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Fire Safety Strategy

Lot 3B, Oakdale South Industrial Estate

Oakdale South Industrial Estate, Horsley Park

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Report Details

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Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY	VERIFIED BY
01	30/05/16	Draft Issue for comment	**Dean Watt** *BEng (Chemical Engineering)*	**Colin Thomson** *BEng (Chemical Engineering)*	
02	22/07/16	Final Issue			**Sandro Razzi** *BE (Building)* *Grad Dip (Performance Based Building & Fire Codes)* *Accredited Fire Engineer* *BPB 0501* *FIEAust* *CPEng 2180287* 

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1 INTRODUCTION

1.1 OVERVIEW

This Fire Engineering Report has been undertaken to nominate proposed Performance Solutions for assessing compliance with the nominated Performance Requirements of the Building Code of Australia 2016 (BCA) [1] in accordance with the methodologies defined in the International Fire Engineering Guideline IFEG [3].

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

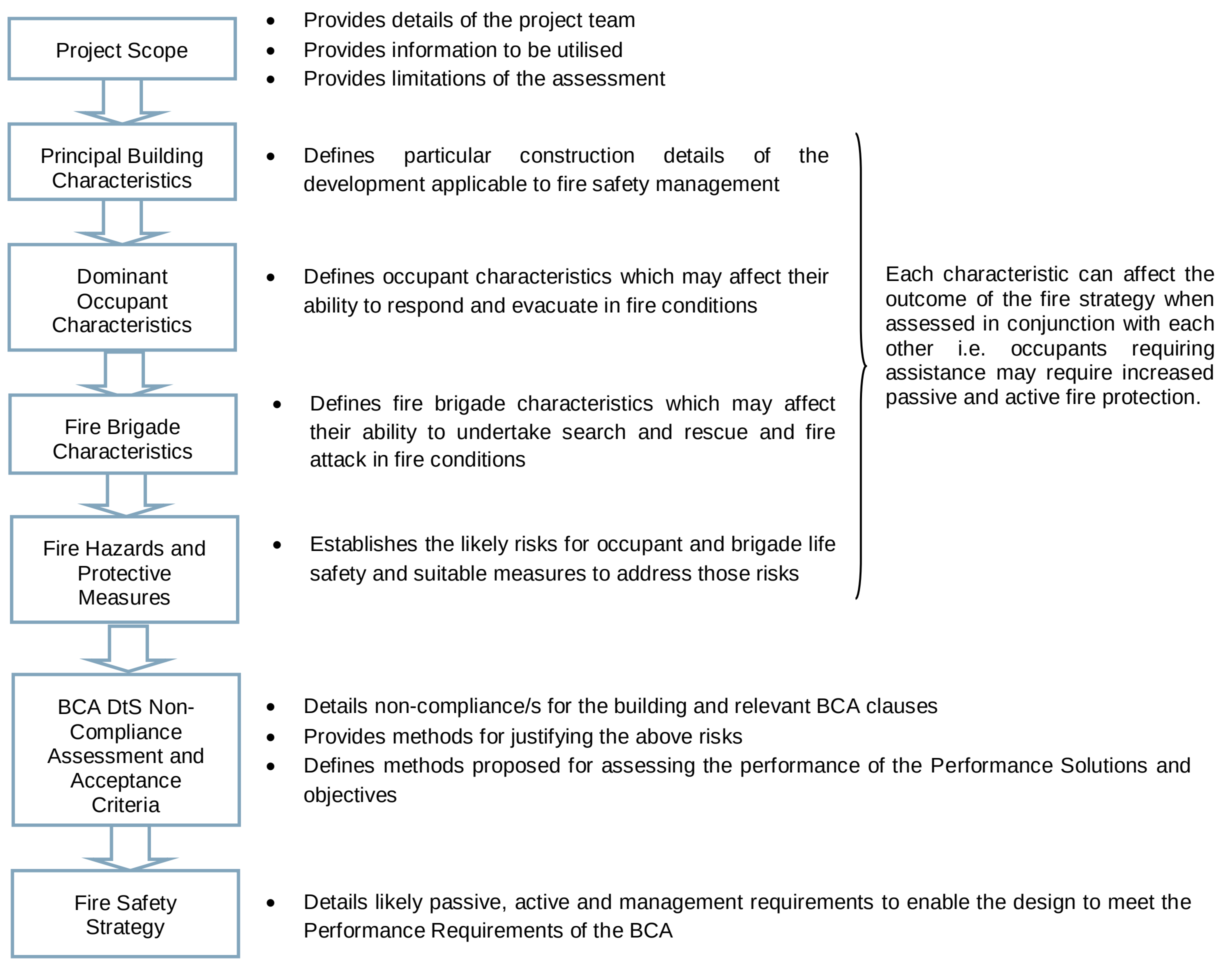


Figure 1-1: Fire Safety Strategy Process

The scope of the Fire Safety Strategy is to detail the nominated non-complying BCA Deemed-to-Satisfy (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 this 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) [9] 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 voids 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?
- **Occupational Health and Safety (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 A0.2 of the BCA [1] outlines how compliance with the Performance Requirements can be achieved. These are as follows:

(a) formulating a Performance Solution which –

(i) complies with the Performance Requirements; or

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

(b) complying with the Deemed-to-Satisfy Solutions; or

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

Section A0.5 of the BCA provides several different methods for assessing that a Performance 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 NCC; or

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

(c) Expert Judgement.

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

Section A0.7 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 Performance Solution: These methods are summarised as follows:

(a) Where a Performance Requirement is satisfied entirely by a Performance Solution:

  (i) Identify the relevant Performance Requirement from the Sections or Part to which the Performance Solution applies.

  (ii) Identify Performance Requirements from other Sections of Parts that are relevant to any aspects of the Performance Solution proposed or that are affected by the application of the Performance Solution.

(b) Where a Performance Requirement is satisfied entirely by a Performance Solution:

  (i) Identify the relevant Deemed-to-Satisfy Provisions of each Section or Part that is to be the subject of the Performance 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 Performance Solution proposed or that are affected by the application of the Deemed-to-Satisfy Provisions that are the subject of the Performance 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 assess strategies that provide acceptable levels of safety.

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

2 PROJECT SCOPE

2.1 OVERVIEW

Project Scope

CORE Engineering Group has been engaged to develop a Fire Safety Strategy for the construction of Lot 3B, Oakdale South Industrial Estate at Oakdale South Industrial Estate, Horsley Park. The purpose of this fire safety strategy is to outline the fire engineering principles that will be utilised in ensuring that the prescriptive Deemed-to-Satisfy (DtS) non-compliances noted in the Building Code of Australia (BCA) report are resolved in order to conform to the building regulations and permit development approval.

The complete fire engineered analysis will be included within the Fire Engineering Report, and as such is not documented herein. This document does however outline the construction and management requirements considered necessary to achieve an acceptable level of life safety within the building as a result of the Performance Solution and to satisfy the Performance Requirements of the BCA.

2.2 RELEVANT STAKEHOLDERS

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

Table 2-1: Relevant Stakeholders

ROLE	NAME	ORGANISATION
Construction Manager	Guy Smith	Goodman
Principal Certifying Authority/BCA Consultant	Dean Goldsmith	Blackett Maguire + Goldsmith
Architect		SBA Architects
Fire Safety Consultant	Colin Thomson Dean Watt	Core Engineering
Fire Safety Engineer	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, Environmental Protection Authority (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 Compliance report prepared by Blackett Maguire + Goldsmith. Project No. 160174 Revision 0, 24/05/2016.
- Architectural plans provided by SBA Architects, as indicated in Table 2-2.

