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Fire Safety Strategy

Oakdale West Precinct 1

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Report Details

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Report Revision History

REV	DATE ISSUED	COMMENT	PREPARED BY	REVIEWED BY
01	31 Mar 16	Draft Issue for comment	**Colin Thomson** *BEng (Chemical Engineering)*	**Graham Morris** *MEng (Structural and Fire Safety Engineering)*
02	07 Sept 16	Final Issue		

TABLE OF CONTENTS

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 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.

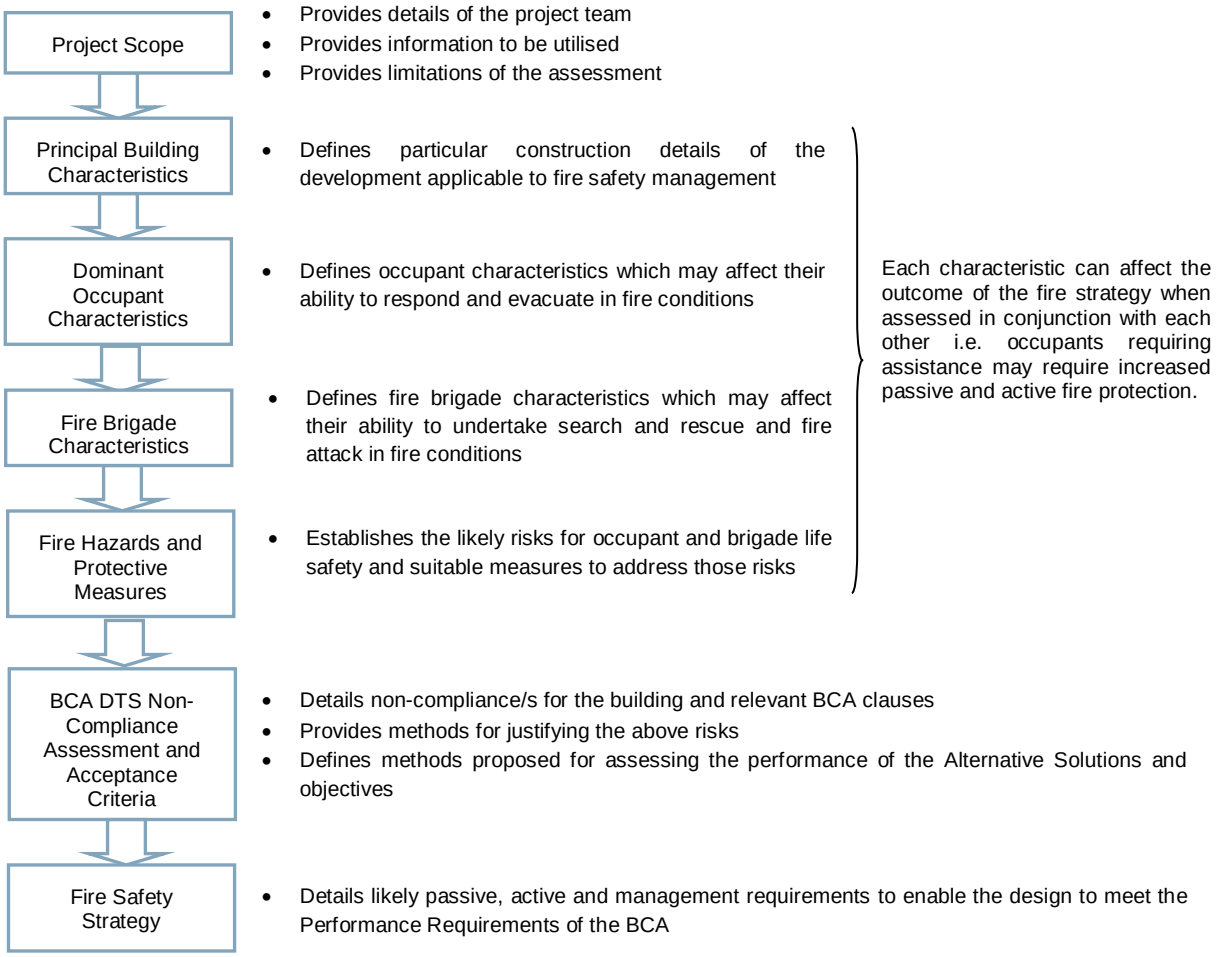

Figure 1-1: Fire Safety Strategy Process

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 objective 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) [8] 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 A0.5 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:

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

(b) Verification Methods such as:

(i) the Verifications Methods in the BCA; or

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

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

(d) Expert Judgment.

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

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

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

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

1.3.2 International Fire Engineering Guidelines

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

CORE Engineering Group has been engaged to develop a Fire Safety Strategy for the construction of multiple warehouse buildings at Oakdale West Estate on 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. This scope is for the Precinct 1 Development only.

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 Alternative Solution and to satisfy the Performance Requirements of the BCA.

2.2 RELEVANT STAKEHOLDERS

This Fire Safety Strategy has been developed collaboratively with the relevant stakeholders identified below:

Table 2-1: Relevant Stakeholders

ROLE	NAME	ORGANISATION
Planning Manager	Guy Smith	Goodman
Principal Certifying Authority/BCA Consultant	Dean Goldsmith	Blackett Maguire + Goldsmith
Architect	TBC	SBA Architects
Fire Safety Consultant	Colin Thomson	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:

- Architectural plans provided by SBA Architects, as indicated in Table 2-2.
- BCA Assessment Report by Blackett Maguire + Goldsmith, #160004, Rev 0, dated 29/03/16.

Table 2-2: Drawings

DRAWING NO.	DESCRIPTION	ISSUE	DATE
OAK 1A DA 10	Building 1A Plan	E	06/09/16
OAK 1B DA 20	Building 1B Plan	E	06/09/16
OAK 1B DA 30	Building 1C Plan	F	06/09/16
15117_OAK MP 02	SSDA Estate Masterplan	M	06/09/16
15117_OAK MP 05	Precinct 1	H	06/09/16

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 6.3. 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 buildings. 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.
- As a Fire Safety Strategy, this report only represents preliminary advice on the design and provisions expected to be required for the final overall design. Changes to the building design and outside requirements from FRNSW or other 3rd parties may change requirements for fire safety.

