of Building 3 for Stage 2. As the future stages of these buildings are constructed these temporary access roads will need to be removed to facilitate the building works and hence for a period of time each of the building will not be provided with perimeter access to one side and as such will be non-compliant for a period of time. For example, during the construction phase of Stage 3, Building 1 will have non-compliant access to the southern side, similarly during Stage 5, Building 1 will have non-compliant access to the southern end and Building 2/3 will have non-complaint access to the southern and northern sides. Refer to Section 7.1 for vehicular access provisions during the six stages.

Based on the 6 m perimeter access path around the buildings, the proposed development is adequately separated from adjoining buildings which would reduce the risk of fire spread between buildings and external fire brigade attack can be considered available options.

Bungarribee Industrial Estate is located south of the M4 and M7 intersection as shown in the Figure below.

Figure 3-1: Site Location

3.2 BUILDING CHARACTERISTIC ASSESSMENT

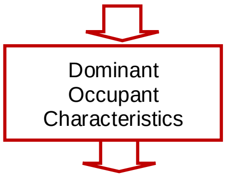
Table 3-1: Building Characteristics Assessment

CHARACTERISTIC	DESCRIPTION	RELEVANCE TO FIRE SAFETY STRATEGY
Location	Bungarribee Industrial Estate, Brabham Drive, Eastern Creek, NSW.	Separation of the building from other property reduces fire spread risk.
Layout	Classified as two large-isolated buildings; namely Building 1 and Building 2/3. The main warehouse of Building 1 is approximately 57,000 m^2 in floor area with a regular linear/rectangular storage layout. Exit doors and roller doors are mainly located on the eastern and western sides. Building 2/3 includes areas of varying temperatures; -24 °C, 0-4 °C and 10-14 °C. Refer to APPENDIX J for floor plans.	Egress simplified by uncomplicated paths in straight lines to exits. Large floor areas and ceiling reservoirs for smoke accumulation. Significant smoke ventilation available via vehicle doors.
Structure	As per Clause C1.1 of the BCA, Building 1 is required to be constructed in accordance with Type A construction (due to the five storey office), however Buildings 2 & 3, and the carpark building are to be constructed in accordance with Type C construction.	An alternative solution has been pursued to reduce the 4 hour FRL requirement to the warehouse areas (Building 1) as per Type A construction for Class 7b and 5 adjoining parts. Refer to Table 0-1 for further details.

CHARACTERISTIC	DESCRIPTION		RELEVANCE TO FIRE SAFETY STRATEGY
Total Floor area	Building 1 – 76,400 m^2 Building 2/3 – 31,200 m^2		Both buildings classified as large-isolated therefore as required to comply with Clause C2.3 of the BCA. The large floor area and extra ceiling height provides additional ceiling space for smoke to move upward before spreading across the ceiling prior to descend to occupant level.
BCA Assessment	Classification	Class 5 (office), 7a (carpark) and 7b (warehouse)	The class 7b warehouse which is connected to the five storey office pulls up the requirement for 4 hours fire rating within Building 1.
	Construction Type	Building 1 - Type A Building 2&3 – Type C Carpark – Type C	An alternative solution has been pursued to reduce the 4 hour FRL requirement to the office areas (Building 1) as per Type A construction for Class 7b and 5 adjoining parts. Refer to Table 0-1 for further details.
	Rise in Storeys	Building 1 – Five (5) Building 2 – Two (2) Building 3 – Two (2) Carpark – Two (2)	The rise in storeys incurs a higher type of construction and hence higher fire resistance levels.
	Effective Height	Building 1: >12m & <25m Building 2&3: <12m Carpark: <12m	With exception of the five storey office, the buildings have a low rise of storeys which will allow for convenient external fire brigade attack to most areas of the buildings.

4 DOMINANT OCCUPANT CHARACTERISTICS

4.1 OVERVIEW



The occupant characteristics are assessed within the Fire Engineering Brief due to the following:

1. Population numbers can dictate the time required to evacuate the building and the required life safety systems to be provided due to evacuation times.
2. Physical and mental attributes affects the occupants capacity to respond to various fire cues and react accordingly.
3. Familiarity of occupants can affect the time taken to evacuate the building and subsequent active / passive requirements.

4.2 DOMINANT OCCUPANT CHARACTERISTIC ASSESSMENT

Table 4-1: Occupant Characteristics Assessment

CHARACTERISTIC	DESCRIPTION	RELEVANCE TO FIRE SAFETY STRATEGY
Population numbers	Based on correspondence from Integration Property who are Metcash's Project Manager, a total of 720 occupants are proposed to occupy the office areas. Further, we have been advised the warehouse staff numbers and shifts are as follows; • Shift 1: 5am-2pm – 160 occupants • Shift 2: 8.30am-6pm – 170 occupants • Shift 3: 2pm-11pm – 70 occupants The evacuation analysis within the warehouse will conservatively assume occupants from all three shifts are present and dispersed evenly throughout the warehouses.	The number of occupants will be a key factor in the evacuation timing, with queuing time reduced where the aggregate exit width is great relative to the population.
Physical and mental attributes	Staff may be employed with disabilities which might affect recognition, response or movement in an emergency situation. In general however, due to the tasks required of warehouse and office staff, it is expected that the degree of physical and mental capabilities requisite for employment in these areas would equip most staff to be able to respond and evacuate by their own power. However, as it is possible that less able individuals may be present, these individuals should be identified and provided with a Personal Emergency Evacuation Plan (PEEP); which may incorporate additional warnings in the form of beacons, pagers or wardens to provide evacuation assistance from trained individuals and will identify appropriate egress routes. Staff may also be under the influence of medication, alcohol or other drugs or affected by fatigue or temporary injury. The building and associated activities or occupant group however	Evacuation timing is affected by recognition of cues, determining the need to evacuate and the speed of travel toward exits.

CHARACTERISTIC	DESCRIPTION	RELEVANCE TO FIRE SAFETY STRATEGY
	will not increase the likelihood of such influence on the population.	
Familiarity with the building	Staff will be familiar with the building, its exits and emergency warning system as per their regular use of the building. Visitors such as delivery drivers, customers and supplier representatives are expected to be in the company of staff who are familiar with the building or can be expected to recall the path taken to their location to the degree that way-finding in clear conditions is not onerous.	Familiarity with the building will assist in decision making and egress in general with knowledge of the available exit paths.
Emergency training	Occupants are expected to have experience in evacuation of the building by the requirement for regular fire drills. Wardens are expected to have basic first aid fire fighting training however the assessment of fire development will not rely on occupant suppression, focusing on the more severe fire scenarios which will challenge the fire safety systems.	Training in operation of first aid fire fighting equipment is not relied upon for this occupant group within the assessment.

5 FIRE BRIGADE CHARACTERISTICS

5.1 OVERVIEW

The fire brigade characteristics are assessed within the Fire Engineering Brief due to the following:

1. Fire Brigade characteristics can dictate the time required for fire brigade intervention including search and rescue and fire attack.

5.2 FIRE BRIGADE ASSESSMENT

The closest two fire stations to the existing site are as follows:

Table 5-1: Station Locations

Station Name	Permanent or Retained	Station Address	Distance from site
Huntingwood	Permanent	42 Huntingwood Drive, Huntingwood NSW 2148	1.3 km drive
Mount Druitt	Permanent	Cnr Belmore Rd and Varian St, Mount Druitt NSW 2770	7.3 km drive

Figure 5-1 Location of site with respect to closest Fire Brigade Station

The closest two fire brigade stations to the project site are located in Huntingwood and Mount Druitt (as confirmed by the NSWFB Website). The figure above illustrates the expected routes from the closest fire station in Huntingwood located at 42 Huntingwood Drive, Huntingwood, 2148. Due to the nature of the FBIM, it is necessary to justify the results through the inclusion of assumptions. The accuracy of results weighs heavily upon the measure of which assumptions are made and the sources from which they are derived. The following are details of the assumptions utilised in this FBIM:

- The initial Brigade notification is via sprinkler activation at approximately 412 seconds in the main warehouse (Using Alperts Calculations see APPENDIX G for details)
- Fire Brigade notification is assumed to occur via a direct monitored alarm. Fire Brigade tactical fire plans are provided.
- The fire stations assigned to the initial turnout are located 1.3 km driving distance from the site.
- The travel speeds have been calculated as follows. Given the stations have been considered to be located within a major city outer suburban area, appliance travel speeds of 29.5 km/h have been adopted for the purposes of the FBIM.

Table 5-2: FBIM data for the NSWFB

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	-

Based on the site being located within a major city outer suburb, the time of travel is therefore equal to:

Table 5-3: Travel Times

Station	Travel Speed (km/h)	Distance (km)	Time Taken to Travel (s)
Huntingwood	29.5 km/h	1.3	159 seconds
Mount Druitt	29.5 km/h	7.3	891 seconds

- On arrival, the fire location is determined at the Fire Indicator Panel.
- Fire fighters access the fire-affected area initially through the main entrance door.
- The fire occurs during business hours and therefore forced entry is not required.
- The first appliance would be expected to commence the initial attack on the fire.

Table 5-4: Determination of Fire Location and Setup

Time Taken for Initial Determination of Fire Location			Time Taken to Travel to Set-up Area	Time Taken to Set Up Water Supply Requirements	
Time to dismount appliance and don BA	Time to conduct safety procedures	Time for warden to communicate with Fire Brigade/ review FIP		Remove, connect and charge hose (Hydrant-Appliance)	Remove and connect hose (Appliance – Booster)
90 sec	30 sec	90 sec	60 sec	90 sec	60 sec

Table 5-5 Summary of the Fire Brigade Intervention Model (FBIM)

Station	Time of Alarm	Fire Fighter Response	Travel Time to Scene	Assumed Set-up Time	Approximate Time of Attack
Huntingwood	412 sec	Included in travel time for NSWFB	159sec	420 sec	991 sec (16 minutes and 31 seconds)
Mount Druitt	412 sec	Included in travel time for NSWFB	891 sec	420 sec	1723 sec (28 minutes and 43 seconds)

As summarised in Table 5-5, the FBIM indicates that the time of attack of the brigade from the nearest fire stations located in Huntingwood and Mount Druitt to the proposed site is approximately 16.5 minutes and 29 minutes respectively after fire ignition.

6 FIRE HAZARDS AND PROTECTIVE MEASURES

6.1 OVERVIEW

The fire hazard analysis forms the basis for the review of non-compliances within the building. In assessing expected and statistically validated hazards, preventative and protective measures are developed commensurate with those expected risks. The following section reviews applicable hazards and recommends possible measures to address those risks. Furthermore, hazards identified can form a justified basis for selected scenarios.

6.2 FIRE STATISTICS

Warehouse statistics

Fire statistics for warehouses and factories in Australia as reported in Technical Report 96-02 [17] show that the most common cause of fires in these types of buildings are incendiary or suspicious followed by electrical faults with welding (hot works) and mechanical failure other common causes.

Figure 6-1: Warehouse Fire Statistics by Cause

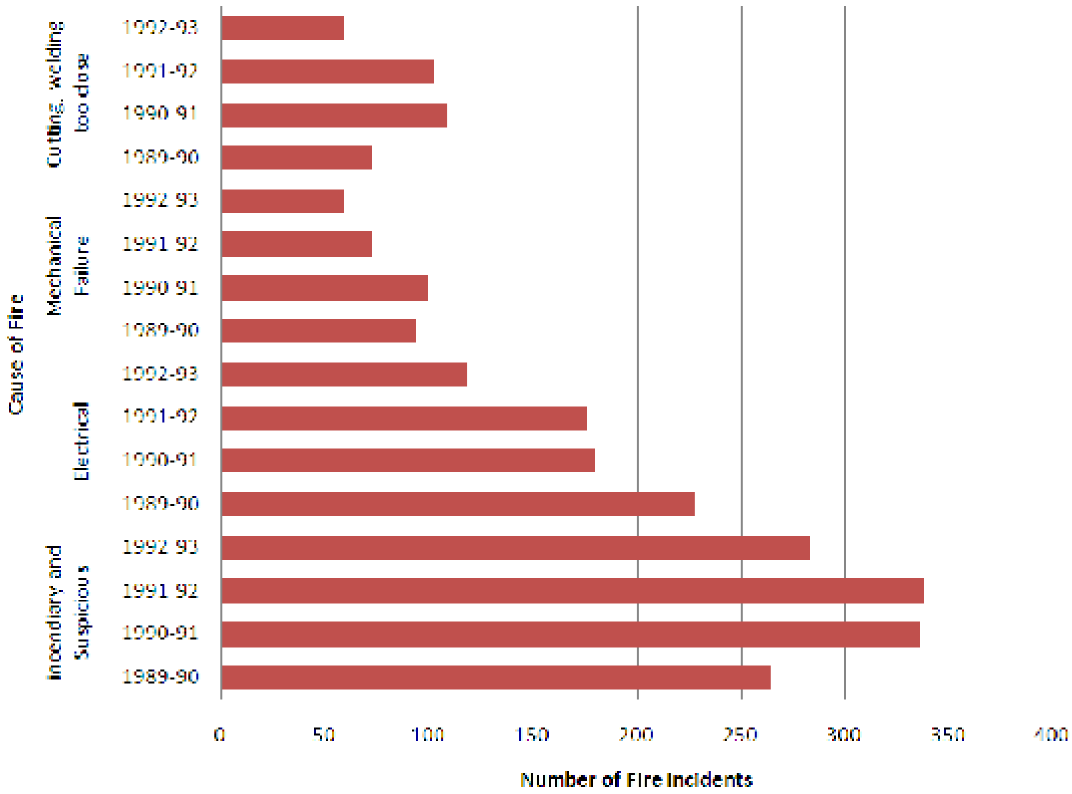
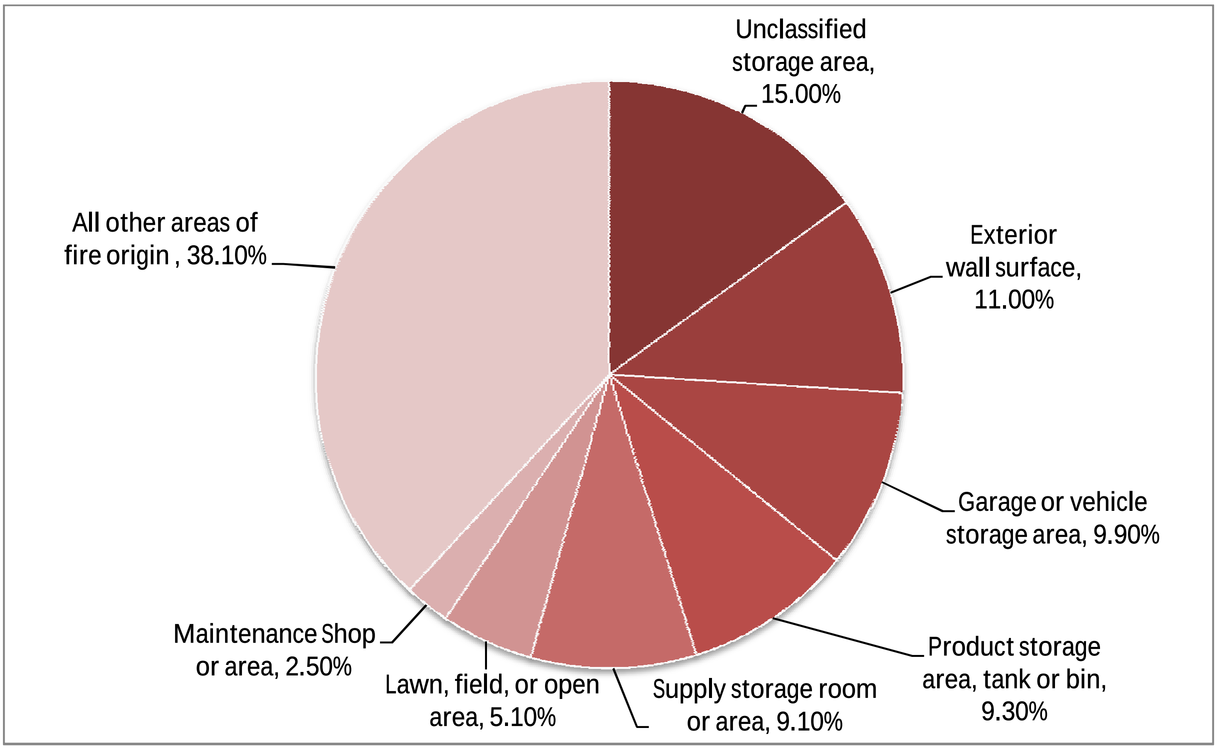


Figure 6-2: Warehouse Fire Statistics by Area of Fire Origin



<u>Office statistics</u>

The office fire statistics collected by NFPA [24] show that:

- Electrical faults is the leading cause of office fire; and
- Equipment fires are the second cause of office fires; and
- Electrical faults are the leading cause of occupant fatalities followed by arson; and
- 40.7% of all occupant fatalities in office buildings were caused by fires started in the office area; and
- 17.7% resulted from fires originated in the office area;

The following charts as shown below illustrate the expected % of fires and civilian deaths that occur with respect to the areas of origin and causes of fire within a typical office building.

Figure 6-3: Area of fire origin in office areas

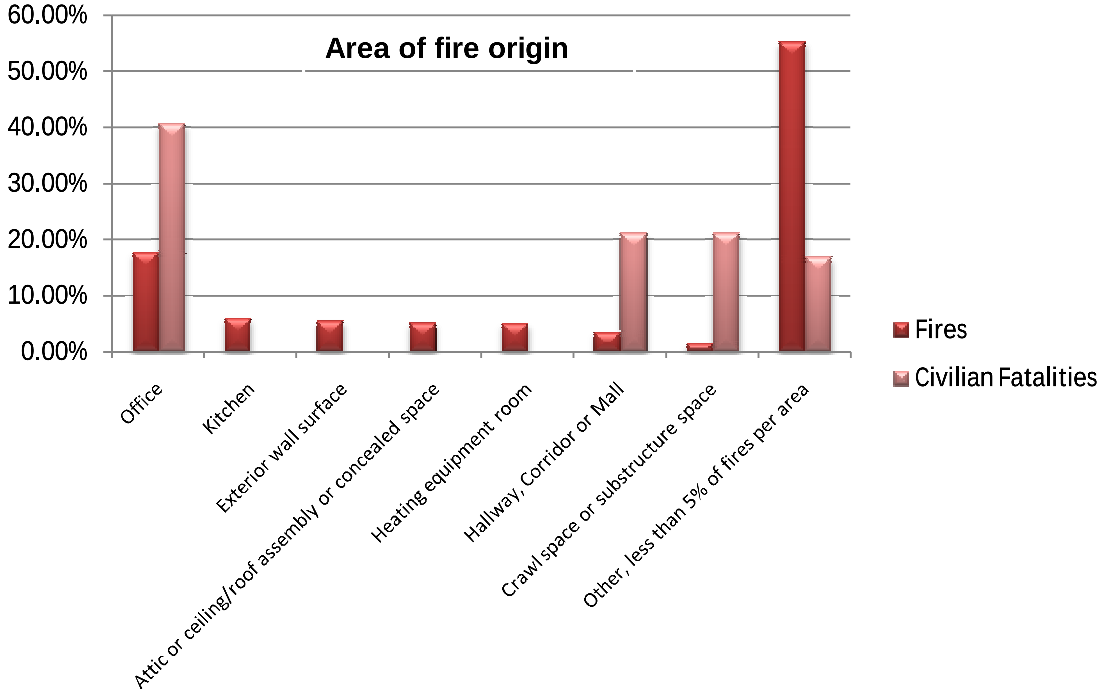
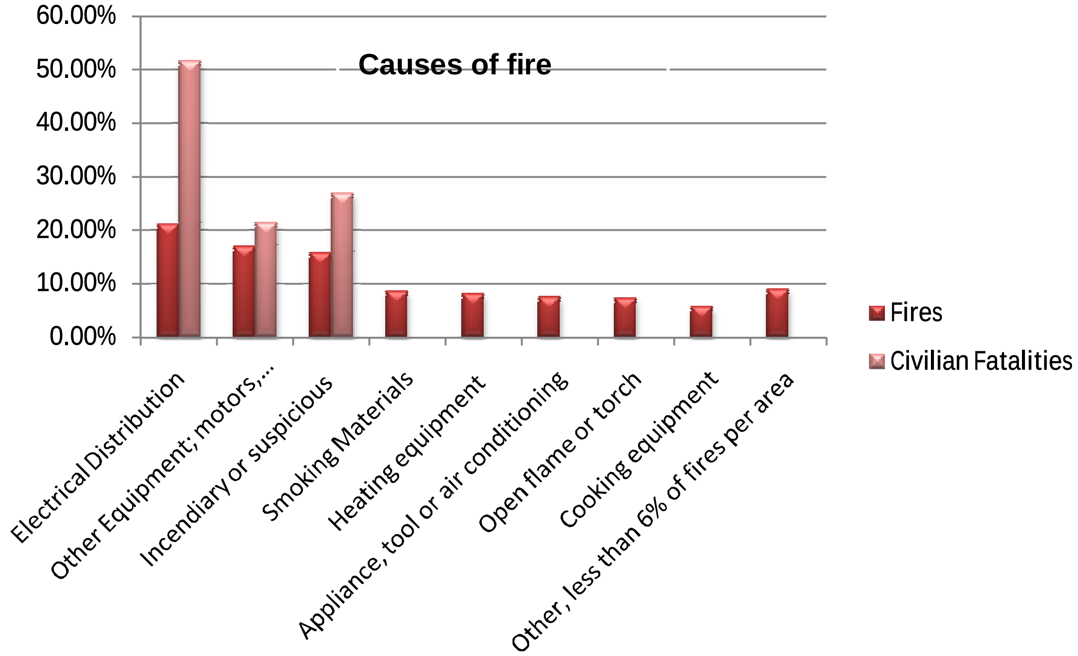


Figure 6-4: Causes of fire in office buildings



Carpark statistics

Based on data supplied by the Melbourne Fire and Emergency Services Board (MFESB) and data on the number of carparks in Melbourne [27], the rate of fire starts in Melbourne CBD carparks is estimated to be 0.00007 fires reported to the fire brigade per car space per year. Although these statistics are based on carparks in Melbourne, caparks in Sydney are not expected to be significantly different. It is understood no more than 399 cars will be present within the proposed carpark. Based on 399 cars within the carpark, the expected probability of vehicle fires is 0.028 fires a year, i.e. one fire every 36 years in this carpark.

The probability of a car fire can also be calculated using American carpark statistics of institutions that manage a total of 778,000 car bays [28]. These public carpark structures were affected by a total of 400 fires requiring fire brigade intervention over 60 years. This provides us with enough statistical data to be able to soundly conclude that fires in carparks occur at a rate of approximately 5.077×10^{-4} fires per car bay of the life of public carpark buildings [28]. Based on 399 cars, there is a 20 % probability of ever having a car fire requiring brigade notification respectively.

It is important to note, the carpark in question is classified as being an open deck carpark which according to the BCA [1] means all parts of the parking storeys are cross-ventilated by permanent unobstructed openings in not fewer than two opposite or approximately opposite sides, and (a) each side that provides ventilation is not less than 1/6 of the area of any other side; and (b) the openings are not less than ½ of the wall area of the side concerned.

Due to the open nature and ventilation within an open-deck carpark, the BCA provides several concessions. Open-deck carparks are exempt from requiring sprinkler protection under Table E1.5, and exempt from requiring smoke detection under Table E2.2a of the BCA. As such, this implies the BCA regards an open-deck carpark as a safe place and hence not requiring any active fire safety systems within.

6.3 FIRE HAZARDS

The potential fire hazards identified throughout this building including the preventative and protective measures proposed and/or available are given below. Table 6-1 addresses likely hazards for the building and suitable mitigating control measures.

1. Hazards due to functions or characteristics are reviewed based on the building in question and relevant statistics; and
2. A description is provided on the nominated hazards; and
3. Relevant preventative / protective measures are provided to address the nominated hazard

Table 6-1: Building Hazard Assessment

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE AND PROTECTIVE MEASURES TO ADDRESS HAZARD
Building layout	Egress provisions	Exit travel distances are up to 110 m to an exit and 220 m between alternative exits within Building 1. Extended travel distances are also evident within the perishables warehouse (Building 2), the fresh warehouse (Building 3) and the carpark.	< Internal fire hose reels. < Exit signage. < ESFR sprinkler system. < Smoke clearance system and/or natural ventilation smoke relief option within Building 1.

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE AND PROTECTIVE MEASURES TO ADDRESS HAZARD
	Exposure hazards	Fire statistics for warehouses and factories in Australia as reported in Technical Report 96-02 [17] show that the most common cause of fires in these types of buildings are incendiary or suspicious followed by electrical faults with welding (hot works) and mechanical failure other common causes. Based on the 6 m perimeter access path around the buildings, the proposed development is adequately separated from adjoining buildings which would reduce the risk of fire spread between buildings and external fire brigade attack can be considered available options.	< ESFR sprinkler system. < External fire hydrants. < Perimeter access for fire brigade exposure coverage.
	Material locations	High storage throughout the warehouse area allows greater vertical fire spread.	< ESFR sprinkler system. < External fire hydrants. < Internal fire hose reels. < Appropriate portable fire extinguishers.
	Processes	Receiving, storage, picking and dispatch of products.	< ESFR sprinkler system. < External fire hydrants. < Internal fire hose reels. < Appropriate portable fire extinguishers.
Activities	Receiving, storage, picking and dispatch of products.		< ESFR sprinkler system. < External fire hydrants. < Internal fire hose reels. < Appropriate portable fire extinguishers.
Ignition sources	Based on the statistical review of warehouse fires contained in Section 6.2 ignition sources relevant to this site, in order of occurrence		
	< Incendiary or suspicious		< Security. < Housekeeping – removal of accessible combustibles. < ESFR sprinkler system.
	< Electrical faults		< Maintenance of equipment. < Housekeeping – separation of combustibles from electrical items. < Portable fire extinguishers.