Table 2-2: Drawings

DRAWING NO.	DESCRIPTION	ISSUE	DATE
OAK TOY DA00	Cover Sheet	A	22/04/16
OAK TOY DA01	Site Plan	C	09/05/16
OAK TOY DA02	Warehouse Plan	C	09/05/16
OAK TOY DA03	W/H Mezzanine Plan	C	09/05/16

DRAWING NO.	DESCRIPTION	ISSUE	DATE
OAK TOY DA04	Roof Plan	C	09/05/16
OAK TOY DA05	Office Plan – Ground Floor	E	11/05/16
OAK TOY DA06	Office Plan – First Floor Dock Office – Ground & First Floor	E	11/05/16
OAK TOY DA07	Elevations Office	B	09/05/16
OAK TOY SK07	Site Plan	G	21/04/16
OAK TOY SK08	Site Plan – Mezzanine	B	21/04/16
OAK MP 02	SSDA Masterplan	X	18/07/16

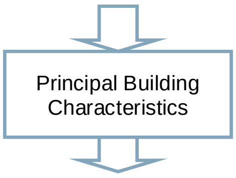
2.4 LIMITATIONS AND ASSUMPTIONS

In this instance the Fire Safety 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 3.
- 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 and 6.4 respectively. The report does not provide guidance in respect of areas, which are used for Dangerous Good storage, processing of flammable liquids, explosive materials, multiple fire ignitions or sabotage of fire safety systems.
- The development complies with the fire safety DtS provisions of the BCA [1] with all aspects for fire and life safety unless otherwise 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 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



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 firefighting 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 LOCATION

The development site is located in Horsley Park, approximately 42 km west of Sydney's central business district. The Oakdale South Industrial Estate site consists of multiple lots and is located on Estate Road connecting to Millner Avenue. This development is on Lot 3B within the estate.

Figure 3-1: Lot 3B Site Location **Source: www.googlemaps.com.au**

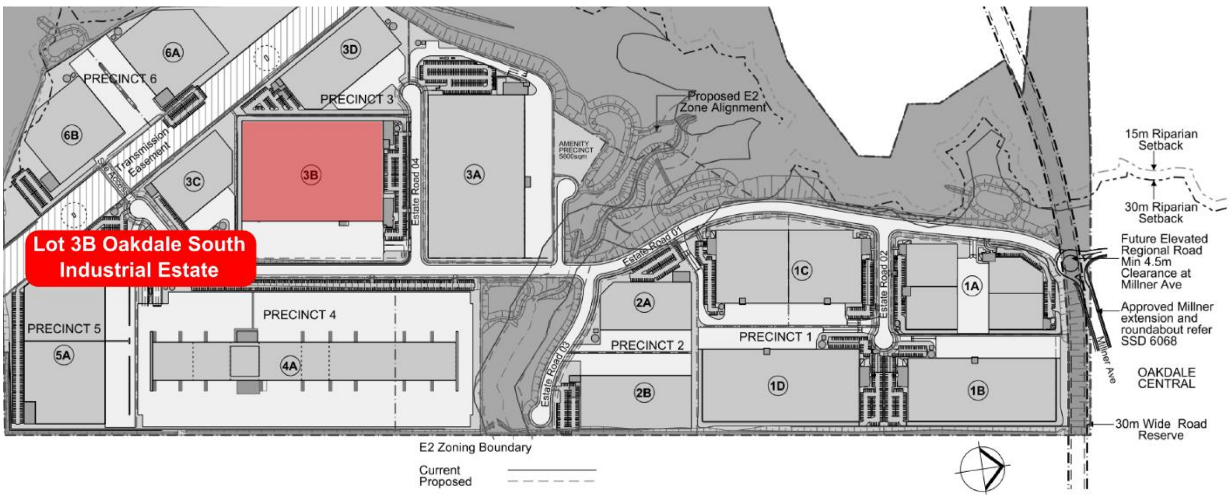


Figure 3-2: Lot 3B Estate Plan

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 in an outer suburb of a major city, the development is provided with the services and facilities expected in an urban setting. The two nearest fire brigade stations provided with permanent staff are Huntingwood and Bonnyrigg Heights approximately 8.5 km and 14 km from the site respectively when considering actual driving directions.

3.3 SITE LAYOUT

Lot 3B is located within the Oakdale South estate as illustrated in Figure 3-2. This report specifically addresses Lot 3B, other lots on this site are addressed in other reports. The total area of the development site is approximately 64,290 m². The warehouse has a floor area of 36,100 m² and a ridge height of 13.7 m. The development contains two ancillary offices, including:

- A 2-storey office (a total floor area of approximately 1,478 m²) is connected to the north-east of the warehouse building.
- A 2-storey dock office (a total floor area of approximately 176 m²) is situated on the eastern side of the warehouse building.

Onsite external carparking to the north of the site. Loading docks and associated hardstand for the warehouse are located on the eastern side of the building.

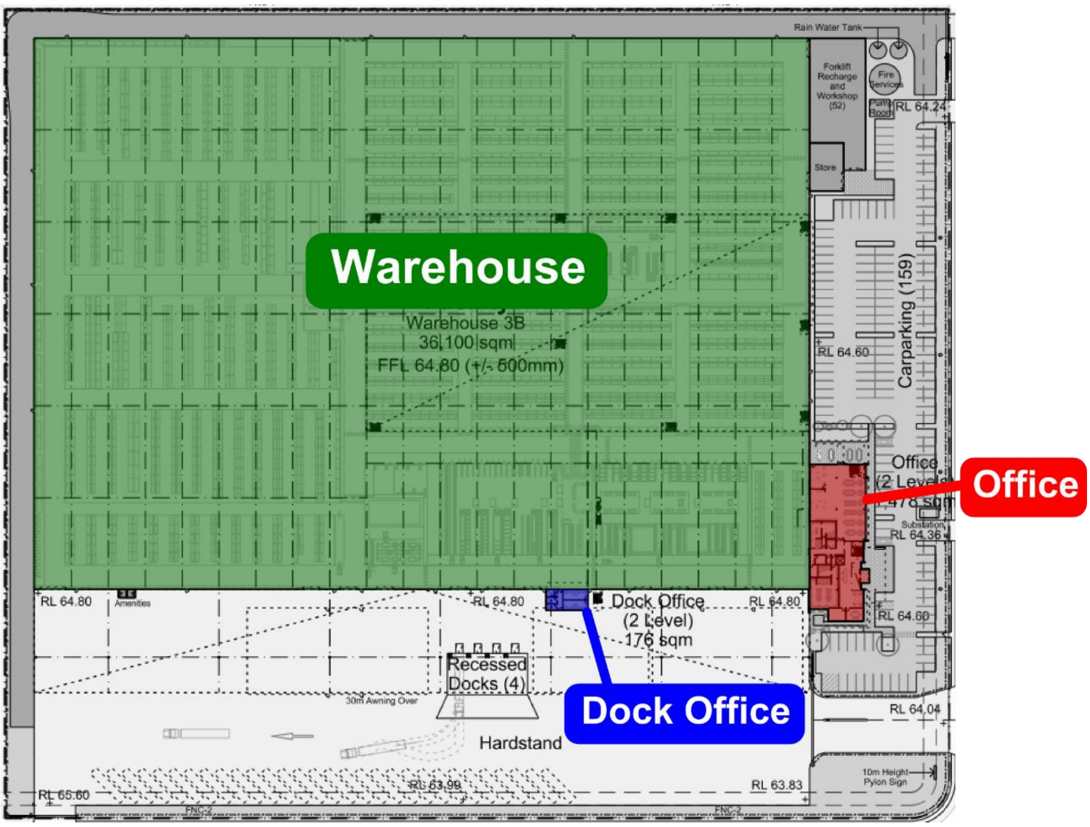


Figure 3-3: Lot 3B Site Plan

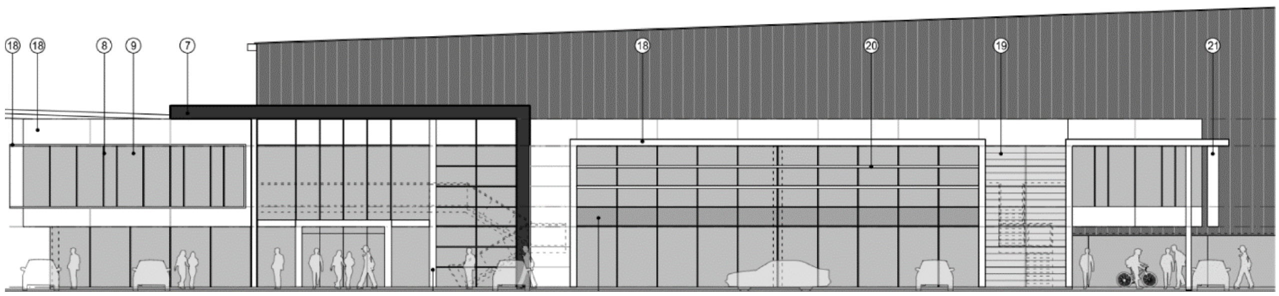


Figure 3-4: North Elevations

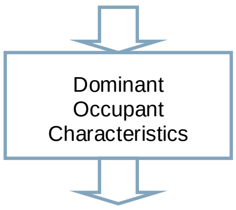
3.4 BCA ASSESSMENT SUMMARY

Table 3-1: BCA Building Characteristics

CHARACTERISTIC	DESCRIPTION
Classification	Class 7b (Warehouse), Class 5 (Office)
Construction Type	Type C Construction (Large Isolated Building)
Rise in Storeys	Two (2)
Effective Height	Less than 12 m
Floor Area	Lot 3B ▪ Warehouse: 36,100 m^2 ▪ Two-Storey Office: 1,478 m^2 ▪ Two-Storey Dock Office: 176 m^2 **TOTAL: 37,754 m^2**