3 PRINCIPAL BUILDING CHARACTERISTICS

3.1 OVERVIEW

Building characteristics are assessed as part of the Fire Safety Strategy 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 LOCATION

The site is located within the Oakdale Industrial Estate (OIE) at Horsley Park, approximately 58 km west of the Sydney Central Business District (CBD). Figure 3-1 shows the regional location of the site in relation to the Sydney CBD.

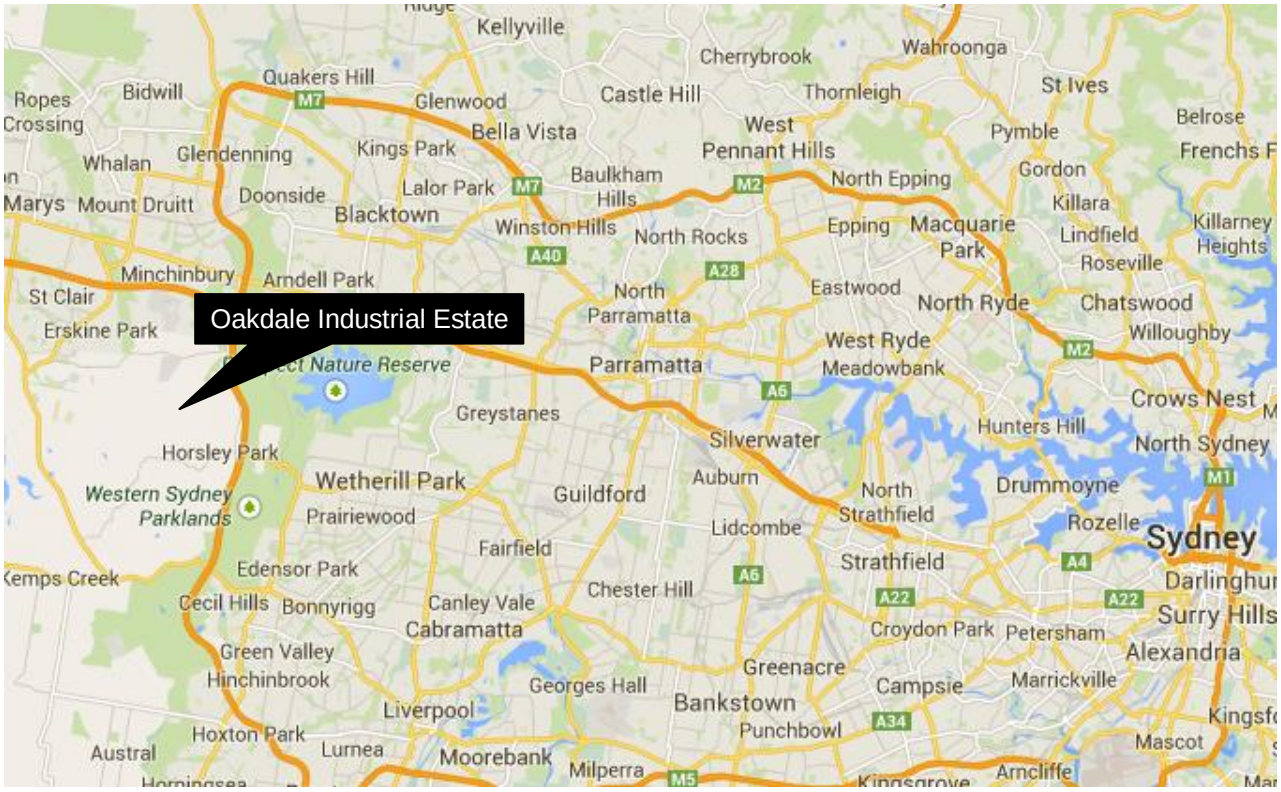

Figure 3-1: Oakdale Industrial Estate Site Location

The Oakdale West 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 that are provided with permanent staff are located in Huntingwood and Mount Druitt approximately 8km and 11km from the estate respectively.

3.3 SITE LAYOUT

The Precinct 1 Development of Oakdale West consists of three separate warehouses, nominally Building 1A, 1B and 1C. This development will form part of a large industrial warehouse estate, as evidenced by Figure 3-2. All other lots are to be provided their own project and S96, therefore this strategy details the Precinct 1 Development of Building 1A, 1B and 1C only.