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE AND PROTECTIVE MEASURES TO ADDRESS HAZARD
	< Hot works		< Safety policies regarding hot works. < Portable fire extinguishers. < Fire hose reels. < ESFR sprinkler system.
	< Mechanical failure		< Regular maintenance of equipment. < Housekeeping – separation of combustible items from machinery. < Machinery and vehicle protocols – safe operating procedures and designated parking areas for forklifts. < Management of risks – reporting of faults.
Fuel sources	Quantity of materials	Larger fuel load permitted by larger compartment volume. Further, fuel load is increased by high rack storage.	< ESFR sprinkler system designed to FM global requirements based on fuel type and physical arrangement.
Fuel sources	Fire behaviour	Vertical fire spread increased by vertical arrangement of fuel. Rate of fire spread variable on fuel type, air flow within fuel packages and material ignitability.	< ESFR sprinkler system designed to FM global requirements based on fuel type and physical arrangement. < Internal fire hose reels. < External fire hydrants.
Fuel sources	Dangerous Goods	No dangerous goods are expected. If storage of polymer laminate products is to be considered, specific toxins and volatile gases may be released. If vehicle fuel is to be stored, appropriate measures will be required for safe storage.	< Portable fire extinguishers appropriate to fire classes. < Adherence to OH&S, dangerous goods and other management procedures where applicable.
Fire origins	Refer to previous charts whereby warehouse fires are likely to occur in the following origins:		
Fire origins	< Exterior wall surface		< Security. < Housekeeping – removal of accessible combustibles.
Fire origins	< Rack product storage < Collectively, other unspecified storage areas		< ESFR sprinkler system. < Portable fire extinguishers. < Fire hose reels. < Fire hydrants. < Housekeeping.

6.4 FIRE LOAD

The fire load within a room or compartment will influence the duration and severity of a fire and resultant hazard to occupants. The effective fire load for the building has been estimated by consideration of the typical spaces within the building.

The following fire loads have been extracted from Chapter 3.4 of the International Fire Engineering Guidelines [3] and are listed in Table 6-2. This data is derived from Switzerland, however is also applicable to buildings in Australia of similar use. The range of occupancies listed below is considered to indicate fuel loads similar to a storage warehouse.

Table 6-2: Fire Load Densities

TYPE OF OCCUPANCY	AVERAGE FIRE LOAD
Storeroom (workshop storerooms etc.)	1200 MJ/m^2
Forwarding, food	1000 MJ/m^2
Forwarding, cardboard goods	600 MJ/m^2
Forwarding, plastic products	1000 MJ/m^2
Liquor store	700 MJ/m^2
Office, Business	800 MJ/m^2
Office, Engineering	600 MJ/m^2
Office, Machinery mfg	300 MJ/m^2
Parking Building	200 MJ/m^2
Underground Garage (private)	> 200 MJ/m^2

The IFEG indicates that the average values should be multiplied by a factor of 1.35 to 1.65 to reach the 90% fractile value and for isolated peak values a factor of 2 should be applied.

6.5 FIRE GROWTH RATE AND INTENSITY

As the fire increases in size, the rate of fire growth accelerates. The growth rate of a fire can result in various hazards for occupants due to the following:

- Protective and preventative measures may not be adequate
- Occupants may have insufficient time to evacuate
- Occupants may perceive a reduced threat from slow growing fires

The rate of fire growth is generally expressed in terms of an energy release rate. The most commonly used relationship is what is commonly referred to as a quadratic t-squared fire. In such a fire, the rate of heat release is given by the expression:

$$Q = \left(\frac{t}{k}\right)^2$$

Where; t is time from ignition of the fire (seconds) and k is the growth time (seconds) for the fire to reach a heat output of 1.055 MW.

The continued growth of a fire defined by the above equation relies on both a sufficient source of fuel and air and assumes that flashover has not been reached. The rate of fire growth can be estimated from data published in British Standard (BS) 9999:2008 [6] as shown below.

Table 6-3: Fire Growth Rates as described in BS 9999:2008

BUILDING AREA PROVIDING FUEL	GROWTH RATE	BUILDING AREA PROVIDING FUEL	GROWTH RATE
Reception area	Slow	Restaurant/Canteen	Medium
Office	**Medium**	Teaching Laboratories	Fast
Shop	Fast	Meeting Room	Medium
Warehouse	**Medium/Fast/Ultra-Fast**	Waiting Room	slow

The faster the growth rate the quicker the fire will reach its maximum HRR. The above growth parameters indicate that the rate of growth in a warehouse is variable depending on the type of material stored.

This ambiguity is clarified in An Introduction to Fire Safety Management [19], where the growth rate of warehouse design fires is further explained based on the fuel load as follows:

Table 6-4: Further Clarification of Warehouse Fire Growth Rates

FIRE GROWTH RATE	EXAMPLES
Medium	Warehouse is likely to have stacked cardboard boxes, wooden pallets.
Fast	Production Unit/Warehouse - baled thermoplastic chips for packaging, stacked plastic products awaiting delivery.
Ultra-fast	Production Unit/Warehouse – flammable liquids, expanded cellular plastics and foam manufacturing, processing, repairing, cleaning and otherwise treating any hazardous goods or materials.

Based on the information in the two tables above, the fire growth rate in the storage warehouse is expected to approximate a Fast T^2 fire growth rate.

Worst Credible Fire Scenario

According to the book titled "Smoke Management in Large Spaces in Buildings" [12], a fire involving wood pallets stacked at 1.5m high is expected to have a growth rate which closely resembles a fast t^2 fire growth rate with a peak heat release rate of approximately 3,700kW/m^2. This discounts the incipient stage of the fire growth and allows for an accelerated fire growth which is considered to be representative of an arson type fire. It shall be assumed the peak heat release rated is expected to be suppressed upon sprinkler activation. Refer to Section 6.7 for the effectiveness of sprinklers.

Sensitivity Fire Scenario

The sensitivity analysis will be as above however partial shielding results in the ESFR system controlling and not fully suppressing the fire. The heat release rate is therefore capped at activation of the nearest sprinkler head.

Redunancy Fire Scenario

Due to the nature of the building as a distribution storage facility, forklifts will be present within each warehouse for the transportation of goods from the racking to the semi-trailers (and vice-versa) which are reversed into a loading dock area along one side of each warehouse. Given the size of these warehouses and number of loading bays for the semi-trailers, numerous forklifts may be expected within each warehouse at any one time. According to a European fire control report for road tunnels published by PIARC – World Road Association, the potential fire size that could be sustained in tunnels is estimated as 15 MW for vans and as 20 MW to 30 MW for lorries loaded with goods [32]. Given numerous forklifts are expected within each warehouse at the same time, our analysis proposes to assume a forklift fire occurring next to the loading bays. The combined effect of a forklift fire occurring next to the loading bays (and semi-trailers) which could potentially catch on fire has been compared to a lorry fire loaded with goods. Based on the above, a sustained design fire of 30 MW is proposed to be used to represent a forklift fire occurring next to the loading bay/semi-trailer area.

The fire growth rate for this commercial vehicle is proposed to be a fast time squared fire, which would reach 30 MW after approximately 13 minutes. This fire growth rate is supported by the PIARC road tunnel fire safety report which lists the peak temperature for commercial vehicles occurring after approximately 20 minutes [32]; note that this PIARC document discusses smoke production, smoke temperatures and sustained heat release rates for commercial vehicle fires but for fire growth rate, this publication states that heat release rate would occur along a similar timeline as smoke temperatures.

This research can be summarised by the following Table 6-5.

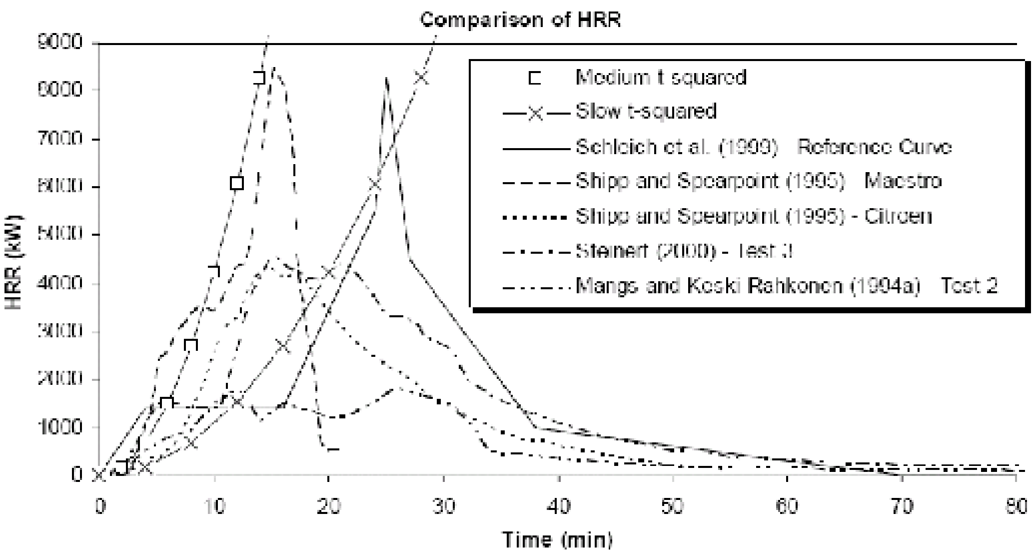
Vehicle Fuel Load	Sustainable Heat Release Rate
1 small passenger car	2.5 MW
1 large passenger car	5 MW
2 to 3 passenger cars	8 MW
1 van	15 MW
1 bus	20 MW
1 lorry with burning goods	20 to 30 MW

Table 6-5: Heat release rates that can be sustained from various vehicle fires [32]

The design fire within the carpark has been based on the data above, experimental research using European cars, as published by Profil – ARBED [33] and test data published by Yuguange. L, [34].

According to Yuguang, L., a number of tests were conducted in order to determine growth rates. The results indicated that whilst one HRR curve was represented by a medium t-squared growth, the rest had a growth rate between a slow and medium t-squared rate. The figure below illustrates the results of the tests undertaken.

Figure 6-5: Heat Release Rate for vehicle fire tests



Based on the above, a medium growth rate has been adopted for the growth rate to use in the calculation. Further, the fire is proposed to grow up to 5 MW (Table 6-5) and remain steady state thereafter.

6.6 FIRE SOOT YIELD

The materials that make up the fuel load will determine the soot yield of a fire. The fire soot yield should be assessed with respect to hazard due to the following:

- Soot yield can affect visibility for occupants trying to escape a fire
- Soot yield can be directly related to other products of combustion which may cause untenable conditions.

The fire load within the warehouse is likely to involve a high volume of cellulosic materials in the form of cardboard packaging and wood pallets along with plastics in the form of packaging, etc. The products stored will also add to the fuel load and will generally be of cellulosic or synthetic plastic nature. Generally cellulosic materials have far lower smoke yields than plastics. A common plastic is polyurethane which has a soot yield of 0.1 kg/kg as referenced from Babrauskas in the NFPA Handbook. Applying the greatest soot yield of any material expected to all the fuel in the compartment will provide a worst case soot production when fire modelling is conducted.

6.7 EFFECTIVENESS OF SPRINKLERS

The building is protected by an ESFR fire sprinkler system in accordance with the requirements of AS 2118.1, BCA DTS provisions and Factory Mutual Loss Prevention Data Sheets (Data Sheets 2-2 and 8-9). This system will have the effect of suppressing the fire once the sprinklers activate. The heat release rate of the fire will therefore begin to be reduced upon sprinkler activation. This has been modelled as a heat release rate reduction which mirrors and reverses the growth rate after activation of the sprinkler system. With reference to the data sheet as of 2002 [25] there have been 6 known fires involving suppression mode sprinkler protection. In all of these incidents, suppression mode protection was successful and no more than four sprinkler heads operated. Therefore for the purposes of this assessment, on the activation of the fire sprinkler system the fire growth is considered to be suppressed in ESFR areas

By comparison, the effectiveness of automatic fire sprinklers in general in limiting fire spread and growth is supported by statistics and studies undertaken into the effects of automatic fire sprinklers within buildings. These studies show that fire sprinkler systems operate and control fires in 81% to 99.5% of fire occurrences [7]. The lower reliability estimates of 81.3% [21] as well as some of the higher values of 87.6% [22] appear to reflect significant bias in data in terms of the small number of fire incidents and the lack of differentiation between fire sprinklers and other fire suppression systems. A number of the lower figures are results of dated studies. It must be noted that the higher reliability of fire sprinklers reported by Marryatt [9] 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 indicate that sprinklers with appropriate maintenance are highly effective in reducing the loss of life and limiting fire spread and in particular the ESFR system has an exemplary record.

According to the FM Global Property Loss Prevention Data Sheets [25], automatic heat/smoke vents would operate before ESFR sprinklers removing hot smoke in the ceiling resulting in critical delay in sprinkler operation. As such, the FM Global recommends that the ESFR sprinkler system should not be installed with the automatic heat/smoke vents. It is likely that the BCA DTS smoke management would hinder and prevent the activation of the sprinkler system as discussed in the FM Global Property Loss Prevention Data Sheets. The failure of the sprinkler system would allow severe fire development and spread within the building which could lead to untenable conditions restricting fire fighter access into the building. Furthermore, rapid fire development and spread could eventually cause several fast response sprinkler heads, over and above the system design requirement, to activate, potentially depleting the water supply serving the sprinkler system. In this instance, the system may be rendered ineffective and unable to hydraulically perform as intended. As such, it is recommended that the removal of the BCA DTS smoke management would allow hot smoke to build up in the ceiling leading to the activation of the sprinkler system.

Full scale fire experiments have been performed by NIST for smoke hazard systems such as smoke exhaust and baffles, and their effects on sprinkler protected fires [26]. The observations recorded from these NIST experimental fire tests indicate that sprinkler spray entrains smoke and hot gases from the ceiling and transports those gases to the floor. These turbulent effects cool smoke and mix hot fire products with cool clean air, resulting in a large volume of low-visibility cool smoke that is not buoyant. Since a hot layer did not form and remain along the ceiling the efficacy of a smoke spill system in these buildings could be considered of a reduced capacity.

7 BCA NON-COMPLIANCE & ASSESSMENT REVIEW

7.1 OVERVIEW

BCA Non-Compliance Assessment

In this instance the BCA non-compliances have been formulated based on the regulatory review as provided by the project building surveyor and / or design team. Where not listed herein the building is required to achieve compliance with relevant DtS provisions or if existing, comply with relevant codes, reports and / or Standards approved at the time of consideration.

The following table lists the departures from the DtS provisions of the BCA for the proposed building and the analysis methodology proposed for the Fire Engineering assessment, which is to be generally in accordance with the IFEG [3].

Table 7-1: Summary of Alternative Solutions

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
C2.3 – Large isolated buildings inter alia Specification E2.2b	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***EP2.2***	The fire compartment size of Buildings 1, 2 & 3 exceeds 18,000 m^2 and 108,000 m^3 and the maximum ceiling height is greater than 12 m, therefore according to the large-isolated building provisions under Clause C2.3(b) of the BCA, a fire sprinkler system in accordance with Specification E1.5 and a smoke exhaust system in accordance with Specification E2.2b is required to be installed within buildings 1, 2 & 3. Note, Buildings 2 and 3 are interconnected by the common battery recharge areas and as such for the purposes of BCA Clause C2.3 they are considered as a single Large Isolated Building. Based on the above, the large-isolated building provisions as per Clause C2.3 of the BCA apply to both Buildings 1 and 2/3. In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide (i) a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes and/or (ii) a natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis. Further, given the floor area of this warehouse is approximately 57,600 m^2, part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to theft issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this options may also lead to false alarms from the sway of racking. The intent of the above solutions (smoke detection, video detection and infra-red detection) is to provide an earlier level of occupant notification in a fire, however it should be noted adoption of these solutions is subject to further fire engineering

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
		analysis. In addition to the above, we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas. Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required, however is subject to further fire engineering analysis. It is understood a fire sprinkler shall be provided throughout Buildings 1, 2 & 3 in accordance with Specification E1.5 of the BCA. It shall be demonstrated that the oversize fire compartment area is not expected to affect occupant life safety, fire brigade intervention and fire spread within the building. Recommendations will be made in consultation with the NSWFB and the design team, and based on the outcomes of the fire engineering analysis.
C2.4 – Requirements for open spaces and vehicular access	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***CP9***	As per Clause C2.4 of the BCA, a minimum unobstructed width of 6 m is required around the building for fire brigade perimeter vehicular access with no part of its furthest boundary more than 18 m from the building. In this instance, the vehicular access path at the south-eastern corner of Building 2 is greater than 18 m from the eastern external wall its setback is non-compliant with the requirements of C2.4. Further, temporary access roads may be required along the southern end of Building 1 during Stages 1 and 3, along with along the southern end of Building 2 and the northern end of Building 3 for Stage 2. As the future stages of these buildings are constructed these temporary access roads will need to be removed to facilitate the building works and hence for a period of time each of the building will not be provided with perimeter access to one side and as such will be non-compliant for a period of time. For example, during the construction phase of Stage 3, Building 1 will have non-compliant access to the southern side, similarly during Stage 5, Building 1 will have non-compliant access to the southern end and Building 2/3 will have non-complaint access to the southern and northern sides. In addition to the above, the vehicular access path along the western side of the proposed facility is 4.5m in parts in lieu of the 6m clear access path. Previous discussions with the NSWFB suggested their in-principle support for the reduced access width along this side on the condition 6m wide points are provided every 50m (refer to APPENDIX I). Refer to Section 7.1 for vehicular access provisions during the six stages. Qualitative and quantitative analysis methods will be adopted to consider Fire Brigade Intervention capabilities to the available vehicular access. Fire risks, exposures and impact on fire operations will be assessed with consideration given to the effectiveness of the fire sprinkler system. Our recommendations will give due consideration to comments offered by the NSWFB.

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
C1.1 – Type of construction required inter alia Specification C1.1 – Fire resisting construction	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***CP1 & CP22***	Due to the proposed main office having a rise in storeys of five (5), Building 1 is required to adopt Type A construction. As such fire ratings in accordance with Table 3 of Specification C1.1 are required. Due to the Class 7b nature of the warehouse 4 hour fire ratings are required to be applied to the building structure. In this regard the following non-compliances will be addressed; • no fire rating to the internal columns in the warehouse (required to be 60/-/- FRL) • no fire rating to the columns incorporated in the external walls of the warehouse (required to be 240/-/-) • Reduction of FRL's to the office structure from 4 hours to 2 hours without the inclusion of a fire wall between the office are the warehouse areas. It is proposed to demonstrate that the oversize fire compartment area (main warehouse) is not expected to affect occupant life safety, fire brigade intervention and fire spread within the building. As such, although the warehouse is linked to the five storeys main office and vice versa, fire spread between these areas is not expected to be any greater than between the same warehouse to a two (2) storey office requiring Type C construction.

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
D1.4 – Exit Travel Distances	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***DP4 & EP2.2***	The distances of travel to an exit within the building are proposed to exceed the BCA DTS limit of 40m. Based on BM+G preliminary regulatory advice the following extended travel distances occur: < Building 1 (Stages 1, 3, & 5 - Warehouse) - Maximum exit travel distance measured from the central area of the Warehouse in each stage is approx. 110m. < Building 1 (Stage 1 - Forklift Recharge Area) – Maximum exit travel distance of 45m. < Building 1 (Stage 1 - Mens Locker Room) – Maximum exit travel distance of 44m. < Building 1 (Dispatch Offices x 2) – Level 1 maximum exit travel distances to a single exit of 24.5m < Building 1 (Stages 1, 4a & 4b - Main Office) – Complies on an open plan basis (on all 5 levels) – proposed fitout will require further assessment. < Carpark Building (Ground & Rooftop Levels - Stage 1) – Maximum worst case exit travel distances of 70m (dependant upon exact position of exits it may be reduced to approx. 55m). < Building 2 (Stage 2 - Warehouse) – Maximum exit travel distances of 70m in freezer. < Building 2 (Stage 2 – Perishables Offices Ground Floor) – Maximum exit travel distances of 53m and distance to a point of choice to alternative exits of 22m. < Building 2 (Stage 5) – Maximum exit travel distances of 70m in freezer. < Building 2 (Stage 2 – Forklift Recharge Area) – Maximum exit travel distances of 55m. < Building 3 (Stage 2 – Warehouse Fresh 0 to 4 degrees) – Maximum exit travel distances of 60m. < Building 3 (Stage 2 – Warehouse Fresh 10-14 degrees) – Maximum exit travel distances of 43m. < Building 3 (Stage 2 – Warehouse Fresh Staging Area) – Maximum exit travel distances of 57m. < Building 3 (Stage 2 – Fresh Offices Ground Floor Male Change Room) – maximum exit travel distances of 43m. < Building 3 (Stage 5) – Maximum exit travel distances of 60m. Note, the above maximum exit travel distances take into consideration the potential racking layout in the warehouse area of each building, however, a final assessment will be required upon confirmation of final racking layout. Both qualitative and quantitative analysis methods will be applied considering the effectiveness of the automatic fire sprinkler system including the additional smoke detection system (areas to be confirmed based on outcomes of the fire engineering analysis), building layout and configuration and occupant warning system in order to allow occupants to evacuate safely. Our analysis will assess, to the degree necessary, that the extended travel distances detailed herein are not expected to adversely affect the life safety of occupants whilst evacuating the building.

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
D1.5 – Distance between alternative exits	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***DP4 & EP2.2***	The distances of travel between alternative exits within the building are proposed to exceed the BCA DTS limit of 60m. Based on BM+G preliminary regulatory advice the following extended travel distances occur: < Building 1 (Stages 1, 3, & 5 - Warehouse) - Maximum distance between alternative exits in each stage is approx. 220m. < Building 1 (Stage 1 - Forklift Recharge Area) – Maximum distance between alternative exits of 80m. < Building 1 (Stage 1 - Mens Locker Room) – Maximum distance between alternative exits of 115m. < Building 1 (Stages 1, 4a & 4b - Main Office) – Complies on an open plan basis (on all 5 levels) – proposed fitout will require further assessment. < Carpark Building (Ground & Rooftop Levels - Stage 1) – Maximum distance between alternative exits of 95m (dependent upon exact position of exits it may be reduced on the ground level). < Building 2 (Stage 2 – Perishables Warehouse) – Maximum distance between alternative exits of 140m in freezer. < Building 2 (Stage 5) – Maximum distance between alternative exits of 140m in freezer. < Building 2 (Stage 2 – Forklift Recharge Area) – Maximum distance between alternative exits of 110m. < Building 3 (Stage 2 – Warehouse Fresh 0 to 4 degrees) – Maximum distance between alternative exits of 115m. < Building 3 (Stage 2 – Warehouse Fresh 10-14 degrees) – Maximum distance between alternative exits of 80m. < Building 3 (Stage 2 – Warehouse Fresh Staging Area) – Maximum distance between alternative exits of 95m. < Building 3 (Stage 5) – Maximum distance between alternative exits of 115m. Note, the above maximum distances take into consideration the potential racking layout in the warehouse area of each building, however, a final assessment will be required upon confirmation of final racking layout. Both qualitative and quantitative analysis methods will be applied considering the effectiveness of the automatic fire sprinkler system including the additional smoke detection system (areas to be confirmed based on outcomes of the fire engineering analysis), building layout and configuration and occupant warning system in order to allow occupants to evacuate safely. Our analysis will assess, to the degree necessary, that the extended travel distances detailed herein are not expected to adversely affect the life safety of occupants whilst evacuating the building.
D1.7 – Travel via fire-isolated exits	< A0.5(b)(i) & (ii) < A0.9(b)(ii) & (c) < A0.10 < ***DP5 & EP2.2***	The southern fire-isolated stair from the main office building discharges into an awning area and involves passing within 6m of glazed openings within the ground floor office in lieu of discharging directly to a road or open space. In this instance, it is proposed for the glazed openings within the ground floor office to be protected with wall-wetting sprinklers internally and as such equivalence with Clause C3.4 of the BCA can be argued. Further, it order to minimise the risk of exposing occupants to

BCA DTS PROVISIONS	ASSEMENT METHODOLOGY & RELEVANT BCA PERFORMANCE REQUIREMENTS	NON-COMPLIANCE WITH BCA DTS PROVISIONS, PROPSOED ALTERNATIVE SOLUTION AND ACCEPTANCE CRITERIA
		excessive radiant heat from a potential fire within the truck loading area/awning at the north-west corner of the main warehouse, it is proposed to construct a 2.4m high wall between the truck area and the discharge path. The alternative solution will assess to the degree necessary that the proposed solution will provide an adequate level of protection for occupants whilst evacuating the building.
E1.8 – Fire control centres	< A0.5(b)(i) < A0.9(b)(ii) & (c) < A0.10 < ***EP1.6***	Given the two large isolated buildings (Building 1 and Building 2/3) have a floor area greater than 18,000 m^2, a fire control centre is required to both of these buildings in accordance with Specification E1.8 of the BCA. In this instance, a single fire control centre for the site will be utilized in lieu of one for each of the two fire-isolated buildings.

Extended Travel Distances and Smoke Exhaust System within the Warehouses

As detailed above, travel distances to and between exits are exceeded within the warehouse areas of the proposed development. In addition, it is proposed to provide an alternative solution to not provide a fully compliant smoke exhaust system within these areas.

Fire and smoke modelling in the building will be undertaken using Fire Dynamic Simulator version 4 (FDS4), which is a CFD program. This program will be used to model credible fire events in the building to provide results for the time until untenable conditions occur and the extent and severity of those conditions. Untenable conditions for occupants and fire brigade personnel with respect fire conditions are discussed below. The time until untenable conditions occur is the Available Safe Egress Time (ASET).