4 DOMINANT OCCUPANT CHARACTERISTICS

4.1 OVERVIEW



The occupant characteristics are assessed within the Fire Engineering Report 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 affect 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 NUMBERS AND DISTRIBUTION

Occupant estimates for the site have been provided by the client, specified below:

- Warehouse: 56 occupants
- Main Office: 8 occupants
- Dock Office: 16 occupants
- A maximum of 138 occupants on site at a changeover of shifts (80 occupants for largest shift)

These estimated populations will form the basis for the fire engineering analysis.

4.3 OCCUPANT 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 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
- ***FRNSW*** are expected to be equipped with safety equipment and will be educated in firefighting 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.

4.4 OCCUPANT FAMILIARITY

The majority of occupants within the building are expected to be staff and therefore the population in general are likely to react favourably in an emergency situation.

- ***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
- ***FRNSW*** 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.

4.5 EMERGENCY TRAINING

Occupants should be familiar with escape procedures through fire drills and designated fire wardens being appointed to mitigate risks under Workplace Health and Safety legislation (AS 3745:2010). Clear escape routes should be maintained with doors unlocked, and no obstructions or rubbish to hinder evacuation.

Staff and visitors are not expected to have fire suppression training and such training is not relied upon for this building population; however, staff are expected to possibly attempt to extinguish a fire or limit fire spread by removing objects in the vicinity of the fire in order to defend their belongings.

5 FIRE BRIGADE CHARACTERISTICS

5.1 OVERVIEW

The fire brigade characteristics are assessed within the Fire Engineering Report due to the fact that Fire Brigade characteristics can dictate the time required for fire brigade intervention including search and rescue and fire attack.

5.2 FIRE BRIGADE ASSESSMENT

Figure 5-1 illustrates the site plan with fire services provided on the site. These include the Fire Services building in addition to the Pump Room.

Vehicular access is achieved through use of Estate Roads 1 and 4 on the eastern and northern boundaries of the site, respectively. A fire trail encircles the building on the southern and western boundaries.

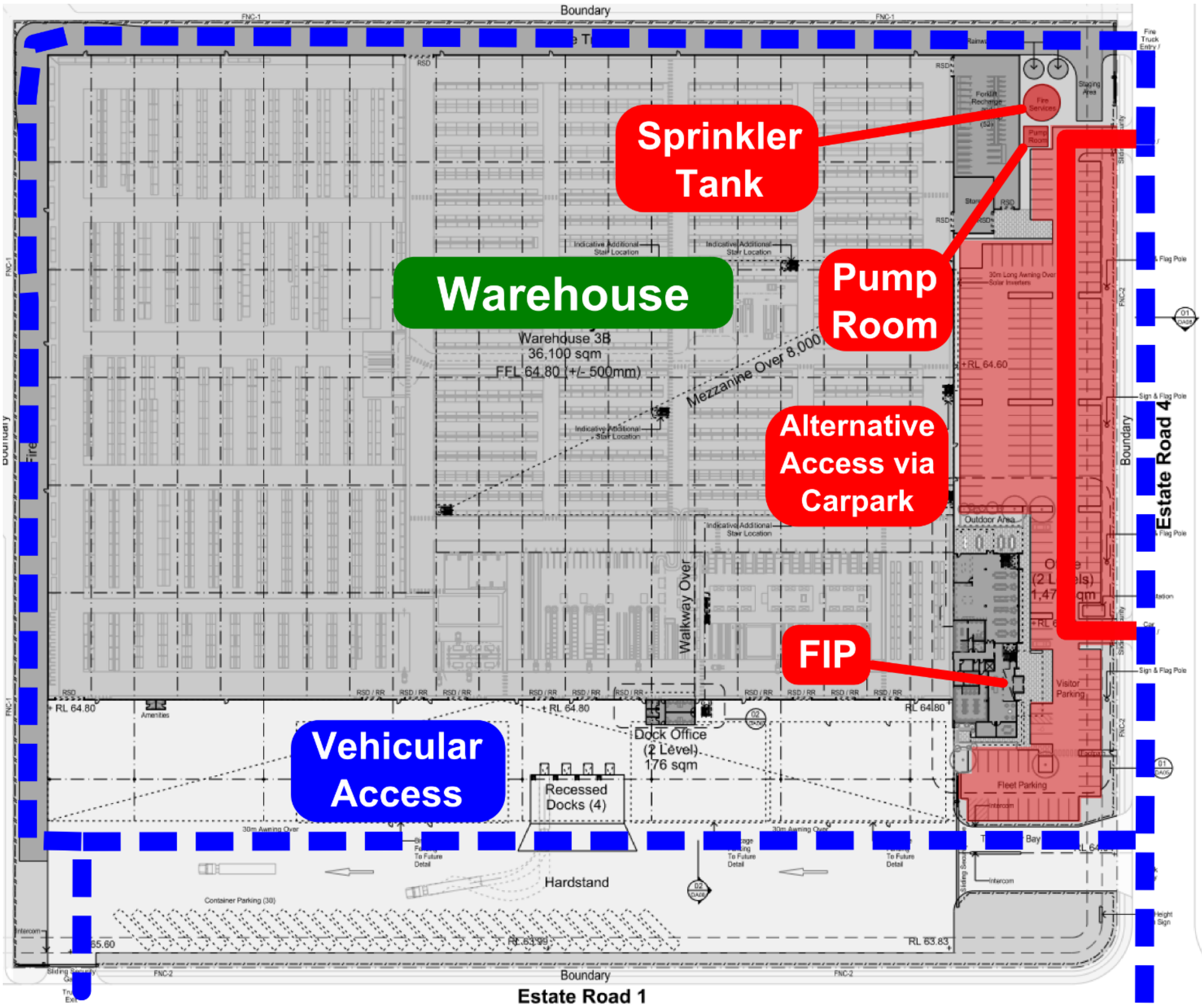


Figure 5-1: Fire Brigade Access and Site Facilities

The building is located within the Fire and Rescue New South Wales (FRNSW) jurisdictional turnout area. The closest two fire stations to the site that are provided with permanent staff are located in Huntingwood and Bonnyrigg Heights approximately 8.5 km and 14 km from the site, respectively.

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 [5]

STRUCTURE USE	FIRES PER YEAR	CIVILIAN FATALITIES PER YEAR	CIVILIAN FATALITIES PER 1000 FIRES
Hospitals	1,288	0	0
Schools	4,060	0	0
Retail/Department Store	1,150	1	0.87
Business offices	**2,890**	**3**	**1.04**
24-hour nursing homes	2,749	5	1.82
Hotels or motels	3,610	11	3.05
Warehouse	**1,270**	**4**	**3.15**
Apartments	106,380	410	3.85
Homes	260,180	2165	8.32

From the NFPA ‘Structure Fires by Occupancy 2007-2011’ Report [5], The civilian fatality rates from 2007 to 2011 highlighted in Table 6-1 show that storage warehouses have a medium risk to life compared to other property types with 3.15 civilian deaths per 1000 fires on average. This indicates a much greater risk per fire than other non-residential occupancies; however, this is balanced by the relatively low number of fires that occur.

6.2.1 Warehouse and Storage Facilities

From the National Fire Protection Association (NFPA) report on ‘Structure Fires in U.S. Warehouses’ [**5**] statistics specific to warehouses can be analysed.

