Project Mustang
Metcash Distribution Centre
Bungarribee Industrial Estate
Huntingwood NSW

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Fire Safety Strategy
Project Mustang
Metcash Distribution Centre

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Report Details

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Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY
01	17/10/2012	Draft Issue for Comment	**Thomas Newton** *Adv. Dip. Mechanical Engineering*	**Trent De Maria** *Grad Cert Performance Based Bdg & Fire Codes, Grad Dip Building Fire Safety & Risk Engineering*
02	23/10/2012	Final Issue		
03	05/11/2012	Final Issue: Revision 01		
04	21/11/2012	Final Issue: Revision 02		

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1 INTRODUCTION

1.1 OVERVIEW

This Fire Safety Strategy 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.

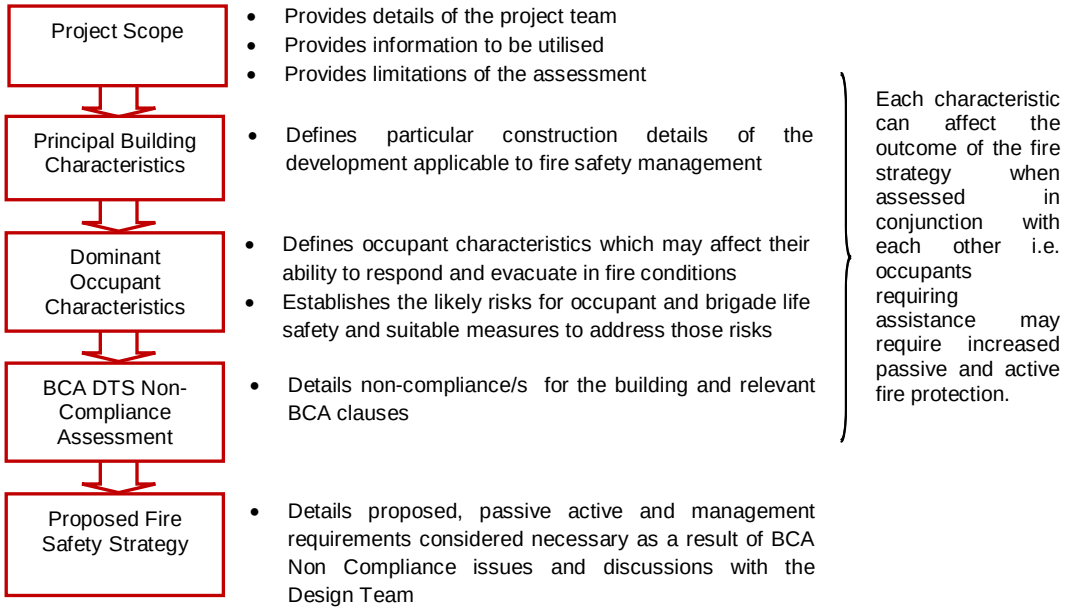


Figure 1-1: Fire Safety Strategy Process

The scope of the Fire Safety Strategy 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 are to protect life, property and the environment from fire according to the Fire Brigade Intervention Model (FBIM) [5] 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.
- **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 Alternate Solution complies with the Performance Requirements. These methods are summarised as follows:

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

(e) 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.

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

(g) 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:

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

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

(iii) 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 Safety Strategy.

2 PROJECT SCOPE

2.1 PROJECT SCOPE

RAWFire Safety Engineering has been engaged to undertake a fire safety review of the extension and refurbishment to the warehouse and distribution facility located in the Bungarribee Industrial Estate, Huntingwood in NSW.

The existing site contains three (3) large storage and dispatch facilities with ancillary office areas and multi-storey carpark for use by Metcash Trading Limited. The new works include an extension of approximately 9,285m^2 of additional floor area at the southern end of Warehouse 1 where a fully automated picking, packing and storage module shall be constructed.

The purpose of this fire safety review is to outline the fire engineering principles that will be utilised in ensuring that the non-compliances with the DTS provisions of the BCA are resolved in order to conform to the building regulations. The complete fire engineered analysis will be completed in the Fire Engineering Report, and as such is not documented herein. This Fire Safety Strategy outlines the construction and management requirements considered necessary to achieve an acceptable level of life safety within the building and satisfy the Performance Requirements of the BCA.

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
Project Manager	Khalid Hourani	Goodman
Principal Certifying Authority	Dean Goldsmith	Blackett Maguire + Goldsmith
Fire Services Consultant	Stephen Trevor	Flame Safe
Architect	Brian Woodmansey	Giles Tribe
Fire Safety Consultant(s)	Thomas Newton Trent De Maria	RAWFire Safety Engineering
Fire Safety Engineers	Sandro Razzi	

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, 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 clients' 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:

- Building BCA compliance assessment produced by Dean Goldsmith of Blackett Maguire + Goldsmith. Report No: 120462, dated 15th November 2012, Revision 1.
- Base building Fire Engineering Report produced by RAWFire Safety Engineering s100643_Metcash_HY_FER_03_01 dated 21st October 2011.
- Architectural plans provided by Khalid Hourani of Goodman, as indicated in Table 2-2.

Table 2-2: Drawings

DRAWING NO.	DESCRIPTION	ISSUE	DATE
12051-01	Cover Sheet and Location Map	C	24-10-2012
12051-02	Site Plan	C	24-10-2012
12051-03	Demolition Plan	C	24-10-2012
12051-04	Warehouse Floor Plan Stage 5A	C	24-10-2012
12051-05	Warehouse Floor Plan Stage 5B	C	24-10-2012
12051-06	Warehouse Floor Plan Stage 5C	C	24-10-2012
12051-06a	Indicative Fitout drawing Stage 5A	A	13-11-2012
12051-07	Complete Staged Development Site Plan	C	24-10-2012
12051-08	Warehouse Sections	C	24-10-2012
12051-09	Warehouse Elevations	C	24-10-2012
12051-10	Coloured Elevations & External Finishes 5A/5B	C	24-10-2012
12051-111	Coloured Elevations & External Finishes 5C	C	24-10-2012

2.4 LIMITATIONS AND ASSUMPTIONS

In this instance the Fire Engineering Strategy is developed based on applicable limitations and assumptions for the development 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 report. 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 6.2. 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 Strategy is only applicable to the completed building. This report is not suitable, unless approved otherwise, to the building in a staged handover.
- Where parties not nominated in Table 2-1 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.

3.2 SITE & DEVELOPMENT DESCRIPTION

The existing site is located in Huntingwood, approximately 40km west of Sydney City. The site is bound by Huntingwood and Brabham Drives to the north and east respectively. To the south is a public reserve between the allotment and the M4 Western Motorway, while the western side of the allotment is bound by an adjoining property.

Figure 3-1: Existing site location *Source: www.nearmap.com.au (02/08/12)*

The two nearest fire brigade stations that are provided with permanent staff are located in Huntingwood and Seven Hills approximately 1km and 9km from the site respectively.

The existing site contains two storage and distribution facilities and a multi-level carpark, as illustrated above. The eastern warehouse is the larger of the two and is referenced herein as Warehouse 1, with the smaller western warehouse referenced as the Western Warehouse.

The portion of the extension is detailed in Figure 3-2 and includes an additional floor area of approximately 9,285m^2. This area will be used as a high bay warehouse storage. The extension shall be constructed on the southern side of Warehouse 1.

