innova services

Fire Safety Engineering
Building Services Engineering

Fire Engineering Report

Existing Residential Development

13-17 Sturt Street & 2A Evans Road, Telopea

Prepared For:

NSW Land and Housing Corporation
Department of Family and Community Services

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1.0 EXECUTIVE SUMMARY

This Fire Engineering Report has been prepared by Innova Services Pty Ltd for NSW Land and Housing Corporation, Department of Family and Community Services (FACS), and relates to an existing residential development located at 13-17 Sturt Street and 2a Evans Road, Telopea. The site comprises of 4 individual residential buildings, which are currently owned and operated by FACS.

Currently all 4 buildings are located on the same allotment. However it is proposed to separate the building at 15 Sturt Street (which is of relatively new construction) from the other buildings via sub-division boundaries. This is to allow the transfer of the building at 15 Sturt Street to Hume Community Housing. The remaining 3 buildings at 13 & 17 Sturt Street and 2a Evans Road will remain with FACS.

Innova Services Pty Ltd has been commissioned to conduct a Fire Engineering Assessment of a proposed Alternative Solution to the Deemed to Satisfy (DTS) provisions of the Building Code of Australia 2014 (BCA) relating to the proposed sub-division.

Table 1 below summarises the Variation to the BCA DTS Provisions, the relevant BCA Performance Requirements, the Assessment Method, the Method of Analysis, and the Acceptance Criteria that have been used in the Fire Engineering Assessment.

Table 1: Summary of Alternative Solution

Alternative Solution	BCA DTS Provisions	Variations to BCA DTS Provisions	BCA Performance Requirements
1	**Clauses C3.2 & C3.4** Protection of openings in external walls	To not protect the openings within the external walls of 13 & 17 Sturt Street, and 2a Evans Road, which will be located within 3m of the new sub-division boundaries. To protect the openings within the external walls of 15 Sturt Street that will be located within 3m of the new sub-division boundary with radiant heat attenuation screens, in lieu of a protection method given under BCA Clause C3.4. To not protect the car park louvre opening within the external wall of 15 Sturt Street that will be located within 3m of the new sub-division boundary.	**CP2, CP8**
	Summary of Fire Safety Strategy	The fire safety strategy is based on: <u>13 & 17 Sturt Street, 2a Evans Street</u> ▪ The characteristics and use of the overall site and the existing buildings, where the risk of fire spread between the subject buildings is unlikely. ▪ Consideration will also be given to the subject buildings remaining with FACS, where the layout and configuration of the buildings is unlikely to change. Where future development works are proposed to the buildings (e.g. re-build), then such works would be subject to BCA Compliance that may require the protection of openings within external walls. <u>15 Sturt Street (windows)</u> ▪ The size and orientation of the subject openings with respect to the sub-division boundaries. ▪ Consideration will also be given to the performance of radiant heat attenuation screens. <u>15 Sturt Street (car park louvre)</u> ▪ The characteristics and use of the car park adjacent to the installed louvre.	
	BCA Compliance and Assessment Method	**A0.5(b)(i)** and **A0.9(b)(i) & (ii)**, as detailed in Section 8.	
	Method of Analysis and Acceptance Criteria	Quantitative and Qualitative Analysis method based on the Acceptance Criteria detailed in Section 9, and the Design Fire Scenarios detailed in Section 10.	

Based on the Fire Engineering Assessment presented in this report, it is the opinion of Innova Services Pty Ltd that the proposed Alternative Solution to the BCA DTS provisions will satisfy BCA Performance Requirements CP2 and CP8, subject to the implementation of the Fire Safety Requirements nominated in Section 2 (***Summary of Fire Safety Requirements***) of this report.