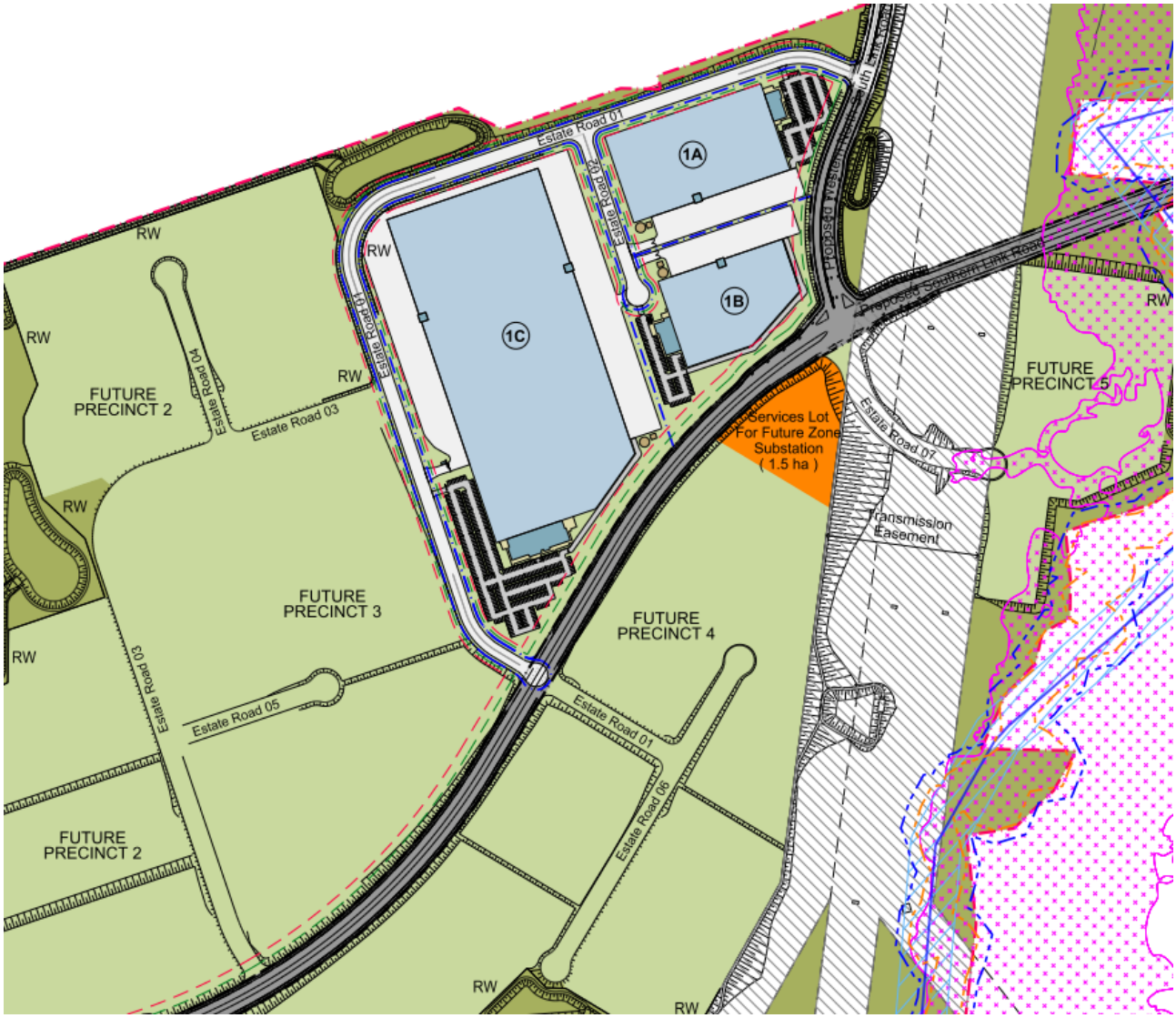

Figure 3-2: Estate Plan – Precinct 1

Building 1A is a single warehouse with ancillary, 2 level office, a 2 level dock office and external onsite car parking. It is considered a large isolated building for certification purposes and as such is provided with a sprinkler system throughout, smoke clearance provisions and vehicular perimeter access around the building.

Building 1B is a single warehouse with ancillary single storey office, a 2 level dock office and external onsite car parking. It is considered a large isolated building for certification purposes and as such is provided with a sprinkler system throughout, smoke clearance provisions and vehicular perimeter access around the building.

Building 1C is a single warehouse with ancillary 2 level office, two 2 level dock offices and external onsite car parking. It is considered a large isolated building for certification purposes and as such is provided with a sprinkler system throughout, smoke clearance provisions and vehicular perimeter access around the building. Building 1C is the largest of the three warehouses in the Precinct 1 Development.

Table 3-1: Building Areas

BUILDING	APPROXIMATE AREA
Building 1A	22,485 m^2
Building 1B	16,180 m^2
Building 1C	79,360 m^2