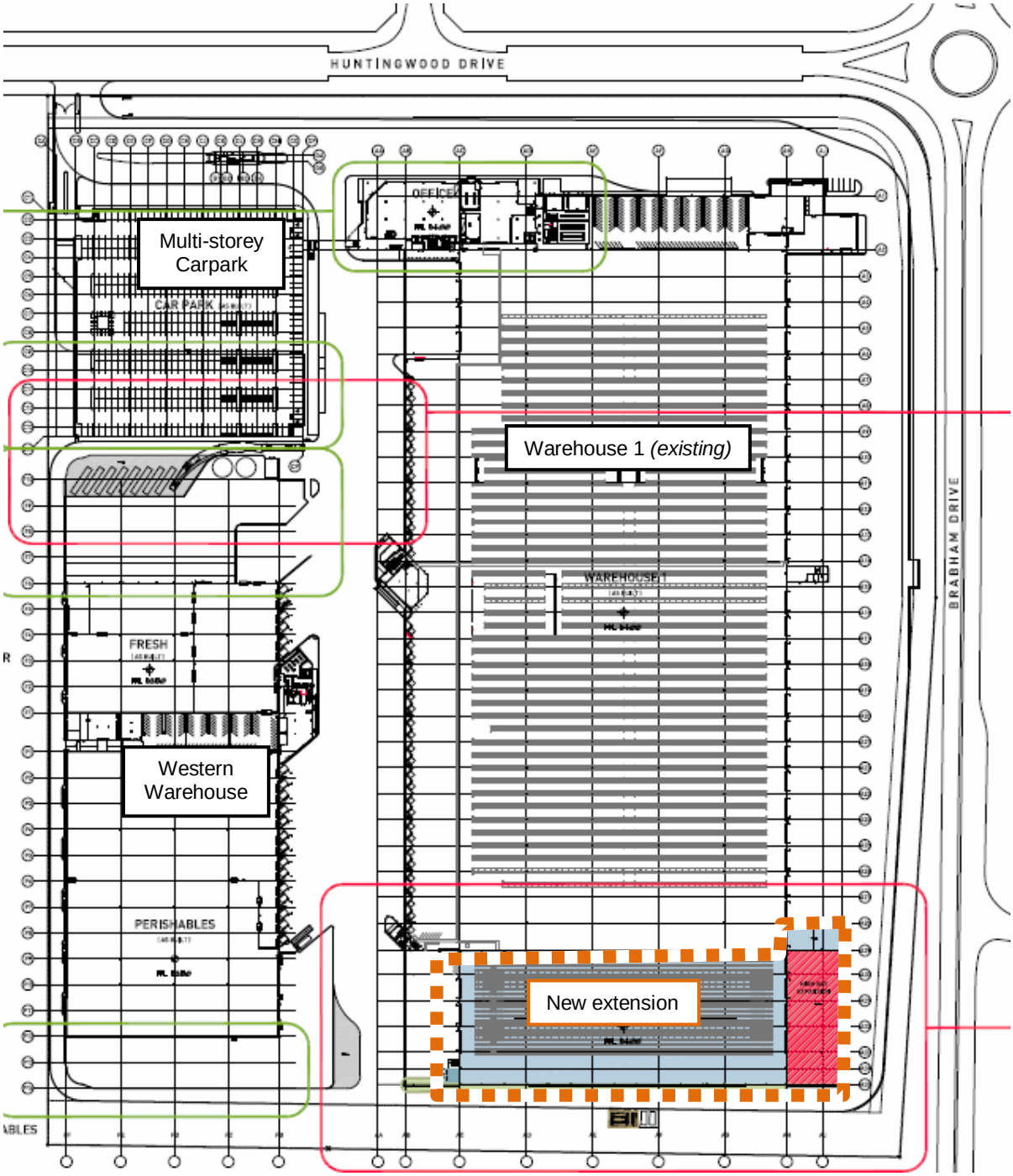


Figure 3-2: Area of new works

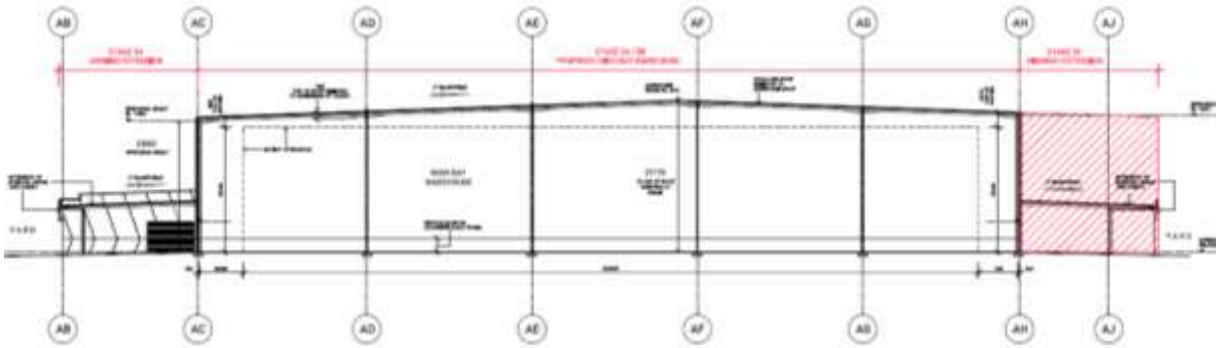


Figure 3-3: Southern elevation

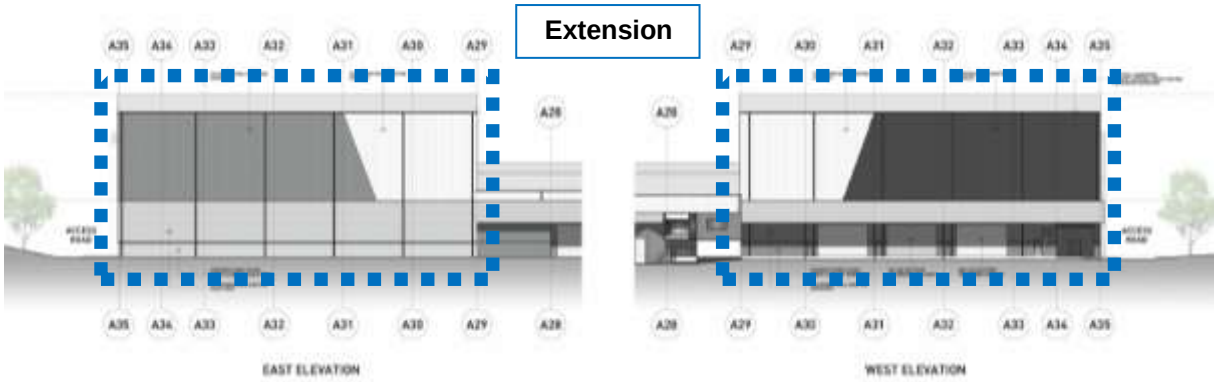


Figure 3-4: Western elevation

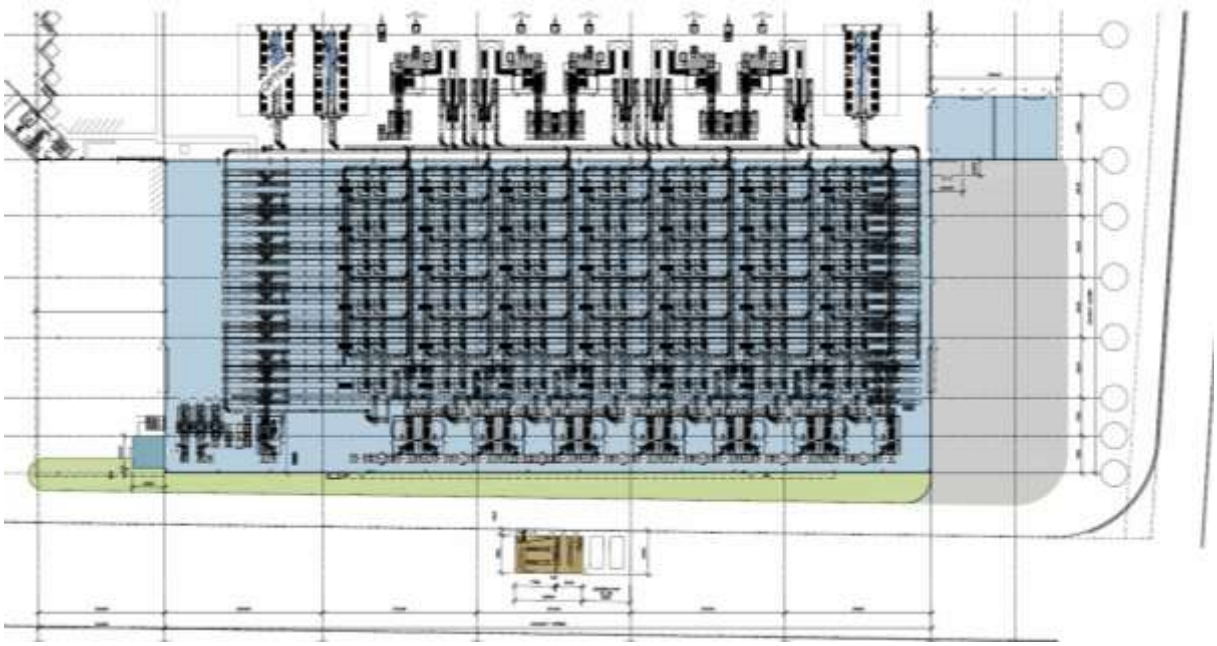


Figure 3-5: Automated machinery layout

The extension shall consist of a fully automated picking, packing and storage module with high bay storage up to 23m above floor level. The extension will have a ridge height of 26m to the underside of

the roofing, with a 5.4m high awning over the dispatch doors on the eastern and western sides of the building.

The automated racking structure shall be separated from the remainder of the warehouse by security fencing to restrict access to maintenance workers only. While maintenance access is provided throughout each racking level, the machinery is treated as a plant facility and for certification purposes Blackett Maguire + Goldsmith have deemed the area within the security fence to consist of plant equipment. Subsequently the new works shall have a rise in storeys of one (1) and forms part of the existing building's fire compartment, thus no alterations to the existing provisions for Type C construction are required as part of the new works.

3.3 BUILDING CHARACTERISTIC ASSESSMENT

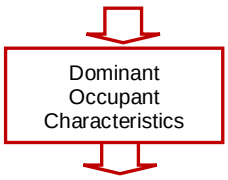
Table 3-1: Building Characteristics

CHARACTERISTIC	DESCRIPTION	
Location	The site is located within the Bungarribee Industrial Estate in Huntingwood, NSW. The two nearest fire brigade stations are located within 9km of the site. The building site influences the likely fire brigade intervention times, and given the close proximity to the nearest fire station is expected to facilitate a relatively convenient and expedient fire brigade response. Furthermore being located within a major city outer suburb the development is provided with the services and facilities expected in an urban setting.	
Layout	The extension shall connect to the existing Warehouse 1 fire compartment and shall contain an automated assembly/dissembling picking and storage facility with high bay storage up to approximately 23m above FFL. The automated plant is separated from the accessible areas by security fencing to restrict access for authorised maintenance staff only, egress through the southern parts of the existing warehouse require occupants to navigate through the additional plant outside the secure zone. Further to this exit doors are provided around the building perimeter to assist in egress from the building. The Western Warehouse includes areas of varying temperatures; -24°C, 0-4°C and 10-14 °C. No additional works shall be completed on this building.	
Structure	Materials and finishes shall be in accordance with the DTS requirements for Type C construction. Construction materials will include concrete and steel with external steel sheeting. Materials used in construction will conform with the testing methodology outlined in the DTS provisions so as to avoid the spread of smoke and fire and minimise the risk to occupants and fire fighters.	
Total Floor area	The completion of the Warehouse 1 extension is to be undertaken in three stages 5A, 5b and 5C, once complete there shall be an additional 9,285m^2 of floor area and 235,000m^3 of volume.	
BCA Assessment	Classification	Class 5 – (Level 1 office/viewing room) Class 7b – (Warehouse) Class 10a – (Switchroom and substation building)
	Construction Type	Type C Construction *(Large Isolated Building)*

CHARACTERISTIC	DESCRIPTION	
	Rise in Storeys	The subject works, i.e. new extension, has a rise in storeys of one (1). However Warehouse 1 has a rise in storeys of two (2). While the racking is provided with maintenance access to each of the racking levels, for certification purposes Blackett Maguire + Goldsmith have deemed this not to be considered as storeys. **NB:** Increasing the number of floors in a building increases the building population, placing more occupants at risk in the event of a fire, and allowing for overcrowding in stairways and other pinch points in the path of egress to a final exit.
	Effective Height	Warehouse 1 and the extension have an effective height of less than 12m.

4 DOMINANT OCCUPANT CHARACTERISTICS

4.1 OVERVIEW



The occupant characteristics are assessed within the Fire Safety Strategy 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 OCCUPANT CHARACTERISTIC ASSESSMENT

Table 4-1: Occupant Characteristics

CHARACTERISTIC	DESCRIPTION
Population numbers	Due to the nature of the building, i.e. fully automated storage facility, occupants will be restricted to maintenance staff only. In this regard the occupant densities listed in Table D1.13 of the BCA are considered to be overly conservative for the subject building extension. However the BCA values shall be used on a preliminary basis to provide an estimated value in the absence of accurate numbers being provided by the building owners. The BCA assumes the following occupant densities per an area's function and use: ■ 1 person per 30 square metres in plant room and warehouse areas.
Population location	The population is expected to be distributed throughout the building. The existing office and manually operated storage areas are considered to 'on average' be more densely populated than the new extension parts.
Physical and mental attributes	Occupants in the building may be of mixed age, although the elderly and children are generally not expected to be present. The population is therefore expected to be that of the general working public and be adults between the ages of 16 to 70. Due to the nature of the work conducted the majority of occupants are assumed to be able bodied people with a small number of less mobile occupants requiring assistance during an evacuation. All occupants are expected to be awake and alert adults or in the direct company of an adult, capable of entering the leaving the building under their own volition. Occupants in all of these areas are not expected to be adversely impaired by drugs, alcohol, fatigue or other adverse conditions to degrees greater than in other warehouse and office buildings. ■ ***Staff and Security*** – are expected to be mobile with normal hearing and visual abilities, and occupants in this group are considered to take and implement decisions independently, and require minimal assistance during evacuation in a fire emergency. This occupant group is expected to be awake and fully conscious at all times when inside the building; and ■ ***Clients / Visitors*** – are expected to be mobile with normal hearing and

CHARACTERISTIC	DESCRIPTION
	visual abilities, this occupant group are expected to be capable of making and implementing decisions independently however may require assistance in locating the nearest and safest egress path in an emergency; and ■ ***External Maintenance Contractors*** – are expected to be mobile with normal hearing and visual abilities and occupants in this group are considered to take and implement decisions independently and require minimal assistance during evacuation in a fire emergency. The contractors are expected to be awake and aware of their surroundings at all times when inside the building; and ■ ***Fire & Rescue NSW*** – are expected to be equipped with safety equipment and will be educated in fire fighting activities and the dangers associated with fire incidents. This occupant group would be expected to be in a position to assist other occupants requiring assistance to evacuate. It is not expected that this occupant group would be present in the building at the time of fire ignition; however, they are expected to enter the building at a later stage to assist with the evacuation of occupants, if required, and to undertake fire suppression activities.
Familiarity with the building	■ ***Warehouse Staff, Maintenance and Security*** – can be expected to have a good familiarity with the building and the fire safety systems provided and may be trained in emergency procedures; and ■ ***Clients and /or Visitors*** – may or may not be familiar with the layout of the building and may require assistance in locating the exits; and ■ ***External Maintenance Contractors*** – this occupant group is expected to have a reasonable familiarity with the building as they would have to undergo site specific induction prior to commencement of work on site; and ■ ***Fire & Rescue NSW*** – are not expected to have any familiarity of the building layout, however are assumed to obtain the required information from the site block plans and tactical fire plans available prior to entering the building. Notwithstanding this they will be equipped with breathing apparatus and specialist equipment to prevent them from being adversely affected by fire hazards.