2.0 Summary of Fire Safety Requirements

Protection of Openings in External Walls

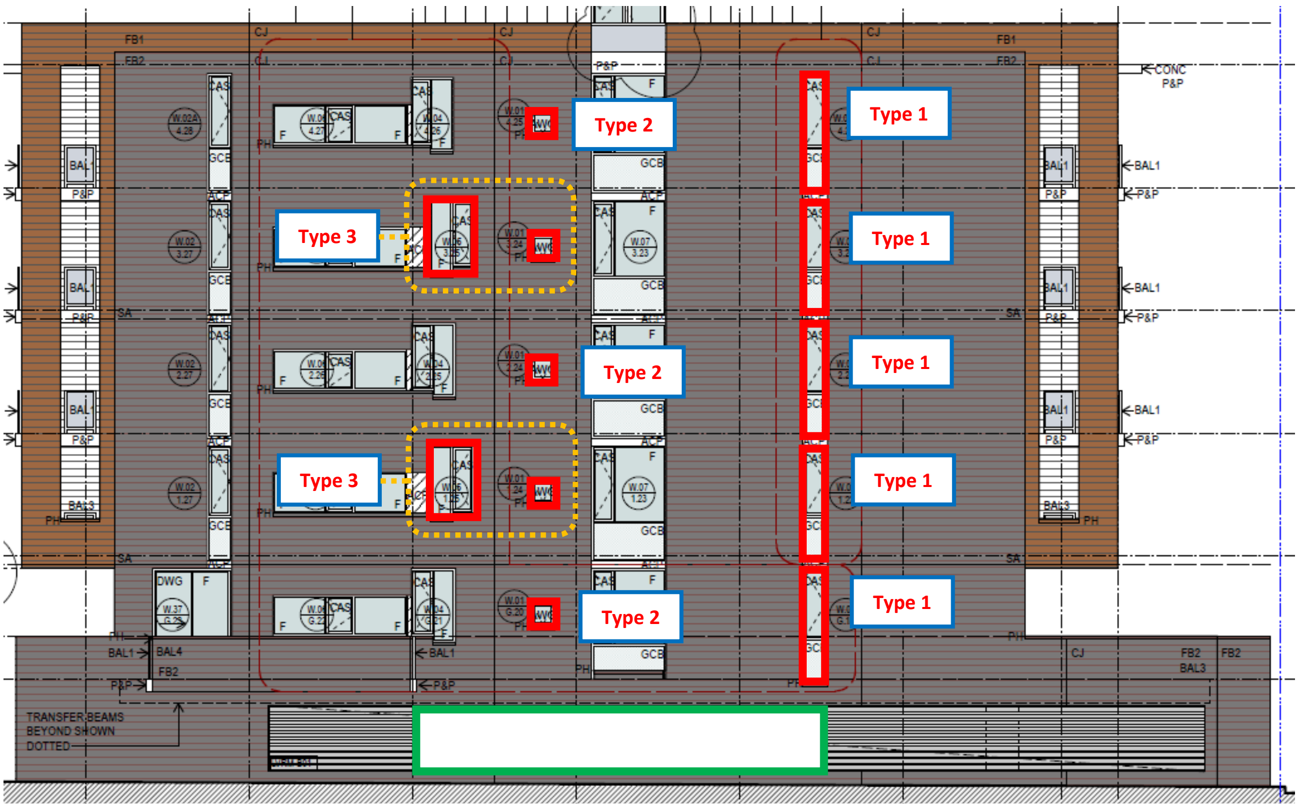
15 Sturt Street, Telopea

1. The window openings within the external walls of 15 Sturt Street Telopea, which will be located within 3m of the eastern sub-division boundary, shall be protected with radiant heat attenuation screens. The subject windows are denoted within this report as Windows Types 1, 2 and 3.

   The required radiant heat attenuation screens shall be of the Firetuff type (or approved equivalent such as Crimsafe), as per CSIRO test report FSZ 0688. The radiant heat attenuation screens shall be capable of deflecting up to 40% of received radiant heat, when tested to AS 1530.4-2005.

   The radiant heat attenuation screens can be installed internally to the awning type openable windows. The existing window frames shall be modified, as necessary, to enable the radiant heat screens to be mechanically fixed to the masonry reveal. There shall be no gaps formed within the frame, to ensure the passage of floating embers through the window openings is mitigated. Guidance on an approved fixing method shall be sought from the manufacturer.

2. The car park louvre opening to 15 Sturt Street Telopea, which will be located within 3m of the eastern sub-division boundary, is not required to be protected in accordance with Clause C3.4 of the BCA.



NOTE: All other openings not highlighted are located greater than 3m from the proposed sub-division boundary

Protection with Radiant Heat Attenuation Screen

No Protection to Car Park Louvre

Figure 1: East Elevation - 15 Sturt Street, Telopea

13 & 17 Sturt Street, and 2a Evans Road Telopea

3. The openings within the external walls of 13 & 17 Sturt Street and 2A Evans Road Telopea, which will be located within 3m of the proposed sub-division boundaries, are not required to be protected in accordance with Clause C3.4 of the BCA.

Management and Use

4. All fire safety systems and measures installed throughout each building shall be maintained and serviced in accordance with relevant Australian Standards and manufacturers guidelines, and shall be certified annually as part of an Annual Fire Safety Statement (AFSS), as applicable for each building.

5. This Fire Engineering Report shall form part of the Fire Safety Schedule for each building, and shall be certified annually as part of the AFSS. Should either of the subject buildings undergo a change in use or classification, or be modified, the Fire Engineering Designs for each building shall be re-evaluated by an appropriately qualified Fire Safety Engineer.

3.0 INTRODUCTION

3.1 PURPOSE OF REPORT

The purpose of this report is to present a Fire Engineering Assessment of a proposed Alternative Solution to the Deemed to Satisfy (DTS) provisions of the Building Code of Australia 2014 (BCA) relating to an existing residential development located at 13-17 Sturt Street and 2a Evans Road, Telopea. The site comprises of 4 individual residential buildings, which are currently owned and operated by FACS.

3.2 SCOPE OF REPORT

This report is limited to an assessment of the proposed sub-division against the identified variation to Clauses C3.2 and C3.4 of the BCA only, as presented in Table 1 of the Executive Summary.

This report is consistent with the objectives and limitations of the BCA. Therefore effects of arson (e.g. from multiple fire starts), terrorism, explosive devices, use of accelerants, and sabotage of fire safety systems and equipment are considered outside the scope of this report.

'Absolute' or '100%' safety is not attainable, and there will always be a finite risk of injury, death or property loss. Also, fire and its effects on people and property are complex and variable. Thus, all stakeholders should understand that a fire safety system may not effectively cope with all possible scenarios.

3.3 BASIS OF REPORT

The content of this report is based on the following Legislation:

- The Building Code of Australia 2014 (BCA).
- NSW Environmental Planning & Assessment Act 1979.
- NSW Environmental Planning & Assessment Regulation 2000.

The content of this report is based on the following texts and references:

- International Fire Engineering Guidelines, 2005 Edition.
- Guide to the BCA, ABCB 2014.

The content of this report is based on the following Documentation:

- Alternative Solution Report prepared by Defire relating to the subject development (Ref: SY100090, Revision R1.2, dated 8 March 2012). Refer also Appendix B for Copy.

3.4 EXCLUSIONS

This report does NOT cover the following:

- A detailed BCA assessment of the proposed sub-division.
- Access for people with disabilities (Part D3 of the BCA).
- System or engineering design of any part of the proposed sub-division.
- Operational checks of fire safety equipment, verification of construction techniques, fire resistance levels or the witnessing of fire drills.
- Compliance or conformance audit for any fire safety system inside the existing buildings.
- Arson (other than as a source of initial ignition), multiple ignition sources, acts of terrorism.
- Protection of property (other than adjoining property).
- Business interruption or losses or personal or moral obligations of the owner/occupier.
- Occupational Health and Safety, and Work Cover Authority Regulations.

3.5 ASSUMPTIONS

It is assumed that apart from the identified variations presented in Table 1 of the Executive Summary, all other fire safety aspects associated with the proposed sub-division will comply with the relevant DTS provisions of the BCA, or have been addressed by other relevant parties.

3.6 REGULATORY FRAMEWORK

A Building Solution will comply with the BCA if it satisfies the Performance Requirements of the BCA. Clause A0.5 of the BCA states that compliance with the Performance Requirements can only be achieved by:

(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;

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

Clause A0.9 of the BCA states that the following Assessment Methods, or any combination of them, can be used to determine that a Building Solution complies with the Performance Requirements:

(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 as described in A2.2.

(b) Verification methods such as –

(i) the Verification 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

3.7 PROJECT STAKEHOLDERS

Table 2 below lists the relevant project stakeholders for the subject development.