First principle occupant evacuation calculations will be conducted to calculate the evacuation time (RSET) from the building. The spreadsheet used adopts a hydraulic flow algorithm based on the restricting door width accommodating all occupants at once, after the furthest occupant arrives at the exit.

The ASET and RSET values for the building will be compared to determine if occupants can safely evacuate from the building in the event of a credible fire scenario. The methodologies for calculating the ASET and RSET values are discussed in the following sections and in greater detail in APPENDIX D.

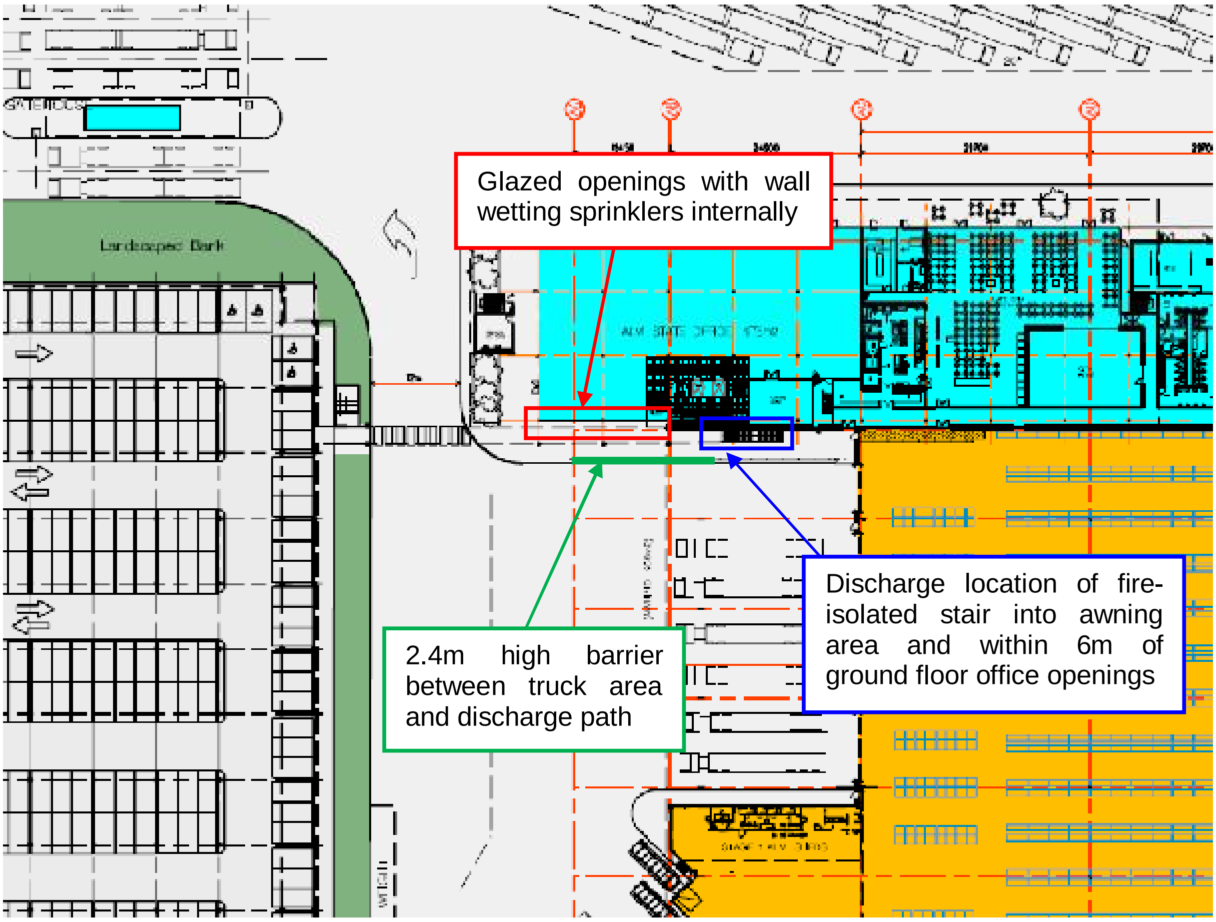
Extended Travel Distances within the Main Office

In order to evaluate the risk to life safety of occupants within the affected areas, part of the alternative solution will involve utilising the earlier notification time afforded by the fast response sprinkler system installed throughout in lieu of the standard response system as required under the DtS provisions of the BCA.

Further, the analysis considers a literature review of the sprinkler effectiveness, the expected fire hazards and fuel loads, building characteristics, and occupant characteristics.

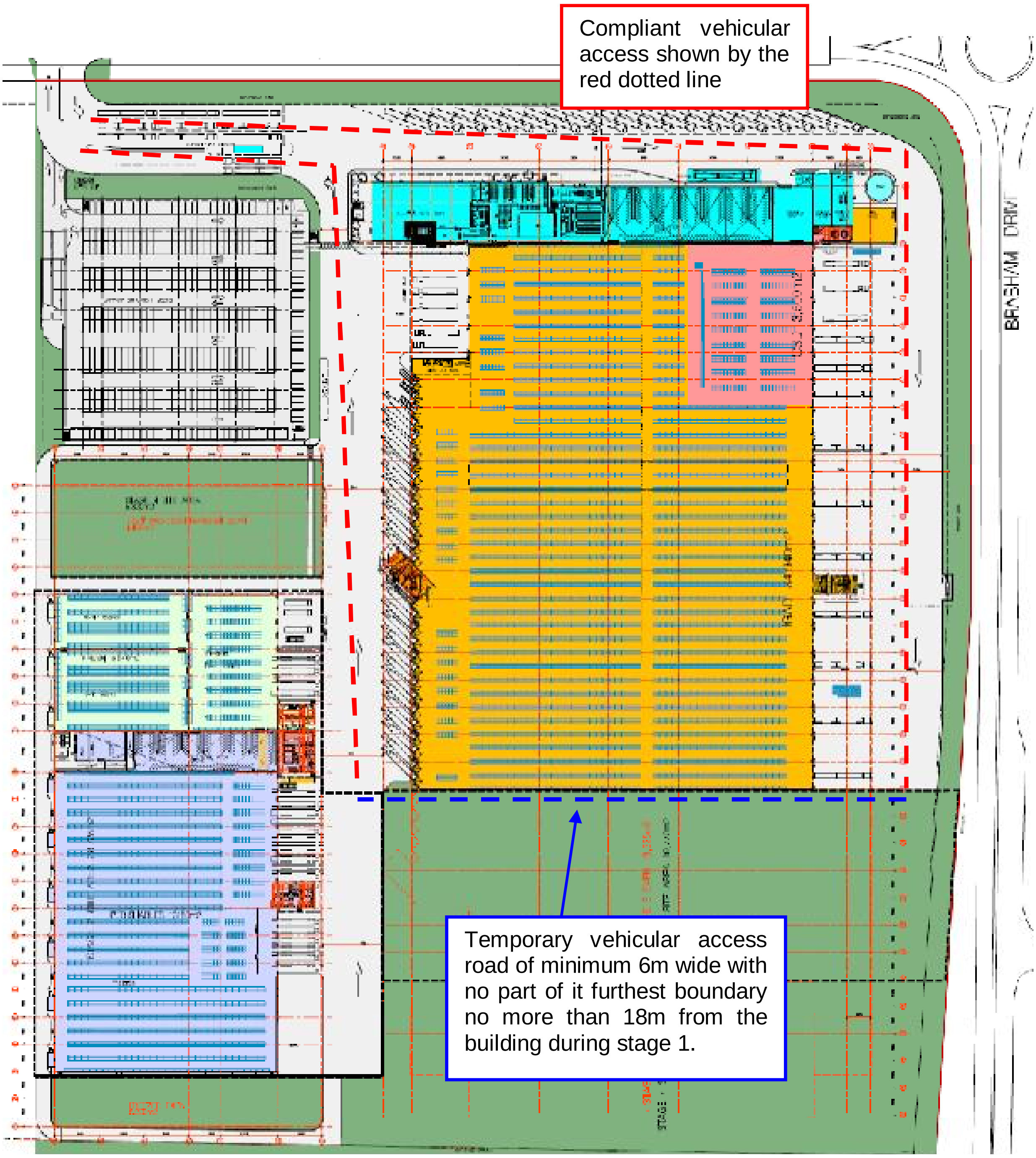
Our analysis will assess, to the degree necessary, that the variation from the DTS provisions will not adversely affect the life safety of occupants whilst evacuating the building.

Figure 7-1: Glazed openings which require wall-wetting sprinklers internally



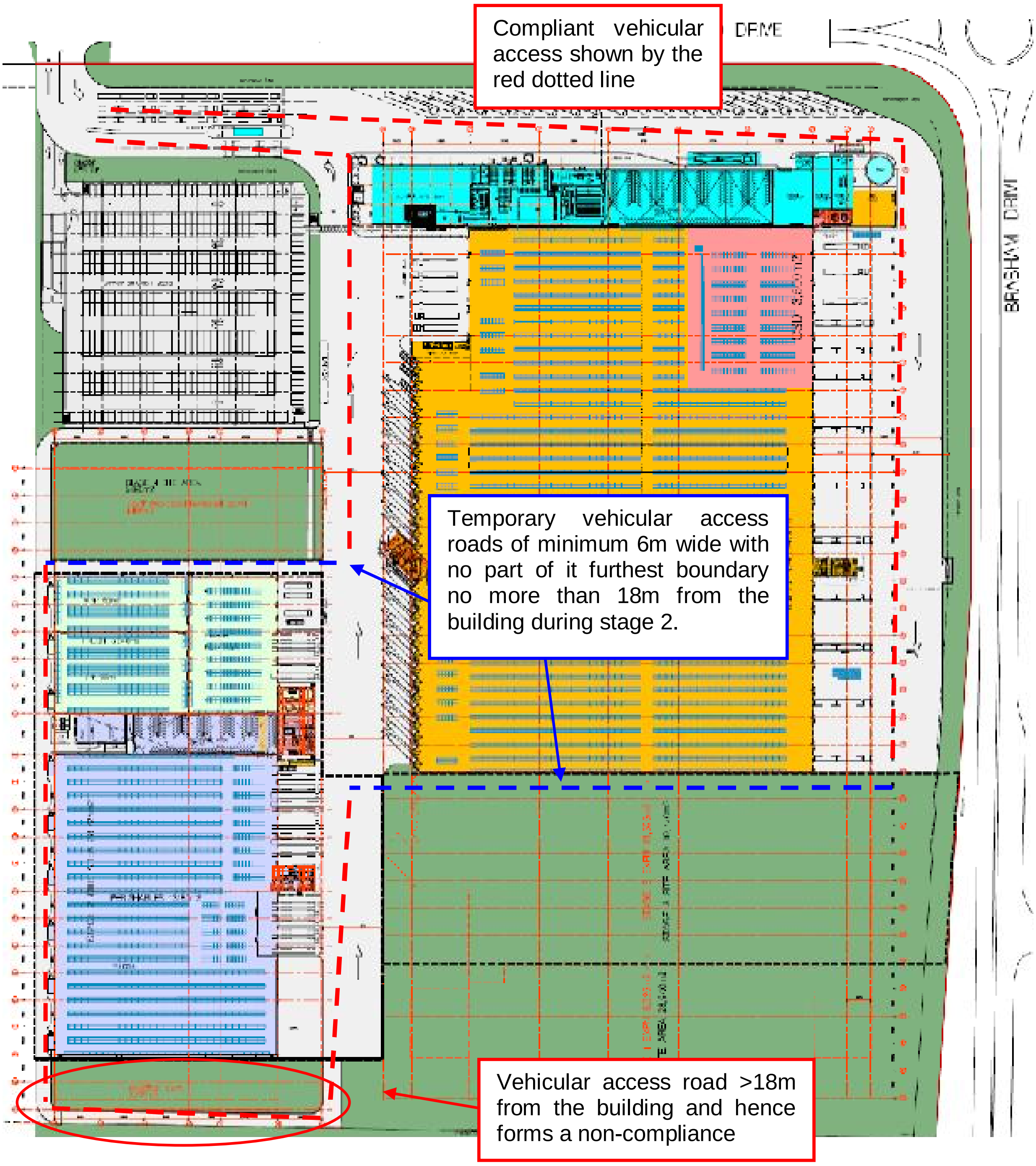
As shown in the figure below, a temporary access road is required along the southern part of the main warehouse for fire brigade access after stage 1 works. The temporary may be crushed rock however must be constructed specifically to be transverse by vehicular traffic (i.e., an aerial appliance). Refer to the NSWFB Policy No 4 (Guidelines for Emergency Vehicle Access) for further reference.
During stage 2, this temporary access road will be removed due to stage 2 works occurring in this area, hence for the duration of stage 2 works, the main warehouse will only be provided within 3 side's compliant access. In order to avoid fire trucks having to reverse or perform a three point turn, continuous access should be provided by a temporary road during stage 2 works. In this instance, the temporary access road to the south of the main warehouse shown in Figure 7-4 may be utilised.

Figure 7-2: Vehicular access during Stage 1



As shown in the figure below, a temporary access road is required along the southern part of the main warehouse and the northern part of the fresh warehouse for fire brigade access after stage 2 works.

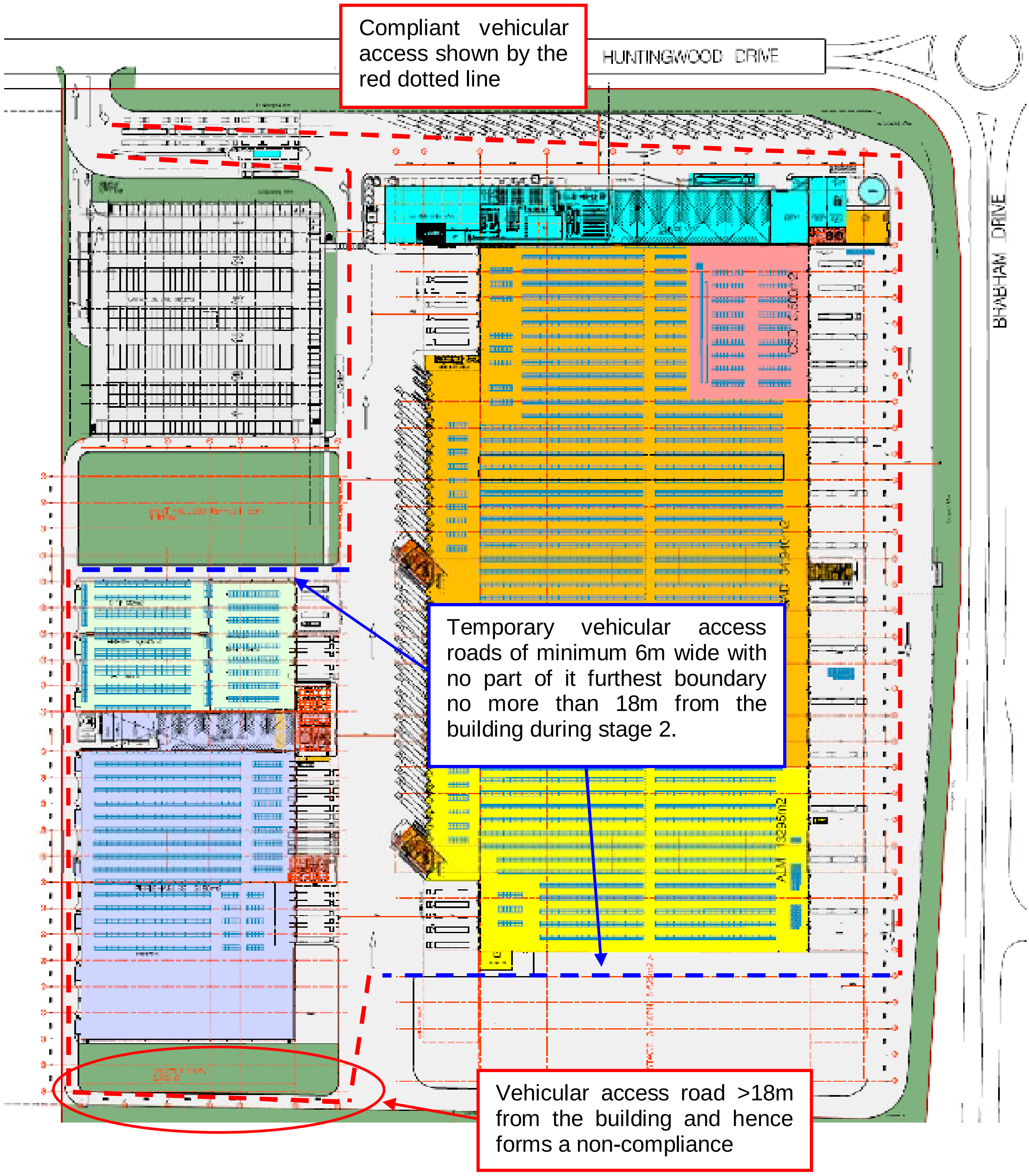
Figure 7-3: Vehicular access during Stage 2



During stage 3, the temporary access road to the south of the main building will be removed due to stage 3 works occurring in this area, hence for the duration of stage 3 works, the southern side of the main warehouse will have one side of non-compliant access. In order to avoid fire trucks having to reverse or perform a three point turn, continuous access should be provided by providing temporary access roads during stage 3 works.

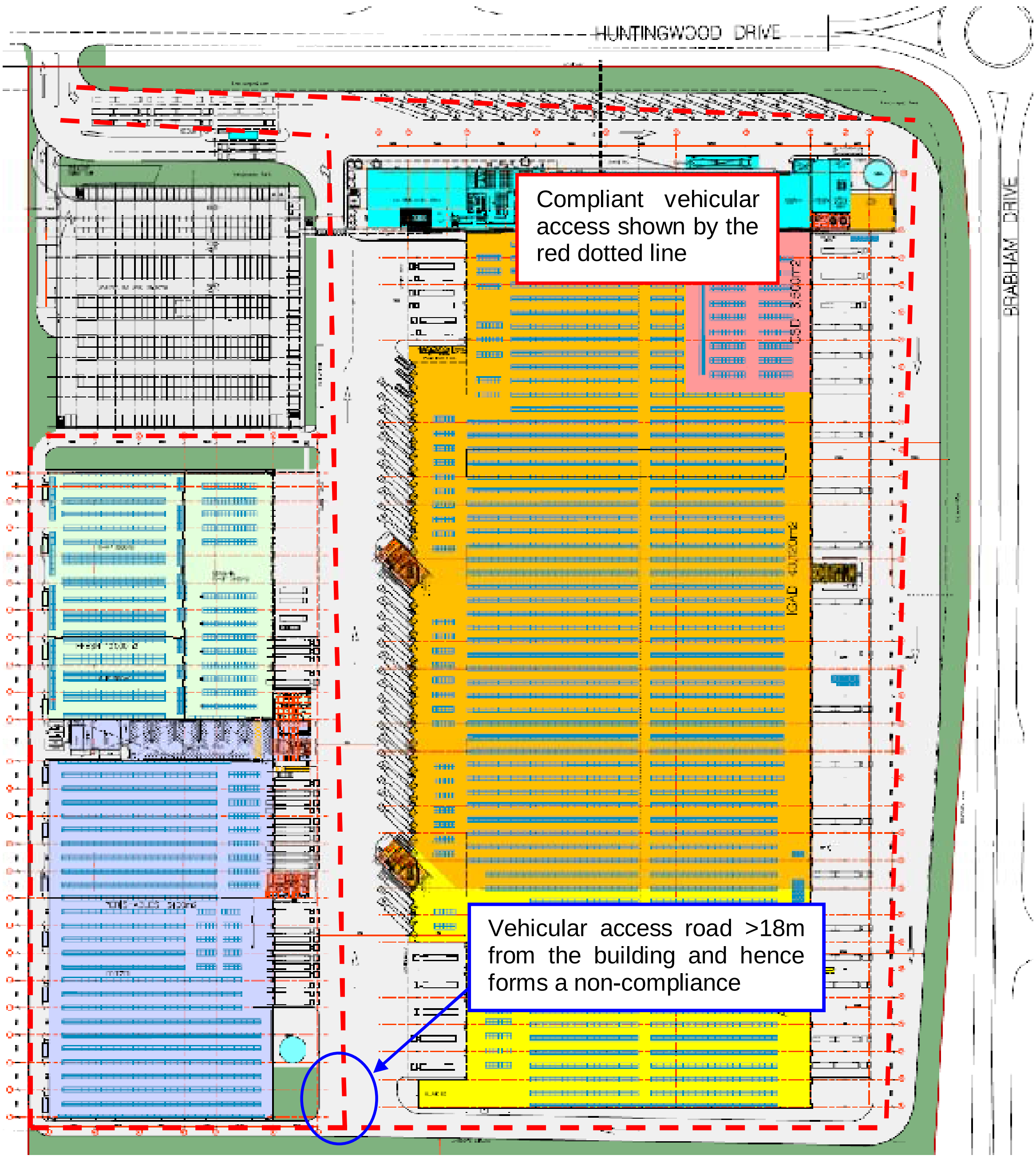
In this instance, the proposed permanent access roads to the southern side of the main warehouse as shown in Figure 7-5 may be utilised.

Figure 7-4: Vehicular access during Stage 3



During stage 4a and 4b works, as work is limited to the main five storey office at the north end of Building 1, the vehicular access provision are no different than shown during stage 3 above.
During the construction of stage 5 works the southern end of Building 1 and the northern and southern ends of Building 2/3 will be non-compliant. In this instance a temporary access road should be provided to prevent fire trucks having to reverse or perform a three point turn.

Figure 7-5: Vehicular access during Stage 5



In addition to the above, the vehicular access path along the western side of the proposed facility is 4.5m in parts in lieu of the 6m clear access path. Previous discussions with the NSWFB suggested their in-principle support for the reduced access width along this side of the proposed facility on the condition 6m wide points are provided every 50m (refer to APPENDIX I). In this instance 6m wide part are located every 10m along the western access path.

For ease of the reader, the figure below shows the vehicular access path 4.5m in width (circled in red) along the northern part of the western path and the access path 6m in width (circled in blue) along the southern part of the western path. It should be noted, the areas of non-compliant (4.5m) and compliant (6m) vehicular access are representative of the whole western side.

Figure 7-6: Reduced width to Vehicular access path

8 TRIAL DESIGN FOR EVALUATION

8.1 OVERVIEW

The trial design dictates the preliminary requirements to achieve the required BCA objectives.

8.2 TRIAL DESIGN

As a result of the identified building and occupant characteristics, fire safety objectives, identified fire hazards, BCA non-compliances and as a consequence of design meetings the Fire Safety Strategy (Trial Design) has been formulated.

In this instance the Fire Engineering requirements as listed in Section 11 are put forward as the trial concept design. These preliminary requirements are put forward to achieve the following:

- Provide possible passive / active fire safety systems which are reviewed via the assessment methodology contained herein.
- Provide sufficient redundancies that are commensurate with expected risks.

Where these recommendations are insufficient further requirements may be put forward in the final Fire Engineering Report.

8.3 BCA METHODOLOGY

The project entails to construction of a large warehouse which consists of a two storey carpark and two (2) large-isolated buildings; namely Building 1 and Building 2/3 (note, Buildings 2 and 3 are interconnected by the common battery recharge areas). This fire engineering brief covers the warehouse development throughout the six stages.

Note, Buildings 2 and 3 are interconnected by the common battery recharge areas and as such for the purposes of BCA Clause C2.3 they are considered as a single Large Isolated Building. Based on the above, the large-isolated building provisions as per Clause C2.3 of the BCA apply to both Buildings 1 and 2/3.

As per Clause C2.4 of the BCA, a minimum unobstructed width of 6 m is required around the building for fire brigade perimeter vehicular access with no part of its furthest boundary more than 18 m from the building. In this instance, the vehicular access path at the south-eastern corner of Building 2 is greater than 18 m from the eastern external wall its setback is non-compliant with the requirements of C2.4. Further, temporary access roads may be required along the southern end of Building 1 during Stages 1 and 3, along with along the southern end of Building 2 and the northern end of Building 3 for Stage 2. As the future stages of these buildings are constructed these temporary access roads will need to be removed to facilitate the building works and hence for a period of time each of the building will not be provided with perimeter access to one side and as such will be non-compliant for a period of time. For example, during the construction phase of Stage 3, Building 1 will have non-compliant access to the southern side, similarly during Stage 5, Building 1 will have non-compliant access to the southern end and Building 2/3 will have non-complaint access to the southern and northern sides. Refer to Section 7.1 for vehicular access provisions during the six stages.

In addition to the above, the vehicular access path along the western side of the proposed facility is 4.5m in parts in lieu of the 6m clear access path. Previous discussions with the NSWFB suggested their in-principle support for the reduced access width along this side on the condition 6m wide points are provided every 50m (refer to APPENDIX I).

As per Clause C1.1 of the BCA, Building 1 is required to be constructed in accordance with Type A construction (due to the five storey office), however Buildings 2 & 3, and the carpark building are to be constructed in accordance with Type C construction. Note, an alternative solution has been pursued to reduce the 4 hour FRL requirement to the office areas as per Type A construction for Class 7b and 5 adjoining parts. Refer to Table 0-1 for further details.

8.4 EGRESS PROVISIONS

8.4.1 Evacuation Strategy

Activation of any sprinkler head or form of detection (if installed) within Building 1 (IGAD, CSD, ALM warehouse(s) and office) shall evacuate all areas of this building. Likewise, activation of any sprinkler head or form of detection (if installed) within Building 2/3 (Perishable and fresh warehouses) shall evacuate all areas of this building.

8.4.2 Extended Travel Distances

Based on the preliminary regulatory advice prepared by Blackett Maquire + Goldsmith (dated 1st August 2010), distances to exits and between alternative exits within Building 1 are up to 110 m and 220 m respectively. These are the greatest distances in comparison to the DtS provisions of the BCA, however refer to Table 0-1 for further information.