5 FIRE BRIGADE CHARACTERISTICS

5.1 OVERVIEW

The fire brigade characteristics are assessed within the Fire Safety Strategy 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

In order to assess the likely fire brigade response times and possible requirements additional to those normally presented within a DTS design an indicative assessment of fire brigade intervention has been undertaken based on the methods defined in the Fire Brigade Intervention Model (FBIM) [5].

Figure 5-1 illustrates the building layout with the site entry points and fire brigade access around the allotment.

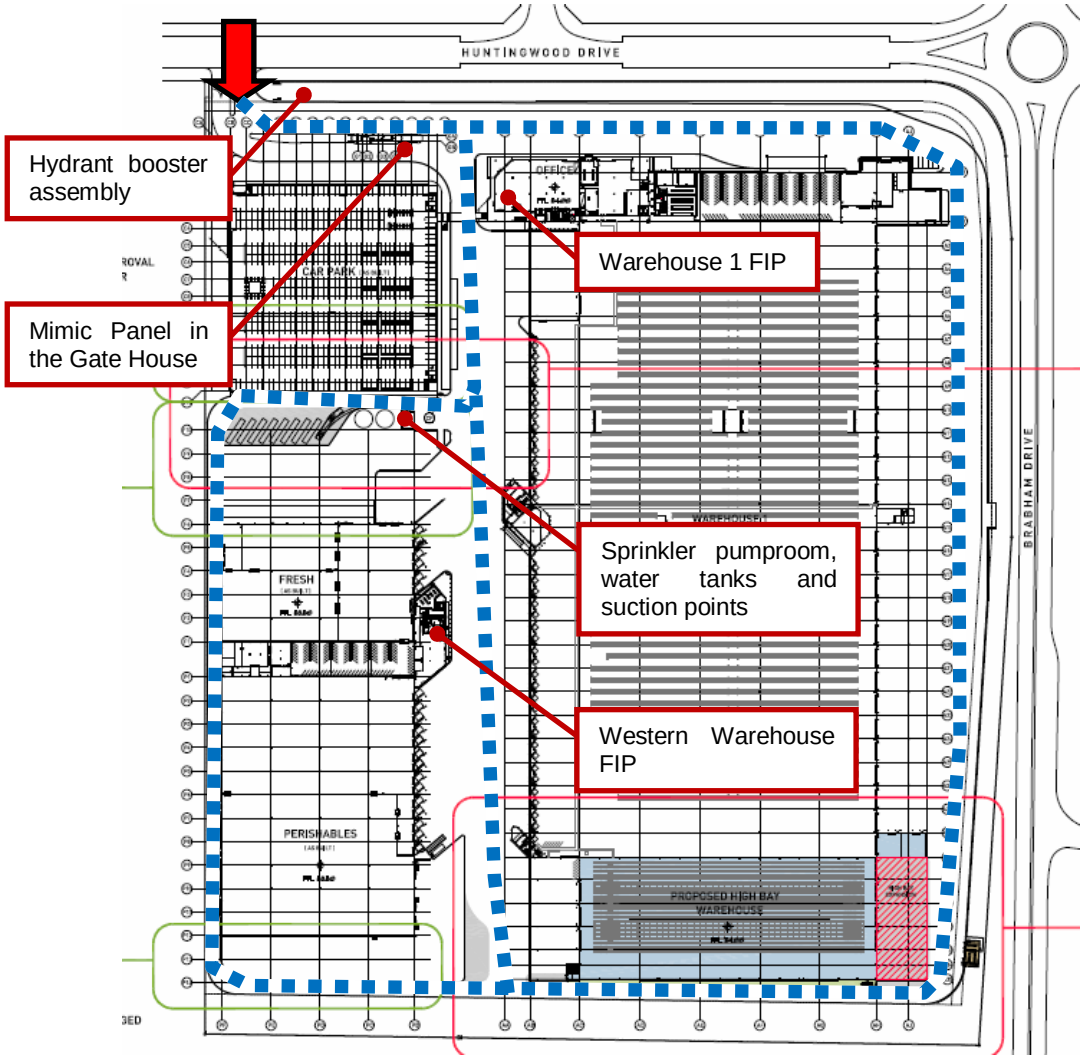


Figure 5-1: Fire brigade access and site facilities

The two nearest fire brigade stations that are provided with permanent staff are located in Huntingwood and Seven Hills approximately 1km and 9km from the site respectively. Figure 5-2 illustrates the expected route to be taken in the event of a fire.

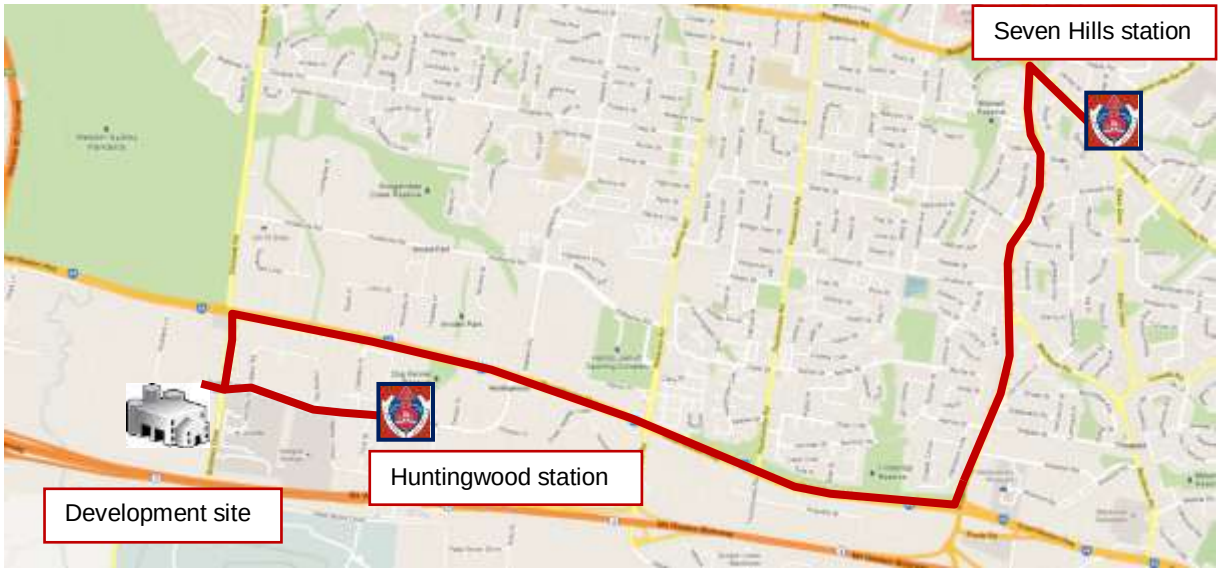


Figure 5-2: Route from the two nearest fire stations

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 model produced details the time it will take for brigade personnel within the aforementioned location to receive notification of a fire, time to respond and dispatch resources, time for resources to reach the fire scene, time for the initial determination of the fire location, time to assess the fire, time for fire fighter travel to location of fire, and time for water setup such that suppression of the fire can commence. The following are details of the assumptions utilised in this FBIM:

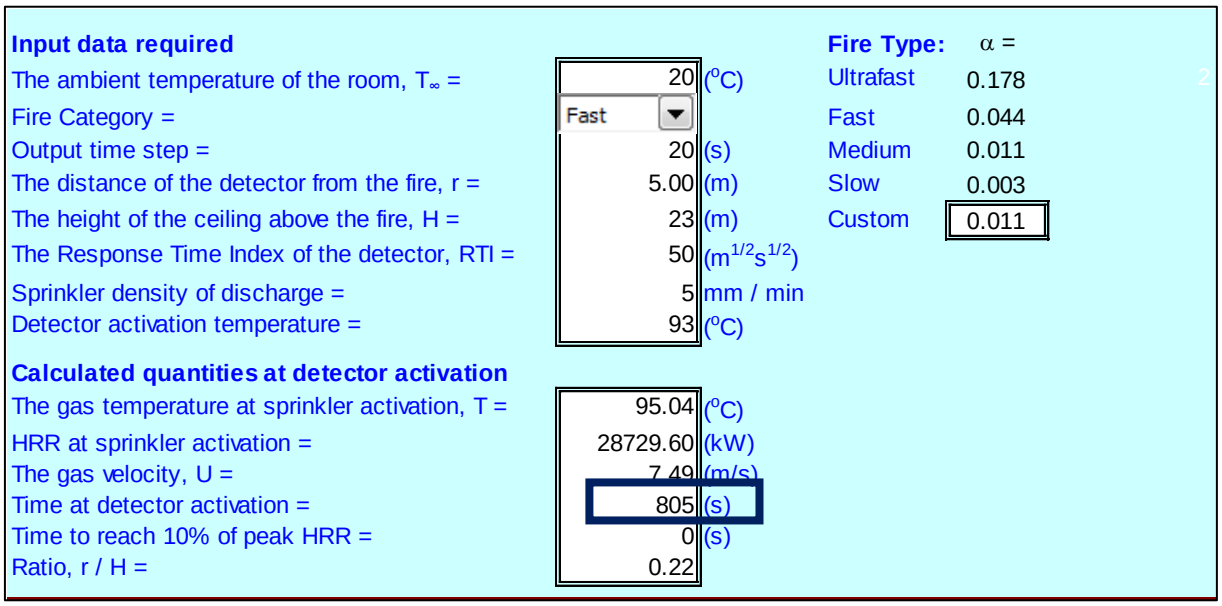
Location of Fire

- This FBIM will only be an indicative model of one fire scenario within the building. For conservative purposes, the FBIM considers a fire in the location from the main entry point, i.e. the south eastern part of the extension.

Time between Ignition and Detection

- Based on calculations using the Alpert's Correlations (Figure 5-3) the initial brigade notification is via the activation of the warehouse sprinkler system. Although in-rack sprinklers shall be provided the assessment conservatively assumes the operation of the roof level sprinklers.

  The alarm time calculated has considered a fire with an Ultra-Fast t-squared fire growth rate, which is expected to be indicative of the type of fire in the high bay racking area. The alarm time following fire ignition was calculated to occur at 805 seconds.



Input data required			Fire Type:	α =
The ambient temperature of the room, T_∞ =	20	(°C)	Ultrafast	0.178
Fire Category =	Fast		Fast	0.044
Output time step =	20	(s)	Medium	0.011
The distance of the detector from the fire, r =	5.00	(m)	Slow	0.003
The height of the ceiling above the fire, H =	23	(m)	Custom	0.011
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 =	93	(°C)		
Calculated quantities at detector activation				
The gas temperature at sprinkler activation, T =	95.04	(°C)		
HRR at sprinkler activation =	28729.60	(kW)		
The gas velocity, U =	7.49	(m/s)		
Time at detector activation =	805	(s)		
Time to reach 10% of peak HRR =	0	(s)		
Ratio, r / H =	0.22			

Figure 5-3: Sprinkler activation

Time for Initial Brigade Notification

- Fire brigade notification is expected to occur via a direct monitored alarm.
- A time for alarms/fire verification and any notification delay is 20 seconds based on Table B of the Fire Brigade Intervention Model. Therefore the time after ignition at which the fire brigade receive the alarm is (805+20) = 825 seconds.