A total of 1,270 structure fires were reported in warehouses between 2007 and 2011. The fires recorded resulted in 4 occupant fatalities, 23 occupant injuries and $188 million in direct property damage per year. Overall, 19% of fires were intentionally set, however no civilian injuries were reported from these fires. Shop tools and industrial equipment caused 8% of fires; however, these fires resulted in 27% of the civilian injuries recorded annually. The leading area of fire origin in warehouses comes from unclassified storage areas, resulting in 13% of fires and 18% civilian injuries.

Figure 6-1 illustrates the leading cause of structure fires in warehouses, while Figure 6-2 indicates the leading areas of origin.

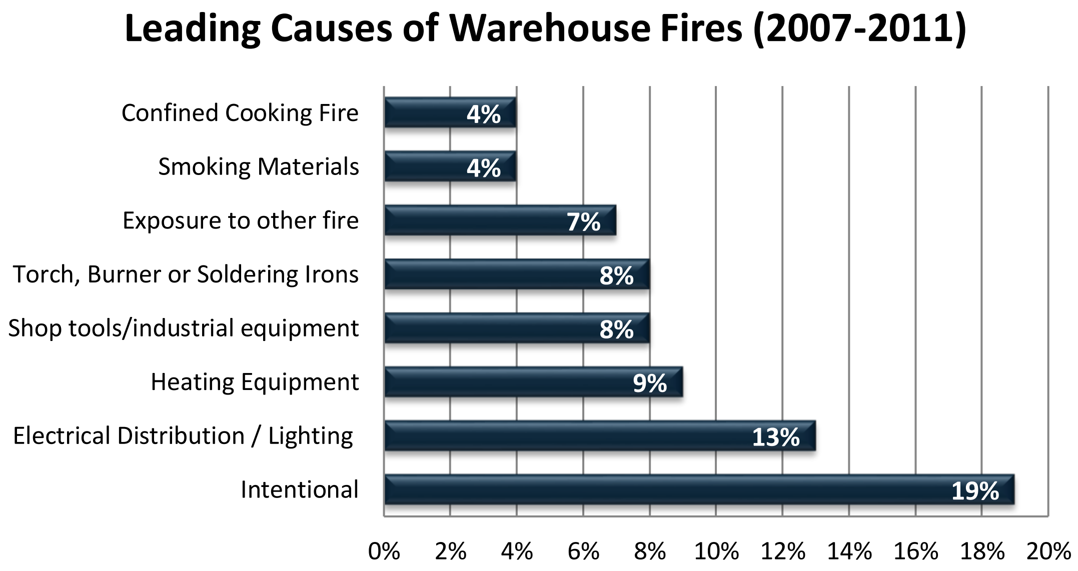


Figure 6-1: Leading Causes of Structure Fires in Warehouses

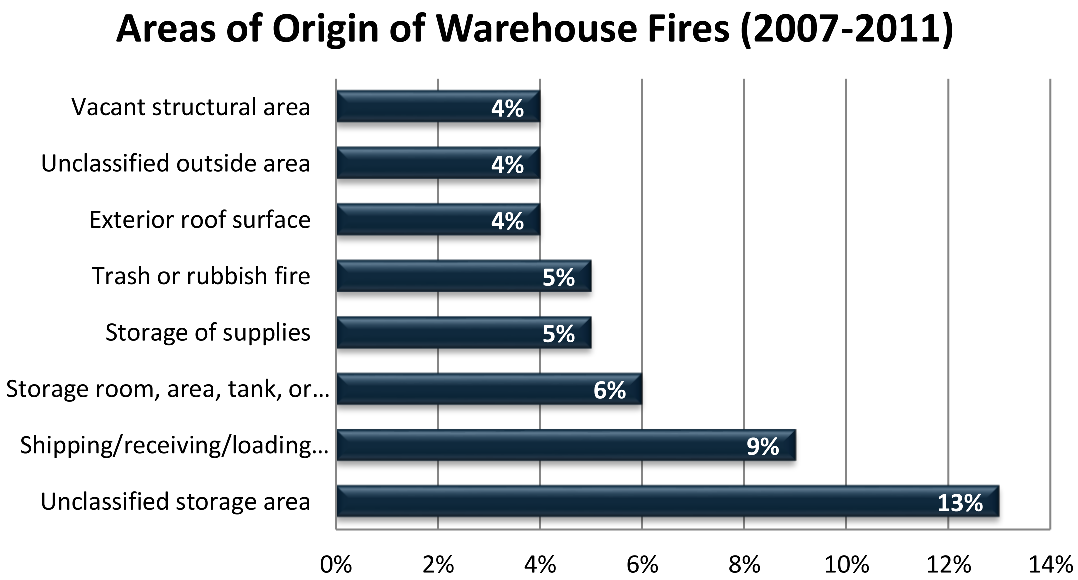


Figure 6-2: Structure Fires in Warehouse Structures by Area of Origin

6.2.2 Office Areas

From the National Fire Protection Association (NFPA) report on 'U.S Structure Fires in Office Properties' [**6**] statistics specific to building types relevant to this development can be analysed.

A total of 3,340 structure fires occurred in offices with 4 occupant fatalities, 44 occupant injuries and $112 million in direct property damage per year from 2007-2011.

The potential fire hazards in terms of leading areas of origins of fires and most frequent causes of fires in the office area of this building are investigated by using statistics for similar buildings. Campbell [**6**] reports that the leading cause of office fires in the US between 2007 and 2011 was cooking equipment followed by electrical/lighting equipment, and heating equipment. This is highlighted in Figure 6-3 with the areas of origin illustrated in Figure 6-4 compounding this data with the most common area of fire origin being in a cooking space. With only 4 civilian fatalities per year in office buildings, fatality data is deemed not to accurately represent risk and so has been omitted from the graphs.

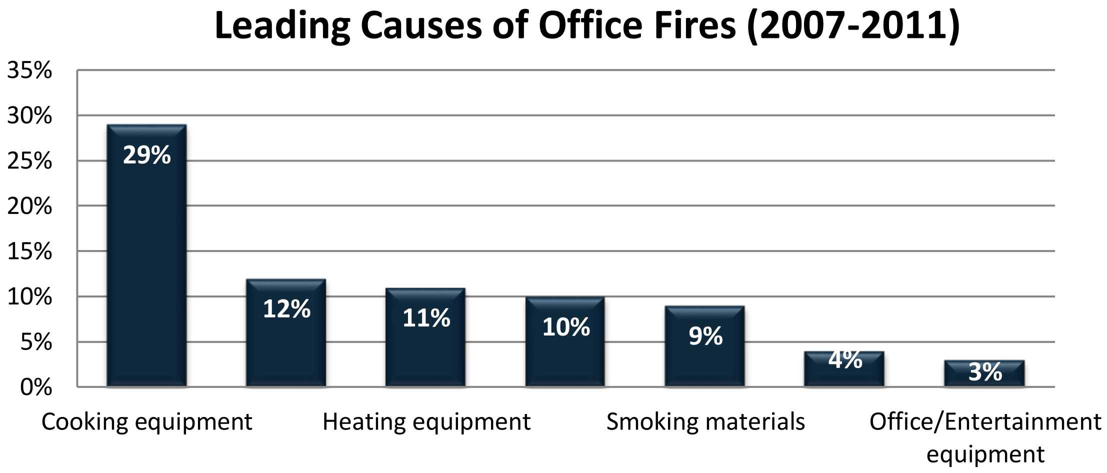


Figure 6-3: Leading Causes of Office Fires [6]

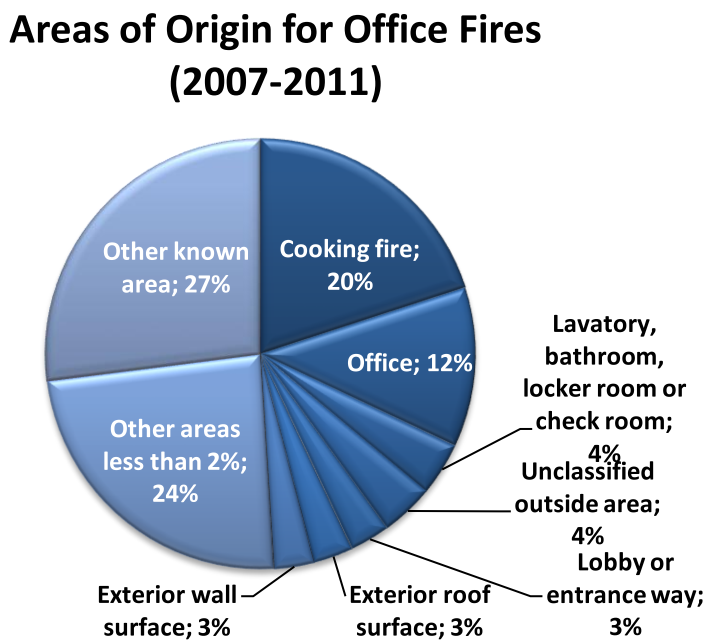


Figure 6-4: Areas of Origin for Office Fires [6]

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% [12] as well as some of the higher values of 87.6% [13] 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 [14] 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 [10] 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. Therefore, for the purposes of this assessment, on the activation of the ESFR fire sprinkler system, the fire growth is considered to be suppressed within the area of activation.