Table 2: Project Stakeholders

Name	Company	Role
David Canagasabey Rajesh-Kumar Pancholi	NSW Land and Housing Corporation Department of Family and Community Services	Client
Jason Powell	Innova Services Pty Ltd	Fire Safety Engineer

3.8 FIRE ENGINEERING BRIEF PROCESS

The purpose of the Fire Engineering Brief (FEB) process is to document the assumptions and parameters to be used in the Fire Engineering Assessment, so that an "in-principle" agreement can be reached between the relevant stakeholders.

For the proposed sub-division works, the FEB process was conducted in the following way:

- Briefing from the Client in regards to the identified variations to the DTS provisions of the BCA.
- Briefing to the Client in regards to the proposed Alternative Solution to demonstrate compliance with the relevant Performance Requirements of the BCA.
- In house discussions at Innova Services Pty Ltd in regards to the Assessment Method, the Method of Analysis, and the Acceptance Criteria to be adopted in the Fire Engineering Assessment to demonstrate that the Alternative Solution will achieve compliance with the relevant Performance Requirements of the BCA.

4.0 DEVELOPMENT DESCRIPTION

4.1 DESCRIPTION OF DEVELOPMENT

This report relates to an existing residential development located at 13-17 Sturt Street and 2a Evans Road, Telopea. The site comprises of 4 individual residential buildings, which are currently owned and operated by FACS. These buildings comprise:

- 13 Sturt Street, Telopea
- 15 Sturt Street, Telopea
- 17 Sturt Street, Telopea
- 2a Evans Road, Telopea

The existing buildings at 13 & 17 Sturt Street and 2a Evans Road are 3 storey low rise residential walk-ups, which are of relatively old construction. The building at 15 Sturt Street is a relatively new seven story residential building constructed over a basement car park (constructed Circa 2012).

Currently all 4 buildings are located on the same allotment. However it is proposed to separate the building at 15 Sturt Street from the other buildings via sub-division boundaries. This is to allow the transfer of the building at 15 Sturt Street to Hume Community Housing. The remaining 3 buildings at 13 & 17 Sturt Street and 2a Evans Road will remain with FACS.

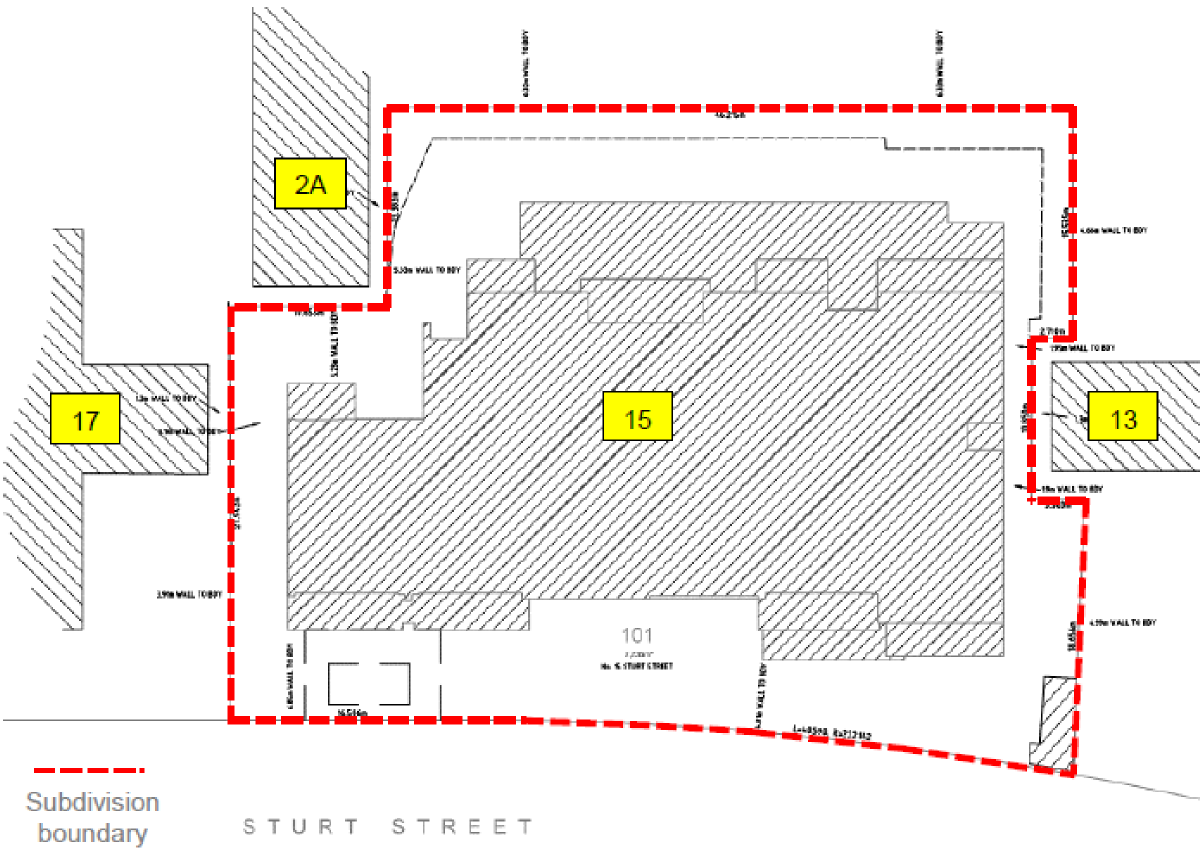


Figure 2: Site Plan with Proposed Sub-Division Boundaries

4.2 BCA ASSESSMENT DATA

The relevant BCA Assessment Data for the subject development is summarised in Tables 3 and 4 below.

Table 3: Relevant BCA Assessment Data (15 Sturt Street)

BCA Reference	BCA Assessment
Classification	Class 2 (residential sole-occupancy units) Class 7a (car parking)
Rise in Storeys	6
No. of Levels Contained	7
Minimum Type of Construction Required	Type A
Effective Height	Less than 25m

Table 4: Relevant BCA Assessment Data (13 & 17 Sturt Street, 2a Evans Road)

BCA Reference	BCA Assessment
Classification	Class 2 (residential sole-occupancy units)
Rise in Storeys	3
No. of Levels Contained	3
Minimum Type of Construction Required	Type A
Effective Height	Less than 12m

5.0 Dominant Occupant Characteristics

5.1 Population and Distribution

The building occupants predominantly comprise of residents and visitors to the residential parts of the building, and associated car parking areas.