Time to Dispatch Resources

- The two fire stations are assumed to be manned at the time of the fire as they are permanently staffed stations.

Time for fire fighters to respond to dispatch call and leave fire station is included in the travel time for fire brigade in NSW (Fire Brigade Intervention Model [5]).

Time to Travel to Scene

Table 5-1: FBIM data for the FRNSW (Table F2 FBIM)

GRAPH	REGION CLASSIFICATION	SPEED (KM/H)	
		μ	σ
F2.1	Major city central business district	26.6	11.3
F2.2	Major city inner suburb	26.3	11.9
F2.3	**Major city outer suburb**	**29.5**	**12.2**
F2.4	Rural town centre	21.6	11.0
F2.5	Rural country	40.5	15.6
	Travel speed through site	8	-

Based on speed data provided by the Fire Brigade Intervention Model (FBIM) [5], this travel speed assumes the brigade is travelling at a mean speed of 29.5km/h (major city outer suburb) with a standard deviation of 12.2km/h. Since the mean speed would result in this particular travel speed occurring 50% of the time, there is an equal likelihood that the travel speed would take longer. Hence, it is desirable to introduce a margin of safety of using a greater percentile of 90%.

In order for the speed to be within the 90% percentile value, a safety factor of 1.28 is applied to the standard deviation as noted in Table 4.3 of Fire Brigade Intervention Model V2.2 [5].

Hence, a mean travel speed will be taken at a much slower travel speed at 29.5 – (12.2 x 1.28) = 13.9km/h which is conservative.

- Appliance travel speeds of 13.9km/h have been adopted for the purposes of modelling, and as such the following travel times are expected:-

Table 5-2: Fire Brigade Arrival Times

STATION	TRAVEL SPEED (km/h)	DISTANCE (km)	TRAVEL TIME (sec)
Huntingwood	13.9 km/h	1 km	259
Seven Hills		9 km	2331

Time for Initial Determination of Fire Location

- On arrival, the fire location is not visible to the approaching brigade personnel, thus requiring information to be obtained from the Fire Indicator Panel (FIP) and evacuating occupants.
- Fire brigade personnel assemble at the FIP in the office building's main entry.
- Fire brigade tactical fire plans will be provided.
- Security procedures are expected to be minimal as brigade personnel will be issued with a key for the site. As such, forced entry into the building is not required.

Time for Water Setup

- The first appliance would be expected to commence the initial attack on the fire.
- Time taken to connect and charge hoses from on-site hydrants to the fire area is based on V3 Table V of the Fire Brigade Intervention Model Guidelines, which indicates an average time of 45.3 seconds, and a standard deviation of 17.1 seconds. Using a 90th percentile approach as documented in the FBIM [5], the standard deviation is multiplied by a constant *k*, in this case being equal to 1.28. Therefore, the time utilised in this FBIM is 45.3 + (1.28 x 17.1) = 68 seconds.

Time for Fire Fighters to Travel to Fire Location

- Time for fire fighters to travel from the FIP to the fire affected area; in this case conservatively assumed to be the furthest point from the main entry in the southern end of Warehouse 1.

Table 5-3: FBIM data for horizontal travel speeds (Table Q FBIM)

GRAPH	TRAVEL CONDITIONS	SPEED (KM/H)	
		μ	σ
Q1	Dressed in turnout uniform	2.3	1.4
Q2	Dressed in turnout uniform with equipment	1.9	1.3
Q3	**Dressed in turnout uniform in BA with or without equipment**	**1.4**	**0.6**
Q4	Dressed in full hazardous incident suit in BA	0.8	0.5

Horizontal egress speeds have been based on fire brigade personnel dressed in turnout uniform in BA. An average travel speed of 1.4m/s with a standard deviation of 0.6m/s are utilised. As such, for the purposes of the calculations, a horizontal travel speed of 1.40-(1.28x0.6) = 0.63m/s is utilised.

- Horizontal travel distances (not including travel via lifts or stairs) will include the following:
  - Travel from the kerb to the Main FIP in the office foyer and finally to the southern corner of the warehouse is approximately 560m.
  - Based on the above travel distance of 560m coupled with an egress speed of 0.63m/s the horizontal travel time expected is approximately 889 seconds.

Search and Rescue

- Search and rescue will consist of a perimeter search of the warehouse; due to the size of the warehouse in comparison to the office it is assumed that a second team will conduct a search of the office in the time required to cover the warehouse. Thus, this will provide fire fighting personnel

with an additional 1,000m of travel. At a speed of 0.63m/s, this will take fire fighting personnel approximately 1,590 seconds.

Table 5-4 Summary of the Fire Brigade Intervention Model (FBIM)

FIRE STATION	TIME OF ALARM	TRAVEL TIME TO SCENE	ASSUMED SET UP TIME	TIME TO REACH THE FIRE BASE	TIME OF ATTACK	PERIMETER SEARCH & RESCUE
Huntingwood	825	259	68	889	2041 (34 min)	3631 sec
Seven Hills		2331			4113 (69 min)	5703 sec

The FBIM indicates that the arrival time of the brigade from the nearest two fire stations is approximately 18 and 53 minutes respectively after fire ignition. It is estimated that it takes another 16 minutes for the fire brigade to carry out activities including determination of fire location, preparation of fire fighting equipment and travel on foot to the fire base. As such, fire fighting activities are expected to commence between approximately 34 and 69 minutes, with preliminary search and rescue completed at 60-95 minutes.

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

In order to assess the most likely fire hazards within the building, and subsequently the risk presented by these hazards it is necessary to develop an understanding of the factors that have an influence on the fire safety of building occupants. The best method in doing so is to review existing statistical data.

Existing data is an invaluable tool in providing an overview of the situations in which occupant deaths have, and are likely to occur, and factors that contribute to more severe fires. This aids in understanding, and helps evaluate the effectiveness of, and the need for various fire safety systems. Reference is made to the American database as it is significantly larger than Australian data sets, but is generally considered to be representative of the Australian situation.

Table 6-1: Fire Statistics in all building types

STRUCTURE TYPE	FIRES PER YEAR	CIVILIAN FATALITIES PER YEAR	CIVILIAN FATALITIES PER 1000 FIRES
Offices	**5,800**	**1**	**0.17**
Storage facilities	**22,900**	**15**	**0.66**
Retail shopping complexes*	NA	NA	0.74
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

*From the FCRC 'Fire Safety in Shopping Centres' Project 6 all other data from the NFPA 'U.S. Fire Problem Overview Report' [11]

Based on the National Fire Protection Association, the statistics are based upon recorded fire events occurring between:

- 2003 – 2007 Structure fires in Warehouses (excluding cold storage)

Note that the statistics below have been compiled from U.S. fires reported to U.S. municipal fire departments between 2003 and 2007, and do not include fires where private or government fire brigades responded or fires that were not reported. Further, it should be noted that cold storage, residential storage and self-storage are excluded. Despite the fact that cold storage is not reported within the statistics it is considered that they still provide a reasonable basis for the general understanding of the risk presented by a high storage warehouse, cold storage or otherwise.

It is a common misconception that fires do not occur in cold store. However, factors such as an ultra dry atmosphere and the highly combustible nature of polyurethane or polystyrene foam insulation, wooden pallets and plastic wrapping present a high fire risk in these environments. Electrical faults from conveyor/transport equipment, lighting, or hot spots caused by maintenance operation can also contribute to this risk. Additionally the holding capacity of a cold store demands specialized high

volume storage racking which can affect the airflow and impede the detection and response to a fire event.

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 U.S. for the following results to be applicable.

Warehouse (excluding cold storage) Fire Statistics

A total of 1,350 structure fires occurred in warehouses. The fires recorded resulted in 5 occupant fatalities, and 21 occupant injuries and $124 million in direct property damage per year. The leading cause of fires in Warehouses (excluding cold storage) is from electrical distribution or lighting resulting in 17% civilian injuries. The leading area of fire origin in warehouses comes from an unclassified storage area resulting in 21% civilian injuries.

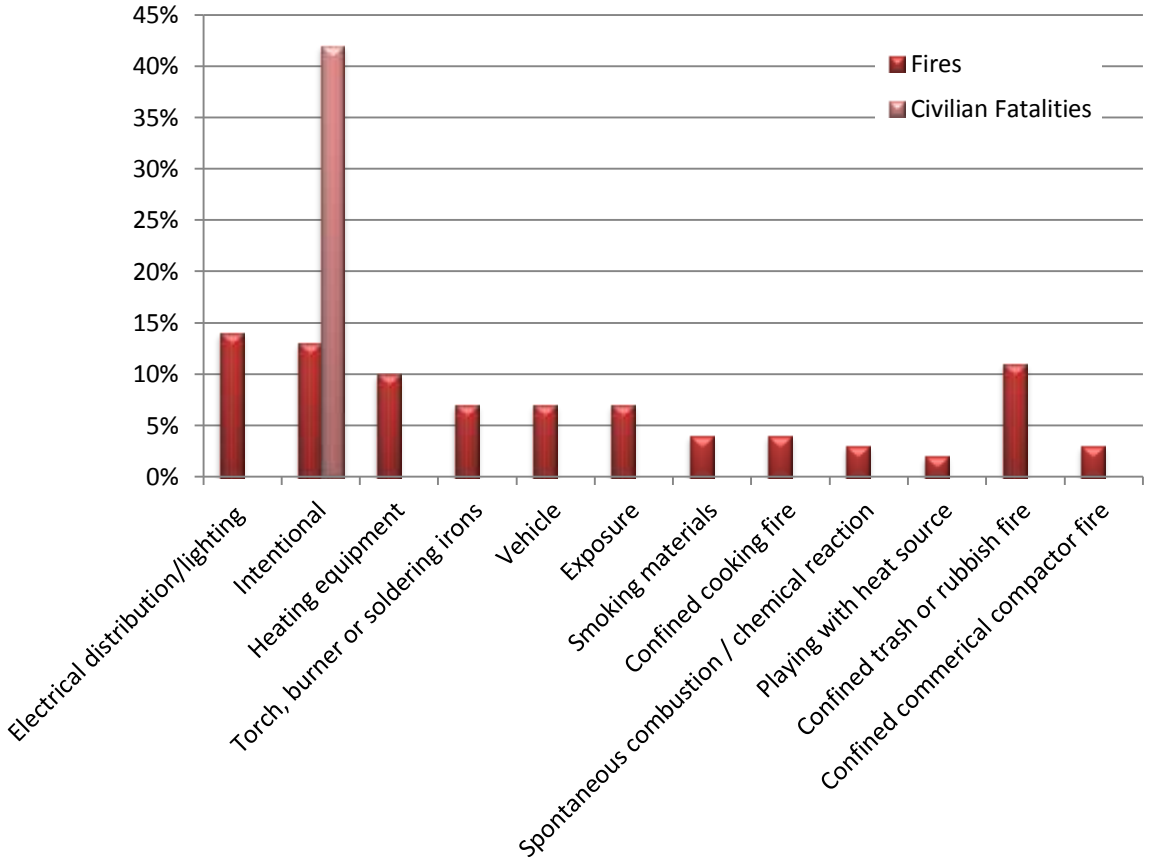


Figure 6-1 Leading causes of fires in warehouse (excluding cold storage) structures

The potential fire hazards (inclusive of the leading causes, as well as area of origin of a fire) identified throughout the development are illustrated in the graphs below. The statistics as illustrated in the figures below have been obtained from the National Fire Protection Association (NFPA) website (www.nfpa.com).