FM Global Data Sheet 2-0 states, *"loss history over the past twenty years indicates 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 [13]. 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 [13] 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 [13].

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%

Statistics for general sprinkler effectiveness in storage properties is provided in the table below which is drawn from the research of Rohr [15]. 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

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 tenant and stored commodities 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
Office, Business	800 MJ/m²
Forwarding facility dealing in; Beverages, food, furniture, glassware, plastic product, printed goods, varnish/polish.	Range from: 200 MJ/m² – 1700 MJ/m²
Storage of rubber products	5,000 MJ/m² per metre stored height
Storage of paper	1,000 MJ/m² per metre stored height

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:

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

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 that the times of fire incubation are not included in the time-squared growth fire models. National Fire Protection Association Standard NFPA 92B [13] provides information on the relevance of time-squared approximation to real fire as depicted in the figure below.

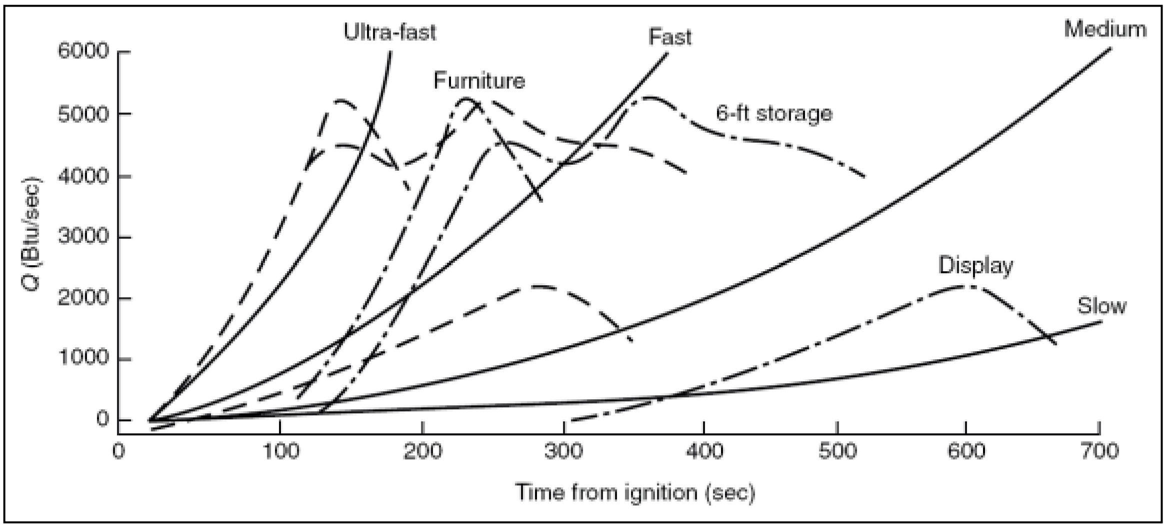


Figure 6-5: NFPA 92B: T-squared fire, rates of energy release

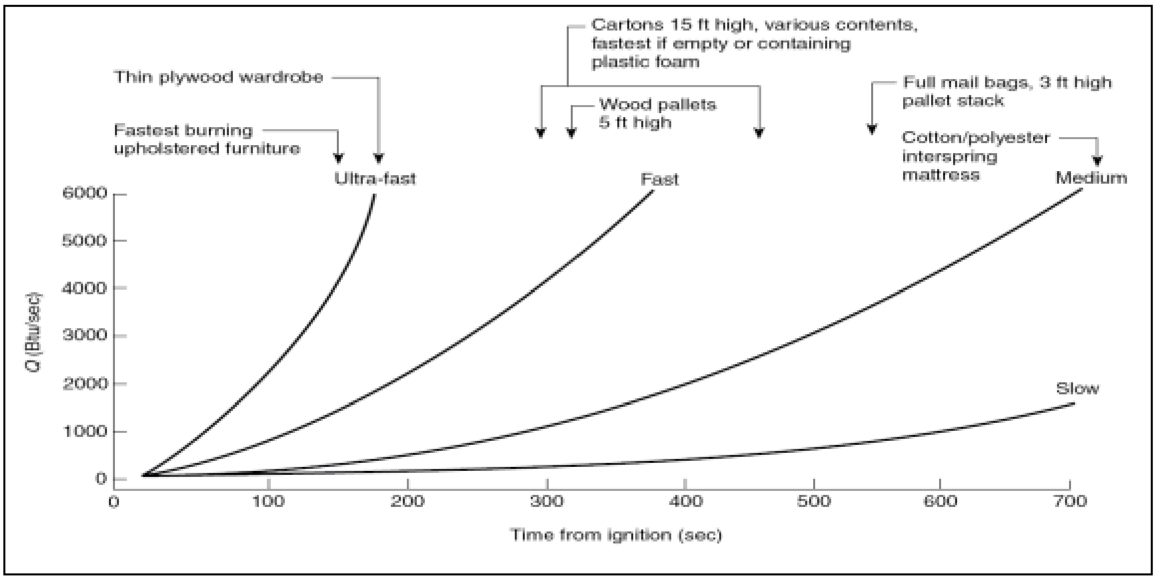


Figure 6-6: NFPA 92B: Relation of t-squared fires to some fire tests

The rate of fire growth can also be estimated from data published in British Standard (BS) 9999:2008 [4] 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
Warehouse	**Medium – Ultra Fast**	**Office**	**Medium**

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
Medium t^2	**Stacked cardboard boxes, wooden pallets.**
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 NFPA Fire Protection Handbook provides test values of soot yield for some common plastics which vary from 0.012 to 0.23 kg/kg [8]. Data for polyurethane is provided in the SFPE handbook which quotes a range between 0.104-0.227 kg/kg [7]. As the quantity of fuel in any particular building is expected to be of mixed type, taking the upper value in the range of plastics is considered overly conservative in representing the entire fuel load. The soot yield, quoted by various sources, for wood is 0.015 kg/kg which confirms that utilising 0.1 kg/kg is a conservative average for fire modelling in pre-flashover conditions where a mixture of plastic and cellulosic fuel is expected.

6.7 FIRE HAZARDS

Subsequent to a review of the relevant fire statistics and hazards presented in Section 6.2, the fire hazards are specific to this building are summarised below.

6.7.1 General Layout

Exits are provided around the buildings' perimeter to allow for multiple alternative egress opportunities. Due to the open nature of the warehouse, there are limited dead end travel routes to exits, however due to the building's large area, extended travel distances to the nearest exit and between alternative exits are present.

No hazards to adjoining buildings have been identified and internal hazards are minimal. Due to the open space and multiple egress opportunities, internal fire exposures are also expected to be minimal as occupants in the area of fire origin are likely to immediately become aware of fire and are likely to commence evacuation.

6.7.2 Activities

It is not expected that regular hot work processes, use of highly flammable materials, manufacturing processes or operation of high friction or high temperature machinery will be performed within the building. The development is a storage facility likely to contain a large number of high piled and racking containing combustibles.

6.7.3 Ignition Sources

Based on the statistical review contained in Section 6.2 ignition sources relevant to this site, in order of occurrence:

Warehouse

- Intentional
- Electrical distribution / lighting
- Heating equipment
- Shop tools / industrial equipment

6.7.4 Fuel Sources

Quantity of Materials

- Warehouse - The racked storage areas are likely to have the densest fire load, with between 200 MJ/m² – 1700 MJ/m² expected depending on the type of items stored.
- Office – 800 MJ/m² with isolated peak values reaching 1,600 MJ/m².