8.4.3 Emergency Lighting

Emergency lighting is to be provided throughout in accordance with BCA DtS Provisions E4.2 and E4.4 and AS 2293.1.

8.4.4 Exit Signage

Exit signage is to be provided throughout in accordance with the BCA DtS Provisions E4.5, E4.6 and E4.8 and AS 2293.1.

8.5 ELEMENTS OF STRUCTURE

As per Clause C1.1 of the BCA, Building 1 is required to be constructed in accordance with Type A construction (due to its connection with the five storey office), however Buildings 2 & 3, and the carpark building are to be constructed in accordance with Type C construction. Note, an alternative solution has been pursued to reduce the 4 hour FRL requirement to the warehouse areas (Building 1) as per Type A construction for Class 7b and 5 adjoining parts. Refer to Table 0-1 for further details.

8.6 SUPPRESSION, DETECTION & WARNING

8.6.1 Sprinkler Protection

An ESFR sprinkler system shall be fitted to the warehouse areas. The system will meet the requirements of the Factory Mutual Guidelines FM 2-2 and where applicable, AS 2118.1 and Specification E1.5 of the BCA. The office areas shall be protected with an AS 2118.1 fire sprinkler system.

8.6.2 Wall-wetting Sprinklers

The southern fire-isolated stair from the main office building discharges into an awning area and involves passing within 6m of glazed openings within the ground floor office in lieu of discharging directly to a road or open space (refer to Figure 7-1).

In this instance, it is proposed for the glazed openings within the ground floor office to be protected with wall-wetting sprinklers internally and as such, equivalence with Clause C3.4 of the BCA can be argued.

The alternative solution involves the installation of Tyco glass wetting sprinkler drenchers internally to the nominated glazing. The design and maintenance of the drencher glass protected system is to be undertaken in accordance as follows:

- The glass windows must be minimum 6mm toughened glass. Glass side panels requiring drencher protection shall be fixed closed and non-openable.
- The maximum dimensions of the glass panels should be compatible with the spray pattern of the Tyco WS Sprinkler System design criteria.

- The maximum distance between two window sprinklers shall be no more than 2.44m in order to provide sufficient coverage to a window and frame.
- Flexible seals are to be used between the top and bottom of the window frames to allow for the expansion of the glass.
- No horizontal mullions are to be installed within the drenchered side of the openings. Furthermore, at least one drencher head must be installed between every vertical mullion (if applicable). Where this is not achievable the drencher heads must be strategically located to ensure complete coverage of the glazed elements.
- Sprinkler drencher system stop valve shall be locked in the open position and monitored, thus activating the local alarm should the status of the valve be change.

The Tyco WS Drenchering system is a tested system which is designed to provide a uniform water spray down the surface of the opening. The data sheet can be found in APPENDIX H which forms the basis of these requirements.

8.6.3 Smoke Detection

Given the floor area of the main warehouse (approximately 57,600 m^2), part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to theft issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this option may also lead to false alarms from the sway of racking. The intent of the above solutions (smoke detection, video detection and infra-red detection) is to provide an earlier level of occupant notification in a fire, however it should be noted adoption of these solutions is subject to further fire engineering analysis.

Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required within the perishables and fresh food areas, however is subject to further fire engineering analysis.

8.6.4 Building Occupant Warning System (BOWS)

An occupant warning system is to be installed throughout the facility in accordance with Specification E1.5 and Clause 6 of Specification E2.2a and is to be interfaced with all sprinkler systems such that the activation of any sprinkler head or form of detection system (if installed) will sound the general evacuation signal.

8.7 SMOKE HAZARD MANAGEMENT SYSTEM

In lieu of the requirement for an automatic smoke exhaust system within the main warehouse (Building 1), it is proposed to provide the following options;

<u>Option 1</u>

A smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes

To conform with NSWFB operational requirements, smoke clearance fans should be provided with 1 air change per hour, however given the large size of the main warehouse, it is proposed to rationalise this extraction rate.

Further, the smoke clearance fans should be installed in accordance with the following requirements:

(a) Be connected to the FIP which can be manually operated only by fire brigade personnel and authorised staff in the event of a fire; and

(b) Fans and fan cabling shall be fire-rated so that fans are capable of operating at 200 ^{O}C for 60 minutes; and

(c) Visible signage shall be provided in accordance with AS/NZS 1668.1-1998 clearly identifying the use and procedures of the fans.

Option 2

A natural ventilation option via the use of ridge vents. This option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis.

In addition to the above options, we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas (Buildings 2 and 3).

8.8 FIRST AID FIRE FIGHTING

8.8.1 Fire Hose Reels

Fire Hose Reels are to be installed in accordance with the provisions within the BCA 2010 and AS 2441. Hose reel coverage will be achieved by utilising full 36 metres hoses and allowing for an additional 4 m hose stream. Internal fire hose reels may be proposed away from exits (>4m) if they are located within an egress path.

8.8.2 Portable Fire Fighting Equipment

Portable fire extinguishers are to be provided throughout in accordance with BCA Table E1.6 and selected, located and distributed in accordance with AS 2444.

8.9 FIRE BRIGADE INTERVENTION

8.9.1 Fire Brigade Notification

An automatic link shall be provided directly to an approved monitoring centre on activation of the sprinkler system and/or fire detection system.

8.9.2 Fire Brigade Rendezvous

The fire brigade rendezvous point shall be located at the main entrance from Brabham Drive.

8.9.3 Fire Indicator Panel

The fire indicator panel is to be located in a suitable location near to the main entrance. This is the dedicated rendezvous location for the fire brigade. Further, given the size of the proposed facility a mimic panel may also be required. Consultation with the NSWFB in this regard is proposed to be undertaken.

8.9.4 Fire Control Centre

Given the two large isolated buildings (Building 1 and Building 2/3) have a floor area greater than 18,000 m^2, a fire control centre is required to both of these buildings in accordance with Specification E1.8 of the BCA.

In this instance, a single fire control centre for the site will be utilized in lieu of one for each of the two fire-isolated buildings.

8.9.5 Tactical Fire Plans

Tactical fire plans are to be provided for use by the fire brigade. These shall be floor plans with the location of the following clearly identified:

- Fire hydrants
- Fire hose reels and fire extinguishers
- Fire indicator and any other repeater panels
- Egress paths
- Control equipment
- Any significant hazards on site
- Identification of rendezvous point
- Sprinkler valve and fire pump rooms
- Isolation valves

- Booster and suction pumps
- The year of original installation and the date of the latest revision to the block plan
- Notice advising “in the event of a fire, ring ‘000’ to ensure fire service response”
- Any other relevant information pertaining to fire brigade intervention.

8.9.6 Fire Hydrants

A fire hydrant system must be provided in accordance with BCA DtS Provision E1.3 and AS 2419.1-2005. In this instance it is assumed the three buildings will be served by a single fire hydrant system with multiple ring mains.

8.10 BUILDING MANAGEMENT PROCEDURES

The ongoing management of the building is as important to maintaining a high level of life safety as the provisions recommended during the design phase of the building.

8.10.1 Fire Precautions During Construction

The requirements of DTS Provision E1.9 of the BCA must be complied with for fire precautions during construction. Scaffolding, wire fencing, barricades and the like must not prevent fire brigade access for vehicles or personnel to essential fire safety components (hydrants, boosters, FIP, etc.) or prevent fire brigade personnel from intervening in the event of a fire.

8.10.2 Maintenance of Fire Safety Equipment

The fire alarm system, sprinkler system, fire hydrants, hose reels, portable fire extinguishers, emergency lighting and all other proposed essential services shall be tested and maintained in accordance with the latest Australian Standards.

8.10.3 No Smoking Policy

A no-smoking policy shall be implemented and enforced through all internal areas of the building.

8.10.4 Hot Works Policy

A hot works policy should be put in place and rigorously enforced to ensure that all hot works, including grinding and welding, are managed to avoid the accidental ignition of fires.

8.10.5 Housekeeping

A Fire Risk Assessment (FRA) or similar method should be adopted upon occupation to determine high risk areas and processes and instigate appropriate control measures. The FRA should be undertaken periodically or upon major alterations to the building layout or to the occupancy demographic or distribution.

8.10.6 Fire Drills and General Fire Safety Training

Fire wardens must be trained in first-aid fire fighting and emergency response. All staff must be inducted with a fire safety brief including the actions necessary on the activation of the building occupant warning system and the location of all emergency egress paths and fire exits.

In addition periodic fire drills should be undertaken and any lessons learned included in future fire safety procedures.

8.10.7 Personal Emergency Evacuation Plan (PEEP)

A personal emergency evacuation plan shall be developed for staff with disabilities. This is a specific evacuation plan developed for those individuals who may take longer or require additional levels of assistance during an evacuation.

8.10.8 Occupant Muster Point

An occupant muster point is to be designated in a suitably safe and open location.

8.10.9 Fire Safety Manual

A fire safety manual shall be developed to provide an overview of all fire safety procedures and systems within the building. The manual will also record false alarms, outcomes from fire drills and provide details of the ongoing maintenance and inspection procedures. The manual should be reviewed annually and a lessons learned exercise undertaken. Any conclusions drawn from this exercise should be implemented into the fire safety procedures.

8.10.10 Premises Security

Arson is a major cause of industrial fires and malicious arson attacks may be well planned to overcome specific fire safety systems. The provision of adequate levels of security is a key parameter in reducing the number or effects of malicious arson attacks in any premises.

8.11 COMMISSIONING REQUIREMENTS

The conclusions and recommendations of this report show the specific items that must be addressed by the relevant persons prior to the EP&A Clause 152 submission, fire brigade inspection and subsequent occupation of the building. Those items not listed must comply with the BCA DtS Provisions.

The appropriate installation and commissioning certificates must be provided to the fire engineer on final inspection prior or during the Clause 152 submission.

9 FIRE SCENARIOS AND PARAMETERS

9.1 OVERVIEW

The selection of appropriate fire scenarios is dependent on the extent of non-compliance issues being addressed, methods of analysis and characteristics of the development. Although a Fire Engineering Analysis can only take into account a finite number of potential fire scenarios which might occur, the number and nature of the fire scenarios considers the worst credible scenarios as determined and agreed with the relevant stakeholders.

The determination of fire scenarios is a crucial step and the validity of the data obtained by analysis and the conclusions drawn in the Fire Engineering Evaluation rely upon the appropriate selection of the design fires.

9.2 DESIGN FIRE SELECTION PROCESS

In order to select appropriate design fires the fire hazards as listed in Section 6 are reviewed. Design fires are selected based on the supporting statistics for fire ignition, number of deaths associated with particular fires and likely hazards associated with the building. With reference to the following table each of the applicable design fire characteristics are detailed with supporting references.

Table 9-1: Fire Scenario Characteristics

FIRE SCEANRIO CHARACTERISTIC	DESCRIPTION / DETAILS
Fire location	Various fire scenarios are proposed within the main warehouse, perishables, fresh food which account for the varying compartment sizes during stages 1-5. It is proposed to demonstrate the larger floor area and smoke reservoir created by high ceiling shall be sufficient in maintaining tenable conditions with respect to occupant life safety and fire brigade intervention. The fire within each scenario will be modelled at the centre of the building allowing smoke spread throughout the building. Further, a fire located in the centre of the warehouse (where the ceiling is at the greatest) will result in a later activation time. Refer to the Figures below for the proposed fire locations.
Fire growth rate	The fire growth rate will be modelled as a fast time-squared fire growth rate based on the information provided by British Standard (BS) 9999:2008 [6] and Fire Safety Management [19].
Maximum heat release rate	The worst credible and sensitivity fire scenarios will assume a fire growing at a Fast T^2 rate and capped at the activation of the sprinkler system, whereas the redundancy will assume a Fast T^2 rate to a peak of 30 MW and then steady state thereafter.
Material soot yield	The soot yield of polyurethane (0.1 kg/kg) will be used in fire modelling as referenced from Babrauskas in the NFPA Handbook. Refer to Section 6.6.
Simulation time	1800 seconds (30 minutes)
Ventilation conditions due to windows, doors or other openings	For modelling purposes, several roller doors will be modelled as open to approximate the overall building leakage ventilation.

FIRE SCEANRIO CHARACTERISTIC	DESCRIPTION / DETAILS
Ventilation conditions due to natural and forced smoke relief	In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide (i) a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes and/or (ii) a natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis. At this stage, both options are being investigated.
Suppression by automatic equipment	For the worst credible scenario, the fire has been decayed at a medium T^2 rate upon the activation of the sprinkler system. For the sensitivity analysis, the fire will remain steady state upon the activation of the sprinkler system. Whereas, the redundancy will consider a fire growing to a peak of 30 MW and then steady state thereafter.
Suppression by occupants	Suppression by occupants will not be considered in this assessment. Fires which may be extinguished by occupants have been excluded from the severe cases which test the Alternative Solution.
Suppression by fire services	Suppression by fire services is relied upon to the extent that blackout and/or overhaul will be required for the suppression case and in addition, suppression will be required for the control case. All scenarios are modelled without including the benefit of fire brigade suppression.

9.3 FIRE SCENARIO SUMMARY

9.3.1 General

An analysis will be undertaken for the proposed fire scenarios utilising the Computational Fluid Dynamics (CFD) Program, Fire Dynamics Simulator (FDS); refer to APPENDIX F for detailed description on the capability and assumptions of FDS. To undertake the modelling it is necessary to nominate a series of worst credible fire scenarios that are the most challenging in terms of occupants life safety. FDS4 will be used during the proposed design development stage to quantitatively assess the environmental conditions within the buildings to satisfy occupant life safety, fire brigade intervention and ultimately, the relevant Performance Requirements of the BCA [1].

In order to determine that the proposed alternate solutions for the proposed facility achieve the performance requirement of the BCA 2010, various scenarios have been selected which represent the most challenging situations for life safety of occupants and hence the proposed subsystems. The intention of these fire scenarios are to demonstrate that in lieu of the extended travel distances and the requirements for a smoke exhaust system, the effectiveness of the sprinkler system coupled with the larger smoke reservoir created by the high roof are sufficient in maintaining tenable conditions with respect to occupant life safety and fire brigade intervention. The factor of safety for an absolute analysis is 1.5 for the credible fire scenario and 1.0 for the sensitivity and redundancy scenarios.

Further, these scenarios will also be used with the FBIM model to demonstrate that routine conditions can be achieved until such time that fire crews are able to set up water supply requirements.

Given the size of the proposed facility and due to the various stages, it is necessary that the fire modelling represents all stages within all buildings. As such, the following fire scenarios have been chosen within each area of the proposed facility.

9.3.2 Main Warehouse – Stage 1

Fire Scenario 1

This scenario represents a fire occurring within the main warehouse (Building 1) when at its smallest size. Fire scenario 1a assumes that a fire ignites within one of the centrally located racking aisles within the IGAD warehouse. This fire is located near the centre of the warehouse in an area where the smoke can spread more or less equally to all areas of the warehouse. The fire is located as shown in Figure 9-1. The fire is assumed to grow at a fast growth rate in line with the type of storage and commodities expected.

As mentioned earlier, the modelled fire for the worst credible fire scenario is assumed to grow at a fast t^2 rate and decay at a medium T^2 rate upon the activation of the sprinkler system.

The sensitivity analysis (scenario 1b) will be as above however partial shielding results in the ESFR system controlling and not fully suppressing the fire. The heat release rate is therefore capped at activation of the nearest sprinkler head.

Further, the redundancy analysis (scenario 1c) for this fire will assume a forklift fire occurring next to the loading area which will grow up to 30 MW and then steady state thereafter. Due to the location of this fire, half the available exits will be unavailable for egress; hence this scenario will test the robustness of the proposed design.

Nil smoke exhaust will be modelled within scenarios 1a, 1b and 1c as described above. In this instance, a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes is proposed.

Scenarios 1d, 1e and 1f are the same as scenarios 1a, 1b and 1c respectively with the exception of the use of ridge vents as a naturally ventilated smoke relief option.

9.3.3 Main Warehouse – Stage 5

Fire Scenario 2

This scenario represents a fire occurring within the main warehouse (Building 1) when at its maximum size. In this scenario smoke may spread further due to the large ceiling reservoir and then forced to descend due to cooling of the smoke.

Scenario 2a assumes that a fire ignites within one of the centrally located racking aisles within the IGAD warehouse. This fire is located near the centre of the warehouse in an area where the smoke can spread more or less equally to all areas of the warehouse. The fire is located as shown in Figure 9-3. The fire is assumed to grow at a fast growth rate in line with the type of storage and commodities expected.

As mentioned earlier, the modelled fire for the worst credible fire scenario is assumed to grow at a fast t^2 rate and decay at a medium T^2 rate upon the activation of the sprinkler system.

The sensitivity analysis (scenario 2b) will be as above however partial shielding results in the ESFR system controlling and not fully suppressing the fire. The heat release rate is therefore capped at activation of the nearest sprinkler head.

Further, the redundancy analysis (scenario 2c) for this fire will assume a forklift fire occurring next to the loading area which will grow up to 30 MW and then steady state thereafter. Due to the location of this fire, half the available exits will be unavailable for egress; hence this scenario will test the robustness of the proposed design.

Nil smoke exhaust will be modelled within scenarios 2a, 2b and 2c as described above. In this instance, a smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes is proposed.

Scenarios 2d, 2e and 2f are the same as scenarios 2a, 2b and 2c respectively with the exception of the use of ridge vents as a naturally ventilated smoke relief option.

9.3.4 Perishables Warehouse (-24°C) – Stage 2

Fire Scenario 3

Given the Perishables warehouse increases in size from 13,995 m^2 to 16,495 m^2 during stages 2 and 5, the outcomes of the fire modelling are not expected to be significantly different. Further, given the same travel distance non-compliances apply during both stages, the smaller warehouse (13,995 m^2) during stage 2 will be modelled within our analysis.

Scenario 3a assumes that a fire ignites within one of the centrally located racking aisles within the Perishables warehouse. This fire is located near the centre of the warehouse in an area where the smoke can spread more or less equally to all areas of the warehouse. The fire is located as shown in Figure 9-2. The fire is assumed to grow at a fast growth rate in line with the type of storage and commodities expected.

As mentioned earlier, the modelled fire for the worst credible fire scenario is assumed to grow at a fast t^2 rate and decay at a medium T^2 rate upon the activation of the sprinkler system.

The sensitivity analysis (scenario 3b) will be as above however partial shielding results in the ESFR system controlling and not fully suppressing the fire. The heat release rate is therefore capped at activation of the nearest sprinkler head.

Further, the redundancy analysis (scenario 3c) for this fire will assume a forklift fire occurring next to the loading area which will grow up to 30 MW and then steady state thereafter. Due to the location of this fire, half the available exits will be unavailable for egress; hence this scenario will test the robustness of the proposed design.

Nil smoke exhaust will be modelled within scenarios 3a, 3b and 3c as described above.

9.3.5 Fresh Warehouse (0-4°C) – Stage 2

Fire Scenario 4

Scenario 4a assumes that a fire ignites within one of the centrally located racking aisles within the Fresh warehouse (0-4°C). This fire is located near the centre of the warehouse in an area where the smoke can spread more or less equally to all areas of the warehouse. The fire is located as shown in Figure 9-2. The fire is assumed to grow at a fast growth rate in line with the type of storage and commodities expected.

As mentioned earlier, the modelled fire for the worst credible fire scenario is assumed to grow at a fast t^2 rate and decay at a medium T^2 rate upon the activation of the sprinkler system.

The sensitivity analysis (scenario 4b) will be as above however partial shielding results in the ESFR system controlling and not fully suppressing the fire. The heat release rate is therefore capped at activation of the nearest sprinkler head.

No redundancy analysis will be undertaken for this warehouse given its smaller size (1,980 m^2) and the temperature controlled environment of this warehouse.

Nil smoke exhaust will be modelled within scenarios 4a and 4b as described above.

9.3.6 Fresh Warehouse (Staging: 10-14°C) – Stage 2

Fire Scenario 5

Given the Fresh warehouse staging area (10-14°C) increases in size from 2,194 m^2 to 3,960 m^2 during stages 2 and 5, the outcomes of the fire modelling are not expected to be significantly different. Further, the travel distances are not expected to be any worse within stage 5. Based on the above, the smaller warehouse (2,194 m^2) during stage 2 will be modelled within our analysis.

Scenario 5a assumes that a fire ignites within one of the centrally located racking aisles within the Fresh warehouse; staging area (10-14°C). This fire is located near the centre of the warehouse in an area where the smoke can spread more or less equally to all areas of the warehouse. The fire is located as shown in Figure 9-2.

As mentioned earlier, the modelled fire for the worst credible fire scenario is assumed to grow at a fast t^2 rate and decay at a medium T^2 rate upon the activation of the sprinkler system.

No sensitivity will be undertaken for this warehouse given its smaller size (2,194 m^2) and the temperature controlled environment of this warehouse. Further, as a conservative measure and to test the robustness of the proposed design half of the exits will be assumed to be blocked.

9.3.7 Carpark – Stage 1

Fire Scenario 6

With reference to Section 6.5, it is proposed to model a car fire located centrally within the carpark (lower floor) where smoke can spread more or less equally to areas. The fire is located as shown in Figure 9-2.

The modelled fire for scenario 6a is assumed to grow at a medium t^2 rate up to a maximum heat release rate of 5 MW and then steady state thereafter. Note, the carpark is classified as an open-deck carpark and hence does not require sprinklers as per the Deemed-to-Satisfy provisions of the BCA.