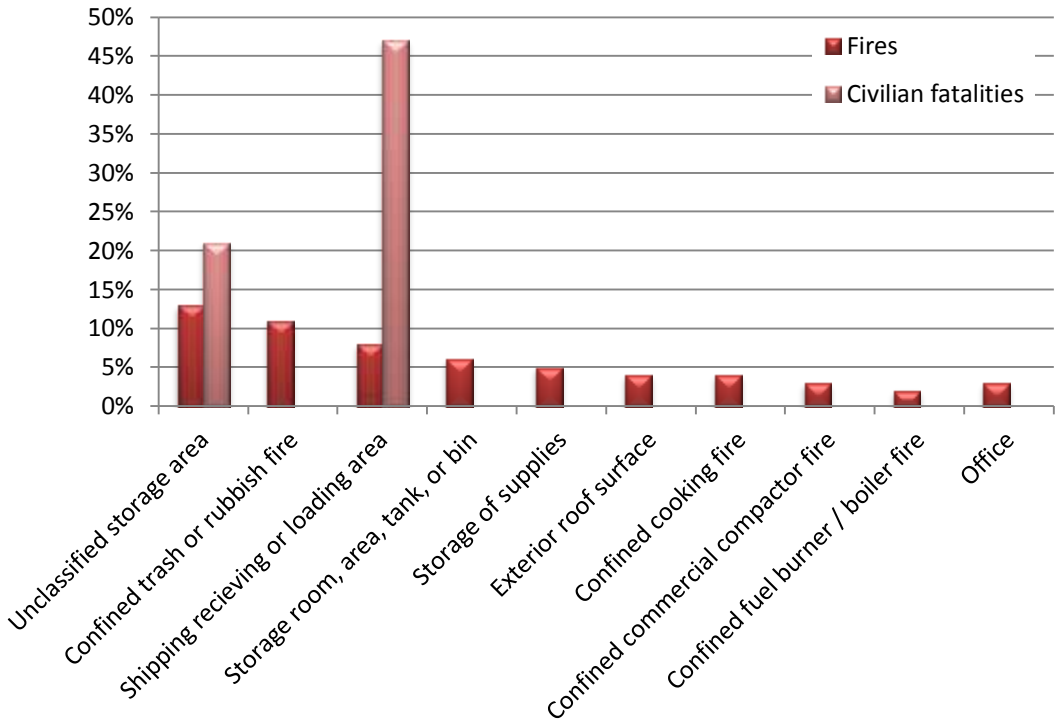


Figure 6-2 Structure fires in warehouse (excluding cold storage) structures by area of origin

6.3 SPRINKLER EFFECTIVENESS & RELIABILITY

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 [3]. The lower reliability estimates of 81.3% [8] as well as some of the higher values of 87.6% [10] 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 [12] 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 storage (ESFR) system has an exemplary record.

With reference to FM Global data sheet (2-2) as of 2002 [5] there had been six known fires involving suppression mode sprinkler protection. In all of these incidents, the sprinkler system was successful in suppressing the fire and no more than four sprinkler heads operated.

FM Global Data Sheet 2-0 states that, FM Global loss history over the past twenty years indicates that approximately 25% of the time, the operation of a single sprinkler will control or suppress a fire if the sprinkler system has been properly designed and installed. This percentage increases to approximately 50% of the time with the operation of 3 or fewer sprinklers, and 75% of the time with the operation of nine or fewer sprinklers.

In addition analysis of the likelihood of sprinkler failure shows that most sprinkler system failures are due to impaired water supplies such as closed valves, blocked pipes, impaired sources, etc., which tend to affect sections of or the entire system [10]. As such, system reliability can be increased by active monitoring of water supplies and controls. The general consensus within the fire protection industry is that problems with individual sprinkler heads are rare. This information combined with sprinkler reliability data is favourable when compared with the reliability of fire compartmentation [3].

Moinuddin and Thomas [10] have found that masonry fire rated construction had a reliability of 81-95%, and gypsum 69-95%, with the upper level in both instances having been reported within the IFEG [3]. Both reported ranges are considered to be less than that offered by automatic sprinkler systems. Table 6-2 lists the effectiveness of sprinkler systems in the event of a fire growing to a size that facilitates sprinkler head activation [10].

Table 6-2: Effectiveness of Sprinkler systems

PROPERTY TYPE	EFFECTIVENESS OF SPRINKLERS IN EVENTS WHERE SPRINKLERS OPERATE
Public Assembly	90%
Educational	93%
Health care / Correctional Centre	95%
Residential (average)	97%
Office / Retail	91%
Manufacturing	93%
Storage	***86%***
Cold Storage	89%
All properties	7%

Statistics for general sprinkler effectiveness in storage properties is provided in the table below which is drawn from the research of Rohr [13]. The data indicates over 77% of storage fires and 84% of manufacturing facility fires are confined to the area of fire origin where sprinklers are fitted.

Table 6-3: The Effectiveness of Sprinkler in Storage 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

According to the tests undertaken by FM Global Property Loss Prevention Data Sheets [5], automatic smoke exhaust systems would operate prior to an installed sprinkler system. This would result in the removal of hot smoke from the ceiling causing a critical delay in sprinkler operation. As such, FM Global recommends that a sprinkler system should not be installed in conjunction with automatic smoke exhaust systems.

It is considered 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 fire development and cause uncontrolled spread throughout the building leading to a more rapid onset of untenable conditions, significant property loss, and restriction of fire fighter access into the building.

Furthermore, rapid fire development and spread could eventually overrun the sprinkler system by resulting in the activation of several fast response sprinkler heads, over and above the system design requirement, potentially depleting the water supply. 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 system would allow hot smoke to build up in the ceiling leading to the activation of the sprinkler system as intended by design parameters which are based on tested systems and therefore improving the likelihood of fire control and/or suppression.

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 6-4. This data is derived from Switzerland, however is also deemed applicable to buildings in Australia of similar use.

The warehouses are considered to generally contain mixed types of commodities, where in some cases cellulosic materials are mixed with plastics and non-combustible materials on the same racks. There is a large amount of data concerning the burning rates of items and materials; however, this information is not often presented such that it is sufficiently generic to be universally adopted.

Also, while the current occupants within the buildings may be known during the design stages of the development the length of their occupancy cannot be definitively identified. Therefore while what can be representative of the current fuel loadings for the enclosure, these may not be the case in the future use of the building. Therefore, it would be a rare assessment in which the specific items forming the fuel load had been tested to provide the fire heat release data. As such it is considered that the application of generic burning rates, translated through simplified mathematical expression (time squared growth rates) is a suitable means of estimating fire development.

Table 6-4: Fire Load Densities

TYPE OF OCCUPANCY	AVERAGE FIRE LOAD
Forwarding facility dealing in; Beverages, food, furniture, glassware, plastic product, printed goods, varnish/polish.	Range from; 200 MJ/m^2 - 1700 MJ/m^2
Storage of rubber products	5000 MJ/m^2/m
Storage of paper	1000 MJ/m^2/m

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 time-squared fire. The basis of the time squared fire arises from the fact that the growth during the flaming stage can be approximated by a smooth curve that can be expressed mathematically. The rate of heat release is given by the expression:

$$Q = (t/k)^2$$

Where: t = time from after ignition of the fire (seconds)

K = the growth time (seconds)

Q = a heat release output of 1.055 MW.

Studies of actual fires have led to the adoption of five (5) standard fire growth rates covering a wide range of potential fire scenarios and fuel loads. It should be noted, the times of fire incubation are not included in the time-squared growth fire models. National Fire Protection Association Standard NFPA 92B [10] provides information on the relevance of time-squared approximation to real fire as depicted in the figure below.

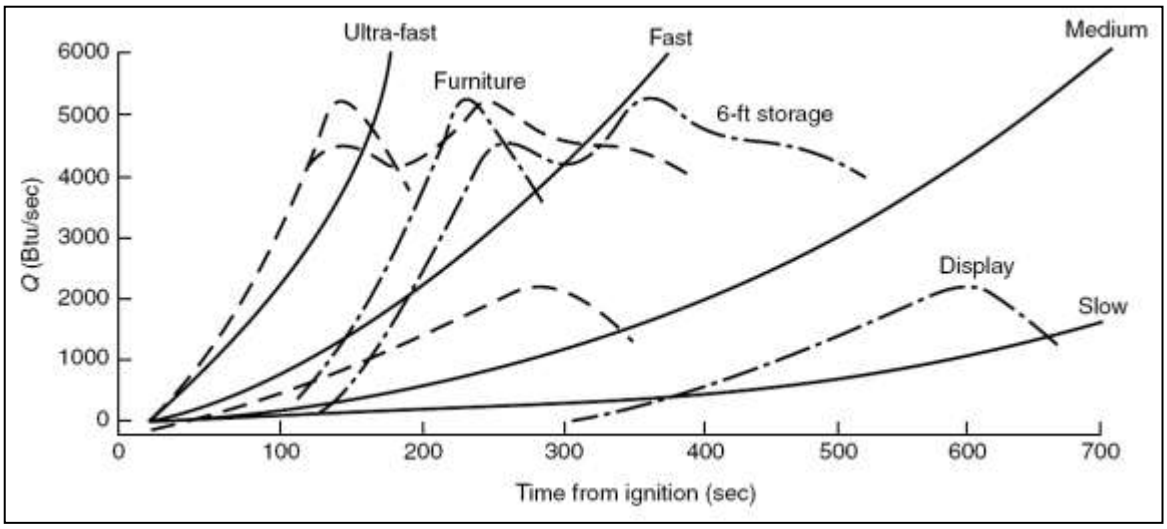


Figure 6-3: NFPA 92B: T-squared fire, rates of energy release

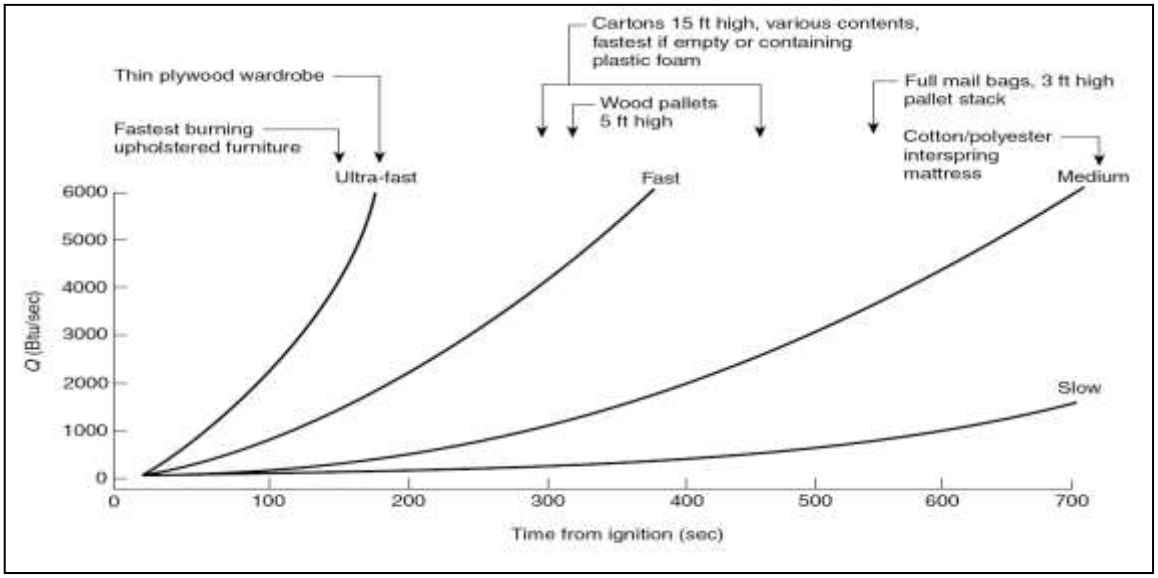


Figure 6-4: NFPA 92B: Relation of t-squared fires to some fire tests

The rate of fire growth can also be estimated from data published in British Standard (BS) 9999:2008 [5] as shown below in Table 6-5, and Table 6-6.