Dangerous Goods

Dangerous goods cannot be discounted from being present in the building. However, the quantity will be limited by the space available and relevant workplace health and safety regulations will apply governing storage allowances (quantity) and requirements.

Location of Materials

Products in high storage racking, store room, waste and rubbish containers. 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. Significant fuel loads will therefore be generally limited to the warehouse and offices.

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 a sprinkler controlled fire. This would be expected to grow at an ultra-fast time-squared fire growth rate until sprinkler activation in the warehouse areas, at which point the sprinklers are expected to suppress or control the fire. A medium t^2 fire growth rate is expected in the office areas.

6.8 PREVENTATIVE AND PROTECTIVE MEASURES

6.8.1 Fire Initiation and Development and Control (Sub-System A)

To minimise the risk of fires initiating and growing to a size which may impact on building occupants, fire safety systems are provided within the building as listed in the following sections.

6.8.2 Smoke Development and Spread and Control (Sub-System B)

It is recognised that smoke is one of the most serious threats to life safety in the event of a fire. Systems in place to reduce risk to occupant safety are as follows:

- The volume of the building acts as a large smoke reservoir to increase the available evacuation time for occupants.
- An automatic smoke exhaust system is provided in the warehouse.

6.8.3 Fire Spread and Impact and Control (Sub-System C)

To limit the extent and impact of fire spread through the buildings, the following are implemented in the building.

- Type C construction
- Sprinkler systems documented in Sub System D

6.8.4 Fire Detection, Warning and Suppression (Sub-System D)

The following active systems provided within the buildings to facilitate occupant warning and suppress a potential fire.

- Occupant Warning System
- Storage mode sprinkler system to warehouse
- Sprinkler system to offices and beneath awnings
- Aspirating smoke detection system in the warehouse
- Fire Hose Reels
- Fire Extinguishers

6.8.5 Occupant Evacuation and Control (Sub-System E)

The building is provided with the following systems to assist in the evacuation of occupants:

- Emergency Lighting
- Exit Signage

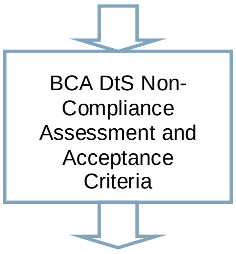
6.8.6 Fire Services Intervention (Sub-System F)

The building is provided with the following systems to assist in fire brigade intervention:

- Fire Hydrants
- Automatic Link to Fire Brigade
- Continuous vehicular perimeter access with minor non-conformances

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 principal certifying authority. 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].

7.2 BCA DTS NON-COMPLIANCE ASSESSMENT

Table 7-1: Summary of Performance Solutions

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
BCA DtS Provisions C2.4: Requirements for open spaces and vehicular access ***Performance Requirement(s)*** CP9	***BCA DtS Provision*** Clause C2.4: The building must be provided with continuous perimeter vehicular access with no part of the roadway less than 6 m in width and no more than 18 m from the building. The pathway must also permit the passage and operations of fire brigade appliances. ***DtS Non-conformance*** The following non-conformance has been identified: • Vehicular access on the northern (Estate Road No.4) and north-eastern (hardstand access driveway) perimeter of the building is greater than 18 m from the building (up to 53 m). ***Performance Solution*** The acceptance of the above non-conformances is based on the following fire safety systems/measures provided: • Access is provided around the whole of the site and although not always continuous, the areas greater than 18 m from the building are accessible for pedestrians and smaller vehicles via the carpark hardstand and dedicated pathways. ***Assessment Methodology*** The assessment methodology follows Clauses A0.2(a), A0.5(b)(ii) and A0.7 of the BCA. An absolute and qualitative approach 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 alternative exits.	***BCA DtS Provision*** Clause D1.4 travel distance to the nearest exit must not exceed 40 metres. Clause D1.5 travel distance between alternative exits must not exceed 60 metres. Clause D1.9 travel distance from any point on a floor to a point of egress to a road or open space by way of a required non-fire-isolated stairway must not exceed 80 m. Discharge from these stairways must not be more than 40 m from one of such doorways or passageways if travel to each of them from the non-fire-isolated stairway is in approximately opposite directions. Clause E2.2 *(Specification E2.2b)* requires an automatic smoke exhaust system be installed.

BCA DTS PROVISIONS & PERFORMANCE REQUIREMENT	PERFORMANCE BASED SOLUTION
Clause D1.9: Travel by non-fire-isolated stairways or ramps. Clause E2.2: Smoke hazard management. ***Performance Requirement(s)*** DP4 & EP2.2	***DtS Non-conformances*** The following non-conformances have been identified in the warehouse: • Travel distance of 107 m to nearest exit from the ground floor under the mezzanine. • Travel distance of 195 m between alternative exits on the ground floor. • Travel distance of 80 m between alternative exits on the mezzanine. • Central exit stairs off warehouse mezzanine discharge at a point that is greater than 40 m from the nearest exit to open space (approx. 78 m). • Total exit distance off the warehouse mezzanine via the non-fire-isolated exit stairs exceeds 80 m (approx. 125 m). • Smoke reservoirs are not provided in tandem with the automatic smoke exhaust system (exceeds horizontal area of 2,000 m², and the warehouse instead acts as a single smoke reservoir). ***Performance Solution*** The Performance Solution will rely upon the volume of the warehouse enclosure and automatic smoke exhaust 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 A0.2(a), A0.5(b)(ii), and A0.7 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 Dynamic (CFD) programs will be used to simulate the fire development and smoke spread in the warehouses with these results utilised in an ASET/RSET time-line analysis.
BCA DtS Provisions Clause E1.3 – Fire hydrants ***Performance Requirement(s)*** EP1.3	***BCA DtS Provision*** Clause E1.3 states that hydrants must be provided for a building with greater floor area than 500 m². Additionally, they must be installed in accordance with AS2419.1:2005. AS2419.1:2005(3.2.3.1) requires that all points on a floor shall be within reach of a 10 m hose stream and a 30 m hose length when connected to an internal fire hydrant outlet. External hydrants are allowed the use of 2 hose lengths (60 m). In addition, hydrant boosters shall be within sight of the main entrance to the building. ***DtS Non-conformance*** Hydrants under awning are to be used as external hydrants (allowing 2 hose lengths). Hydrant booster is to be positioned so that it is not within sight of the main office entry. ***Performance Solution*** The hydrants located beneath the awning are to have all the requirements of external hydrants per AS2419.1:2005, except that they are located within the building footprint. The brigade will be able to easily notice the hydrant booster, and should not be impeded in their operations by the booster not being visible from the main office. ***Assessment Methodology*** The assessment methodology will adhere to Clauses A0.2(a), A0.5(b)(ii) and A0.5(d), and A0.7 of the BCA. The analysis shall be comparative and quantitative with qualitative arguments to demonstrate that considering these hydrants as being external will not negatively impact the internal hose coverage nor the safety of the brigade as they fight a fire within the warehouse.

8 PROPOSED FIRE SAFETY STRATEGY

8.1 OVERVIEW

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 solutions.

This Section provides guidance for the design and application of fire safety measures. It highlights specific design considerations for a range of fire safety measures that will undergo analysis as part of the Fire Engineering Report to ascertain whether the relevant Performance Requirements of the BCA are satisfied. Design guidance (general informative details and specific requirements) for a range of specific fire safety measures is provided. This list is not exhaustive and the use of other fire safety measures including new technologies will require additional review.

8.2 PASSIVE FIRE PROTECTION

8.2.1 Type of Construction Required

The building shall be built in accordance with the BCA DtS provisions for Type C fire-resisting construction, as a large-isolated building.

8.3 EGRESS PROVISIONS

8.3.1 Evacuation Strategy

Activation of any detectors or sprinkler heads shall initiate the evacuation of all areas of the building. Dedicated fire wardens from the warehouse and office areas shall ensure that all clients, visitors, and staff are promptly evacuated.