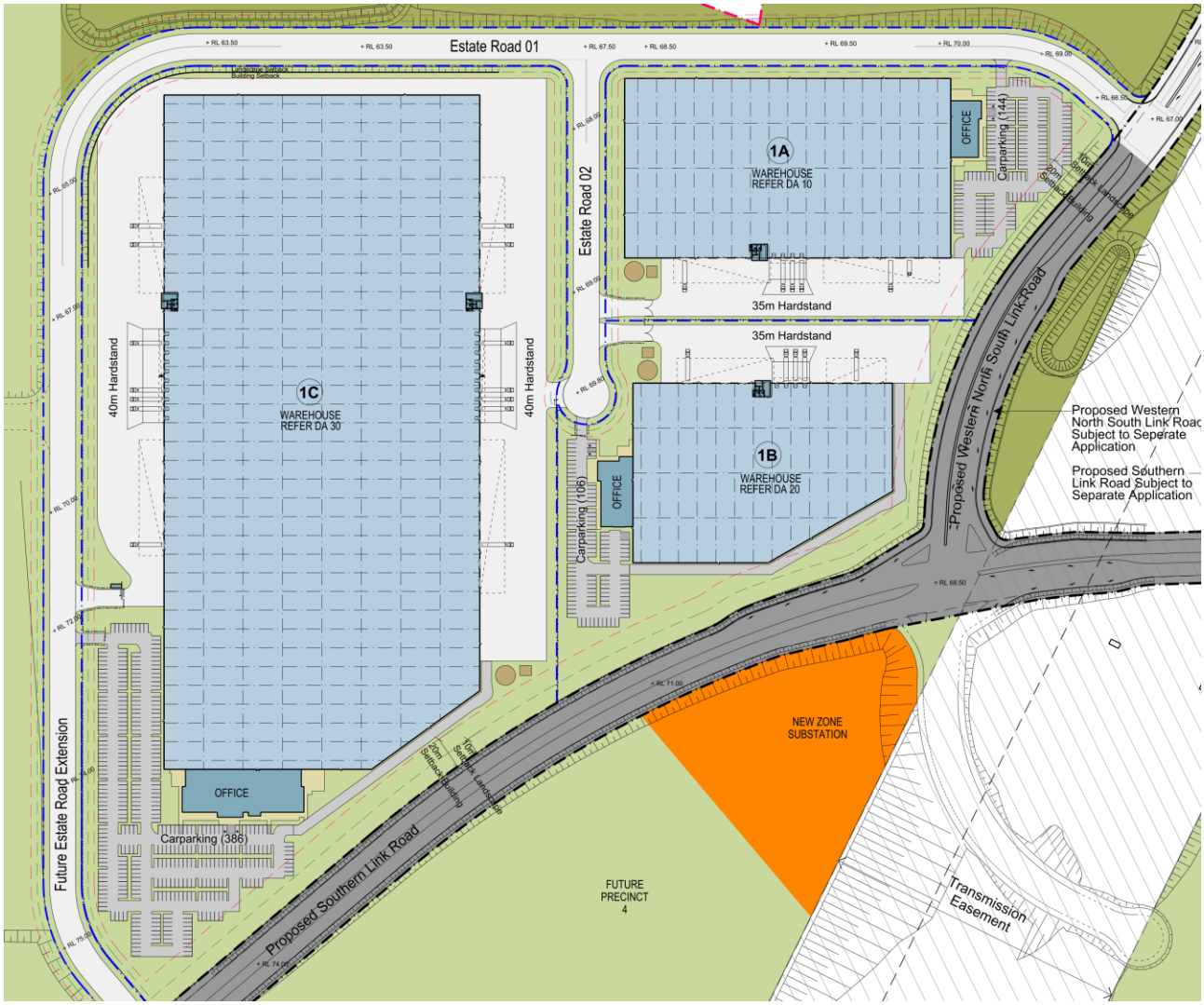

Figure 3-3: Site Plan

3.4 BCA ASSESSMENT SUMMARY

Table 3-2: BCA Building Characteristics

CHARACTERISTIC	DESCRIPTION	
Classification	All 3 buildings: Class 5 (Office) and Class 7b (Warehouse) Pump Rooms and Tanks – Class 10b	
Construction Type	Each building is Type C Construction (*Large Isolated Building*)	
Rise in Storeys	Building 1A and 1C: Rise in storeys of two (2) Building 1B: Rise in storeys of one (1)	
Effective Height	All buildings less than 12m	
Floor Area *Approximate – for information only*	**Building 1A – Total**	**22,485m^2**
	Warehouse 1A	21,115m^2
	Office 1A	1,180m^2
	Dock Office 1A	190m^2

CHARACTERISTIC	DESCRIPTION	
	Building 1B – Total	**16,180m^2**
	Warehouse 1B	15,190m^2
	Office 1B	800m^2
	Dock Office 1B	190m^2
	Building 1C – Total	**79,360m^2**
	Warehouse 1C	75,255m^2
	Office 1C	3,725m^2
	Dock Office 1C	380m^2

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 affect the occupant's 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

The BCA assumes the following occupant densities per an area's function and use according to Table D1.13:

- Warehouse: 30m^2 per person
- Office: 10m^2 per person

Both the warehouse and office space have large amounts of their areas set aside for storage, desks and other equipment which will reduce the available space for personnel occupation. Therefore, these values will be reduced, as large amounts of the office and warehouse will prove to be 'un-occupiable' due to fixed structures. These values result in the following estimated populations, per the BCA Assessment report.

Table 4-1: Estimated Building Population (DTS Table D1.13)

BUILDING PART	WAREHOUSE POPULATION	OFFICE POPULATION
Building 1A	210	110
Building 1B	152	80
Building 1C	752	328

These values likely far exceed the likely occupant numbers of the building, however for a conservative estimate the values will be used for evacuation purposes within the building in the absence of specific advice from the tenant.

4.3 OCCUPANT ATTRIBUTES

Occupants in the proposed 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 is 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 buildings 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.

- **Warehouse Staff and Security** – can be expected to have a good familiarity within the building they are located and the fire safety systems provided and may be trained in emergency procedures; and
- **Office Staff** – can be expected to have a good familiarity with the administration areas of the building they are located and the means of exits from these parts. General familiarity of their building as a whole and the location of main exits; and
- **Clients / visitors** – may or may not be familiar with the building layout 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 within which they are located 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.

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.

Clear escape routes should be maintained with doors unlocked, and no obstructions or rubbish to hinder evacuation.

Staff members are likely to have undergone AS3745:2010 emergency training for the occupant's WHS requirements. However, this is the employer's responsibility and as such, it is not directly relied upon for any assessment.

5 FIRE BRIGADE CHARACTERISTICS

5.1 OVERVIEW

The fire brigade characteristics are assessed within the Fire Safety Strategy 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 Building 1A site. Building 1A shall have dedicated site facilities including a hydrant booster at the entrance to the site, an FIP at the main office area, and a Pump Room and Sprinkler tank that are accessible from the perimeter access around the site.

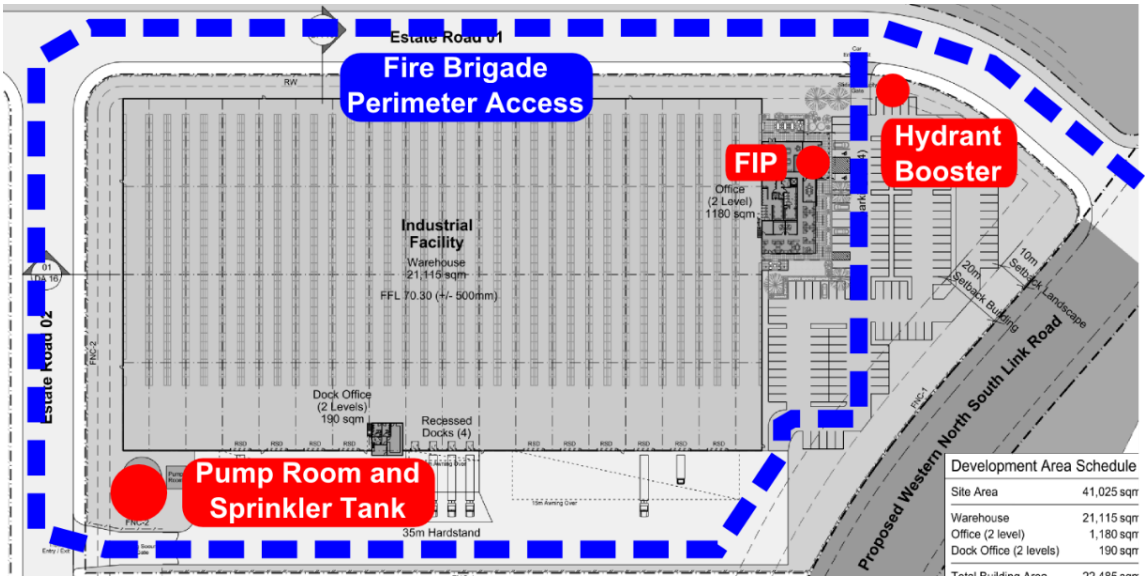

Figure 5-1: Fire Services Facilities – Building 1A

Figure 5-2 illustrates the site plan with fire services provided on the Building 1B site. Building 1B shall have dedicated site facilities including a hydrant booster at the entrance to the site, an FIP at the main office area, and a Pump Room and Sprinkler tank that are accessible from the perimeter access around the site.