Table 6-5: Summary of Fire Growth Rates per Building Type

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 variation in warehouse growth rates can be understood from the following table illustrating the types of stored items.

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

FIRE GROWTH RATE	STORED MATERIALS
Slow t^2	Banking hall, limited combustible materials.
Medium t^2	Stacked cardboard boxes, wooden pallets.
Fast t^2	***Baled thermoplastic chips, stacked plastic products, and baled clothing.***
Ultra-Fast t^2	***Flammable liquids, expanded cellular plastics and foam.***

From the above tables (and figures) it is concluded that the likely fire scenarios in the high bay racking may be approximated by an Ultra-Fast standard time-squared fire growth rate curve, while the office areas can be approximated with a Medium time-squared fire growth rate.

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 contain a variety of plastics and cellulosic materials. 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. As a conservative input into the computer fire/smoke modelling all material involved in the fire has therefore assumed to be plastic.

6.7 FIRE HAZARD SUMMARY

Subsequent to a review of the relevant fire statistics and hazards presented in Section 1 the fire hazards for the building are listed in the following table. Hazards due to functions or characteristics are reviewed based on the building in question and relevant statistics; and

1. A description is provided on the nominated hazards; and
2. Relevant preventative / protective measures are provided to address the nominated hazards.

Table 6-7: Building Hazard Assessment

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS
Building layout	Egress provisions	Exits are provided around the building perimeter to allow for multiple alternative egress opportunities. Access into the automatic racking machinery is restricted to maintenance workers only and therefore explicit BCA requirements do not apply for occupant egress. Areas within the warehouse have limited dead end travel routes to exits. However due to the size of the building extended travel distances to the nearest of the alternative exits and between alternative exits exist. Within the subject building it is not expected that there will be any greater exposure to fire as a result of the alternative solution. No hazards to adjoining buildings have been identified, hazards generally relate to any internal exposures. Occupants in the area of fire origin are expected to be	Type C construction, BCA Spec C1.1 (Table 5). Fire Hydrants, BCA Clause E1.3, AS2419.1:2005 Fire Hose Reels, BCA Clause E1.4, AS2441:2005

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS		PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS
		aware of fire and commence evacuation.	Fire Extinguishers, BCA Clause E1.6, AS2444:2004 Automatic Suppression System, AS2118.1:1999 Occupant Warning System, AS1670.1:2004 Clause 3.22. Smoke Clearance System, Alternative Solution in lieu of BCA Spec E2.2b. Automatic Link to Fire Brigade, BCA Spec E1.5. Emergency Lighting, BCA Clause E4.2/E4.4, and AS2293.1:2005. Exit Signage, BCA Clause E4.5, NSW E4.6, NSW E4.8, AS2293.1:2005.
Activities	With regard to activities it is not expected that regular hot work processes, manufacturing processes or operation of high friction or high temperature machinery will be performed within the building. The storage of hazardous and flammable materials will be present and shall be stored in accordance with the Workcover OH&S, Australian Standards and other applicable regulatory requirements. The development is a storage and dispatch facility containing a large number of high piled and racking containing combustibles. Items within the automatic storage areas are present in the racking between 24-36hrs before being dispatched onwards. Thus there is no degradation of old stock. Notwithstanding the assumed turnover, the storage is assumed to be constantly filled to capacity due to the constant rolling stock. ■ Corridors, stairs and lobbies will generally be used only for transient purposes, occupants travelling to and from the various parts of the building.		
Ignition sources	Based on the statistical review contained above the ignition sources relevant to this site; ■ Mechanical equipment (applicable to the picking machinery) ■ Lighting equipment ■ Intentional fire starts ■ Stored waste or rubbish ■ Heating equipment		
Fuel sources	Quantity of materials	Dangerous goods will be stored in the automatic picking/storage area, however these will be located in designated areas with quantity limitations appropriate to the commodity's contents, flammability and interaction with other materials.	
	Location of materials	Specifically to the area concerned products will be stored in the high bay automatic picking racks or along the product assembly line. The lobbies, stairways and corridors are to be maintained clear of furniture, stored items and the like and constructed with materials and assemblies in accordance with C1.10 to reduce fire spread and smoke production in the event of fire in common areas.	
	Fire behaviour	Fire growth rates will vary with fuel type and conditions of ventilation and compartmentation. The most likely outcome of any fire outbreak within the building is expected to be sprinkler or foam controlled fire (as applicable to the commodity). Prior to suppression, control, a fire would be expected to grow at an Ultra-Fast time squared fire growth rate.	

POTENTIAL HAZARDS DUE TO:	DESCRIPTION / DETAILS	PREVENTATIVE & PROTECTIVE MEASURES TO ADDRESS HAZARDS
Fire origins	Refer to previous charts whereby fires are likely to occur in the following origins: ■ High storage racking areas. ■ Waste and rubbish containers. ■ Store room.	

7 BCA DTS NON-COMPLIANCE ASSESSMENT

7.1 OVERVIEW

In this instance the BCA DTS 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 clauses 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 & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
BCA DTS Provisions C2.4 – Vehicular access **Performance Requirement** CP9	***BCA DTS Provision*** Clause C2.4 requires vehicular access as a continuous means of passage for emergency vehicles in a forward direction around the entire building. The roadway is required to have a width of no less than 6m and be located within 18m of the building. ***Non Compliance*** Whilst vehicular access is provided around the whole of the building, access around the south-eastern corner is in excess of 18-metres from the building. ***Alternative Building Solution*** The Alternative Solution will, in consultation with Fire & Rescue NSW demonstrate that the configuration of perimeter access combined with the fire safety systems installed within the building ensure that fire fighting capabilities are not adversely disadvantaged. ***Assessment Methodology*** The assessment methodology follows Clauses A0.9(b)(ii), A0.9(c) and A0.10 of the BCA based on an absolute approach. A qualitative fire safety engineering assessment shall be completed to establish that the design matches the relevant Performance Requirement in facilitating direct adequate access and entry into the building to undertake fire and emergency intervention activities.
BCA DTS Provisions Clause D1.4: Distance to the nearest exit. Clause D1.5: Distance between exits. Clause EP2.2: Smoke hazard management	***BCA DTS Provision*** Clause D1.4 states that no point on a floor shall be more than 20-metres from a point where travel to two alternative exits is available, with an additional 20-metres travel permitted from that point to the nearest exit. Clause D1.5 states that the travel distance between alternative exits must not exceed 60-metres. Clause E2.2 *(inter alia Table E2.2a)* requires large isolated buildings with a ceiling height above 12-metres and a floor area or volume more than 18,000m^2 or 108,000m^3 respectively to be equipped with an automatic smoke exhaust system. ***Non-Compliance*** The following DTS non-compliances in the staging area directly to the north of the caged automated racking enclosure have been identified in the building's BCA Assessment Report.

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
Performance Requirement DP4 & EP2.2	■ Travel distances of up to 30m to a point of choice, 140m to the nearest exit and 220m between alternative exits. ***NB:*** *The above listed travel distances are based on occupants travelling north through the automated rack loading area, into the existing warehouse and then to an exit on the eastern or western side of the building. Additional egress provisions in this area shall be incorporated, i.e. conveyor walkovers, elevated platforms and access stairs etc. such that the egress distances are reduced to within the limitations set in the base building fire engineering.* ***That is, the following maximum travel distances shall be achieved; 110m to the nearest exit and 220m between alternative exits.*** ■ A manually operated smoke clearance system shall be provided in lieu of the DTS required automatic smoke exhaust system in line with the base building fire engineered alternative solution. ***Alternative Solution*** The Alternative Solution will rely upon the volume of the warehouse enclosure to act as a smoke reservoir for hot combustion products with significant reserve so as to provide the population with adequate time to safely evacuate the building prior to the onset of untenable conditions. ***Assessment Methodology*** The assessment methodology will adhere to Clauses A0.5(b)(i), A0.9(b)(ii), and A0.10 of the BCA. The analysis will be absolute and quantitative where the results of the deterministic assessment are measured directly against the agreed acceptance criteria, with a supporting qualitative argument. Computational Fluid Dynamics (CFD) will be used to simulate the fire development and smoke spread in the warehouse with these results utilised in an ASET/RSET time-line analysis to demonstrate occupant and fire brigade life safety.
BCA DTS Provisions Clause E1.3: Fire hydrant system. Clause E1.4: Fire hose reels. **Performance Requirement** EP1.1 & EP1.3	***BCA DTS Provision*** Clause E1.3 states that a fire hydrant system must be provided in accordance with AS2419.1, in which AS2419.1:2005 requires the system cover all parts of the building's floor area. Clause E1.4 states that fire hose reels must be provided in accordance with AS2441, in which AS2441:2005 requires the system cover all parts of the building's floor area. ***Non-Compliance*** Fire hydrant and hose reel coverage shall not be provided such that compliant coverage is achieved on the central ground floor parts of the automated racking enclosure. ***Alternative Solution*** The Alternative Solution shall demonstrate that the intricate layout of machinery and limited access routes through the automated racking enclosure make the use of a manual suppression system incorporating a hose significantly restricted by an occupant's ability to pull the hose through the equipment. The solution further relies on the lack of human presence in the area and the provision for a full in-rack sprinkler system to assist in fire suppression prior to fire brigade arrival. ***Assessment Methodology*** The assessment methodology will adhere to Clauses A0.5(b)(ii), A0.9(b)(ii), and A0.9(c) of the BCA. The analysis will be absolute and qualitative in demonstrating life safety and fire suppression are not adversely affected above a DTS design.

8 PROPOSED FIRE SAFETY STRATEGY

The fire safety strategy outlined below has been proposed to satisfy the fire and life safety objectives specified for this project by the relevant stakeholders. In addition, the fire safety strategy is required to adequately address the specific fire and life safety hazards identified for the proposed development, and as such have been generally derived from the preventative and protective measures outlined within the BCA, and fire engineering literature and research. Where items of non-compliance have not been identified by the design team in the concept design it is considered that those items are expected to be Deemed-to-Satisfy (DTS) solutions.

The specified Fire Safety Strategy will undergo analysis as part of the Fire Engineering Report to ascertain whether the relevant Performance Requirements of the BCA are satisfied. The fire safety strategy will incorporate the following elements:-

8.1 FIRE RESISTANCE PROVISIONS

8.1.1 Fire Resisting Construction

All new structures or modifications to existing structures shall be in accordance with the requirements of Type C construction for Class 7b buildings, as listed in Specification C1.1 of the BCA 2012.