Figure 9-1: Stage 1 layout showing proposed fire locations

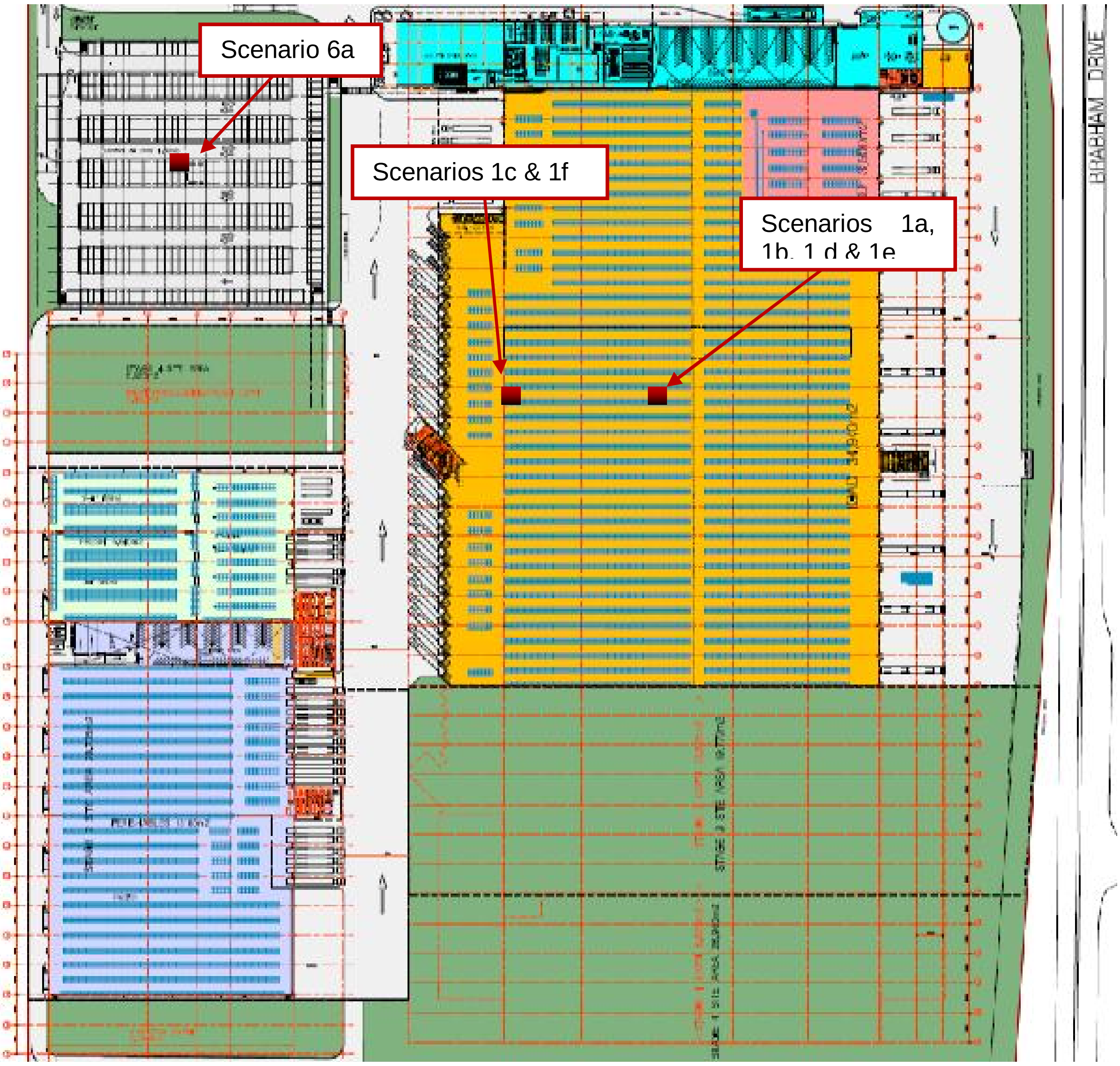


Figure 9-2: Stage 2 layout showing proposed fire locations

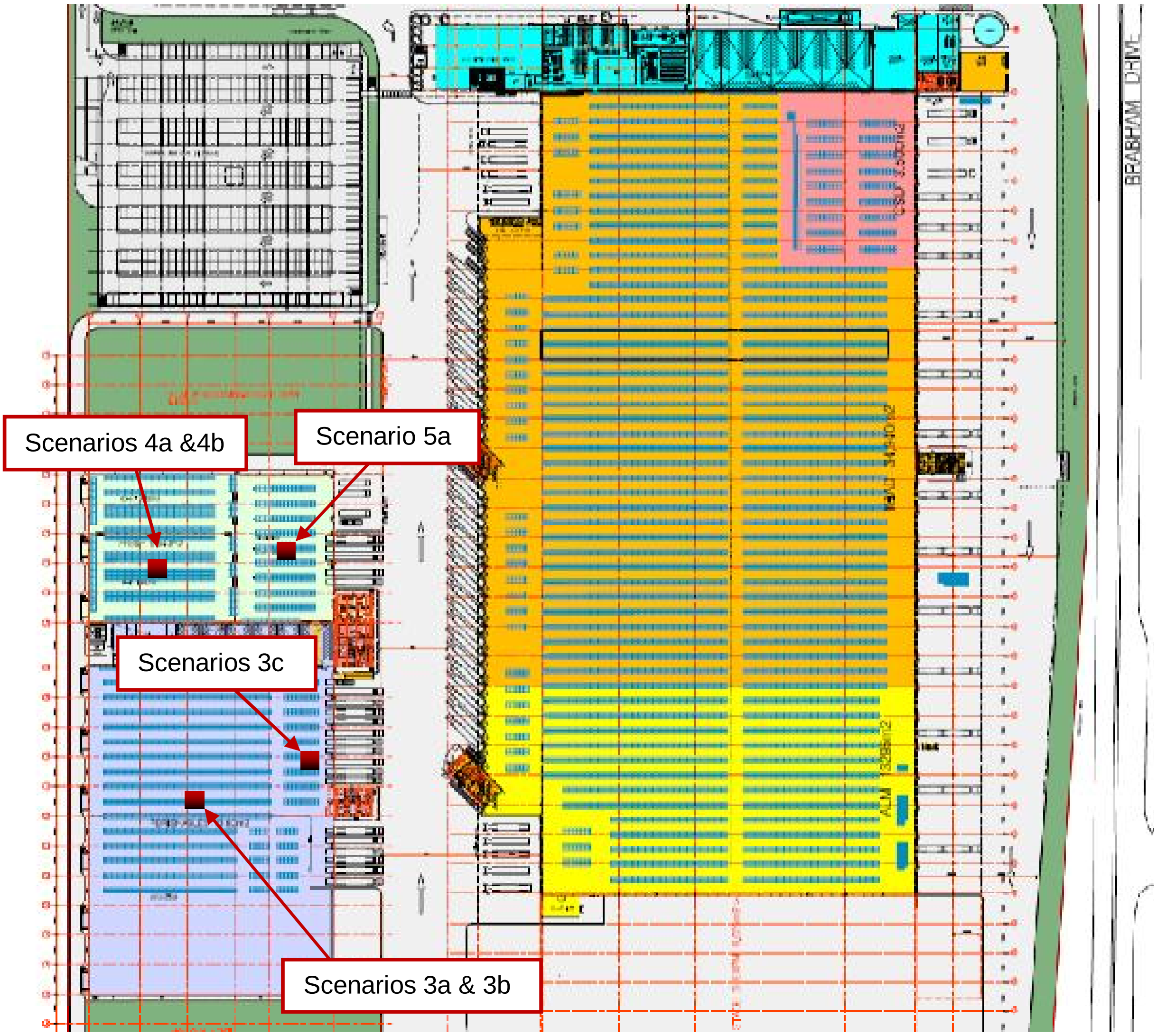


Figure 9-3: Stage 5 layout showing proposed fire locations

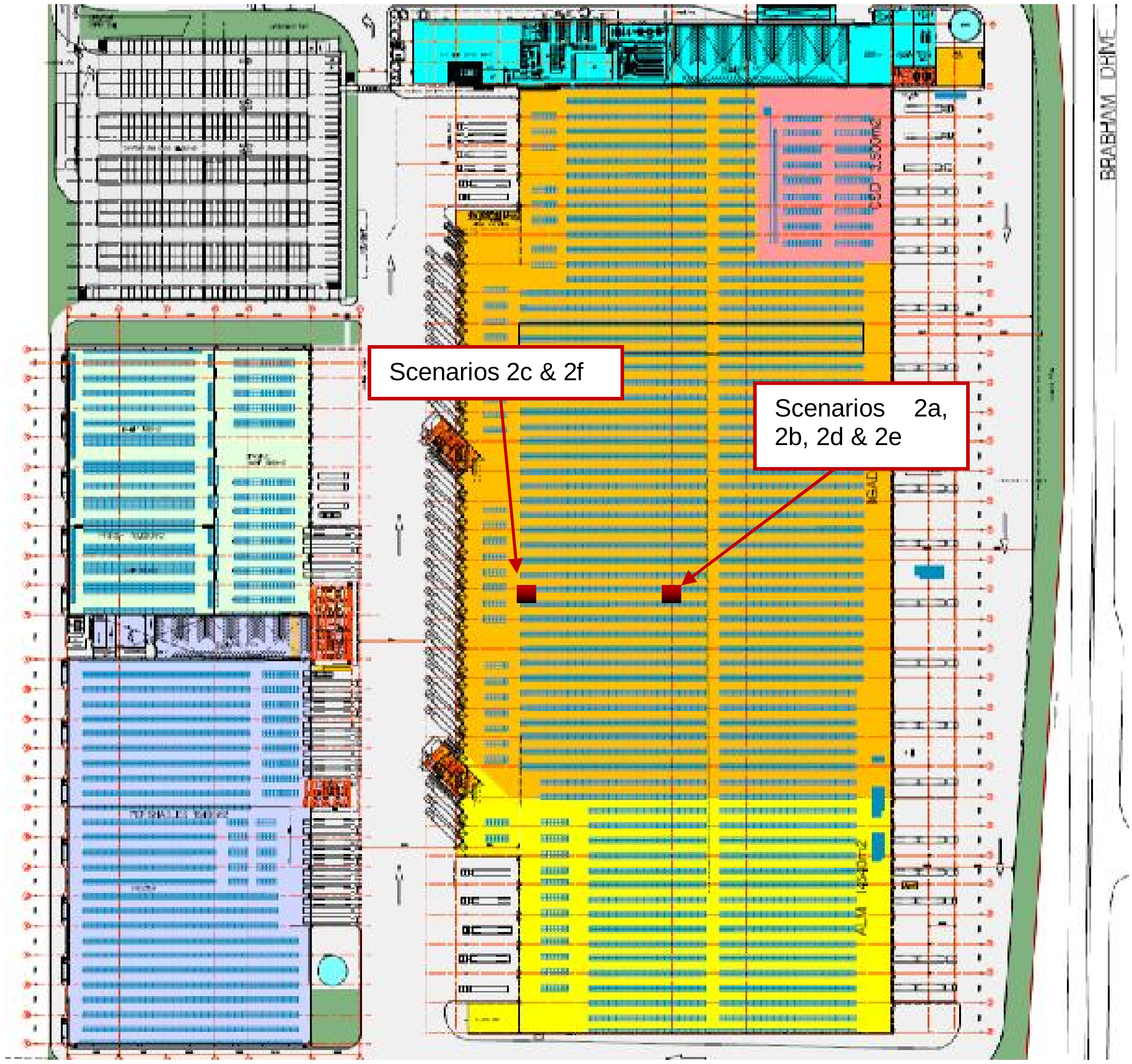


Table 9-2: Summary of Modelled Scenarios

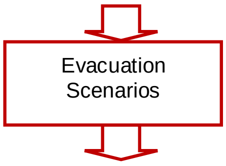
Fire Scenario	Fire Growth Rate	Maximum HRR	Material / Soot Yield	Simulation time	Fire Service System Characteristics
Main warehouse – Stage 1					
1a - Worst Credible	Fast	Medium decay rate upon activation of the fire sprinkler system (suppressed fire)	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. Manual smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.
1d - Worst Credible					• Ridge vents modelled as a naturally ventilated option for smoke relief. • ESFR sprinkler system modelled to control (not suppress) the fire.
1b - Sensitivity	Fast	Steady state upon activation of the fire sprinkler system (controlled fire)	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. Manual smoke clearance system proposed. • Failure of the ESFR sprinkler system.
1e - Sensitivity					• Ridge vents modelled as a naturally ventilated option for smoke relief. • Failure of the ESFR sprinkler system.
1c - Redundancy	Fast	Up to 30 MW and steady state thereafter	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. Manual smoke clearance system proposed. • Failure of the ESFR sprinkler system.
1f - Redundancy					• Ridge vents modelled as a naturally ventilated option for smoke relief. • Failure of the ESFR sprinkler system.
Main warehouse – Stage 5					
2a - Worst Credible	Fast	Medium decay rate upon activation of the fire sprinkler system (suppressed fire	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. Manual smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.

Fire Scenario	Fire Growth Rate	Maximum HRR	Material / Soot Yield	Simulation time	Fire Service System Characteristics
2d - Worst Credible					• Ridge vents modelled as a naturally ventilated option for smoke relief. • ESFR sprinkler system modelled to control (not suppress) the fire.
2b - Sensitivity	Fast	Steady state upon activation of the fire sprinkler system (controlled fire)	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. Manual smoke clearance system proposed. • Failure of the ESFR sprinkler system.
2e - Sensitivity					• Ridge vents modelled as a naturally ventilated option for smoke relief. • Failure of the ESFR sprinkler system.
2c - Redundancy	Fast	Up to 30 MW and steady state thereafter	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. Manual smoke clearance system proposed. • Failure of the ESFR sprinkler system.
2f - Redundancy					• Ridge vents modelled as a naturally ventilated option for smoke relief. • Failure of the ESFR sprinkler system.
Perishables warehouse (-24°C) – Stage 2					
3a - Worst Credible	Fast	Medium decay rate upon activation of the fire sprinkler system (suppressed fire	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. • No smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.
3b - Sensitivity	Fast	Steady state upon activation of the fire sprinkler system (controlled fire)	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. • No smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.
3c - Redundancy	Fast	Up to 30 MW and steady state thereafter	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. • No smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.

Fire Scenario	Fire Growth Rate	Maximum HRR	Material / Soot Yield	Simulation time	Fire Service System Characteristics
Fresh warehouse (0-4 °C) – Stage 2					
4a - Worst Credible	Fast	Medium decay rate upon activation of the fire sprinkler system (suppressed fire	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. • No smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.
4b - Sensitivity	Fast	Steady state upon activation of the fire sprinkler system (controlled fire)	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. • No smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.
Fresh warehouse (10-14 °C) – Stage 2					
5a - Worst Credible	Fast	Steady state upon activation of the fire sprinkler system (controlled fire)	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust modelled. • No smoke clearance system proposed. • ESFR sprinkler system modelled to control (not suppress) the fire.
Carpark – Stage 1					
6a - Worst Credible	Medium	Up to 5 MW and steady state thereafter	Polyurethane 0.1kg/kg	30 mins	• No smoke exhaust required. • No sprinkler system required.

10 EVACUATION SCENARIOS AND PARAMETERS

10.1 OVERVIEW



A spreadsheet calculator based on first principle calculations will be used to calculate the evacuation time (RSET) from the building. This method accounts for the distance of travel and the speed of occupant movement as well as the complications of queuing and flow rate due to the occupant number and the width restriction in parts of the egress paths.

10.2 EVACUATION MODELLING PROCESS

In order to select appropriate evacuation scenarios the fire hazards as listed in Section 6 and the occupant characteristics as listed in Section 4 are reviewed. Evacuation scenarios are selected based on the supporting occupant characteristics as listed in Section 4 and APPENDIX F. With reference to the following table each of the applicable evacuation characteristics are detailed with supporting references.

Table 10-1: Evacuation Scenario Characteristics

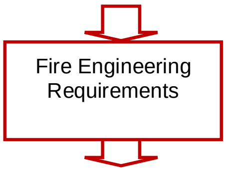
EVACUATION CHARACTERISTIC	DESCRIPTION / DETAILS
Population numbers	Based on correspondence from Integration Property who are Metcash's Project Manager, we have been advised the warehouse staff numbers and shifts are as follows; • Shift 1: 5am-2pm – 160 occupants • Shift 2: 8.30am-6pm – 170 occupants • Shift 3: 2pm-11pm – 70 occupants The evacuation analysis within the warehouse will conservatively assume occupants from all three shifts are present and dispersed evenly throughout the warehouses. Refer to Table 4-1.
Population location	In reality the occupants are expected to be distributed evenly across the warehouses however the evacuation analysis will model the maximum number of occupants within each warehouse being initially located at the maximum distance from the nearest exit.
Physical and mental attributes	Staff may be employed with disabilities which might affect recognition, response or movement in an emergency situation. In general however, due to the tasks required of warehouse and office staff, it is expected that the degree of physical and mental capabilities requisite for employment in these areas would equip most staff to be able to respond and evacuate by their own power. Refer to Table 4-1 for further details.
Familiarity with the building	All employees are expected to be regular workers and thus familiar with the building. Any visitors are expected to be in the company of employees. Refer to Table 4-1 for further details.
Emergency training	Emergency training is not relied upon for this assessment.

EVACUATION CHARACTERISTIC	DESCRIPTION / DETAILS
Alarm time	Based on FDS modelling of sprinkler activation time. Further, visual cues of the smoke layer spreading across the majority of the ceiling of the warehouse will be used. In addition to the above, a form of detection (if proposed) may be required within the proposed facility.
Pre-movement time	180 seconds – for occupants familiar with the building and its alarm system. (Proulx, SFPE Handbook [14])
Travel speed	0.8 m/s – for horizontal travel of occupants with a locomotion disability (Bryan, SFPE Handbook [5])
Distance of travel to nearest exit	Up to 110m in lieu of 40m to an exit within the main warehouse. Refer to Table 0-1 for further details.
Distance between exits	Up to 220m in lieu of 60m between alternative exits within the main warehouse. Refer to Table 0-1 for further details.
Egress provisions	Exit doors are located around the perimeter of each warehouse. Half the total exits will be considered to be available within the sensitivity analysis to test the robustness of the proposed design.

Table 10-2: Summary of Evacuation Scenarios

SCENARIO NUMBER	POPULATION NUMBERS	POPULATION LOCATION	Alarm Time	PRE-MOVEMENT TIME	TRAVEL SPEED	EGRESS PROVISIONS
A	Numbers for each warehouse to be determined based on total occupant numbers as per Table 10-1.	Occupants are located at the most disadvantaged point with respect to egress.	Alarm time may involve a combination of the below; • Sprinkler activation, • Visual cues of smoke layer across ceiling, • Smoke detection (if proposed).	180 sec	0.8 m/s	All exits available
B	Numbers for each warehouse to be determined based on total occupant numbers as per Table 10-1.	Occupants are located at the most disadvantaged point with respect to egress.	Alarm time may involve a combination of the below; • Sprinkler activation, • Visual cues of smoke layer across ceiling, • Smoke detection (if proposed).	180 sec	0.8 m/s	Half of total exits are considered available

11 FIRE ENGINEERING REQUIREMENTS



The following are preliminary requirements for the Trial Design identified herein and summarises the design requirements, to be undertaken by others, likely to achieve the nominated fire safety objectives of this report.

All other items not specifically addressed are to be in accordance with DtS provisions of the BCA or as accepted by the relevant authorities. Any change in this information to suit future building works or re-organisation will require further analysis to confirm compliance with the regulations and this Fire Engineering Brief.

Table 11-1: Fire Engineering Requirements

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
Fire Resistance Levels and Compartmentation	The two large-isolated buildings; Building 1 and Building 2/3 must have a minimum structural fire resistance level (FRL) in accordance with the BCA Type A and B fire resisting construction respectively with the exception of the items discussed within Table 0-1 above.	Table C1.1 and Specification C1.1 of the BCA.
	All materials and assemblies are to achieve early fire hazard indices.	BCA C1.10 and Specification C1.10.
	All dangerous goods shall be in accordance with the relevant dangerous goods legislation.	Dangerous goods consultant has been engaged and a detailed report will be provided for guidance.

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
Access and Egress	With the exception of the extended travel distances, as specified herein, all access and egress requirements of the BCA relevant to this building must be complied with.	Section D of the BCA DtS Provisions and via an alternative solution.
	Open spaces and vehicular access shall be in accordance with Clause C2.4 of the BCA DtS Provisions with the exception of the non-compliance as detailed within Table 0-1. Refer to Section 7.1 for vehicular access provisions during the six stages. It is understood the vehicular turning areas around the proposed facility shall comply with NSW FB Policy 4.	Assessed via an alternative solution. Our recommendations will give due consideration to comments offered by the NSWFB.
	Door hardware on all required exits, is to be in accordance with the current regulations such that all required exits shall be available for emergency egress.	Section D of the BCA 2010.
	Door swings to comply with Clause D2.20 of the DtS provisions of the BCA.	BCA Clause D2.20.
	All required emergency exit doors which may be locked due to security requirements shall unlock upon activation of the general fire alarm or power failure.	BCA Clause D2.21.
Services and Equipment	It is assumed the three buildings will be served by a single fire hydrant system with multiple ring mains. *Note, a combined fire sprinkler and fire hydrant system is considered unacceptable in this instance.*	BCA DtS Provision E1.3 and AS 2419.1
	Fire hose reels must be installed.	BCA DtS Provision E1.4 and AS 2441
	A fire sprinkler system is to be installed throughout the building. *Note, a combined fire sprinkler and fire hydrant system is considered unacceptable in this instance.*	- An ESFR sprinkler system shall be provided throughout the warehouse areas in accordance with Factory Mutual Guidelines FM2-2 and where applicable, BCA Specification E1.5 and AS 2118.1; and - The fire sprinkler system within the office areas shall be in accordance with AS 2118.1.

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
	As part of the alternative solution to address the non-complying discharge location of the southern fire-isolated stair from the main office, it is proposed to install wall-wetting sprinklers to the internal side of the glazed openings as per Figure 7-1. The design and maintenance of the drencher glass protected system is to be undertaken in accordance as follows: i. The glass windows must be minimum 6mm toughened glass. Glass side panels requiring drencher protection shall be fixed closed and non-openable. ii. The maximum dimensions of the glass panels should be compatible with the spray pattern of the Tyco WS Sprinkler System design criteria. iii. The maximum distance between two window sprinklers shall be no more than 2.44m in order to provide sufficient coverage to a window and frame. iv. Flexible seals are to be used between the top and bottom of the window frames to allow for the expansion of the glass. v. No horizontal mullions are to be installed within the drenchered side of the openings. Furthermore, at least one drencher head must be installed between every vertical mullion (if applicable). Where this is not achievable the drencher heads must be strategically located to ensure complete coverage of the glazed elements. vi. Sprinkler drencher system stop valve shall be locked in the open position and monitored, thus activating the local alarm should the status of the valve be change.	AS 2118.2. Tyco Technical Data Sheet or an approved alternate drencher head technical data sheet.

<table>
<tr><th>FIRE SAFETY SUB-SYSTEM</th><th>FIRE ENGINEERING REQUIREMENT</th><th>STANDARD OF INSTALLATION</th></tr>
<tr><td></td><td><u>Building 1</u>

In lieu of the requirement for an automatic smoke exhaust system within the main warehouse, it is proposed to provide the following options;

<u>Option 1</u>

A smoke clearance system which shall be manually activated by the fire brigade and used for post incident smoke clearance purposes.

To conform with NSWFB operational requirements, smoke clearance fans should be provided with 1 air change per hour, however given the large size of the main warehouse, it is proposed to rationalise this extraction rate.

Further, the fans should be evenly distributed throughout the main warehouse with the following requirements:

(a) The smoke clearance fans shall be connected to the FIP which can be manually operated only by fire brigade personnel and authorised staff in the event of a fire; and

(b) Fans and fan cabling shall be fire-rated so that fans are capable of operating at 200 ^{O}C for 60 minutes; and

(c) Visible signage shall be provided in accordance with AS/NZS 1668.1-1998 clearly identifying the use and procedures of the fans.

<u>Option 2</u>

A natural ventilation option via the use of ridge vents. The latter option is being investigated in further detail with the relevant fire authority; however final justification of either solution will be subject to further fire engineering analysis.

Further, given the floor area of this warehouse is approximately 57,600 m^2, part of the alternative solution may involve providing a level of smoke detection to provide an earlier level of occupant warning. It has been highlighted by the design team, this solution may lead to false alarms due to dust from the forklifts and fumes from the semi-trailers. Due to theft issues, Metcash have CCTV cameras down every aisle which is manned at the gatehouse (i.e. a manual system). As such, part of the alternative may involve the use of a video detection system to detect radiant heat whilst utilising the CCTV infrastructure. Infra-red detection may also be also be an option however this options may also lead to false alarms from the sway of racking.</td><td>< AS 1668.1
< AS 1670.1
Assessed via an alternative solution.

Our recommendations will give due consideration to comments offered by the NSWFB.</td></tr>
</table>

FIRE SAFETY SUB-SYSTEM	FIRE ENGINEERING REQUIREMENT	STANDARD OF INSTALLATION
	Building 2 As part of the alternative solution we are aiming to negate the requirement for a smoke exhaust system within the perishables and fresh food areas. Similar to the main warehouse, a form of detection to provide an earlier level of occupant notification in a fire may be required however this requirement is subject to further fire engineering analysis.	Assessed via an alternative solution.
	Portable fire extinguishers must be provided throughout the building.	BCA DtS Provision E1.6 and AS 2444.
	An Occupant Warning System must be installed and connected to the fire sprinkler system and any form of detection system installed.	BCA Specification E2.2a Clause 6 and AS 1670.1.
	Emergency lighting must be installed.	BCA DtS Provision E4.2 and AS 2293.1.
	Exit signs and direction signs to exits must be installed.	BCA DtS Provision E4.6 and AS 2293.1.
	A fire indicator panel must be installed within the main entry. Further, given the size of this facility a mimic panel may also be required.	AS 1670.1.
Maintenance and Commissioning	The recommended fire safety systems must be replaced with equivalent systems in all future works and the recommended fire safety systems must be applied to any renovations or new works.	
	Periodic inspection, testing and maintenance of all fire safety systems, fire hydrants, fire hose reels (where provided), emergency lighting, exit signage, doors, fire resistance, portable fire extinguishers, etc. should be implemented.	AS 1851-2005.
	Under all circumstances it is important to keep as much of the system fully operational as is practical. Should any building works extend over a number of days, the system must be re-instated as far as practical at the end of each day.	
Building Management Requirements	No smoking policy throughout all public areas of the building.	
	Keep unnecessary combustible loads to a minimum in public areas via regular housekeeping, including the removal of random storage and accumulated debris.	
	Building Management Procedures provided in Section 8.10 shall be adopted.	

12 REFERENCES

1. ABCB, "Building Code of Australia, Volume One", CanPrint Communications, Canberra 2010.
2. ABCB, "Guide to the BCA 2010", CanPrint Communications, Canberra 2010.
3. ABCB, "International Fire Engineering Guidelines", ABCB, Canberra, 2005.
4. Australasian Fire Authorities Council, 'Fire Brigade Intervention Model V2.1', November 1997.
5. Bryan, John L., Behavioural Response to Fire and Smoke", Section Three – Chapter 12, The SFPE Handbook of Fire Protection Engineering 3rd Edition, National Fire Protection Association, Quincy Massachusetts USA 2002.
6. BS 9999: Code of practice for fire safety in the design, management and use of buildings, October 2008
7. Budnick, E.K. "Automatic sprinkler system reliability", Fire Protection Engineering, Issue No. 9, Winter 2001.
8. Fruin, J.J. Pedestrian Planning and Design. Metropolitan association of Urban designers and environmental planners Inc, 1971, New York.
9. Marryatt, H.W., "Fire: A Century of Automatic Sprinkler Protection in Australia and New Zealand 1886-1986", Australian Fire Protection Association, Melbourne, Australia, 1988.
10. Nelson, H.E. "BUD" and Mowrer, F.W. Emergency Movement. The SFPE Handbook of Fire Protection Engineering (3rd Ed.) DiNenno, P.J (ed.) National Fire Protection Association, Quincy, MA 02269, 2002 pp. 3/367-380
11. NIST – National Institute of Standards and Technology, U.S. Department of Commerce, NIST Special Publication 1018-5; Fire Dynamics Simulator (Version 5), Technical Reference Guide, Volume 2: Verification
12. PD 7974-6:2004, "The application of fire safety engineering principles to fire safety design of buildings – Part 6: Human factors: Life safety strategies – Occupant evacuation, behaviour and condition (Sub-system 6)", BSI British Standards.
13. Predtechenskii, V.V. and Milinskii, A.I. Planning for foot traffic in buildings (translated from Russian). Stroizdat publishers, Moscow, 1969. English translation published for National Bureau of Standards and the National Science Foundation, Washington, by Amerind Publishing Co. Pvt. Ltd, New dehli, India (1978)
14. Proulx, G. Movement of People: the evacuation timing. The SFPE Handbook of Fire Protection Engineering (3rd edition), DiNenno, P.J. (ed.) National Fire Protection Association, Quincy, MA 02269, 2002 pp. 3/342-366
15. Society of Fire Protection Engineers "Engineering Guide to Human Behaviour in Fire", Review Draft August 2002, The SFPE Engineering Guide to Human Behaviour in Fire, June 2002.
16. Society of Fire Protection Engineers, 'Handbook of Fire Protection Engineers', 3rd Edition, 2002.
17. Technical Report FCRC-TR 96-02: Building Fire Scenarios – An analysis of Fire Incident Statistics, Fire Code Reform Research Program, March 1996
18. The Chartered Institute of Building Services Engineers, 'CIBSE Guide E, "Fire engineering', 2nd Edition, September 2003.
19. Furness, A, Muckett, M; Introduction to Fire Safety Management, June 2007.
20. PD 7974-1:2003, "Application of fire safety engineering principles to the design of buildings – Part 1: Initiation and development of fire within the enclosure of origin (Sub-system 1)", BSI British Standards.
21. Mawhinney J.R. and Tamura G.T., "The Effect of Automatic Sprinkler Protection on Smoke Control Systems", ASHRAE Transactions, Vol. 100, No. 1, pp. 494-513, 1994.