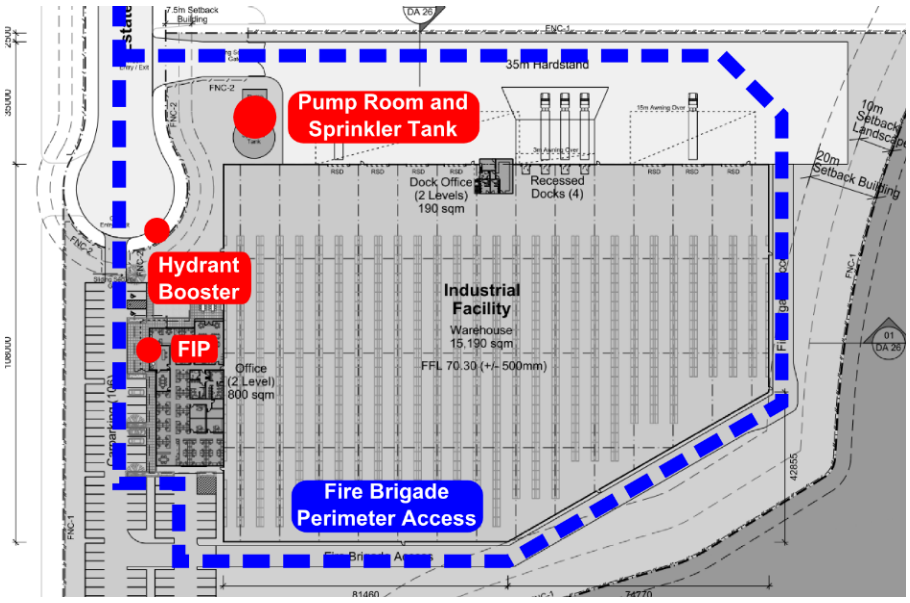

Figure 5-2: Fire Services Facilities – Building 1B

Figure 5-3 illustrates the site plan with fire services provided on the Building 1C site. Building 1C shall have dedicated site facilities including a hydrant booster at the entrance to the site, an FIP at the main office area, and a Pump Room and Sprinkler tank that are accessible from the perimeter access around the site.

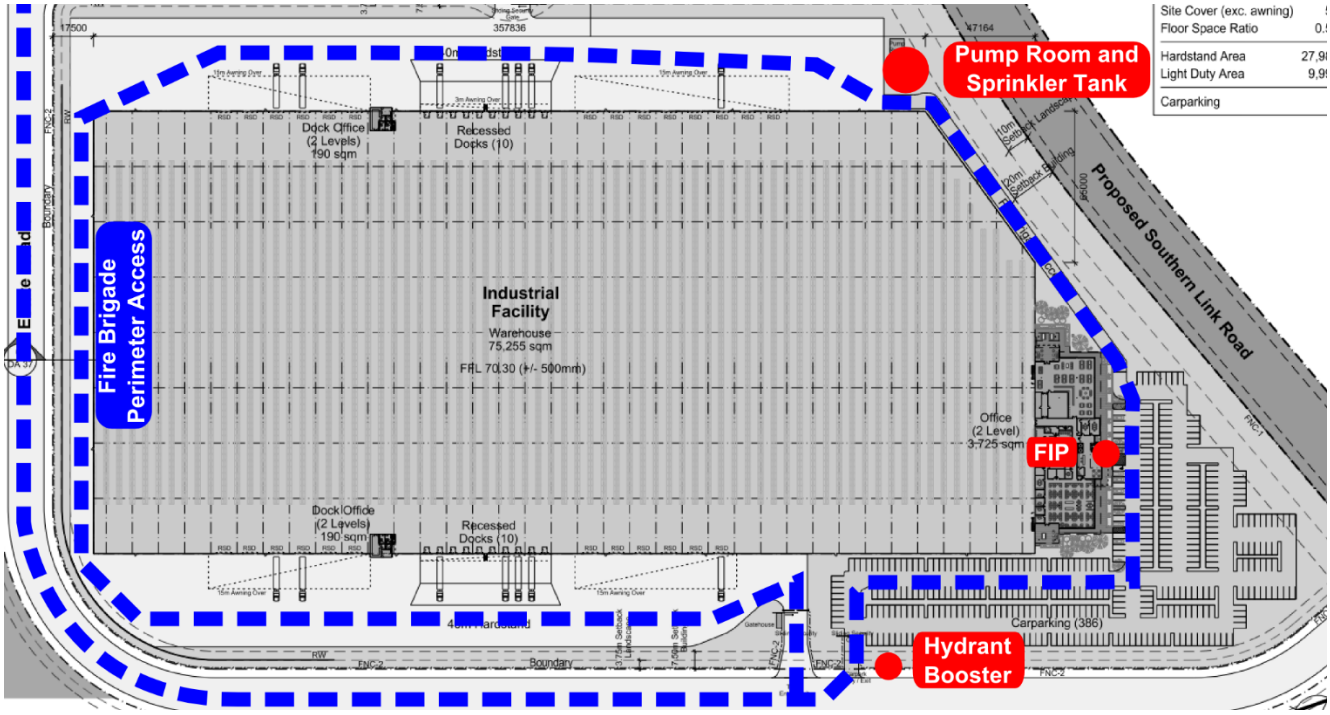

Figure 5-3: Fire Services Facilities – Building 1C

The building is located within the Fire and Rescue New South Wales (FRNSW) jurisdictional turnout area. The two nearest fire brigade stations that are provided with permanent staff are located in Huntingwood and Mount Druitt approximately 8km and 11km from the estate 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 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 continued growth of a fire defined by the above equation relies on both a sufficient source of fuel and air and assumes that flashover has not been reached. The rate of fire growth can be estimated from data published in British Standard (BS) 9999:2008 [4] as shown below.

Table 6-1: Fire Growth Rates as described in BS 9999:2008

BUILDING AREA PROVIDING FUEL	GROWTH RATE	BUILDING AREA PROVIDING FUEL	GROWTH RATE
Office	Medium	Warehouse	Medium to Ultra-Fast

From the above table it is concluded that the likely fire scenarios in a warehouse may be approximated by an ultra-fast time-squared fire growth rate curve, with an office being a medium fire growth rate curve.

6.3 FIRE HAZARDS

The fire hazards are specific to this building are summarised below.