8.1.2 Early Fire Hazard Properties

Floor, wall and ceiling linings shall comply with the requirements of BCA Clause C1.10 and Specification C1.10 to reduce the spread of fire and the generation of toxic smoke products.

8.2 ACCESS AND EGRESS PROVISIONS

8.2.1 Evacuation Strategy

Activation of any sprinkler head or detector shall initiate the evacuation of all areas of the building. As the extension forms part of the large isolated building that is Warehouse 1, the alarm tone shall be sounded throughout all parts of warehouse 1. Dedicated fire wardens from the warehouse and office areas shall ensure that all clients, visitors, and staff are promptly evacuated.

8.2.2 Egress Provisions

The travel distances to a point of choice, to the nearest exit, and between alternative exits must comply with the BCA DTS requirements with the following exceptions which shall be assessed as part of an Alternative Solution;

The following travel distances in the staging area, directly to the north of the caged automated racking enclosure, have been identified in the building's BCA Assessment Report.

- It should be noted that the Authority Having Jurisdiction has defined the automatic racking system to be plant equipment, and as such the egress provisions through the maintenance areas of the racking enclosure are not dictated by the BCA.
- Travel distances of up to 30m to a point of choice, 140m to the nearest exit and 220m between alternative exits.

Note: *The above listed travel distances are based on occupants travelling north through the automated rack loading area, into the existing warehouse and then to an exit on the eastern or western side of the building. Additional egress provisions in this area shall be incorporated, i.e. conveyor walkovers, elevated platform with access stairs etc. such that the egress distances are reduced to within the limitations set in the base building fire engineering.*

Subsequently the following maximum travel distances shall be achieved;

- ***No more than 110m to the nearest exit and 220m between alternative exits.***

The egress route measured in the building's BCA assessment report and the approximate travel route required to reduce the distances to commensurate to the base building report are illustrated in Figure 8-1.

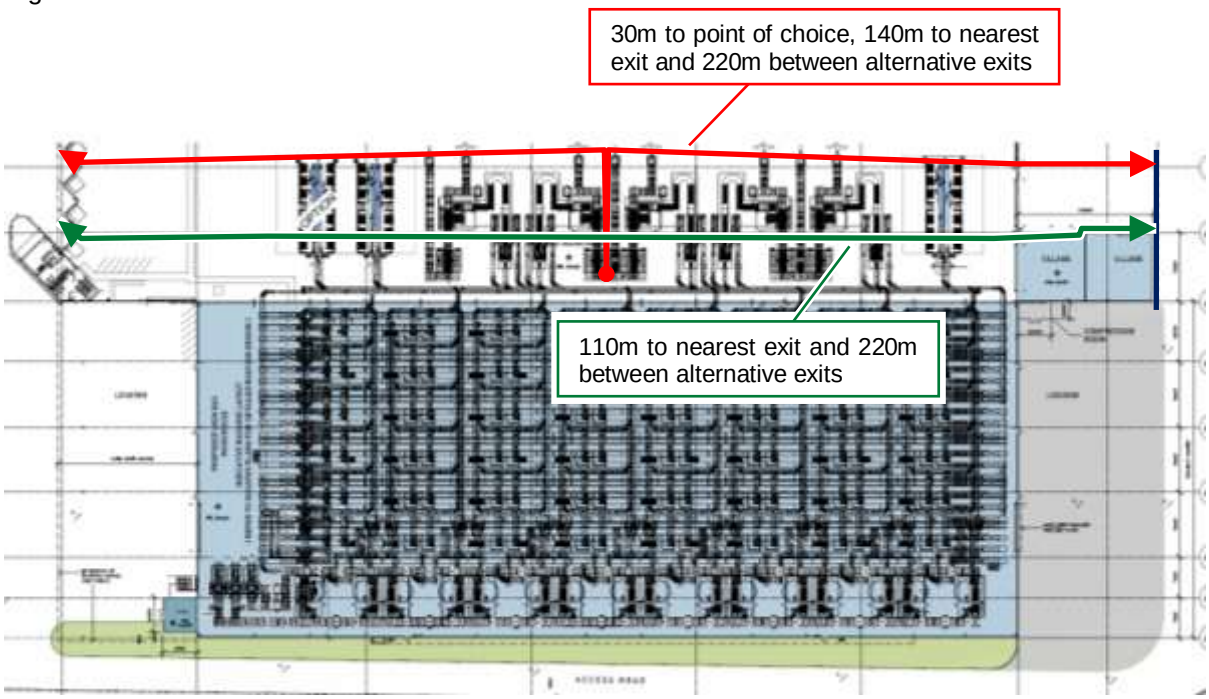


Figure 8-1: Egress provisions

- Further to the above, access shall be made available around the perimeter of the secured area to permit maintenance workers to egress from the space. All entry/exit doors fully compliant with the regulatory requirements of the BCA and secured to prevent unwarranted access.

8.2.3 Door Hardware, Operation and Mechanisms

All exit doors and doors in a path of travel to an exit are required to be DTS compliant throughout. This includes the swing of doors, the applied latching and locking mechanisms and the force required mechanism used to open sliding doors.

8.2.4 Signage and Lighting

Emergency lighting is to be provided throughout in accordance with DTS Provisions E4.2 and E4.4 of the BCA 2012 and AS2293.1:2005.

Exit signage is to be provided throughout in accordance with the DTS Provisions E4.5, E4.6, E4.8 of the BCA 2012 and AS2293.1:2005.

8.3 SERVICES AND EQUIPMENT PROVISIONS

8.3.1 Fire Indicator Panels

The existing services on site shall be retained with all new automatic sprinkler, occupant warning and smoke hazard management systems interconnected to the Main Fire Indicator Panel (FIP) at the office entry to Warehouse 1 and the Mimic Panel in the Gate House.

Where a separate fire fan control panel is installed this shall be upgraded to provide signalling and control facilities for the new manual smoke clearance system.

All modifications to the existing fire indicator and mimic panels shall be in accordance with the prescriptive requirements of BCA Specification E2.2a and AS1670.1:2004. The FIPs must be capable of isolating, resetting, and determining the fire location within the development, while the Mimic panel is only required to be capable of determining the fire location.

- The main FIP must be connected to a direct brigade notification alarm and building occupant warning systems that shall both initiate upon fire detection by the sprinkler and/or smoke detection systems.
- Smoke clearance fan controls shall be provided at the FIP, if a separate fire fan control panel is provided it shall include a display to indicate the operation or otherwise of the fans.
    - The panel shall include clear signalling of the operational status of the fans. A local fire fan control panel shall include override controls of smoke clearance and supply fans.

8.3.2 Building Occupant Warning System

The existing building occupant warning system shall be extended to cover the area of new works such that an audible alarm is provided throughout all parts of the completed building.

Any new works or modification to the existing system shall be in accordance with the prescriptive requirements of AS1670.1:2004, Specification E1.5 and Clause 6 of Specification E2.2a of the BCA 2012.

- The occupant warning system shall be connected to the FIP such that the alarm tone is sounded throughout all areas upon fire detection by the existing smoke detection system and the sprinkler systems installed throughout the fire compartment.
- To facilitate the audibility of the occupant warning alarm the automated racking system shall stop upon detection of a fire in the building.

8.3.3 Fire Sprinkler System

An in-rack automatic fire sprinkler system shall be provided throughout the automated racking with additional sprinklers installed at roof level above. The systems shall be connected to the existing system facilities including the reserve water supply, sprinkler pumpsets and fire indicator/mimic panels. The system shall be programmed to initiate the building occupant warning system and direct brigade alarm upon activation of any sprinkler head in the system.

Any new works or modifications to existing systems shall be in accordance with the prescriptive requirements of AS2118.1:1999. The following minimum design requirements shall be provided.

- All existing blockplans shall be updated to reflect any new works.
- The existing warehouse and new storage areas are to be separated with a draft curtain. The draft curtain must form a non-combustible partition below the underside of the roofing between the areas served by the storage mode sprinkler system and the new installation.

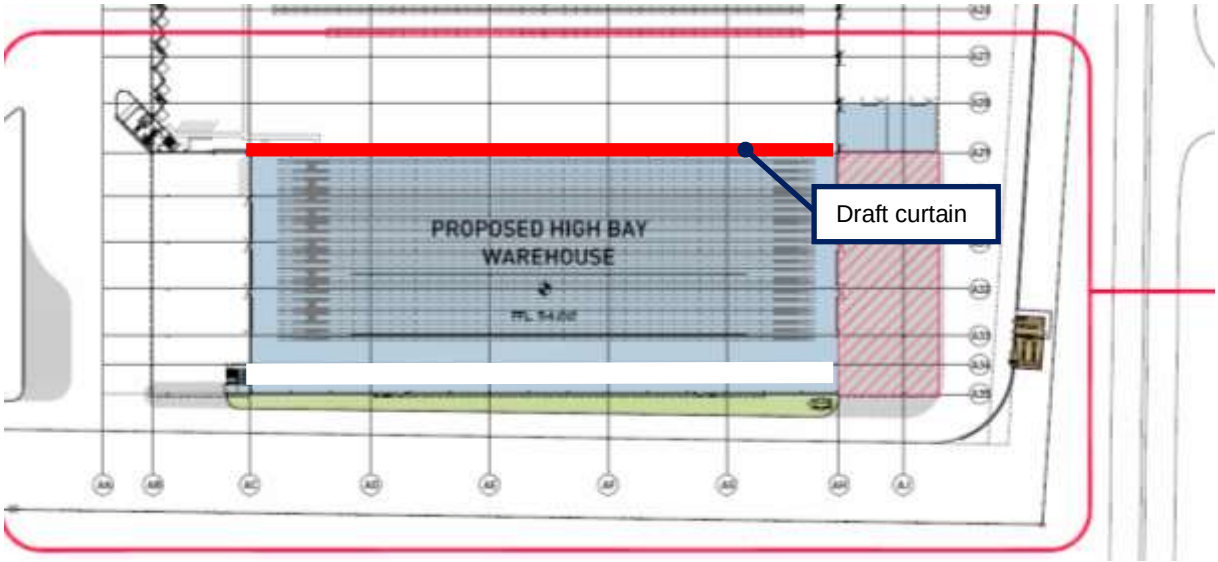


Figure 8-2: Indicative draft stop location

- The system shall be designed and installed appropriate to the commodity types, quantities and locations in the racking system with additional measures being provided as per the regulatory requirements. This may include, but is not limited to; wire caging, solid shelving and/or barriers.
- To reduce the probability of fire spread the automated racking machinery shall stop upon detection of a fire in the building.

8.3.4 Smoke Detection System

The existing automatic smoke detection system is not required to be extended to cover the area of new works. However the existing system shall be connected to the occupant warning alarm such that if a fire is detected in the existing building the alarm is initiated throughout the automated racking area.

To reduce the probability of fire spread the automated racking machinery shall stop upon detection of a fire in the building.

8.3.5 Fire Hose Reels

The existing fire hose reel system shall be extended throughout the general access areas of the extension. All new works and any modification to the existing system shall be in accordance with the prescriptive requirements of Clause E1.4 of the BCA 2012 and AS2441:2005.