22. Kook, K.W., “Exterior Fire Propagation in a High-Rise Building,” Master’s Thesis, Worcester Polytechnic Institute, Worcester, MA, November 1990.
23. Rohr, Kimberly. “U.S. Experience with Sprinklers”, Fire Analysis and Research Division, NFPA, Quincy, MA.
24. Marty Ahrens, (2001) “U.S. Fire Problem Overview Report”, NFPA, Quincy, MA.
25. FM Global Data Sheet 2-2, Installation rules for suppression mode automatic sprinklers, 2002.
26. McGrattan, Kevin. “Sprinkler, Smoke & Heat Vent, Draft Curtain Interaction – Large Scale Experiments and Model Development” NISTIR 6196-1, National Institute of Standards and Technology, United States Department of Commerce, Gaithersburg Maryland, September 1998.
27. I R Thomas, (2004), “Fires in Carparks”, Fire Australia February 2004, Eastside Printing.
28. BHP Steel: Structural steel Development Group, Report No MRL/Ps69/89/006. “Fire Safety in Car Parks”.
29. McGrattan, K, ‘Fire Dynamics Simulator (Version 4) Technical Reference Guide’, National Institute of Standards and Technology, NIST Special Publication 1018, March 2006.
30. McGrattan, K., G. P. Forney, ‘Fire Dynamics Simulator (Version 4) User’s Guide’, National Institute of Standards and Technology, NIST Special Publication 1019, March 2006.
31. Forney, G. P., K. McGrattan, ‘User’s Guide for Smokeview Version 4 - A Tool for Visualizing Fire Dynamics Simulation Data’, National Institute of Standards and Technology, NIST Special Publication 1017, March 2006.
32. PIARC Committee on Road Tunnels, “Fire and Smoke Control in Road Tunnels”, PIARC – World Road Association, Paroi Nord, France, 1999.
33. ProfilARBED-Recherches, "Development of design Rules for Steel Structures subject to Natural Fires in Closed Car Parks", 7210-SA/211/318/518/620/933, Luxemburg, 1999.
34. Yuguang, L., “Assessment of Vehicle Fires in New Zealand Parking Buildings”, Fire Engineering Research Report, May 2004.

APPENDIX A RELEVANT FIRE STATISTICS

The statistics below have been compiled from U.S. fires reported to U.S. municipal fire departments between 1994 to 1998, and do not include fires where private or government fire brigades responded or unreported fires [24]. These statistics represent a much greater number of events than Australian statistics and therefore have a greater statistical reliability. Building construction types and fire hazards are estimated to be sufficiently similar between Australia and the US for the following results to be applicable.

AREA OF FIRE ORIGIN IN WAREHOUSES

It is evident from the following table that the most common location for fire ignitions and for fire deaths is in the unclassified storage areas of warehouses.

Area of Fire Origin	Fires	Civilian Fatalities
Unclassified storage area	15.0%	10.7%
Exterior wall surface	11.0%	0.0%
Garage or vehicle storage area	9.9%	22.5%
Product storage area, tank or bin	9.3%	5.5%
Supply storage room or area	9.1%	9.3%
Lawn, field, or open area	5.1%	8.9%
Maintenance Shop or area	2.5%	7.7%
All other areas of fire origin	38.1%	35.4%
Total	**100% 22,900 fires per year, average**	**100.0% 15 fatalities per year, average**

Table 12-1 – Storage properties related to fire origin – annual average

FIRE FATALITIES IN DIFFERENT BUILDING TYPES

The following table contrasts the number of fires recorded in the US per year, the corresponding number of civilian fatalities, and the ratio of civilian fatalities to fires in various types of buildings. These results clearly show that the risk to life in offices and storage buildings are disproportionably lower than any other building type, despite the relatively high number of storage building fires.

Structure Type	Fires per year, average	Civilian Fatalities per year, average	Civilian Fatalities per 1000 fires
Offices	5,800	1	0.17
Storage facilities	22,9000	15	0.66
Public assembly, excluding eating/drinking	6,000	5	0.83
Facilities that care for the sick	2,600	5	1.92
Hotels & Motels	4,900	28	5.7
Apartments	96,200	632	6.57
Homes	406,400	3,498	8.61
Dwellings & Manufactured Homes	310,200	2,867	9.24

Table 12-2 – Fire fatalities in different building types

NSW FIRE BRIGADES

The annual NSW Fire Brigade statistical report for 2001/2002 provides the reliability for buildings fires, as given in Table A3.

Fire Sprinkler Performance	Public Assembly	Educational	Institutional	Residential	Shop, Store, Office	Basic Industry, Utility, Defence, Manufacturing	Storage	Other	Total
Equipment operated, performance									
Extinguished fire	8	0	7	16	15	6	5	0	57
Prevented spread, but did not extinguish	3	1	0	5	6	4	1	1	21
Did not prevent spread	1	0	0	0	1	0	0	0	2
Other	0	0	0	0	0	1	0	0	1
Total	**12**	**1**	**7**	**21**	**22**	**11**	**6**	**1**	**81**
Equipment should have operated but did not	0	0	0	1	0	1	0	0	2
Equipment present but fire too small to require operation	8	1	1	8	14	5	2	1	40
No equipment present in room or space of fire origin	243	167	128	2803	333	139	211	254	4278
Other	1	2	0	4	0	2	3	1	13
Total	**264**	**171**	**136**	**2837**	**369**	**158**	**222**	**257**	**4414**

Table 12-3 – Fire sprinkler performance by property type (building fires only)

APPENDIX B SPRINKLER EFFECTIVENESS

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" [23]. The relevant statistical data are summarised in the following tables. These data were recorded from fires that had been reported to U.S. municipal fire departments during the period of 1989 – 1998.

Property Use	Civilian Deaths per Thousand Fires		
	Without Sprinklers	With Sprinklers	Percent Reduction
Public assembly properties	0.8	0.0	100%
Stores and offices	1.0	0.3	74%
Industrial facilities	1.1	0.0	100%
Manufacturing facilities	2.0	0.8	60%
Storage facilities	1.0	0.0	100%

Table 12-4 – The effectiveness of sprinkler in reducing civilian deaths in fires

Property Use	Average Direct Property Damage per Fire		
	Without Sprinklers	With Sprinklers	Percent Reduction
Public assembly properties	$21,600	$6,500	70%
Stores and offices	$24,400	$12,200	50%
Industrial facilities	$30,100	$17,200	43%
Manufacturing facilities	$50,200	$16,700	67%

Table 12-5 – The effectiveness of sprinkler in reducing direct property damage in fires

The summarised statistical data indicate that sprinklers are highly effective in reducing the loss of life and property in fires. Further, when sprinklers were present, fires do not spread beyond the area of fire origin in 89.3% of public assembly fires, 83.0% of industrial facility fires, 84.3% in manufacturing facility fires, and 77.8% in storage facility fires; refer to the Table 12-6, Table 12-7, Table 12-8, and Table 12-9. With appropriate maintenance, sprinklers have a high reliability of activating and preventing or limiting fire spread.

Extent of Flame Damage	Fires with sprinkler protection	Fires without sprinkler protection
Confined to object of origin	69.3%	47.7%
Confined to area of origin	20.3%	21.9%
Confined to room of origin	5.0%	7.7%
Confined to fire-rated compartment of origin	0.7%	0.9%
Confined to floor of origin	0.7%	2.5%
Confined to structure of origin	3.7%	17.0%
Extended beyond structure of fire origin	0.3%	2.3%
Total:	3,000 fires	10,040 fires

Table 12-6 – The effectiveness of sprinkler in public assembly properties

Extent of Flame Damage	Fires with sprinkler protection	Fires without sprinkler protection
Confined to object of origin	61.0%	29.8%
Confined to area of origin	22.0%	13.1%
Confined to room of origin	4.9%	5.7%
Confined to fire-rated compartment of origin	2.4%	0.7%
Confined to floor of origin	2.4%	1.4%
Confined to structure of origin	7.3%	39.4%
Extended beyond structure of fire origin	0.0%	10.3%
Total:	410 fires	2,820 fires

Table 12-7 - The effectiveness of sprinkler in industrial facilities

Extent of Flame Damage	Fires with sprinkler protection	Fires without sprinkler protection
Confined to object of origin	61.0%	45.3%
Confined to area of origin	23.3%	21.3%
Confined to room of origin	6.6%	7.6%
Confined to fire-rated compartment of origin	1.0%	1.2%
Confined to floor of origin	1.4%	1.8%
Confined to structure of origin	5.8%	18.9%
Extended beyond structure of fire origin	0.8%	3.8%
Total:	4,980 fires	5,030 fires

Table 12-8 - The effectiveness of sprinkler in manufacturing facilities

Extent of Flame Damage	Fires with sprinkler protection	Fires without sprinkler protection
Confined to object of origin	50.0%	19.9%
Confined to area of origin	27.8%	14.1%
Confined to room of origin	6.7%	4.9%
Confined to fire-rated compartment of origin	1.1%	0.6%
Confined to floor of origin	2.4%	1.1%
Confined to structure of origin	10.0%	45.0%
Extended beyond structure of fire origin	2.2%	14.3%
Total:	900 fires	29,330 fires

Table 12-9 - The effectiveness of sprinkler in storage facilities

APPENDIX C ACCEPTANCE REQUIREMENTS

Occupant Life Safety Criteria

The tenability criteria for occupant life safety is based on the SFPE Handbook of Fire Protection Engineering [and CIBSE Guide E – Fire Engineering, which requires temperature, visibility and toxicity conditions to be maintained so that they do not endanger human life, by satisfying either one of the following criteria:

Criteria 1 – Smoke layer above 2.1 m

The limiting condition for tenable condition with radiant heat from a hot layer or other fire condition is 2.5 kW/m^2. This radiant heat level generally occurs when temperatures are approximately 200^{O}C in small enclosures with relatively low ceiling heights. Therefore, the acceptance criteria are when the smoke layer height is greater than 2.1 m and the smoke temperature is less than 200^{O}C.

Criteria 2 – Smoke layer below 2.1 m

Untenable conditions are considered to occur if the smoke layer drops below 2.1 m and any of the following temperature, visibility and toxicity limits are exceeded:

- Smoke Temperature > 60^{O}C
- Visibility < 10 m (optical density < 0.1 m^{-1})
- CO Toxicity > 1,400 ppm

Toxicity is generally considered to be acceptable if the visibility criterion is satisfied.

Fire Brigade Life Safety Criteria

The Fire Engineering Assessment considers fire-fighter life safety where occupant tenability limits have been exceeded and intervention is required by the Fire Brigade.

Search and rescue operations require enclosure to be safe for fire fighters. According to the Fire Brigade Intervention Model V2.2 the following criteria are used to determine the tenable conditions for fire fighters relative to height of 1.5m above floor level:

Routine Condition

Elevated temperatures, but not direct thermal radiation

- Maximum Time: 25 minutes
- Maximum Air Temperature: 100^{o}C (in lower layer)
- Maximum Radiation: 1kW/m^2

Hazardous Condition

Where firefighters 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^{o}C (in lower layer)
- Maximum Radiation: 3kW/m^2

Extreme Condition

These conditions would be encountered in a snatch rescue situation or a retreat from a flashover

- Maximum Time: < 1 minutes
- Maximum Air Temperature: > 235^{o}C (in lower layer)
- Maximum Radiation: > 10kW/m^2

An FBIM model is to be conducted to demonstrate that a primary search by attending fire crews can be undertaken.

.

APPENDIX D ASSESSMENT METHODOLOGY

TIME LINE ANALYSIS

The aim of a time line analysis is to provide a method for determining if a performance based solution is acceptable and ensures life safety in situation where travel distance, smoke extract and other non-compliance issues exist in a building. The design evaluation depends upon a time based comparison of the time available for occupants to escape before conditions become untenable (Available Safe Egress Time – ASET) and the escape time (Required Safe Egress Time – RSET). The ASET RSET relationship can be seen below.

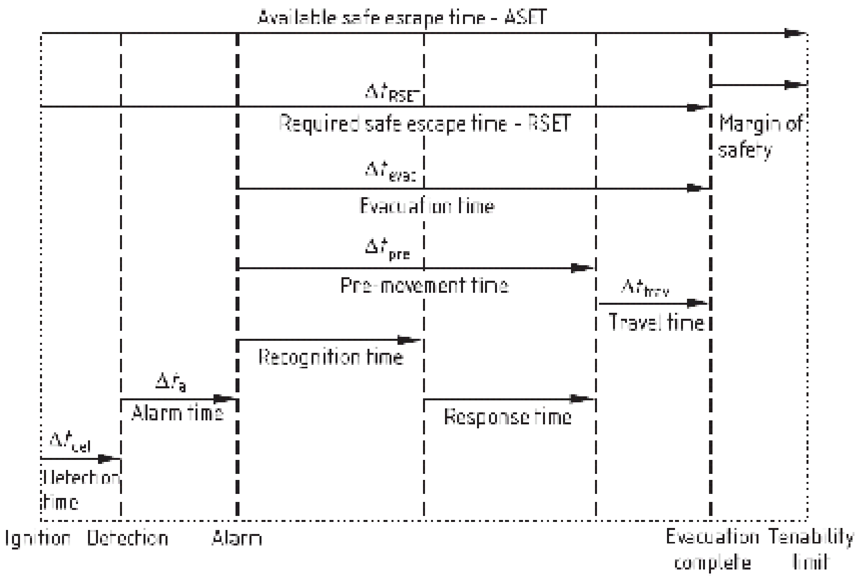


Figure 12-1: ASET – RSET TIME LINE

Available Safe Egress Time

The prediction of the ASET requires the use of fire modelling techniques, in this case computational fluid dynamics software Fire Dynamics Simulator (FDS). The geometry, design fire including the growth curves for major toxic products, smoke and heat must be defined and worst credible fire scenarios developed for modelling. The point at which it is deemed that the conditions within the enclosure have become untenable due to the effects of fire and smoke is called the Tenability Criteria. This criterion is defined in the following sections.

Required Safe Egress Time

The RSET is the time taken for the occupants to escape and depends upon the detection time, types of warning systems and range of other factors related to occupant evacuation behaviour and movement. Broadly speaking this evacuation behaviour can be broken down into two categories; Pre-movement behaviour and Travel behaviour.

The pre-movement behaviour involves the response of occupants before they start to move toward an exit and the time taken to recognise a fire cue. An important finding of behavioural research is that this time is often longer than the travel time. The travel behaviour involves the movement of occupants into and through escape routes taking into account congestion and flow rates through openings as well as typical walking speeds.

Required Safe Egress Time (RSET) = Alarm Time + Pre-Movement Time + Travel Time

Margin of Safety

An important consideration in any timeline analysis is the margin of safety (t_{margin}) and is represented by the difference between the ASET (t_{ASET}) and RSET (t_{RSET}) as shown in the following equation:

$$t_{margin} = t_{ASET} - t_{RSET}$$

APPENDIX E FIRE MODELING DETAILS

FIRE DYNAMICS SIMULATOR

A Computational Fluid Dynamics (CFD) fire model has been produced to determine the ASET. The fire model being used is Fire Dynamics Simulator (FDS). Fire Dynamics Simulator (FDS) is a Computational Fluid Dynamics (CFD) model of fire-driven fluid flow that solves the governing equations of fluid dynamics with a particular emphasis on fire and smoke transport.

The model solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally driven flow with an emphasis on smoke and heat transport from fires. The partial derivatives of the conservation equations of mass, momentum and energy are approximated as finite differences, and the solution is updated in time on a three-dimensional, rectilinear grid. Thermal radiation is computed using a finite volume technique on the same grid as the flow solver. Lagrangian particles are used to simulate smoke movement and sprinkler sprays.

FDS is documented by two publications, the Technical Reference Guide [29] and the FDS User's Guide [30]. The FDS User's Guide describes how to use the model and the Technical Reference Guide describes the underlying physical principles, provides a comparison with some experimental data and discusses the limitations of this model.

Smokeview is a companion program that produces images and animations of the FDS calculations. Smokeview is documented in the Smokeview User's Guide [31].

FDS and Smokeview have been developed and are currently maintained by the Fire Research Division in the Building and Fire Research Laboratory (BFRL) at the National Institute of Standards and Technology (NIST). NIST has developed a public website to distribute FDS and Smokeview and support users of the programs. The website (http://fire.nist.gov/fds/) also includes documents that describe various parts of the model in detail.

MODEL LIMITATIONS

It is used for low speed flow with an emphasis on smoke and heat transport from fires and is not valid for modelling blasts or explosions.

The use of rectilinear geometry although suitable for most buildings may require simplification. Sawtooth function can be used to lessen the effect of this simplification or the use of finer grids.

Prescribed heat release rate provides flow velocities and temperatures within 5 to 20% of experimental results. However, where heat release rate is predicted this uncertainty of the model is higher. This is due to the material properties being not fully known, physical process of combustion, radiation and solid phase heat transfer are more complicated than their mathematical representation in FDS and the results of the calculations are sensitive to numerical and physical parameters. It should be noted that the heat release rate in this analysis were prescribed and not predicted.

FDS uses a mixture fraction model for combustion where the reaction of fuel and oxygen is infinitely fast and is representative of a large scale well ventilated fire. For under-ventilated fires where fuel and oxygen may mix but not burn are complex phenomenon and not within the capability of the current model.

There is no Reynolds-Averaged Navier-Stokes (RANS) capability in the current version of FDS Input Data Files

ASSUMPTIONS

As the FDS model requires high computing power a number of assumptions and simplifications have been made to the model as noted below:

(i) Multiple grid meshes have been used to represent the model in FDS.

(ii) Uniform grids with grid sizes smallest to largest from the mesh with fire plume to remote areas.

(iii) The meshes abut each other such that there is one single computation domain for the FDS analysis.

(iv) Grid cell size generally 250 mm in x, y and z directions near the fire and 500 mm in x, y and z directions in remote areas. The predictions are sensitive to the grid size with smaller grid sizes able to capture more features of the flow.

(v) The heat release rate was prescribed and not predicted by the model. Where sprinklers were modelled, sprinklers did not suppress any fires but controlled fires.

(vi) Reaction type – polyurethane with soot yield of 0.1. The fuel involved in the fire has been modelled as pure polyurethane with regards to production of smoke products.

(vii) Model duration of 30 minutes has been considered.

APPENDIX F EVACUATION MODELLING

Verification and Validation

The pre-movement time data used in this analysis was taken from findings of various studies collated by Proulx [14] in the SFPE Handbook. This data was collected from video records of occupant behaviour in a small number of fire incidents and a significant number of unannounced evacuations in a range of occupancies.

The walking speed of 0.8m/s is based on horizontal travel speeds gathered from a number of different sources. Unimpeded walking speeds are typically quoted as being around 1.2m/s with Pauls [22] quoting 1.25m/s, based on empirical studies in office buildings. Nelson and Mowrer [10] quote 1.19m/s which is derived from the work of Fruin [8], Pauls [22] and Pretechenskii and Milinskii [13]. It should be noted that the walking speed range depends on the type of occupancy and that the very young and old tend to have lower walking speeds as do women compared to men.

Alperts correlations are empirical relationships developed from actual fire tests [reference section of SFPE]. This model assumes that the temperature and velocity of the fire gases at a point away from the source are related to the instantaneous heat release rate of the fire. This assumption neglects the time required for transport of the fire gases from the source to the detector. Also, because the correlations are based on the total heat release rate rather than only the convective heat release rate, errors will be introduced when the convective fraction differs from that in the tests used to develop the correlations.

Calculating Alarm Time

The alarm activation is considered to occur via the provided sprinkler system and via visual detection. As the building is assumed to be fully occupied by occupants during the day, visual detection is considered to occur regardless of detector activation in the area surrounding the point of ignition and in areas more remote, the spread of smoke will provide a reinforcing secondary cue to encourage a faster occupant response to the alarm. Alarm time on the level of fire origin has been considered to be zero where the floor is fully occupied and a number of occupants will be near any possible ignition due to the uniform distribution of occupants. In other floors, alarm time is taken to be the activation time of smoke alarms.

Alpert's correlation calculations [17] are used initially to determine the activation time of the sprinkler system with final determination by FDS modelling results. In both methods the activation time is taken as that of the nearest sprinkler head in the first radial ring around the fire. A sprinkler activation temperature of 101°C and a response time index (RTI) of $50m^{0.5}s^{0.5}$ are to be adopted.

Pre-Movement Time

Pre-movement time typically applies only to areas remote from the room of fire origin where they may receive only a single cue to the presence of a fire and where those cues do not present an immediate threat to their health and safety. An example is where an occupant remote from the fire origin may smell smoke however would be unsure of its origin and may take investigative action or rationalise that it is 'normal'.

In assessing the likely response of the occupants, the issue of pre-movement time must be addressed. In the case of occupants who are awake and in the vicinity of the fire, the decision to evacuate is likely to be a function of the perceived threat associated with the fire. If the fire is not perceived as threatening, then the occupants may decide not to evacuate. However, if the opposite is true, evacuation will begin almost at once. It is assumed that most of the occupants will associate flaming fires and black smoke with a threatening situation. Thus, in undertaking calculations of evacuation, this can be assumed to commence once a threat is perceived.

In the situation where the occupants are intimate with the development of the fire (area of fire origin), it is reasonable to suggest that occupant avoidance will be immediate, as they will be presented with multiple fire cues and would include:

- Visual - smoke and flames
- Tactile - heat radiated and convected from fire
- Audible - sound generated by burning materials
- Olfactory - smell of smoke and other combustion products

The pre-movement time depends primarily upon the design behavioural scenario category and the fire safety management level, with some effect of building complexity. Although, it is possible to make an adequate estimation of evacuation times for most situations by considering two main criteria, the pre-movement times of the first few occupants in an enclosure to move (pre-movement time of the 1st percentile of occupants) and the pre-movement times of the last few occupants to move (99th percentile of occupants). However, data on pre-movement time distributions for different behavioural scenarios are currently limited. Some measured distributions exist with suggested default values for pre-movement time 1st and 99th percentiles for different design behavioural scenarios.

Based on Table 3-13.1 of SFPE Handbook [14], the estimated delay time (pre-movement time) for the proposed building is taken as approximately 180 seconds or 3 minutes after smoke detector activation for occupants distant from the fire location. Where secondary cues exist however, such as significant smoke spread on the occupied floor, this is considered to reinforce the threat indicated by the audible alarm and encourages a more rapid response from occupants. Where both the alarm and smoke are present, the pre-movement time will be reduced to zero. These pre-movement times will be used for pre-movement calculations in the evacuation modelling.

Occupant Travel Times

The performance-based approach suggests the use of a hydraulic or effective width method to calculate travel times in a building. These times then are adjusted using efficiency factors to reflect the characteristics of the occupancy. With this approach standard travel speeds and occupant densities are used in calculations.

An alternative method to that is to reflect the occupancy characteristics in the movement modelling by using travel speeds and occupant densities, which are reflective of the particular occupancy being modelled. This approach avoids the need for further time adjustments.

APPENDIX G ALPERTS CORRELATION

Input data required

The ambient temperature of the room, T_∞ =	20	(°C)
Fire Category =	Fast	
Output time step =	20	(s)
The distance of the detector from the fire, r =	2.5	(m)
The height of the ceiling above the fire, H =	13	(m)
The Response Time Index of the detector, RTI =	50	($m^{1/2}s^{1/2}$)
Sprinkler density of discharge =	5	mm / min
Detector activation temperature =	101	(°C)

Fire Type:	α =
Ultrafast	0.178
Fast	0.044
Medium	0.011
Slow	0.003
Custom	0.02

Calculated quantities at detector activation

The gas temperature at sprinkler activation, T =	106.14	(°C)
HRR at sprinkler activation =	7507.60	(kW)
The gas velocity, U =	6.42	(m/s)
Time at detector activation =	412	(s)
Time to reach 10% of peak HRR =	0	(s)
Ratio, r / H =	0.19	

Time (s)	Heat Release Rate (kW)	Gas Temperature (°C)	The gas velocity (m/s)	Detector temperature, (°C)	Sprinkler controlled HRR
0	0.00	20.00	0.00	20.00	0.00
20	17.78	21.53	0.86	20.21	17.78
40	71.11	23.86	1.36	21.12	71.11
60	160.00	26.62	1.78	22.84	160.00
80	284.44	29.72	2.15	25.25	284.44
100	444.44	33.08	2.50	28.22	444.44
120	640.00	36.69	2.82	31.59	640.00
140	871.11	40.49	3.13	35.29	871.11
160	1137.78	44.49	3.42	39.23	1137.78
180	1440.00	48.65	3.70	43.37	1440.00
200	1777.78	52.97	3.97	47.68	1777.78
220	2151.11	57.44	4.23	52.15	2151.11
240	2560.00	62.05	4.48	56.76	2560.00
260	3004.44	66.78	4.73	61.50	3004.44
280	3484.44	71.64	4.97	66.37	3484.44
300	4000.00	76.61	5.20	71.35	4000.00
320	4551.11	81.70	5.43	76.44	4551.11

APPENDIX H WS TYCO DRENCHERING SYSTEM

tyco / Fire & Building Products

Technical Services: Tel: (800) 381-9312 / Fax: (800) 791-5500

Model WS™ — 5.6 K-factor Specific Application Window Sprinklers, Horizontal and Pendent Vertical Sidewall

General Description

The Model WS, 5.6 K-factor, Horizontal Sidewall and Pendent Vertical Sidewall, Specific Application Window Sprinklers are fast response, glass bulb type spray sprinklers.

These sprinklers are the first sprinklers ever to be specifically Listed to provide protection for heat strengthened or tempered glass windows using closed sprinklers. As part of the testing, the gas flow required to achieve the time/temperature relationship specified in ASTM E119 was established in a test furnace without sprinkler protection. A window assembly protected with Model WS Specific Application Window Sprinklers was then installed in the test furnace and the same gas flow conditions were maintained for a two hour test period. No cracking or visible damage to the window was permitted during the test period (even when a hose stream was directed at the window).