8.3.2 Egress Provisions

In the warehouse, the travel distances to the nearest exit and between alternative exits must be compliant with the BCA DtS requirements with the following exceptions identified and illustrated in Figure 8-1 and Figure 8-2:

- Travel distances may extend up to 107 m to the nearest exit and 195 m between alternative exits in the warehouse in lieu of 40 m and 60 m, respectively.
- Travel distance up to 80 m between alternative exits on the mezzanine.
- Central exit stairs off warehouse mezzanine discharge at a point that is greater than 40 m from the nearest exit to open space (approx. 78 m).
- Total exit distance off the warehouse mezzanine via the non-fire-isolated exit stairs exceeds 80 m (approx. 125 m).

These non-conformances shall be addressed through a Performance Solution.

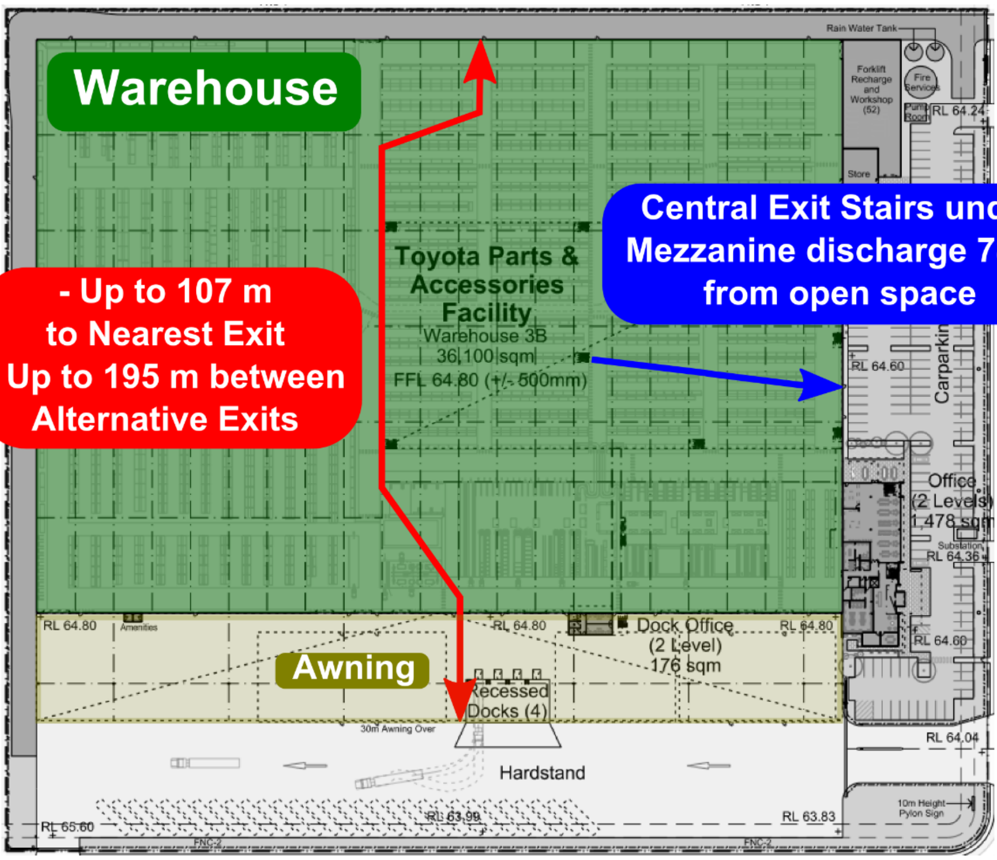


Figure 8-1: DtS non-compliant travel distances to nearest exits and between alternative exits on the ground floor of the warehouse

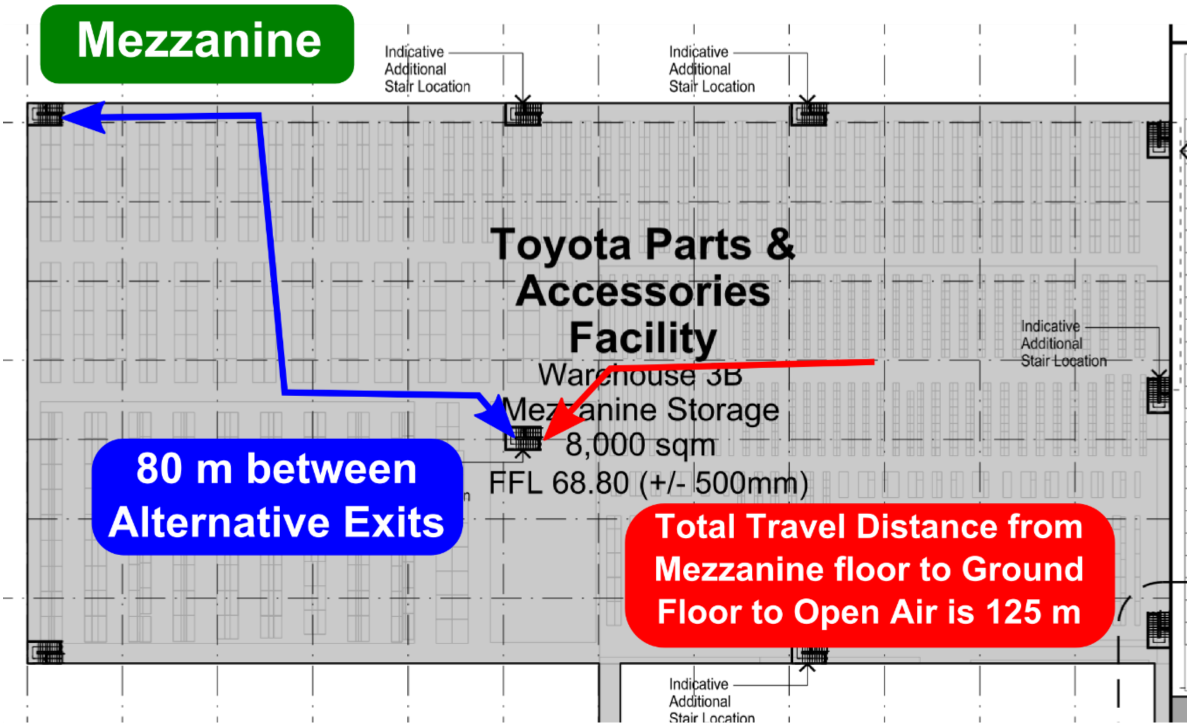


Figure 8-2: DtS non-compliant travel distances to nearest exits and between alternative exits on the mezzanine floor of the warehouse

8.3.3 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 the building. This includes the swing of doors, the applied latching and locking mechanisms and the force required on mechanism used to open sliding doors.

8.3.4 Signage and Lighting

Emergency lighting is to be provided throughout the building in accordance with DtS Provisions E4.2 and E4.4 of the BCA 2016 and AS2293.1:2005.

Exit signage is to be provided throughout the building in accordance with the DtS Provisions E4.5, E4.6, E4.8 of the BCA 2016 and AS2293.1:2005.

8.4 ACTIVE FIRE PROTECTION SYSTEMS

8.4.1 Building Occupant Warning System

A building occupant warning system shall be provided throughout all parts of the building. The system shall be in accordance with the prescriptive requirements of Specification E1.5 and Clause 6 of Specification E2.2a of the BCA 2016 and AS1670.1:2015.

- The occupant warning alarm shall be sounded throughout all areas of the building upon fire detection by the smoke detection or sprinkler systems.

8.4.2 Smoke Detection System

An aspirating detection system will be used to detect the presence of smoke within the warehouse in accordance with AS1670.1:2015.

8.4.3 Fire Sprinkler System

A fire sprinkler system shall be provided throughout the building in accordance with the relevant regulatory requirements. The site shall have an independent system with dedicated fire pump, water supply tank and booster assemblies.

- In the offices and beneath the warehouse awning the system shall comply with BCA Specification E1.5 and AS2118.1:1999.
- In the warehouse a storage mode system shall be provided in accordance with BCA Specification E1.5 and AS2118.1:1999, with the sprinkler head location, spacing and design capacity in accordance with Factory Mutual Guidelines 2-0 and 8-9 (or NFPA regulations). Sprinkler activation temperature must be no greater than 101°C and have a Response Time Index (RTI) of less than 50 $m^{1/2}s^{1/2}$ (i.e. fast response type).

Upon detection of a fire the building occupant warning alarm shall be initiated throughout the building and the direct brigade notification activated.