5.2 State, Physical and Mental Attributes

Residents of the subject buildings could comprise of persons of all ages and backgrounds that could potentially respond differently to various fire cues. During the day, residents are typically mobile and their response time to a possible fire scenario is likely to be minimal. However at night, residents are typically sleeping and their response time to a possible fire scenario is expected to be delayed.

5.3 Familiarity with the Building

Occupants of the residential units are considered to be long-term residents, and are expected to be familiar with the building layout and the location of exits.

5.4 Level of Assistance and Emergency Training

Residents of the subject buildings are considered to be generally mobile, not requiring assistance to evacuate the building in an emergency, as per the relevant DTS provisions of the BCA.

Residents of the buildings are not expected to be trained in early fire-fighting and emergency response. In the event of fire, some residents may opt to remain within their respective sole-occupancy units and wait for fire brigade intervention.

5.5 Disabled Occupants

People with disabilities are considered to be assisted by able-bodied carers, family and /or friends.

Managing the evacuation of people with disabilities relies on the individual building management systems, procedures and training, which are outside the scope of the BCA, but can substantially contribute to the overall evacuation efficiency from the subject buildings. Therefore disabled access and egress should be addressed in an emergency evacuation plan and management procedures developed for people with disabilities.

6.0 HAZARD IDENTIFICATION

6.1 GENERAL

In identifying potential fire hazards, the following factors are considered:

- General building layout and construction.
- Building activities.
- Potential ignition sources.
- Combustible contents.

6.2 GENERAL BUILDING LAYOUT AND CONSTRUCTION

Refer to Section 4 of this Report for a description of the subject development. Currently all 4 buildings are located on the same allotment. However it is proposed to separate the building at 15 Sturt Street from the other buildings via sub-division boundaries. This is to allow the transfer of the building at 15 Sturt Street to Hume Community Housing. The remaining 3 buildings at 13 & 17 Sturt Street and 2a Evans Road will remain with FACS.

6.3 BUILDING ACTIVITIES

The subject development is predominantly used for residential purposes, with associated amenities and car parking. Given the use of the subject development, it is unlikely that the installed fire safety systems will be isolated for long periods of time for building and / or fitout works.

6.4 POTENTIAL IGNITION SOURCES AND AREAS OF FIRE ORIGIN

Fire & Rescue NSW Statistics for the years 2004/2005 and 2006/2007 nominate the following ignition factors within residential properties:

- Unattended heat sources (approximately 23%).
- Undetermined, non reported and not applicable (approximately 16%).
- Incendiary and suspicious (approximately 10%).
- Short circuits or electrical failures (approximately 8%).

It was reported that between 45.7 - 49.0% of fires originated in a kitchen or cooking area, between 10.5 - 13.0% of fires originated in a sleeping area, between 8.6 - 9.0% of fires originated in a lounge area, and approximately 3.1% of fires originated in a garage or vehicle storage area.

6.5 COMBUSTIBLE CONTENTS

The following items are considered highly combustible within this type of occupancy, and these material forms are the most likely to be ignited first, and / or contribute to the development and spread of fire:

- Motor vehicles within the car parking areas.
- Storage within the car parking areas, housing combustible materials.
- Curtains and window blinds, bedding and clothing.
- Cooking materials.
- Residential furniture, furnishings and surface finishes.
- Electrical equipment, electrical wiring, and cable insulation.
- Storage of paper, cardboard, stationary, and other combustible materials / goods.
- Rubbish, trash and waste.

7.0 Design Objectives

7.1 Regulatory Objectives

The main objectives of the Building Code of Australia (BCA) include:

- Life safety of occupants.
- Facilitation of fire brigade operations.
- Protection of adjacent buildings.

The objectives of the BCA are met when the relevant Performance Requirements of the BCA are satisfied. Thus, an Alternative Solution will comply with the BCA if it satisfies the relevant Performance Requirements of the BCA.

7.2 Relevant Performance Requirements

The relevant Performance Requirements of the BCA (*being CP2 and CP8)* associated with the proposed Alternative Solution are presented below. The proposed Alternative Solution must comply with these Performance Requirements.

CP2 *(a) A building must have elements which will, to the degree necessary, avoid the spread of fire -*

(i) to exits; and

(ii) to sole-occupancy units and public corridors; and

(iii) between buildings; and

(iv) in a building.

(b) Avoidance of the spread of fire referred to in (a) must be appropriate to -

(i) the function or use of the building; and

(ii) the fire load; and

(iii) the potential fire intensity; and

(iv) the fire hazard; and

(v) the number of storeys in the building; and

(vi) its proximity to other property; and

(vii) any active fire safety systems installed in the building; and

(viii) the size of any fire compartment; and

(ix) fire brigade intervention; and

(x) other elements they support; and

(xi) the evacuation time.

CP8 *Any building element provided to resist the spread of fire must be protected, to the degree necessary, so that an adequate level of performance is maintained -*

(a) where openings, construction joints and the like occur; and

(b) where penetrations occur for building services.

8.0 APPROACH AND METHOD OF ANALYSIS

8.1 APPROACH

The Fire Engineering Assessment contained within this report will utilise an Absolute Approach to assess the Alternative Solution. An Absolute Approach is where the Alternative Solution is assessed against the relevant Performance Requirements of the BCA, as permitted under Clauses A0.5(b)(i) and A0.9(b)(ii) of the BCA.

8.2 METHOD OF ANALYSIS

13 & 17 Sturt Street, 2a Evans Street

A Qualitative Analysis will be undertaken to assess the Alternative Solution against the relevant Performance Requirements of the BCA. The analysis will be based on assessing the risk of fire spread between the subject buildings and the existing building at 15 Sturt Street via openings within the external walls.

15 Sturt Street (windows)

A Quantitative radiant heat assessment will be undertaken to calculate both the potential radiant heat flux emitted from, and received by, the subject openings that will be located less than 3m from the sub-division boundary (being 1.9m).