The success of the Model WS Specific Application Window Sprinkler is based on its specially designed deflector that ensures that the spray pattern wets the entire surface of the window, and its fast response thermal sensitivity.

Based on this successful testing, the Model WS Specific Application Window Sprinkler can be used as interior protection of windows or glazing in a sprinklered building or non-sprinklered building. Also, the Model WS Specific Application Window Sprinkler can be used as a open sprinkler for "Outside Sprinkler Protection against Exposure Fire", using the design requirements of NFPA.

As with any specific application sprinkler, the installation instructions included in this data sheet must be precisely followed. ICC Evaluation Service, Underwriters Laboratories of Canada (ULC), or Building Materials Evaluation Commission (BMEC) guidelines apply, consult the specific approval report.

WARNING

The Model WS Specific Application Window Sprinklers described herein must be installed and maintained in compliance with this document, as well as with the applicable standards of the National Fire Protection Association, in addition to the standards of any other authorities having jurisdiction. ***Failure to do so may impair the performance of these devices.***

The owner is responsible for maintaining their fire protection system and devices in proper operating condition. The installing contractor or manufacturer should be contacted with any questions.

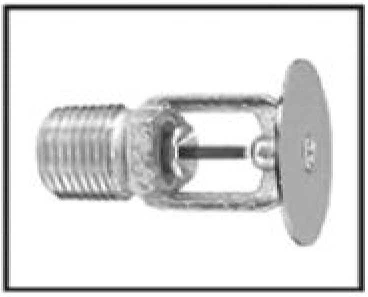
IMPORTANT

Always refer to Technical Data Sheet TFP700 for the "INSTALLER WARNING" that provides cautions with respect to handling and installation of sprinkler systems and components. Improper handling and installation can permanently damage a sprinkler system or its components and cause the sprinkler to fail to operate in a fire situation or cause it to operate prematurely.

Sprinkler Identification Number

TY3388 - Horizontal Sidewall
TY3488 - Pendent Vertical Sidewall

TY3388 is a redesignation for C3388.
TY3488 is a redesignation for C3488.



Page 1 of 8 JULY, 2005 TFP620

Technical Data

Approvals
UL, C-UL, and ULC Listed.
NYC under MEA 289-04-E.
(The approvals only apply to the service conditions indicated in the Design Criteria section.)

Additional Recognition
- ICC Evaluation Service (ICC-ES Legacy Report NER-516)
- Building Materials Evaluation Commission (BMEC 01-11-263)

Pipe Thread Connection
1/2 inch NPT

Discharge Coefficient
K = 5.6 $GPM/psi^{1/2}$
(80,6 $LPM/bar^{1/2}$)

Temperature Rating
155°F/68°C & 200°F/93°C

Finish
Polyester Coated, Chrome Plated, or Natural Brass

Physical Characteristics
Frame . . . . Brass
Button . . . . Bronze/Copper
Sealing Assembly . . . . Beryllium Nickel w/Teflon†
Bulb . . . . Glass (3 mm dia.)
Compression Screw . . . . . . Brass
Deflector . . . . Brass/Bronze
† DuPont Registered Trademark

The glass bulb contains a fluid that expands when exposed to heat. When the rated temperature is reached, the fluid expands sufficiently to shatter the glass bulb, allowing the sprinkler to activate and water to flow.

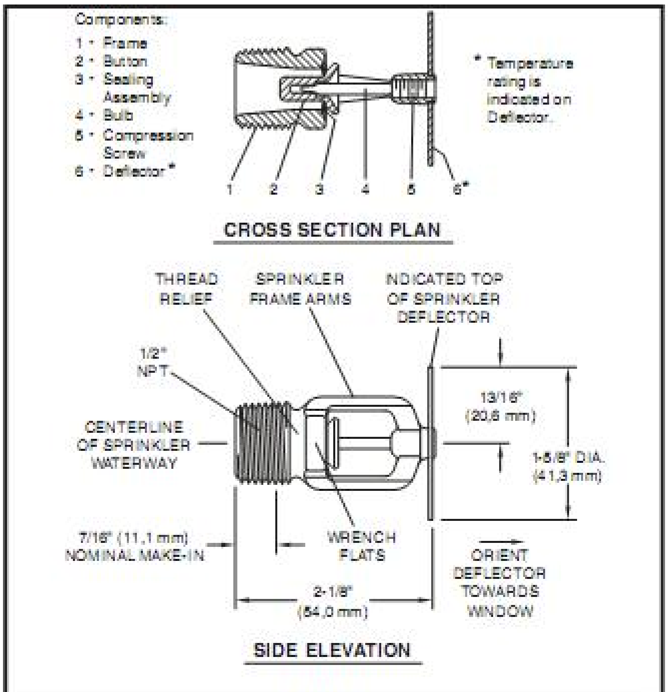


FIGURE 1
MODEL WS, HORIZONTAL SIDEWALL
SPECIFIC APPLICATION WINDOW SPRINKLER

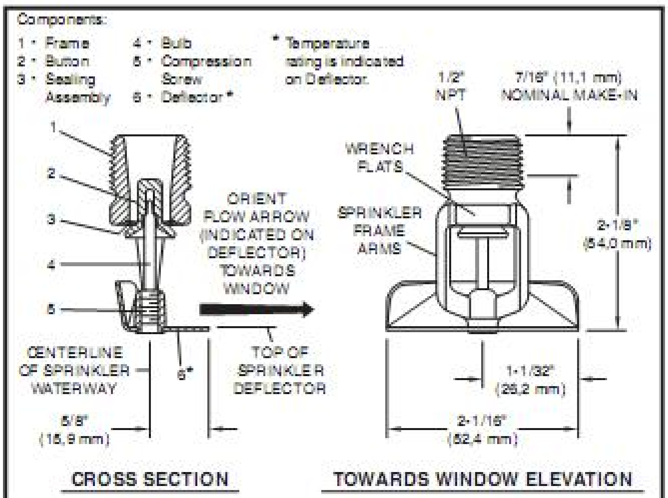


FIGURE 2
MODEL WS, VERTICAL PENDENT SIDEWALL
SPECIFIC APPLICATION WINDOW SPRINKLER

Design Criteria

The Model WS Window Sprinklers are listed by UL and C-UL, and NYC Approved (MEA 335-01-E) for use as a "Specific Application Window Sprinkler" and as open sprinklers for "Outside" use. These sprinklers are also recognized by the International Code Council Evaluation Service, Underwriters Laboratories of Canada (ULC), and the Building Materials Evaluation Commission (BMEC) for use in the Province of Ontario, Canada as providing a two-hour equivalency for a fire separation assembly, when installed in accordance with the NES Report (NER 516), ULC/ORD-C263.1 Appendix A, and BMEC Report (01-11-263).

NOTE

NER 516 can be obtained at www.icc-es.org. ULC/ORD-C263.1 Appendix A and BMEC 01-11-263 may be obtained by contacting Technical Services.

Area Of Use:

When acceptable to the Authority Having Jurisdiction and unless modified by one of the reports mentioned above, the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are part of a fire separation provided:

a) in an interior fire separatèn, the window sprinklers are installed on both sides of the window in the fire separation. (Ref. Figure 3A-1),

b) in jurisdictèns where exterior spatial separation (i.e., separation from adjacent space) is defined as protecting an adjacent building from a fire in your building, window sprinklers are installed on the interior side of the building (Ref. Figure 3A-2), or

c) in jurisdictions where exterior spatial separatèn is defined as protecting your building from a fire in an adjacent building (i.e., exposure protection), open window sprinklers are installed on the exterior side of the building (Ref. Figure 3A-3).

System Type:

Interior Protection - Wet Systems.

Outside Exposure Protection - Deluge.

Glass Type:

Non-opererable, heat-strengthened, tempered, single-glazed (single pane); non-opererable, heat-strengthened, tempered, double-glazed (double pane or insulated); or, non-opererable, stronger glass window assemblies. In all three cases, each individual pane of the window assembly is to be minimum 6 mm (1/4") thick.

Type of Window Frame/Mullion:

Noncombustible Frame with a standard EPDM rubber gasket seal. Vertical joints of glass panes must be connected by butt-joints sealed with a silicone sealant between the individual panes or by Noncombustible Mullions (Ref. Figure 3B-1 & 3B-2).

Maximum Length Of Window Assembly:

Unlimited.

Maximum Height Of Window Assembly:

13' (3,96 m) (Ref. Figure 3C & 3D).

Maximum Distance Between Window Sprinklers:

8' (2,44 m) (Ref. Figure 3B-1 & 3B-2).

Minimum Distance Between Window Sprinklers:

6' (1,83 m) (Ref. Figure 3B-1 & 3B-2), unless separated by a baffle or mullion of sufficient depth to act as a baffle. (A mullion will act as a baffle, when in the case of the Pendent Vertical Sidewall, the mullion extends to the back of the sprinkler deflector, and in the case of the Horizontal Sidewall, the mullion extends to the sprinkler wrench flat.)

Minimum Distance From Standard Sprinklers:

6' (1,83 m) unless separated by a baffle.

Sprinkler Location:

Mullioned Glazing Assemblies - Locate window sprinklers within each mullioned glazing segment (Ref. Figure 3B-1).

Butt Jointed Glazing Assemblies - Locate window sprinklers on maximum 8' (2,44 m) centers (Ref. Figure 3-B-2).

Maximum Distance From Vertical Mullion:

4' (1,22 m) (Ref. Figure 3B-1).

Minimum Distance From Vertical Mullions:

4" (101,6 mm) (Ref. Figure 3B-1).

Intermediate Horizontal Mullions:

Intermediate Horizontal Mullions were not tested with the window sprinkler. Their use is outside the scope of the "Specific Application" Listing for the window sprinklers (Ref. Figure 3B-3).

Deflector Location:

Sprinkler Deflectors must be located as described below in order to ensure that the entire surface of the glass window is covered. Sprinkler Deflectors are positioned with respect to the window frame, not the ceiling.

Horizontal Sidewall - Locate within the outside edge of the window frame from 1/2" to 4" (12,7 mm to 101,6 mm) away from the glass and 2" ± 1" (50,8 mm ± 25,4 mm) down from the top of exposed glass (Ref. Figure 3C).

Pendent Vertical Sidewall - Locate 4" to 12" (101,6 mm to 304,8 mm) from the face of the glass and 3" ± 1" (76,2 mm ± 25,4 mm) down from the top of exposed glass (Ref. Figure 3D).

Minimum Clearance From Face Of Glass To Combustible Materials:

All combustible materials shall be kept 2" (50,8 mm) from the front face of the glass. This can be accomplished by a minimum 36" (914,4 mm) pony wall or other method acceptable to the Authority Having Jurisdiction.

Escutcheon Assemblies:

The window sprinklers can be used with any metallic flush or extended escutcheon, provided the dimensions from the sprinkler deflector to the window frame and glass surface as specified in this data sheet are maintained. These sprinklers are not listed for recessed applications.

Recommended Hydraulic Requirements:

The Authority Having Jurisdiction should be consulted to determine the hydraulic requirements for each installation.

Interior Protection Sprinklered Building - Identify which compartmented area has the most hydraulically demanding window sprinklers. Calculate all of the sprinklers within a compartmented area or the number of window sprinklers required to cover a combined linear length of glass equal to 1.2 x the square root of the system area of operation, whichever is greater. For example if the building design area is 1500 ft^2 then 1.2 x $(1500\ ft^2)^{1/2}$ = 46.5 linear feet of glass or 1.2 x $(139\ m^2)^{1/2}$ = 14,2 linear meters of glass. Add the window sprinkler demand to your most demanding hydraulic design area.

Interior Protection Non-Sprinklered - Calculate all the sprinklers on the most demanding side of the glazing assembly within the enclosure.

Exterior Exposure Protection - Calculate all sprinklers controlled by the deluge valve using the design requirements of NFPA.

Duration Of Water Supply:

The duration of the water supply must comply with the requirements of NFPA. In the event the window sprinklers are being used to provide the equivalency of a fire rating, the water supply must be capable of supplying water for the required rating period.

Minimum Flow Per Sprinkler:

20 GPM (75,7 LPM) for sprinkler spacing of 6 to 8 ft. (1,83 to 2,44 m) or 15 GPM (56,8 mLPM) for sprinkler spacing less than 6 ft, (1,83 m).

Maximum Pressure Per Sprinkler:

Horizontal Sidewall = 70* psi (4,83 bar).

Vertical Sidewall = 175 psi (12,07 bar).

*The 70 psi is only for cold solder purposes. If there is a baffle or mullion of sufficent depth to act as a baffle, separating the sprinklers, the maximum pressure is 175 psi.

Installation

The Model WS Specific Application Window Sprinklers must be installed in accordance with the following instructions:

NOTES

Do not install any bulb type sprinkler if the bulb is cracked or there is a loss of liquid from the bulb. With the sprinkler held horizontally, a small air bubble should be present. The diameter of the air bubble is approximately 1/16 inch (1,6 mm).

A leak tight 1/2 inch NPT sprinkler joint should be obtained with a torque of 7 to 14 ft.lbs. (9,5 to 19,0 Nm). A maximum of 20 ft.lbs. (28,5 Nm) of torque is to be used to install sprinklers. Higher levels of torque may distort the sprinkler inlet with consequent leakage or impairment of the sprinkler.

Step 1. The pendent vertical sidewall sprinkler must be installed only in the pendent position with the centerline of the sprinkler parallel to the glass surface. The sprinkler must be orientated so that the direction of flow indicated on the sprinkler deflector is facing the window. The horizontal sidewall sprinkler must be installed only in the horizontal position with the centerline of the sprinkler perpendicular to the glass surface. The sprinkler must be orientated so that the word "Top" indicated on the sprinkler deflector is facing the top of window frame.

Step 2. With pipe thread sealant applied to the pipe threads, hand tighten the sprinkler into the sprinkler fitting.

Step 3. Wrench tighten the Sprinkler using only the W-Type 20 (End A) Sprinkler Wrench (Ref. Figure 4). The W-Type 20 (End A) Sprinkler Wrench is to be applied to the Sprinkler Wrench flats only.

When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are in an interior fire separation, the window sprinklers are installed on both sides of the window in the fire separation.

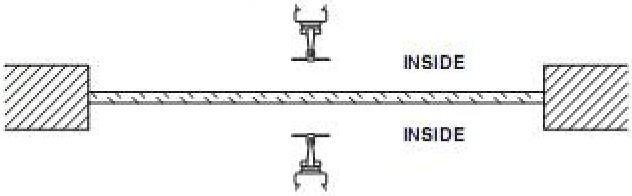


FIGURE 3A-1 — INTERIOR FIRE SEPARATION

When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are part of a fire separation provided in jurisdictions where exterior spatial separation is defined as protecting an adjacent building from a fire in your building, window sprinklers are installed on the interior side of the glass.

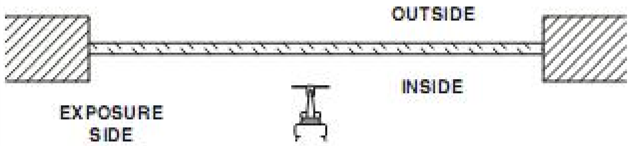


FIGURE 3A-2 — EXTERIOR FIRE SEPARATION — SPRINKLERS INSIDE

When acceptable to the Authority Having Jurisdiction the Model WS Specific Application Window Sprinklers may be used in either a sprinklered or unsprinklered building to protect nonoperable window openings that are part of a fire separation provided in jurisdictions where exterior spatial separation is defined as protecting your building from a fire in an adjacent building, open window sprinklers are installed on the exterior side of the glass.

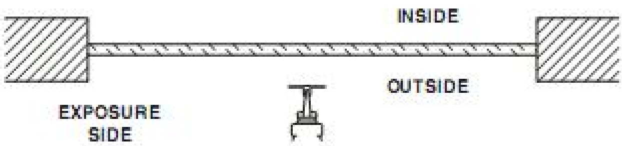
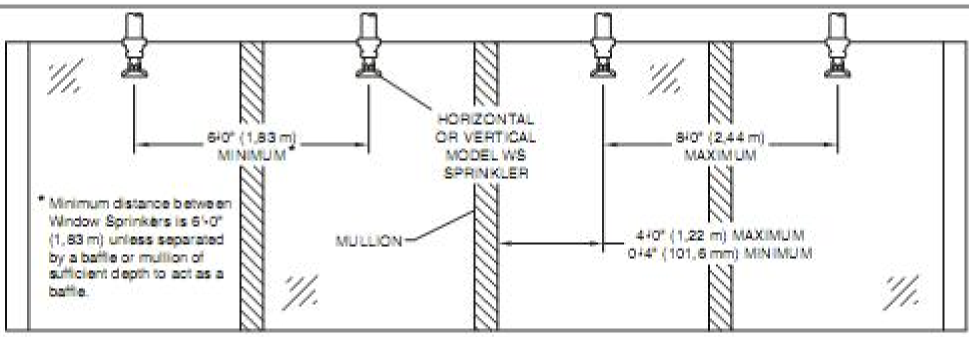


FIGURE 3A-3 — EXTERIOR FIRE SEPARATION — SPRINKLERS OUTSIDE

FIGURE 3A
TYPICAL NONOPERABLE WINDOW OPENINGS



A Window Sprinkler must be provided at each window glazing segment, regardless of width of segment. If segment is less than 6'-0", a baffle or mullion to act as a baffle must be provided.

FIGURE 3B-1 — MULTIPLE WINDOWS SEPARATED BY MULLIONS

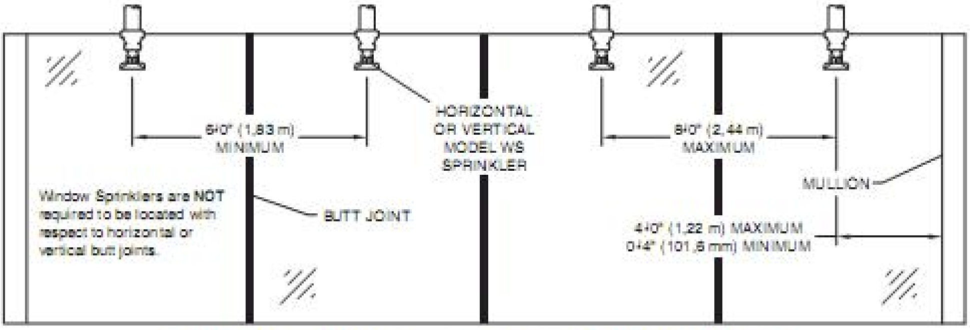


FIGURE 3B-2 — MULTIPLE WINDOWS SEPARATED BY BUTT JOINTS

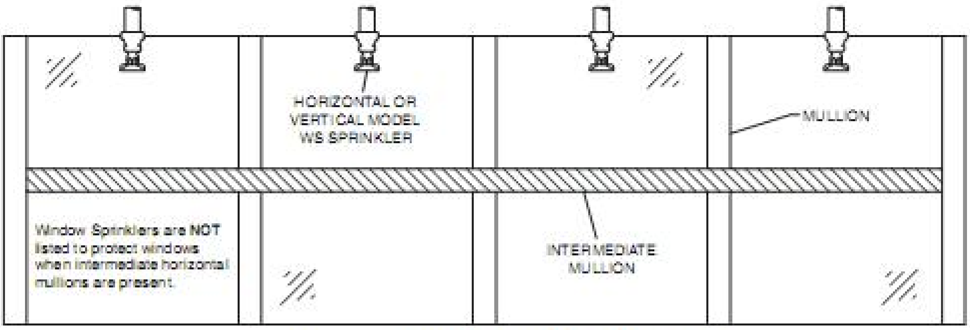


Figure 3B-3 — WINDOWS WITH HORIZONTAL MULLIONS

FIGURE 3B
WINDOW MULLIONS AND BUTT JOINTS

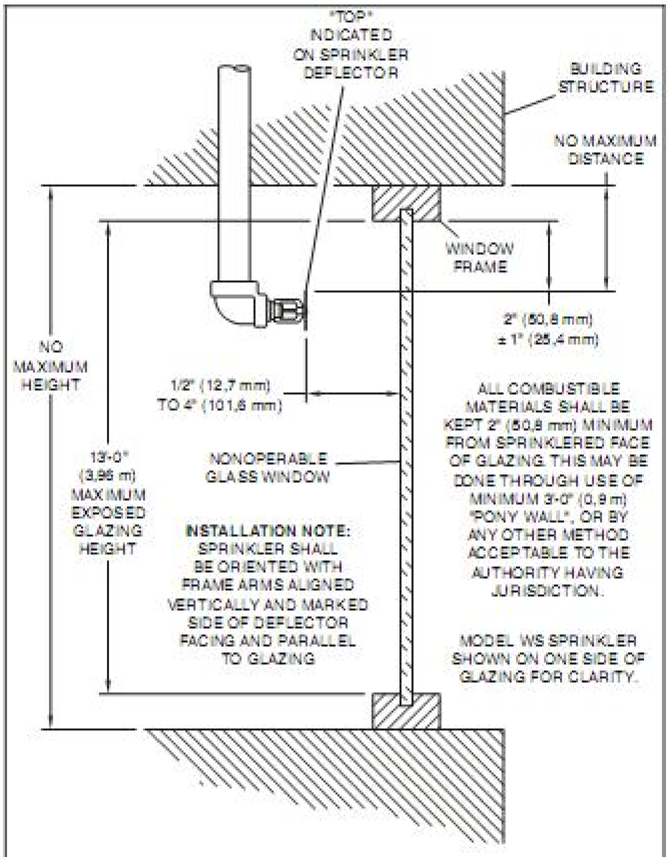


FIGURE 3C
MODEL WS HORIZONTAL SIDEWALL SPRINKLER TYPICAL INSTALLATION

Care and Maintenance

The Model WS Specific Application Window Sprinklers must be maintained and serviced in accordance with the following instructions:

NOTE

Before closing a fire protection system main control valve for maintenance work on the fire protection system that it controls, permission to shut down the affected fire protection systems must be obtained from the proper authorities and all personnel who may be affected by this action must be notified.

Sprinklers that are found to be leaking or exhibiting visible signs of corrosion must be replaced.

Automatic sprinklers must never be painted, plated, coated, or otherwise altered after leaving the factory. Modified sprinklers must be replaced. Sprinklers that have been exposed to corrosive products of combustion, but have not operated, should be replaced if they cannot be completely cleaned by wiping the sprinkler with a cloth or by brushing it with a soft bristle brush.

Care must be exercised to avoid damage to the sprinklers - before, during, and after installation. Sprinklers damaged by dropping, striking, wrench twist/slippage, or the like, must be replaced. Also, replace any sprinkler that has a cracked bulb or that has lost liquid from its bulb. (Ref. Installation Section).

The owner is responsible for the inspection, testing, and maintenance of their fire protection system and devices in compliance with this document, as well as with the applicable standards of the National Fire Protection Association (e.g., NFPA 25), in addition to the standards of any other authorities having jurisdiction. The installing contractor or sprinkler manufacturer should be contacted relative to any questions.

It is recommended that automatic sprinkler systems be inspected, tested, and maintained by a qualified Inspection Service in accordance with local requirements and/or national codes.

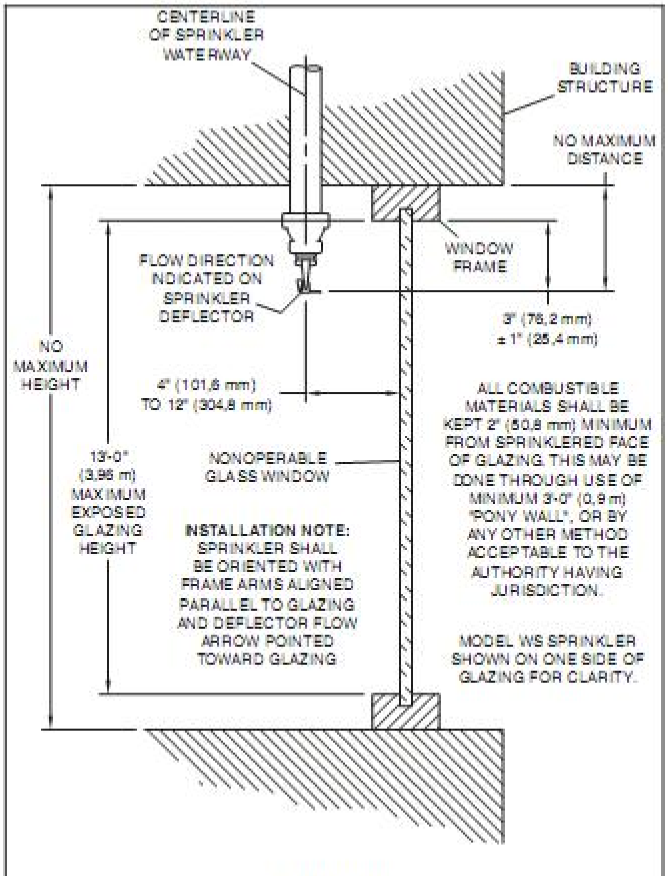


FIGURE 3D
MODEL WS VERTICAL PENDENT SIDEWALL SPRINKLER TYPICAL INSTALLATION

Limited Warranty

Products manufactured by Tyco Fire & Building Products are warranted solely to the original Buyer for ten (10) years against defects in material and workmanship when paid for and properly installed and maintained under normal use and service. This warranty will expire ten (10) years from date of shipment by Tyco Fire & Building Products. No warranty is given for products or components manufactured by companies not affiliated by ownership with Tyco Fire & Building Products or for products and components which have been subject to misuse, improper installation, corrosion, or which have not been installed, maintained, modified or repaired in accordance with applicable Standards of the National Fire Protection Association, and/or the standards of any other Authorities Having Jurisdiction. Materials found by Tyco Fire & Building Products to be defective shall be either repaired or replaced, at Tyco Fire & Building Products' sole option. Tyco Fire & Building Products neither assumes, nor authorizes any person to assume for it, any other obligation in connection with the sale of products or parts of products. Tyco Fire & Building Products shall not be responsible for sprinkler system design errors or inaccurate or incomplete information supplied by Buyer or Buyer's representatives.