6.3.1 General Layout

Exits are provided around the buildings' perimeter to allow for multiple alternative egress opportunities. Due to the open nature of a warehouse, there are limited dead end travel routes to exits, however due to each 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 commence evacuation.

6.3.2 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 any of the buildings. The developments are storage facilities and therefore likely to contain a large number of high piled and racking containing combustibles.

6.3.3 Ignition Sources

Ignition sources relevant to this site, in order of occurrence:

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

6.3.4 Fuel Sources

The high-racked storage (further detailed below) of materials throughout each warehouse presents a high source of fuel.

Quantity of Materials

- Warehouse - The racked storage areas are likely to have the densest fire load, with between 200MJ/m^2-1700MJ/m^2 expected depending on the type of items stored.
- Office - 800MJ/m^2 with isolated peak values reaching 1600MJ/m^2

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 warehouses 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 any of these buildings is a sprinkler controlled fire. This fire 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 of each building.

6.3.5 High-Racked Storage

Within each warehouse, no specific hazards are expected to be associated with the storage of these goods themselves, but the use of high-rack storage creates a dense amount of material, increasing the hazard from a fire spread and fuel availability point of view. The use of high-racked storage is typical in warehouse environments. The use of ESFR sprinklers are specifically designed to handle these types of storage situations.

6.4 PREVENTATIVE AND PROTECTIVE MEASURES

6.4.1 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 preventative safety systems are provided within each building as listed in the following sections. As the overall fire strategy is expected to be consistent within each building for the majority of the items, only where strategy differs are these items highlighted. Otherwise, the stated controls will be present within all 3 buildings.

6.4.2 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. To that effect, the following systems are design to increase the life safety of occupants in each warehouse:

- The volume of each building acts as a large smoke reservoir to increase the available evacuation time for occupants.
- A manual smoke clearance system is provided in each warehouse with a total exhaust rate of 1 air change per hour.

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

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

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

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

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

- Building Occupant Warning System.
- Storage mode sprinkler system to all warehouse areas of each building.
- Sprinkler system to office, dispatch areas and awnings.
- Smoke detection in Offices 1B and 1C.
- Fire Hose Reels.
- Fire Extinguishers.

6.4.5 Occupant Evacuation and Control (Sub-System E)

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

- Emergency Lighting.
- Exit Signage.

6.4.6 Fire Services Intervention (Sub-System F)

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

- Fire Control Centres.
- Fire Hydrants.
- Automatic Link to Fire Brigade.

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 buildings 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 Alternative Solutions

BCA DTS VARIATION	BCA PROCESS FOR REVIEW OF BUILDING SOLUTIONS
Vehicular Perimeter Access **BCA DTS Provisions** Clause C2.4: Perimeter Vehicle Access **Performance Requirements** CP9	**Relevant BCA DTS Provisions** Clause C2.4 states that the building must be provided with continuous perimeter vehicular access with no part of the roadway less than 6m in width and no more than 18m from the building. **DTS Variation** ■ Vehicular access is greater than 18m from the external walls of Building 1A and 1B. ■ Vehicular access is discontinuous in the southwest corner of Building 1C. **Alternative Solution** Continuous vehicle access in a forward direction is provided around each building. The majority of the access pathway is adjacent to each building to allow quick access into the building. The extended distance from Building 1A and 1B is along the Estate road, and is not expected to inhibit brigade operations as it is the primary carriage way around the sides of the buildings. The extended distance will be traversed quickly due to the wide road present. Staging will be available closer to the building at the most likely staging areas, such as the office and loading docks areas. The discontinuous access for Building 1C is where the loading dock discharges back to the main road, and vehicles then must transition to the parking lot. Forward motion is still maintained around the entire perimeter and the additional distance required to be traversed to re-enter the site is expected to have minimal impact on brigade operations. **Approaches and Method of Analysis** The assessment methodology follows Clauses A0.5(b)(i) and A0.9(b)(ii) of the BCA. An absolute and qualitative approach shall be completed to establish that the design matches the relevant Performance Requirement in facilitating direct, adequate access and entry into each building to undertake fire and emergency intervention activities. **Acceptance Criteria** Access is provided to and around the development to facilitate fire brigade and other emergency services intervention.
Warehouse Travel Distances and Smoke Hazard Management **BCA DTS Provisions** Clause D1.4:	**Relevant BCA DTS Provisions** Clause D1.4 & D1.5: travel distance to the nearest exit must not exceed 40-metres and travel distance between alternative exits must not exceed 60-metres. Clause E2.2 (Table E2.2a): requires a large isolated building be provided with an automatic smoke exhaust system with extraction rates as detailed in BCA Spec E2.2b and smoke zones no greater than 2000m^2. **DTS Variation** ■ Building 1A: Travel distances of up to 73m to the nearest exit and 140m between