The emitting radiant heat source at the subject openings is conservatively assumed to have a minimum emissivity of 0.9[1]. The Emissivity is defined as the ratio of the radiant heat flux emitted by an object to that emitted by a black body at the same temperature and under the same conditions. Emissivity is a measure of the efficiency of the surface of an object as a radiator.

NOTE: *Program Radiation within the Firewind package will be used for the radiant heat assessment. Firewind is a collection of fire engineering programs which has grown out of an earlier FIRECALC CSIRO*[2] *and FIREFORM NIST*[3]*.*

15 Sturt Street (car park louvre)

A Qualitative Analysis will be undertaken to assess the Alternative Solution against the relevant Performance Requirements of the BCA. The analysis will be based on assessing the risk of fire spread between the car park and the adjoining allotment via the ventilation louvre opening to the external wall of the car park.

[1] Buchanan AH, Structural Design for Fire Safety, John Wiley & Sons, England, 2001
[2] Division of Building, Construction & Engineering, Top Ryde, Sydney
[3] USA, National Institute of Standards and Technology

9.0 ACCEPTANCE CRITERIA

13 & 17 Sturt Street, 2a Evans Street

In relation to 13 & 17 Sturt Street and 2a Evans Street, the Alternative Solution is to comply with BCA Performance Requirements CP2 and CP8 in terms of ensuring the risk of fire spread between the subject buildings and the building at 15 Sturt Street, via openings within the external walls, is mitigated to the degree necessary.

15 Sturt Street (windows)

In relation to 15 Sturt Street, the Alternative Solution is to comply with BCA Performance Requirements CP2 and CP8 in terms of ensuring the risk of fire spread between the building and the sub-division boundary, via openings within the external walls, is mitigated. A Quantitative radiant heat assessment will be undertaken to calculate both the potential radiant heat flux emitted from, and received by, the subject openings.

Emitted Radiation

Verification Method CV1, as nominated within the BCA, will be used to assess the amount of heat radiation emitted by the subject openings to the sub-division boundary. Verification Method CV1 states that compliance with BCA Performance Requirement CP2(a)(iii), to avoid the spread of fire between buildings on adjoining allotments, is verified when it is calculated that:

- A building will not cause heat flux in excess of those set out in column 2 of Table CV1 at locations within the boundaries of an adjoining property set out in column 1 of Table CV1 where another building may be constructed.

Table 5: BCA Table CV1

Column 1	Column 2
Location	**Heat Flux (kW/m^2)**
On boundary	80
1m from boundary	40
3m from boundary	20
6m from boundary	10

Received Radiation

Verification Method CV1, as nominated within the BCA, will be used to assess the amount of heat radiation received at the subject openings in the event of fire on the sub-division boundary. Verification Method CV1 states that compliance with BCA Performance Requirement CP2(a)(iii), to avoid the spread of fire between buildings on adjoining allotments, is verified when it is calculated that:

- When located at the distances from the allotment boundary set out in column 1 of Table CV1, a building is capable of withstanding the heat flux set out in column 2 of Table CV1 without ignition.

As the subject openings will be fitted with radiant heat attenuation screens the Fire Engineering Analysis will adopt a limit of **25 kW/m^2** of received radiation. This level of radiation represents the limitation in which non-piloted ignition of cotton fabric (e.g. curtains) occurs after prolonged exposure, as referenced in AS 1530.4-2005[4]. *NOTE: The provision of radiant heat attenuation screens to openable windows will assist in prohibiting the passage of embers through the openings, which will help to mitigate the possibility of piloted ignition of easily ignitable materials.*

[4] Australian Standard, Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance test of elements of construction.

15 Sturt Street (car park louvre)

In relation to the car park louvre opening to 15 Sturt Street, the Alternative Solution is to comply with BCA Performance Requirements CP2 and CP8 in terms of ensuring the risk of fire spread between the car park and the adjoining allotment via the ventilation louvre is mitigated to the degree necessary.

10.0 DESIGN FIRE SCENARIOS

General

In consideration of the hazard assessment contained in Section 6, the most likely cause of ignition within the residential parts of the subject buildings will be unattended heat sources (e.g. cooking activities). For the basement car parking areas of 15 Sturt Street, statistics by Denda[5] have shown that a fire within a car park rarely involves more than 2 cars. It was found that of the 404 car park fires surveyed, 93% were limited to a single car and a further 5% where limited to 2 cars.

Considering that fire sprinklers are installed within the subject residential buildings, a fire can be expected to grow to flashover conditions involving a majority of the combustible items within the area or room of fire origin.

13 & 17 Sturt Street, 2a Evans Street

In relation to 13 & 17 Sturt Street and 2a Evans Street, a fire will be considered in the following locations of the subject development to appropriately assess the Alternative Solution.

- A flashover fire within a residential unit of 15 Sturt Street, located adjacent to an opening that will be located within 3m of the proposed sub-division boundaries.
- A flashover fire within a residential unit of 13 & 17 Sturt Street and 2a Evans Road, located adjacent to an opening that will be located within 3m of the proposed sub-division boundaries.

The design fires will be considered in a qualitative manner to assess the risk of fire spread between the subject buildings and the building at 15 Sturt Street, via openings within the external walls.

15 Sturt Street (windows)

Emitted Radiation

A fire within a residential unit of 15 Sturt Street, located adjacent to the subject openings, will be considered when assessing the level of heat radiation emitted by the openings to the sub-division boundary. Alam and Beever (Ref[6]) found that an average surface temperature of 800°C is considered to exist as a result of flames from a fire emerging from open windows and / or doors. However, maximum temperatures of around 900°C were also observed within a room. Therefore an average temperature of **850°C (1123K)** will be adopted for a compartment fire.

Table 6 below summarises the size of each opening that will be assessed. Each opening has been considered as a radiation panel. An augmentation factor of 25% has been applied to the height of each opening to account for flames emanating out of the opening (as per Appendix B of AS 2118.2).