IN NO EVENT SHALL TYCO FIRE & BUILDING PRODUCTS BE LIABLE, IN CONTRACT, TORT, STRICT LIABILITY OR UNDER ANY OTHER LEGAL THEORY, FOR INCIDENTAL, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO LABOR CHARGES, REGARDLESS OF WHETHER TYCO FIRE & BUILDING PRODUCTS WAS INFORMED ABOUT THE POSSIBILITY OF SUCH DAMAGES, AND IN NO EVENT SHALL TYCO FIRE & BUILDING PRODUCTS' LIABILITY EXCEED AN AMOUNT EQUAL TO THE SALES PRICE.

THE FOREGOING WARRANTY IS MADE IN LIEU OF ANY AND ALL OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

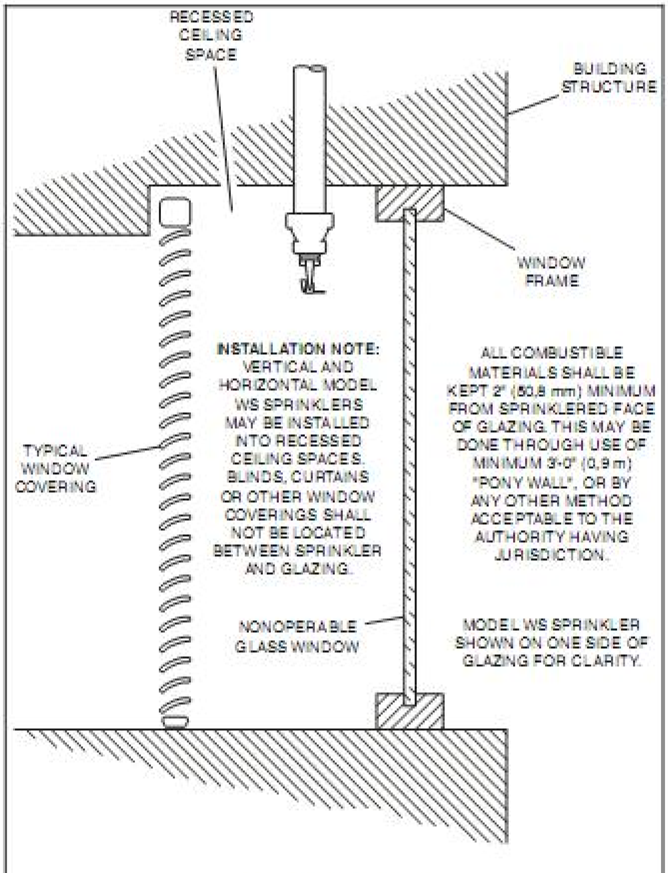


FIGURE 3E
MODEL WS VERTICAL PENDENT SIDEWALL SPRINKLER RECESSED CEILING TYPICAL INSTALLATION

FIGURE 4
W-TYPE 20 SPRINKLER WRENCH

Ordering Procedure

Contact your local distributor for availability.

Sprinkler Assemblies with NPT Thread Connections:
Specify: Model WS, (Specify SIN), (specify Horizontal or Vertical Pendent) Specific Application Window Sprinkler, with (specify temperature rating), (specify finish), P/N (specify).

WS (TY3388) Horizontal Sidewall Window Sprinkler

155°F/68°C, Natural Brass . . . . P/N 50-305-1-155
155°F/68°C, Chrome Plated . . . . P/N 50-305-9-155
155°F/68°C, White Coated . . . . P/N 50-305-4-155
155°F/68°C, White RAL9010* . . . . P/N 50-305-3-155

200°F/93°C, Natural Brass . . . . P/N 50-305-1-200
200°F/93°C, Chrome Plated . . . . P/N 50-305-9-200
200°F/93°C, White Coated . . . . P/N 50-305-4-200
200°F/93°C, White RAL9010* . . . . P/N 50-305-3-200

WS (TY3488) Vertical Pendent Sidewall Window Sprinkler

155°F/68°C, Natural Brass . . . . P/N 50-304-1-155
155°F/68°C, Chrome Plated . . . . P/N 50-304-9-155
155°F/68°C, White Coated . . . . P/N 50-304-4-155
155°F/68°C, White RAL9010* . . . . P/N 50-304-3-155

200°F/93°C, Natural Brass . . . . P/N 50-304-1-200
200°F/93°C, Chrome Plated . . . . P/N 50-304-9-200
200°F/93°C, White Coated . . . . P/N 50-304-4-200
200°F/93°C, White RAL9010* . . . . P/N 50-304-3-200

*Eastern Hemisphere sales only.

Sprinkler Wrench:
Specify: W-Type 20 Sprinkler Wrench, P/N 56-000-1-106.

APPENDIX I CORRESPONDANCE FROM NSWFB

Alan Caulfield

Subject: FW: FW: NSWFB Access

From: Benjamin HughesBrown [mailto:Benjamin.HughesBrown@fire.nsw.gov.au]
Sent: Tuesday, 2 March 2010 6:04 PM
To: Sandro Razzi
Subject: Re: FW: NSWFB Access

Sandro,

Following discussion with Inspector Peter Nugent and Senior Firefighter George Baldock, the NSWFB provides in-principle support for the continuous 4m vehicular access around the building without the requirement of the 6m points every 50m.

This is conditional on further review of the building through the standard FEB and Clause 144 submission and when placed into context with other compliance issues as well as confirmation that continuous forward motion and appropriate turning capacity for fire brigade vehicles around the building is provided.

Regards,

Benjamin Hughes-Brown
MIFireE, MIEAUST, CPEng, NPER
Senior Engineer
Structural Fire Safety Unit
NSW Fire Brigades

Phone: (02) 9742 7400
Mobile: 0402 433 236
Fax: (02) 9742 7483
Email: benjamin.hughesbrown@fire.nsw.gov.au

>>> "Sandro Razzi" <srazzi@rawfire.com.au> 1/03/2010 4:08 pm >>>
Hi Ben,

Can I get a comment on this proposal please. Self explanatory but please call me should you wish to discuss. I see it conforms with Guideline 4 but would like your support before I go back to my client.

Thanks in advance,

Sandro Razzi | Director
Mobile :: 0412 389 484 Email :: srazzi@rawfire.com.au

Level 7, 191 Clarence Street Sydney NSW 2000
Tel 02 9299 6605 Fax 02 9299 6615
www.rawfire.com.au

1

APPENDIX J KEY DRAWINGS

Figure 12-2: Site Plan – Stage 1

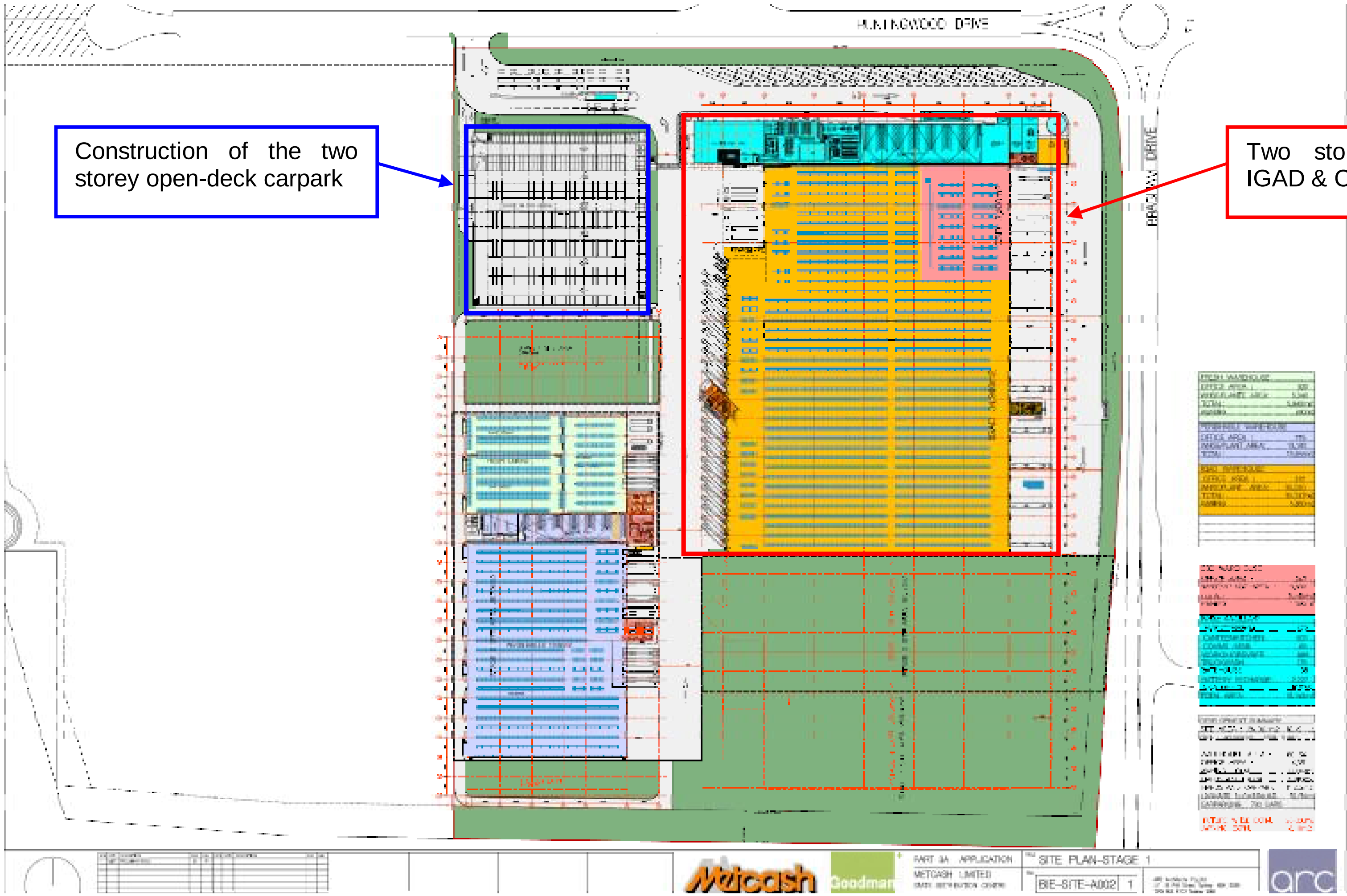


Figure 12-3: Site Plan – Stage 2

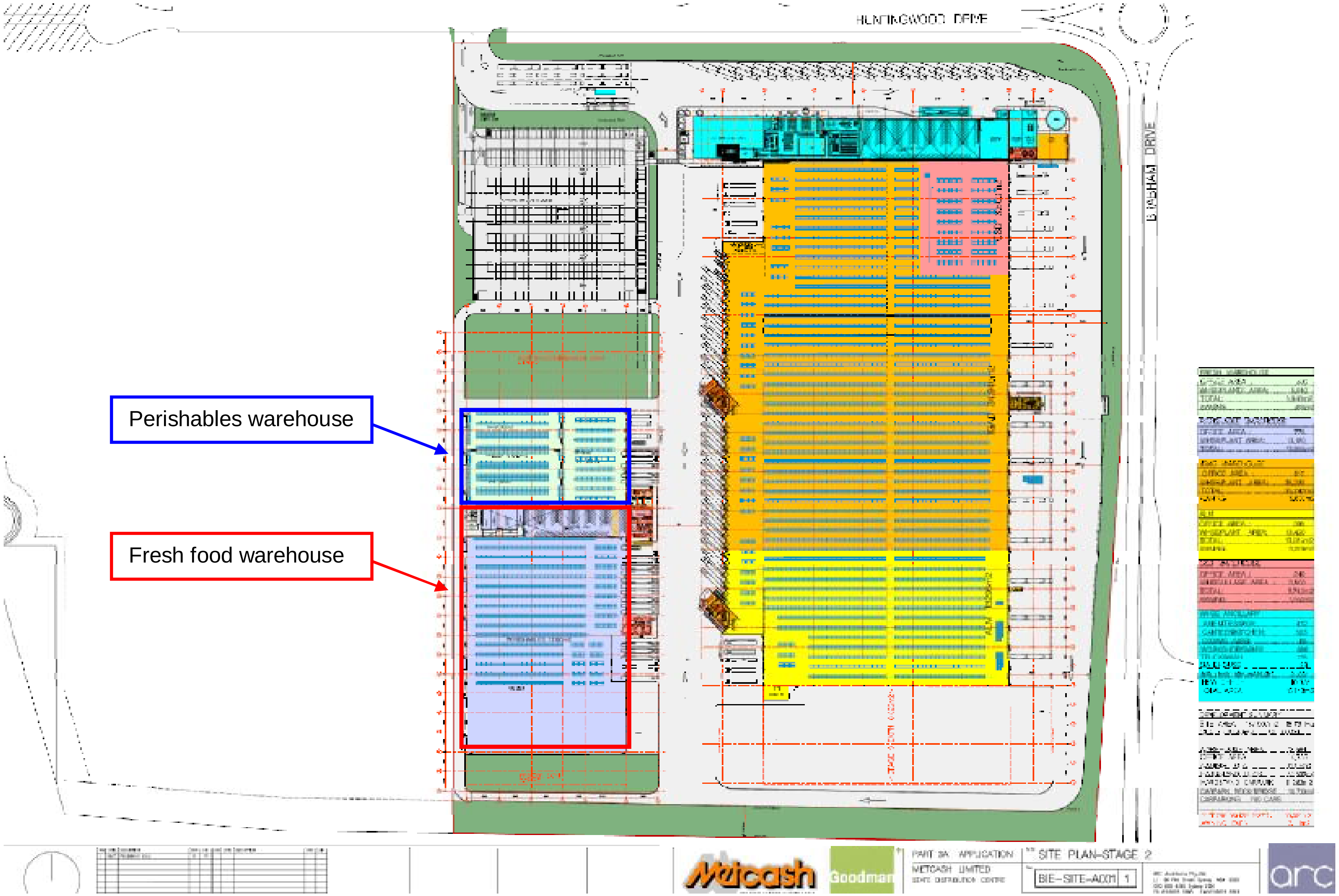


Figure 12-4: Site Plan – Stage 3

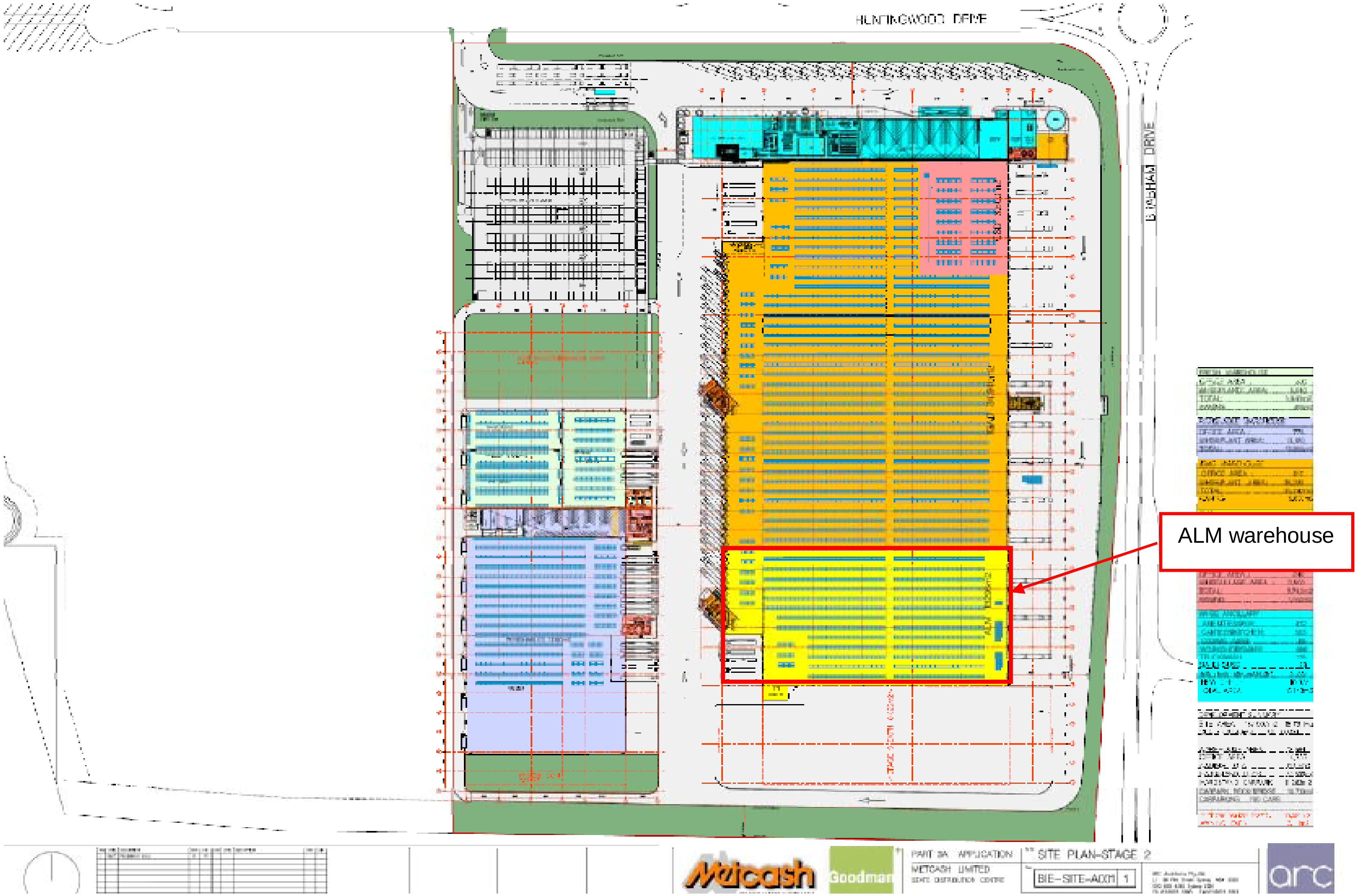


Figure 12-5: Site Plan – Stage 4a

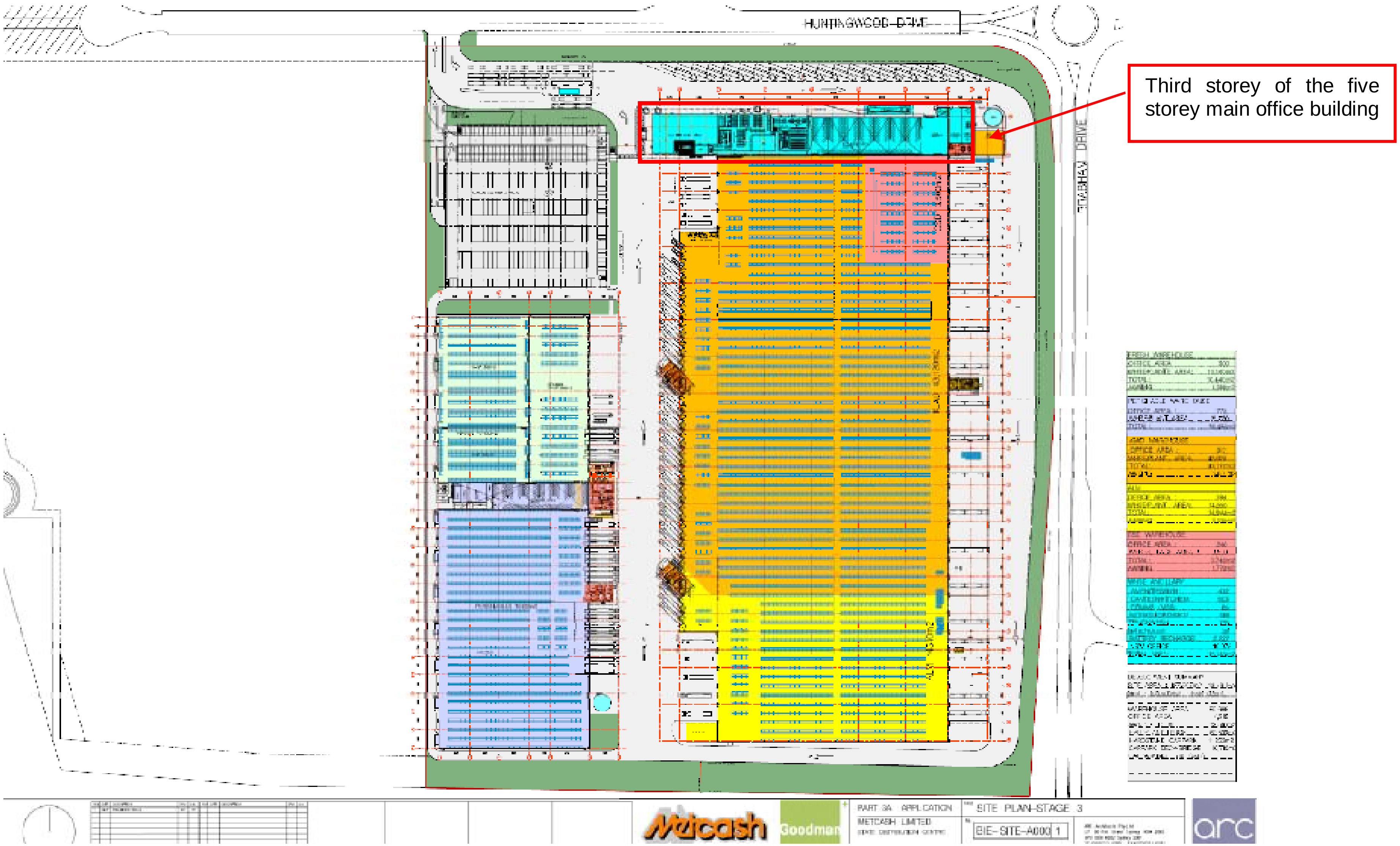


Figure 12-6: Site Plan – Stage 4b

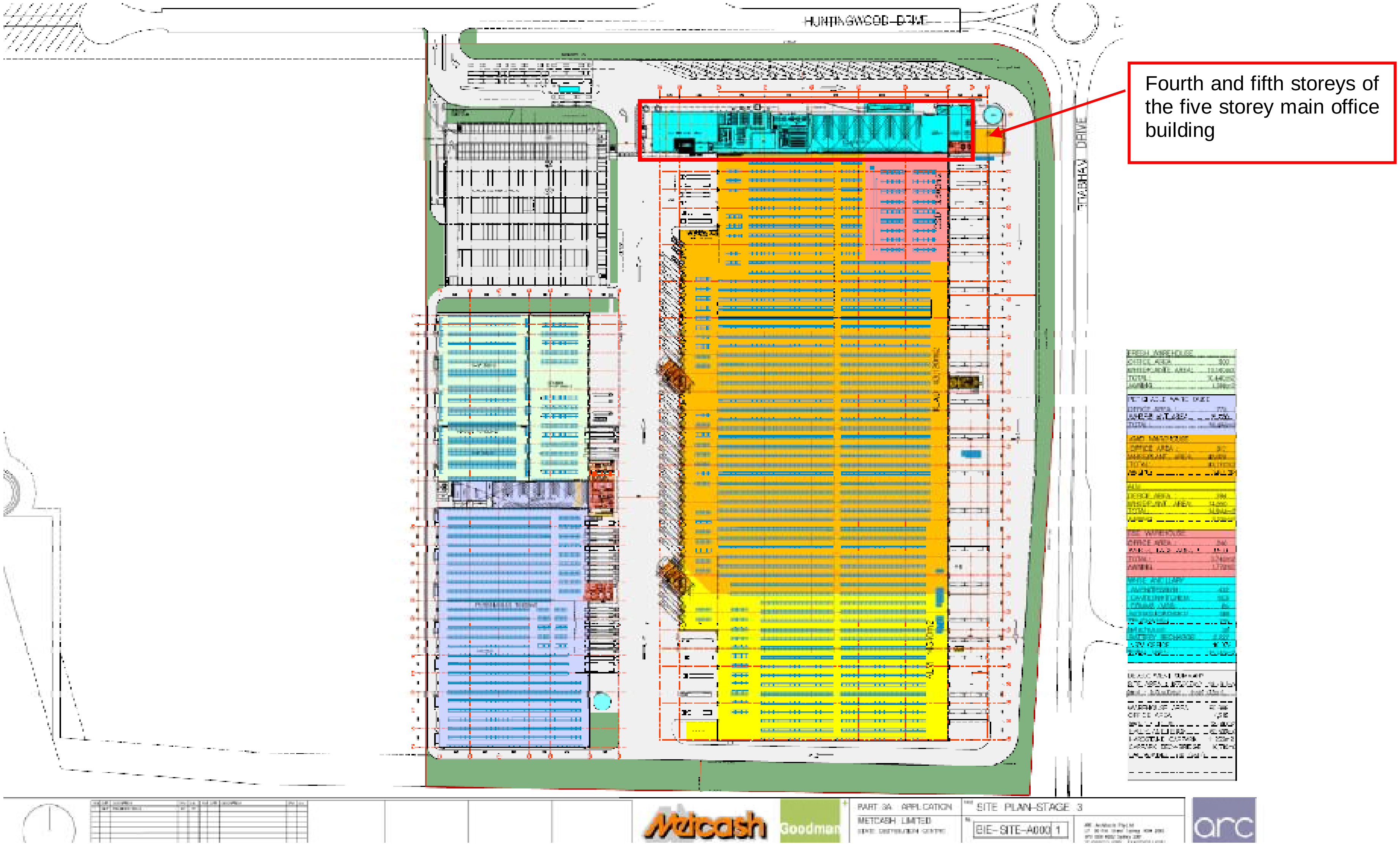


Figure 12-7: Site Plan – Stage 5