BCA DTS VARIATION	BCA PROCESS FOR REVIEW OF BUILDING SOLUTIONS
Travel distances Clause D1.5: Alternative Exits Clause E2.2: Smoke Hazard Management **Performance Requirements** DP4, EP2.2	alternative exits exist in the warehouse in lieu of 40m and 60m respectively. ■ Building 1B: Travel distances of up to 68m to the nearest exit and 130m between alternative exits exist in the warehouse in lieu of 40m and 60m respectively. ■ Building 1C: Travel distances of up to 100m* to the nearest exit and 200m* between alternative exits exist in the warehouse in lieu of 40m and 60m respectively. ■ A rationalised manual smoke exhaust system shall be provided to each warehouse, with reduced rates (approx. one enclosure air change per hour) & single reservoir. **Note: These distances have been assessed as greater than 100m/200m (118m/226m respectively), however it is unlikely given past FRNSW feedback that extended distances over 100m to an exit will be accepted.* **Alternative Solution** The volume of the warehouse areas acts as a smoke reservoir for hot combustion products, providing the population with adequate time to safely evacuate the building prior to the onset of untenable conditions. Additionally, the sprinkler system is expected to limit the fire growth upon activation. **Approaches and Method of Analysis** The analysis will be absolute, quantitative and deterministic in accordance with Clause A0.5(b)(i) and A0.9(b)(ii). CFD analysis is utilised to model the expected smoke behaviour in each warehouse and subsequently an ASET/RSET time-line analysis is undertaken to determine safe occupant evacuation. **Acceptance Criteria** Occupants must be able to egress from the building under tenable conditions with the following relationships satisfied:- ■ $ASET_{BC} \geq 1.5 \times RSET_{BC}$ ■ $ASET_{BC} \geq RSET_{RED}$ ■ $ASET_{SEN} \geq RSET_{BC}$
Office Travel Distances **BCA DTS Provisions** Clause D1.4: Travel distances **Performance Requirements** DP4, EP2.2	**Relevant BCA DTS Provisions** <u>Clause D1.4:</u> travel distance to a point of choice within an office must not exceed 20m. Travel distance to the nearest exit, given more than one exit, must not exceed 40m. **DTS Variation** ■ Building 1B: Travel distances of up to 30m* to a point of choice and up to 49m to the nearest exit. ■ Building 1C: Travel distances of up to 24m to a point of choice and up to 49m to the nearest exit. **Note: This distance has been assessed as greater than 30m (36m), however this distance is considered to be excessive and likely required to be reduced below 30m for assessment to be accepted.* **Alternative Solution** Fire detection within the office area will be improved due to the presence of an AS1670.1 smoke detection system, in addition to the DTS required sprinkler system. This is expected to reduce the time to detection, providing an earlier warning and so improving conditions occupants will be egressing under, thereby offsetting the additional distance to the point of choice and nearest exit. **Approaches and Method of Analysis** The assessment methodology adheres to BCA clauses A0.5(b)(ii) and A0.9(c). An RSET/RSET comparison will be undertaken on the provision of smoke detectors in addition to automatic sprinklers. A supporting qualitative discussion on the conditions occupants will evacuate in will also be given. **Acceptance Criteria** Occupants must be demonstrated to be able to evacuate in equivalent or better conditions than presented in a DTS compliant design.

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

Each building shall be built in accordance with the BCA DTS provisions for Type C fire-resisting construction, as large-isolated buildings.

8.3 EGRESS PROVISIONS

8.3.1 Evacuation Strategy

Activation of any sprinkler heads (and detection where installed) shall initiate the evacuation of all areas of the affected warehouse. Dedicated fire wardens for each warehouse and associated office areas shall ensure that all clients, visitors, and staff are promptly evacuated from the affected warehouse.

8.3.2 Egress Provisions

The travel distances to point of choice, the nearest exit and between alternative exits must be compliant with the BCA DTS requirements with the following exceptions identified below.

Table 8-1: Summary of DTS non-compliant Travel Distances within Warehouses

LOCATION	TRAVEL DISTANCE TO NEAREST EXITS	TRAVEL DISTANCE BETWEEN ALTERNATIVE EXITS
Building 1A - Warehouse	73m	140m
Building 1B - Warehouse	68m	130m
Building 1C - Warehouse	100m*	200m*

**These distances have been assessed as greater than 100m/200m (118m/226m respectively), however it is unlikely given past FRNSW feedback that extended distances over 100m to an exit will be accepted. Further consultation and potentially design changes may be required to reduce travel distances to a recommended maximum of 100m to an exit.*

Table 8-2: Summary of DTS non-compliant Travel Distances within Offices

LOCATION	TRAVEL DISTANCE TO POINT OF CHOICE	TRAVEL DISTANCE TO NEAREST EXIT
Building 1B - Office	30m*	49m
Building 1C – Office	24m	49m

**This distance has been assessed at 36m which likely will require reduction as it is quite excessive to a point of choice. Further consultation and potentially design changes may be required to reduce travel distances to a recommended 30m maximum to a point of choice within office areas.*

These non-conformances shall be addressed through Alternative Solutions, reliant on the occupant characteristics and systems specified as noted herein.

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 each 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 each building in accordance with DTS Provisions E4.2 and E4.4 of the BCA and AS2293.1:2005.

Exit signage is to be provided throughout each building in accordance with the DTS Provisions E4.5, E4.6, E4.8 of the BCA 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 each 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 and AS1670.1:2004.

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

The occupant warning alarm shall be sounded throughout all areas of the affected building upon activation of the smoke detection system in Office 1B and 1C.

8.4.2 Fire Sprinkler System

A fire sprinkler system shall be provided throughout each building in accordance with the relevant regulatory requirements.

- In the offices and beneath the warehouse awnings the system shall comply with BCA Specification E1.5 and AS2118.1:1999.
- In the warehouse area of each building, a storage mode sprinkler 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 $50m^{1/2}s^{1/2}$ (i.e. fast response type).
- The arrangement of the sprinkler tank and suction points for each building is to meet FRNSW guidelines: http://www.fire.nsw.gov.au/gallery/files/pdf/guidesheets/SFSU_Guide_sheet_Hardstands.pdf

8.4.3 Smoke Detection

Due to the extended travel distances within the Offices of Building 1B and 1C, an AS1670.1 compliant smoke detection system is to be installed throughout Office 1B and Office 1C. The activation of the smoke detection system will activate the building occupant warning system.

8.5 FIRST AID FIRE FIGHTING

8.5.1 Fire Hose Reels

Fire hose reel shall be provided throughout each 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 36m hose length with a 4m water stream (i.e. maximum 40m coverage from the hose location).

8.5.2 Portable Fire Fighting Equipment

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

8.6 FIRE BRIGADE INTERVENTION

8.6.1 Fire Indicator Panel

An FIP must be installed to each building in accordance with BCA Specification E2.2a and AS1670.1:2004 and have the following capabilities:

- The FIP panel must be capable of isolating, resetting, and determining the fire location within the associated 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 clearance fan controls shall be provided at the FIP, if a separate fire fan control panel is provided it shall include clear signalling of the operation or otherwise, of the fans.

8.6.2 Fire Hydrants

A dedicated hydrant system, with independent booster assembly, must be provided for each building.

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

- 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 systems must be capable of providing coverage to all parts of the building based on a 30m (internal hydrant connections) and a 60m (external hydrants) hose length with an additional 10m water stream. The design shall also take into account the FRNSW 50/25 spacing guidelines:
    - As 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 50m of an external hydrant and 25m of an internal hydrant.
- Directional signage shall be provided within each warehouse to provide guidance to FRNSW personnel to internal hydrant locations. This may take the form of providing block plans at all external hydrants.
- 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 blockplan 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 2m either side, and 3m above the hydrant connection point) or be setback more than 10m 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.
- The hydrant booster for each site is to be visible from the main entrance to the associated building.
- The hydrant booster is to be installed such that a brigade appliance staging at the hydrant booster will not block the perimeter access path.