Table 6: Summary of Openings to be Assessed

Opening Type	Width (m)	Height (m)	Adjusted Height (m)
Type 1	0.60	1.70	2.13
Type 2	0.60	0.60	0.75
Type 3	0.60 0.60	1.70 0.60	2.13 0.75

[5] Parking Garage Fire. A Statistical Analysis of Parking Garage Fires in the United States: 1986-1988, 1992. Denda, D.F. Parking Market Research Company, Virginia USA.
[6] T. Alam and P. Beever, "Flashover fires – An experimental program," CESARE Report 96-003, October 1996, Centre for Environmental Safety and Risk Engineering, Victoria University of Technology, Melbourne, Australia (1996).

Received Radiation

The subject openings will be assessed against the radiant heat exposures that are set out in Column 2 of Table CV1 of the BCA. The heat flux limitations nominated in BCA Table CV1 (as reproduced in Table 5 above) is calculated using the following formula:

$$y^{-1} = a + bx^{1.5} + cx^{0.5} \quad \text{.................................equation (1)}$$

where: y = heat flux (kW/m^2), a = 0.0125, b = 0.0046, c = 0.0079, x = distance (m)

This equation is also represented graphically in Figure 3 below for varying distances from a property boundary.

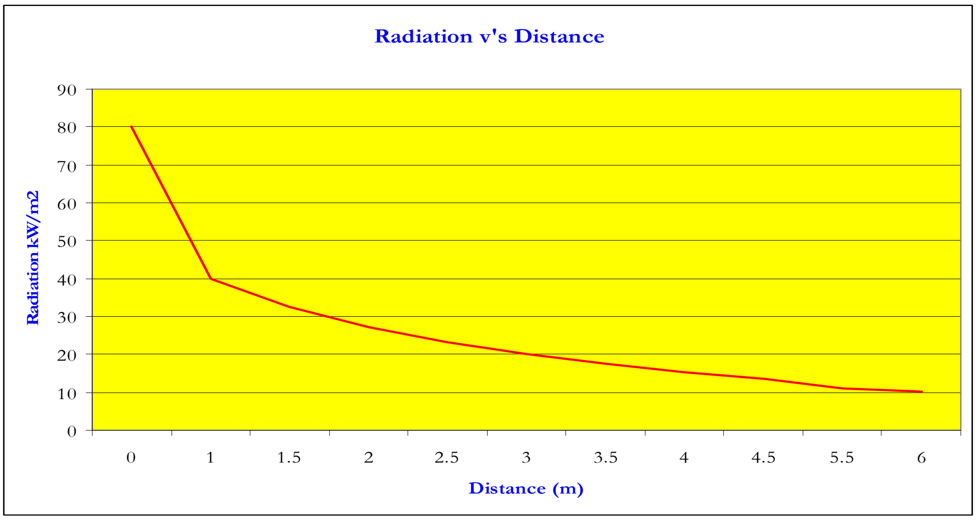


Figure 3: Allowable Heat Flux for Varying Distances from a Property Boundary

15 Sturt Street (car park louvre)

A quantitative design fire will not be considered, as the assessment of fire spread between the car park and the adjoining allotment via the ventilation louvre will be based on a qualitative assessment and discussion.

11.0 FIRE ENGINEERING ASSESSMENT

11.1 INTRODUCTION

Table 7 below provides a summary of the relevant regulatory and assessment criteria associated with the Alternative Solution.

Table 7: Summary of Alternative Solution

Regulatory and Assessment Criteria	Comments / Description
BCA DTS Provisions	Clauses C3.2, C3.4
Variation to BCA DTS Provisions	To not protect the openings within the external walls of 13 & 17 Sturt Street, and 2a Evans Road, which will be located within 3m of the new sub-division boundaries. To protect the openings within the external walls of 15 Sturt Street that will be located within 3m of the new sub-division boundary with radiant heat attenuation screens, in lieu of a protection method given under BCA Clause C3.4. To not protect the car park louvre opening within the external wall of 15 Sturt Street that will be located within 3m of the new sub-division boundary.
BCA Performance Requirements	CP2, CP8
Approach and Method of Analysis	A0.5(b)(i), and A0.9(b)(i) & (ii); Absolute Assessment; Quantitative and Qualitative Analysis
Acceptance Criteria	Ensuring the risk of fire spread between the subject buildings, via openings within the external walls, is mitigated to the degree necessary.