8.5 FIRST AID FIRE FIGHTING

8.5.1 Fire Hose Reels

Fire hose reel shall be provided throughout the building in accordance with Clause E1.4 of the BCA 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 areas of the building based on a 36 m hose length with a 4 m water stream (i.e. maximum 40 m coverage from the hose location).

8.5.2 Portable Fire Fighting Equipment

Portable fire extinguishers are to be provided throughout the building in accordance with Table E1.6 of the BCA and selected, located, and distributed in accordance with AS2444:2001. As a guidance:

• General office areas	Dry Powder (ABE type)	2.5Kg
• Computer/server rooms	CO_2	3.5 Kg
• 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

8.6 FIRE BRIGADE INTERVENTION

8.6.1 Fire Indicator Panels

The building shall be provided with a Main Fire Indicator Panel (FIP) within a compliant fire control centre at the main entry to the main office.

The Main FIP must be installed in accordance with BCA Specification E2.2a and AS1670.1:2015 and have the following capabilities.

- The FIP panel must be capable of isolating, resetting, and determining the fire location within the building.
- A red strobe shall be installed at the entry door to the FIP to alert arriving fire brigade of the fire alarm origin and FIP location.
- Smoke exhaust 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 exhaust and supply fans.

8.6.2 Fire Hydrants

A dedicated hydrant system, with independent booster assembly, must be provided for Lot 3B.

The fire hydrant system shall be in accordance with BCA Clause E1.3 and AS2419.1:2005 with the following specifications:

- Hydrants located beneath the warehouse awning shall be considered as external hydrants and be provided with protection as required
  - Fall-back hydrants are to be provided where external hydrants under awnings are used.
- The systems must be capable of providing coverage to all parts of the building based on a 30 m (internal hydrant connections) and a 60 m (external hydrants) hose length with an additional 10 m water stream.
- Per the request of FRNSW, where internal hydrants are installed within the warehouse these shall be designed to allow progressive movement through the building such that an internal hydrant is within 50 m of an external hydrant and 25 m of an internal hydrant.
- As far as possible the hydrant system should consist of external hydrant points, with internal hydrants only provided to achieve coverage to those areas not able to achieve coverage from external hydrant points.
- The system shall incorporate a ring main with isolation valves that are external to the building and numbered with the corresponding numbers indicated on the block plan at the booster assembly.
- External hydrant connections shall be provided with the heat shields per the requirements of AS2419.1 (i.e. FRL 90/90/90 2 m either side, and 3 m above the hydrant connection point) or be setback more than 10 m from the building.
- All hydrant connection points and the booster assembly 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.

8.6.3 Automatic Smoke Exhaust System

The warehouse shall be provided with an automatic smoke exhaust system. The smoke exhaust system shall be designed to achieve the following minimum performance requirements:

- To initiate upon activation of the sprinklers or smoke detection system within the warehouse.
- Fire rated fans and fire rated cabling shall be designed to operate at 200°C for a period no less than 60-minutes.
- System capacity must be capable of an exhaust rate equal to 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 exhaust system’s designed operational capacity. The make-up air shall be provided at low level by:

- Permanently open natural ventilation louvers; and/or
- Perforated roller shutters; and/or
- Mechanically operated louvers that open upon activation of the fans. All motors and cables to automatic louvers, vents or supply fans must be fire rated to operate at 200°C for a period of 60 minutes.

8.6.4 Vehicular Perimeter Access

The vehicular perimeter access pathway shall be provided around the whole of the building. These 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 with the following exception permitted:

- Vehicular access on the northern (Estate Road No.4) and north-eastern (hardstand access driveway) perimeter of the building is up to 53 m, in lieu of 18 m.

To facilitate the perimeter access non-conformances, the following measures shall be provided as part of the Performance Solution:

- All gates, security fencing and boom gates shall be readily openable by the fire authorities. This can be achieved through one, or a combination of, the following –
  - Fitted with locks that are openable with a 003 key; and/or
  - Fitted with locks / latches that are openable with a master key, swipe or badge with copies of these keys/swipes/badges provided to the two local fire brigade stations; and/or
  - Mechanical gates and boom gates shall open on fire trip and power failure.
- Access through the bordering carpark on the northern perimeter of the building is achievable for personnel and light brigade vehicles.

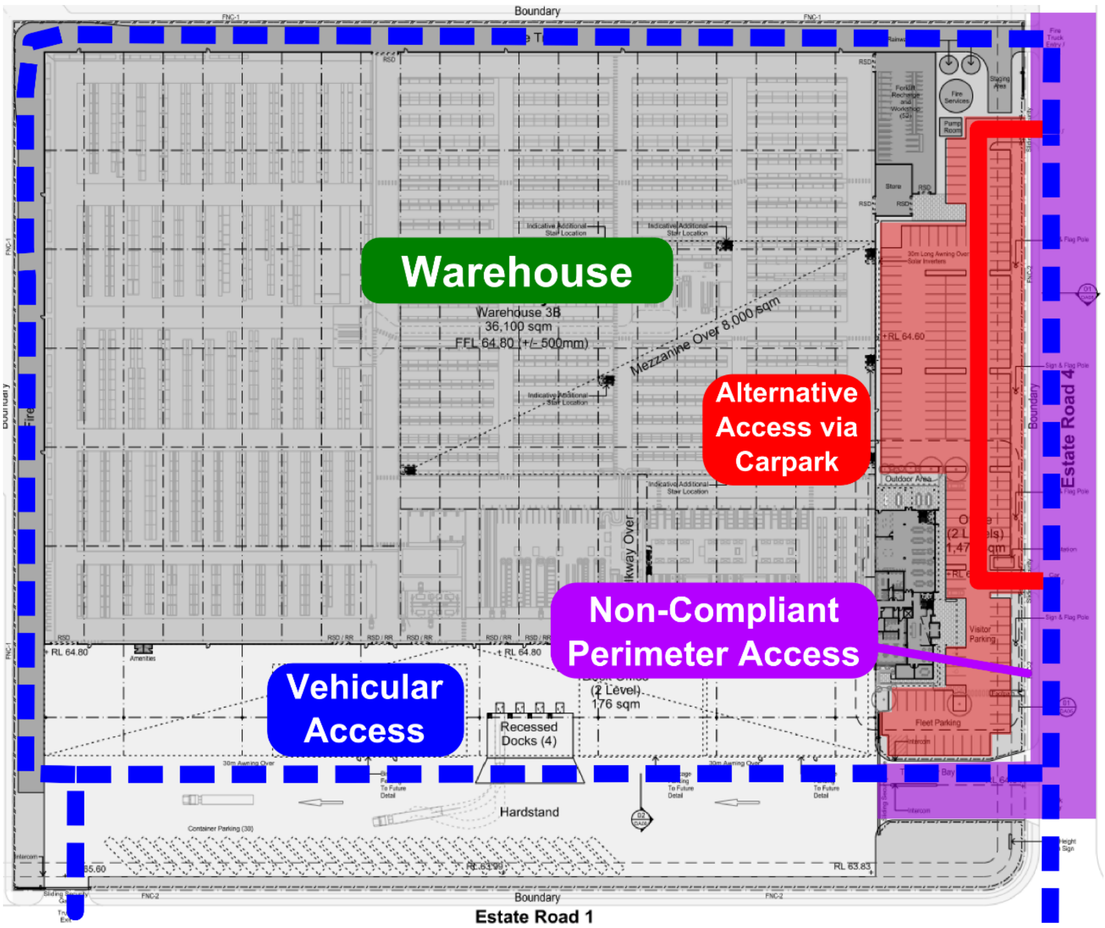


Figure 8-3: Vehicular Perimeter Access Path

8.7 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.

8.7.1 Maintenance of Fire Safety Equipment

The fire detection systems, fire sprinkler systems, emergency warning systems, 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.

The smoke exhaust system shall be tested in accordance with the AS1851 requirements for an automatic smoke exhaust system as applicable.

8.7.2 Evacuation Plan

An evacuation plan should be developed for the site in accordance with AS3745:2010.

- Standard fire orders should be displayed throughout the building.

9 REFERENCES

1. ABCB, “Building Code of Australia, Volume One”, CanPrint Communications, Canberra 2016.
2. ABCB, “Guide to the BCA 2016”, CanPrint Communications, Canberra 2016.
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