- Locations should be signposted and readily accessible to occupants. Use of facilities should be monitored for abuse, mistreatment and servicing. The fire hose reels shall be located within 4m of an exit and provide coverage to all general access areas of the building based on a 36m hose length with a 4m water stream (i.e. maximum 40m coverage from the hose location).
- ***Note:*** *The fire hose reel design does not require to the system to achieve compliant coverage through the caged automatic racking enclosure.*

8.3.6 Portable Fire Fighting Equipment

Portable fire extinguishers are to be provided throughout the area of new works in accordance with the prescriptive requirements of Table E1.6 of the BCA 2012 and the extinguisher type selected, located, and distributed in accordance with AS2444:2001.

■ Plant rooms	Dry Powder (ABE)	2.5 Kg
■ Designated exits	Dry Powder (ABE)	4.5 Kg
■ Adjacent each fire hose reel cabinet	Dry Powder (ABE)	4.5 Kg

8.4 FIRE BRIGADE INTERVENTION

8.4.1 Fire Brigade Rendezvous

The existing fire brigade rendezvous point being maintained at the main FIP to each building where tactical fire plans are provided such that these shall form the fire control centres for each building.

8.4.2 Fire Hydrants

The existing fire hydrant system shall be extended throughout the general access areas of the extension. All new works and modifications to the existing system shall be in accordance with the prescriptive requirements of the BCA 2012 Clause E1.3 and Part E1 and AS2419.1:2005.

- The system must be capable of providing coverage to all general access areas of the building based on a 30m (internal hydrant connections) and a 60m (external hydrant connections) hose length with an additional 10m water stream. Where internal hydrants are provided blockplans no smaller than A4 in size shall be provided on the external adjacent to the nearest exit door for fire brigade reference.
- The fire hose reel design does not require to the system to achieve compliant coverage through the caged automatic racking enclosure. However at a minimum, external hydrant points shall be provided adjacent each exit door on the southern side of the building, with additional points made available on the eastern and western sides of the extension as appropriate.
- Flows and pressures are required to be achieved as per the current regulatory requirements.

- The existing ring main shall be extended to accommodate the new hydrant points. The new ring main shall be provided with isolation valves as required by AS22419.1:2005 that are external to the building and numbered with the corresponding numbers indicated on the blockplan at the booster assembly.
- All existing blockplans shall be updated to reflect any new works.
- External hydrant connections shall be provided with the heat shields per the requirements of AS2419.1 (i.e. FRL 90/90/90 2m either side, and 3m above the hydrant connection point) or be setback more than 10m from the building.
- All connection points must be fitted with Storz hose couplings which comply with Clause 7.1 and 8.5.11 AS2419.1:2005. Further information is available from the FRNSW Guide Sheet No.4 '*Hydrant system connectors*' available at www.fire.nsw.gov.au.

8.4.3 Manual Smoke Clearance System

Commensurate to the existing base building fire engineering, a manually operated smoke clearance system shall be installed to the warehouse extension in lieu of the DTS required automatic smoke exhaust. The smoke clearance system shall be designed to achieve the following minimum performance requirements.

- Initiation switches shall be located on the main FIP, or an adjacent fan control panel, at the building entry.
- Signs alerting the Fire Brigade to the operation of the smoke clearance system must be provided.
- Fire rated fans and fire rated cabling shall be used and designed to operate at 200°C for a period of 60 minutes.
- System capacity must be capable of one enclosure air change per hour.
- It is recommended that multiple fans be provided and be evenly distributed to otherwise comply with the requirements of Specification E2.2b Clause 5 of the BCA.
- Adequate make-up air shall be provided at low level to facilitate the clearance system's designed operational capacity. The make-up air shall be provided at low level by:-
  - Permanently open natural ventilation louvers; and/or
  - Mechanically operated louvers that open upon activation of the fans. All motors and cables must be fire rated to operate at 200°C for a period of no less than 60 minutes.
  - If used for general ventilation, the air flow rate at any sprinkler head must be less than 1.5m/s and the system must shut down automatically upon any fire alarm, with manual override available to fire fighters.

8.4.4 Vehicular Perimeter Access

The existing vehicular perimeter access pathway shall be relocated and upgraded as required to provide access around the area of new works. This shall be designed and constructed in all-weather surface capable of supporting all FRNSW appliances in accordance with BCA Clause C2.4 and NSW Fire Brigade Policy No. 4 '*Guidelines for emergency vehicle access*', available at http://www.fire.nsw.gov.au/gallery/files/pdf/guidelines/vehicle_access.pdf.

The pathway shall form a continuous access in a forward direction with a minimum unobstructed width of 6m and no part of its furthest boundary more than 18m from the area of new works with the following exceptions to be addressed by an Alternative Building Solution;

- Prior to stage 5C the vehicular access pathway around the south-eastern corner of the building is permitted to be in excess of 18m from the structure. The details of this location are illustrated below.

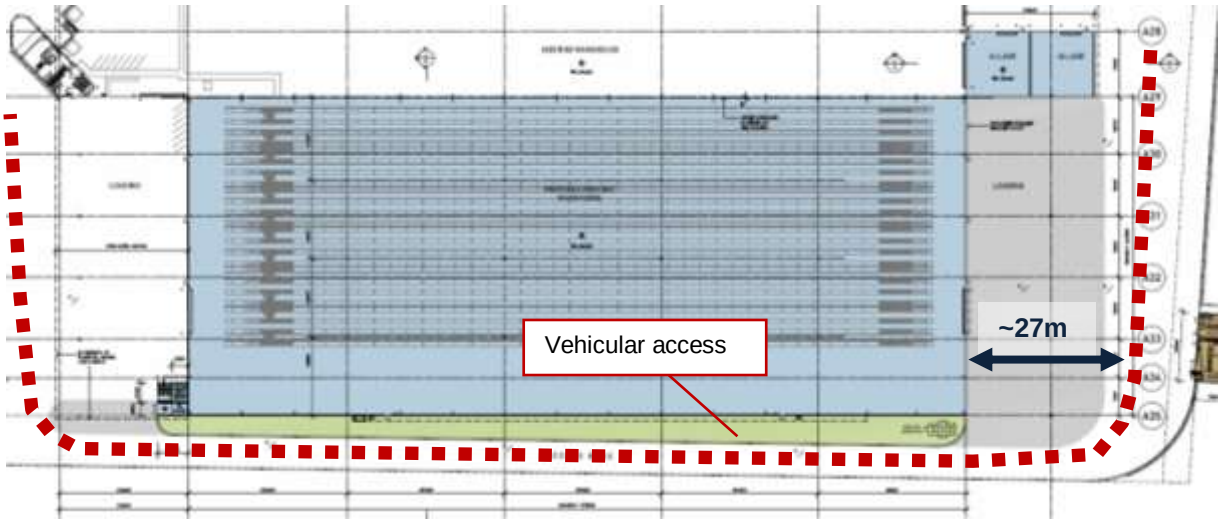


Figure 8-3: Non-compliant vehicular perimeter access

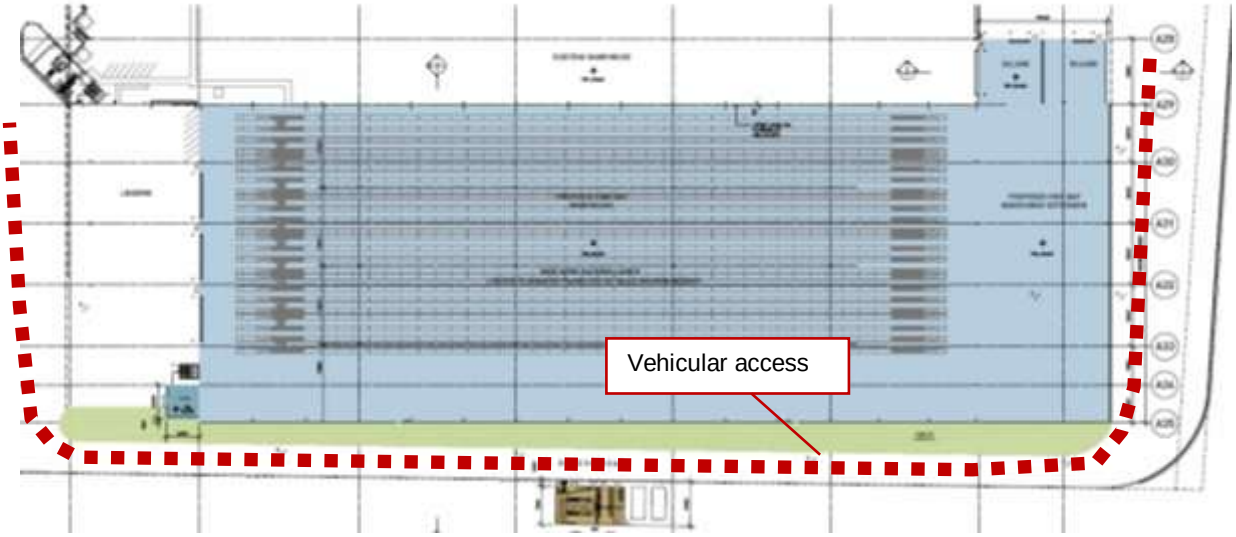


Figure 8-4: Compliant vehicular perimeter access following the completion of stage 5C

8.5 BUILDING MANAGEMENT PROCEDURES

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

8.5.1 Distribution of Commodities

The storage commodities to pass through the automated picking/packing system shall be classified and monitored to ensure that the quantities of any dangerous goods, i.e. hazardous, flammable or corrosive goods do not exceed the limitations defined in AS3833:2007 for 'Minor Storage'.

The picking system shall be programmed to ensure that incompatible goods are suitably segregated, with dedicated areas for each product (i.e. aerosols to be stored within a wire caged area, acidic and alkaline products to be segregated etc.). Further all items listed as dangerous or hazardous goods shall be located on the lowest storage level to avoid fire spread due to ignited flammable liquids.

Note: The quantities, locations, and distances of separation between stock items are to be confirmed in a Preliminary Hazard Analysis Report.

8.5.2 Maintenance of Fire Safety Equipment

The fire detection system, fire sprinkler system, emergency warning, fire hydrants, hose reels, portable fire extinguishers, emergency lighting and any other fire safety equipment shall be tested and maintained in accordance with Australian Standard AS1851 or other relevant testing regulatory.

As the smoke clearance system is developed as an Alternative Solution and therefore no testing regime is listed in AS1851, however the system shall be tested in accordance with the AS1851 requirements for an automatic smoke exhaust system.

8.5.3 No Smoking Policy

A no-smoking policy shall be implemented and enforced through all internal areas of the building, with designated smoking areas provided externally away from building openings and areas used for external yard storage.

8.5.4 Housekeeping

A Fire Risk Assessment (FRA) or similar method should be adopted upon occupation to determine high risk areas, processes and fuel loads 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.

8.5.5 Fire Drills and General Fire Safety Training

All fire wardens are to be trained in first-aid fire fighting and emergency response. All staff shall be inducted with a fire safety brief including the actions necessary on the activation of the building emergency 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.

8.5.6 Evacuation Planning and Risk Management

An evacuation plan should be developed in accordance with AS3745:2010, with standard fire orders displayed throughout the building. Further to this AS4360:2204 should be consulted regarding risk management in the site.

8.5.7 Assembly Area

An assembly area is to be designated in a suitably safe and open location.

8.5.8 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.

8.5.9 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.

8.5.10 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.

9 REFERENCES

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APPENDIX A SITE LAYOUT