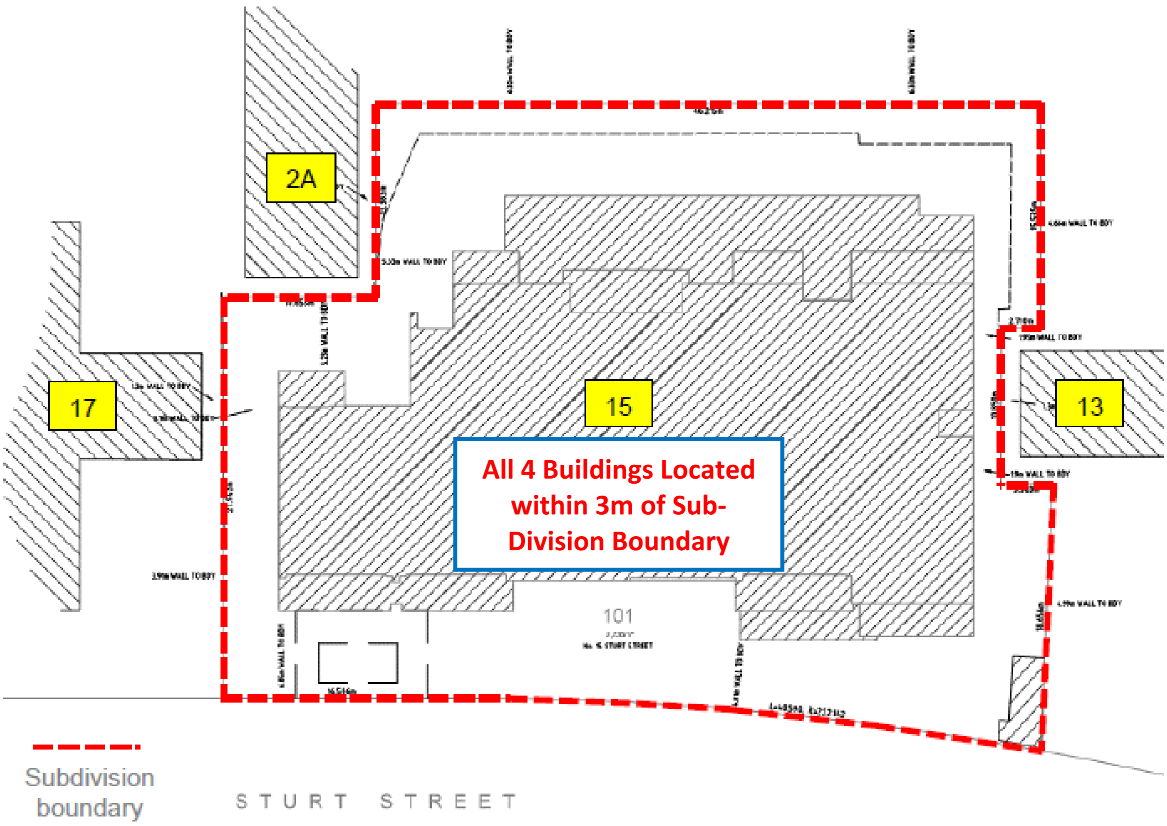
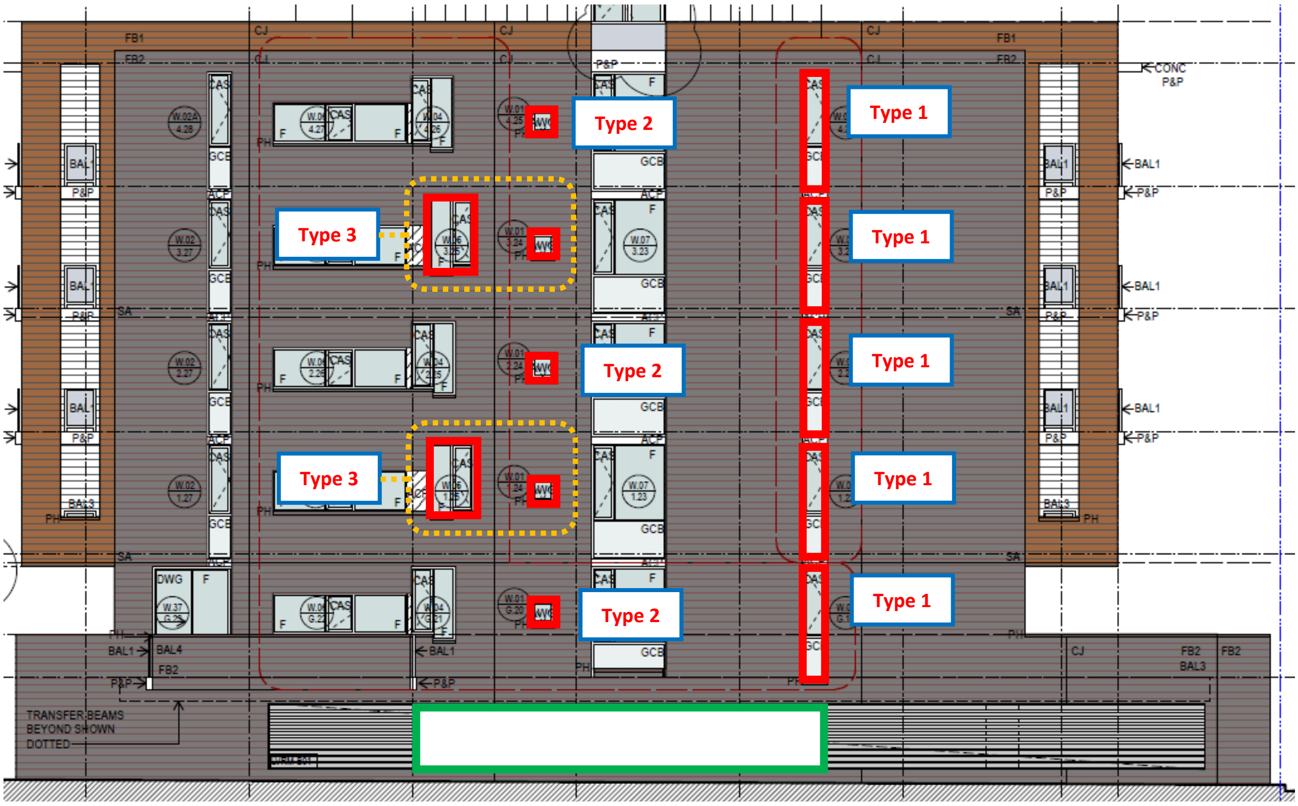


Figure 4: Site Plan with Proposed Sub-Division Boundaries



NOTE: All other openings not highlighted are located greater than 3m from the proposed sub-division boundary

Protection with Radiant Heat Attenuation Screen

No Protection to Car Park Louvre

Figure 5: East Elevation - 15 Sturt Street, Telopea

11.2 Relevant BCA DTS Provisions

Clause C3.2 of the BCA states, in part, that openings in an external wall that is required to have an FRL must be protected in accordance with Clause C3.4 if the distance between the opening and the fire-source feature to which it is exposed is less than 3m from the allotment boundary. Clause C3.4 of the BCA nominates acceptable methods of protection that are required under Clause C3.2, and for window openings include:

- external wall-wetting sprinklers used with windows that are automatic closing or permanently fixed in the closed position; or
- –/60/– fire windows that are automatic closing or permanently fixed in the closed position; or
- –/60/– automatic closing fire shutters.

11.3 Basis of BCA DTS Provisions

The Guide to the BCA states that the intent of Clause C3.2 is ***"To require any opening in external walls to be protected, only where the wall is required to have an FRL, to prevent the spread of fire from the boundary of an adjoining allotment, or one building to another building on the same allotment"***. The Guide to the BCA states that the intent of Clause C3.4 is ***"To set out acceptable methods of protection required for different types of openings in a building"***.

The Guide to the BCA states that Verification Method CV1 is ***"A means to verify whether or not a building proposal achieves the requirements of CP2(a)(iii) in minimising the risk of fire spreading between buildings on adjoining allotments. A fire in one building should not cause the spread of fire to another building, because such fire spread potentially endangers public safety, health and amenity"***.