8.6.3 Manual Smoke Clearance System

In lieu of the BCA required automatic smoke exhaust system, each building and associated warehouse area shall be provided with manually operated smoke clearance systems.

The manual smoke clearance systems shall be designed to achieve the following minimum performance requirements.

- Initiation switches shall be located on the Main FIP, or an adjacent panel, at the office’s main entry for the associated building.
- 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 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 for the relevant enclosure.
- 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 associated warehouse clearance system's designed operational capacity, to a maximum of 2.5m/s velocity through the open areas provided for make-up air. This make up air may be provided through:
  - 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. 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. This includes confirming swept paths through the parking lot areas, which may constitute pinch points for access.

The departures from the compliant vehicular perimeter access shall be handled as an Alternative Solution and are indicated below.

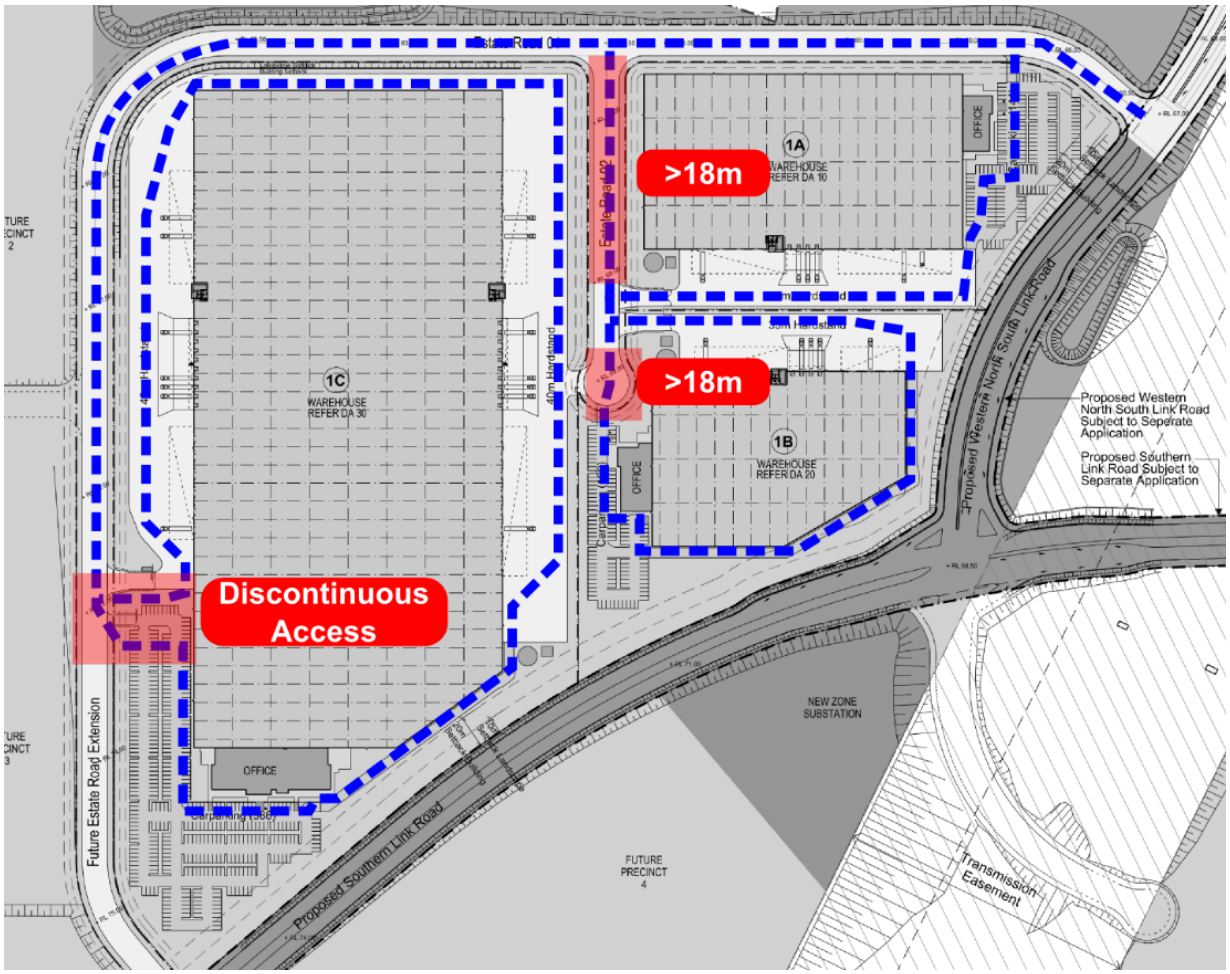

Figure 8-1: Perimeter Access Non-Compliances

8.6.5 Hardstand for FRNSW Vehicles

A hardstand area capable of supporting FRNSW appliances is to be provided adjacent to each sprinkler pump room and tank to serve the suction points.

The sprinkler/booster suction point connections are to be designed in accordance with NSWFB guideline available at http://www.fire.nsw.gov.au/gallery/files/pdf/guidesheets/SFSU_Guide_sheet_Hardstands.pdf to ensure perimeter access is maintained while an appliance is connected.

Similarly, for each fire hydrant and sprinkler booster it must be ensured that an appliance connected to the booster valves will not obstruct the perimeter access path for the associated building.

8.7 BUILDING MANAGEMENT PROCEDURES

The ongoing management of each 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.

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 each 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.
3. ABCB, “International Fire Engineering Guidelines”, ABCB, Canberra, 2005.
4. BS 9999: Code of practice for fire safety in the design, management and use of buildings, October 2008.
5. Campbell, R., “Structure Fires in U.S. Warehouses”, National Fire Protection Association, Quincy MA, June 2013.
6. Society of Fire Protection Engineers, ‘Handbook of Fire Protection Engineers’, 3rd Edition, 2002.
7. National Fire Protection Association, ‘Fire Protection Handbook’, 19th edition, Volumes I and II, 2003.
8. “Fire Brigade Intervention Model V2.2”, Australasian Fire Authorities Council, October 2004.