11.4 ASSESSMENT OF ALTERNATIVE SOLUTION

Introduction

It is proposed to separate the building at 15 Sturt Street from the other buildings via sub-division boundaries. As a result all 4 buildings will now be located on separate allotments, and within 3m of an allotment boundary (refer also to Figure 4 above).

Assessment of Fire Spread (15 Sturt Street - Windows)

As part of the overall fire safety strategy for the overall site, the existing window openings within the external walls of 15 Sturt Street Telopea, which will be located within 3m of the eastern sub-division boundary (being 1.9m), will be protected with radiant heat attenuation screens. Refer also Figure 5 above.

A radiant heat assessment has been undertaken to calculate both the potential radiant heat flux emitted from, and received by, the subject openings which will be located less than 3m from the sub-division boundary (being 1.9m). This has been done to determine the likelihood of the spread of fire between buildings on adjoining allotments via the subject openings.

Emitted Radiation

Table 8 below presents the results of the radiant heat assessment which compares the potential heat flux emitted from the subject openings in the event of fire against the limitations given under Verification Method CV1 of the BCA.

Table 8: Radiant Heat Flux Emitted from Subject Openings

CV1 Limit (kW/m²)	On Boundary	1m over Boundary	3m over Boundary	6m over Boundary
	80	**40**	**20**	**10**
Type 1	17.99	8.57	< 20	< 10
Type 2	7.37	< 40	< 20	< 10
Type 3	24.24	11.57	4.29	< 10

The above results show that the radiant heat flux emitted from the subject openings will not cause heat flux in excess of the CV1 limits within the boundaries of the adjoining allotment. Refer to Appendix A of this report for the output data from program Radiation. In consideration of the above, the amount of radiant heat flux emitted from the subject building is unlikely to result in the spread of fire between buildings on adjoining allotments via the subject openings.

Received Radiation

Table 9 below presents the results of the radiant heat assessment to determine whether the subject openings, which will be fitted with radiant heat screens, will be able to withstand potential heat flux received from future buildings that could be constructed on the adjoining allotment.

Table 9: Radiant Heat Flux Received at Subject Openings

Building Elevation	Received Heat Flux (kW/m²)	Attenuated Heat Flux (kW/m²)	Limit (kW/m²)	Pass / Fail
Type 1	28.22	**16.93**	25	**Pass**
Type 2	28.22	**16.93**	25	**Pass**
Type 3	28.22	**16.93**	25	**Pass**

NOTES:

- *The radiant heat flux received at the subject openings, which are orientated parallel to the allotment boundary, has been calculated using Equation 1 as given in Section 10.*

The above results show that the potential radiant heat flux received at the subject openings will NOT exceed **25 kW/m²**. In consideration of the above, the amount of radiant heat flux received at the subject building is unlikely to result in the spread of fire between buildings on adjoining allotments via the subject openings.

Discussion on Radiant Heat Attenuation Screens

The intent of a radiant heat attenuation screen is to reduce the amount of radiant heat that passes through the opening from one side to the other. Research[7] conducted by the CSIRO has shown that radiant heat attenuations screens will deflect up to 40% of the radiant heat received at an opening, when tested to Australian Standard AS 1530.4. This will therefore reduce the risk of non-piloted ignition of easily ignitable materials, such as curtains.

Radiant heat screens comprise of a tightly woven stainless steel mesh. This will assist in prohibiting the passage of floating embers through an opening, thus minimising the risk of piloted ignition of easily ignitable materials, such as curtains. Therefore an advantage of using a radiant heat attenuation screen is that they enable the windows they are protecting to remain openable to improve amenity and to satisfy the natural ventilation requirements of the BCA. Figure 6 below illustrates the performance of a radiant heat attenuation screen.

NOTE: *The existing windows to be protected with radiant heat attenuation screens comprise of awning type openings. As such it is not possible to fit the radiant heat screens externally to the building. Therefore the radiant heat screens will be installed internally within the window reveal. It is our opinion that this method of installation is acceptable provided the screens can be mechanically fixed to the masonry reveal of the window. Similar installations are not uncommon, and guidance on an approved fixing method will be sought from the manufacturer.*

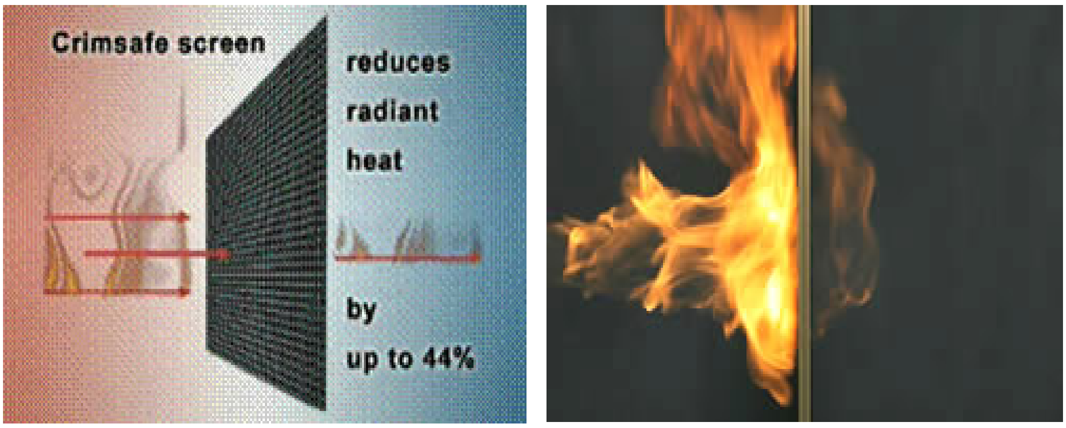


Figure 6: Performance of Radiant Heat Attenuation Screens

[7] Fire Test on a Security Window Screen, FSZ 0688, CSIRO, August 1999

Assessment of Fire Spread (15 Sturt Street - Car Park Louvre)

Introduction

As outlined above, it is not proposed to protect the car park louvre opening within the external wall of 15 Sturt Street which will be located within 3m of the new sub-division boundary (being 1.9m). Therefore the main issue to be addressed is to ensure the risk of fire spread between the car park and the adjoining allotment via the ventilation louvre is mitigated to the degree necessary. A plan of the basement level car park and the location of the ventilation louvre is shown in Figure 7 below.

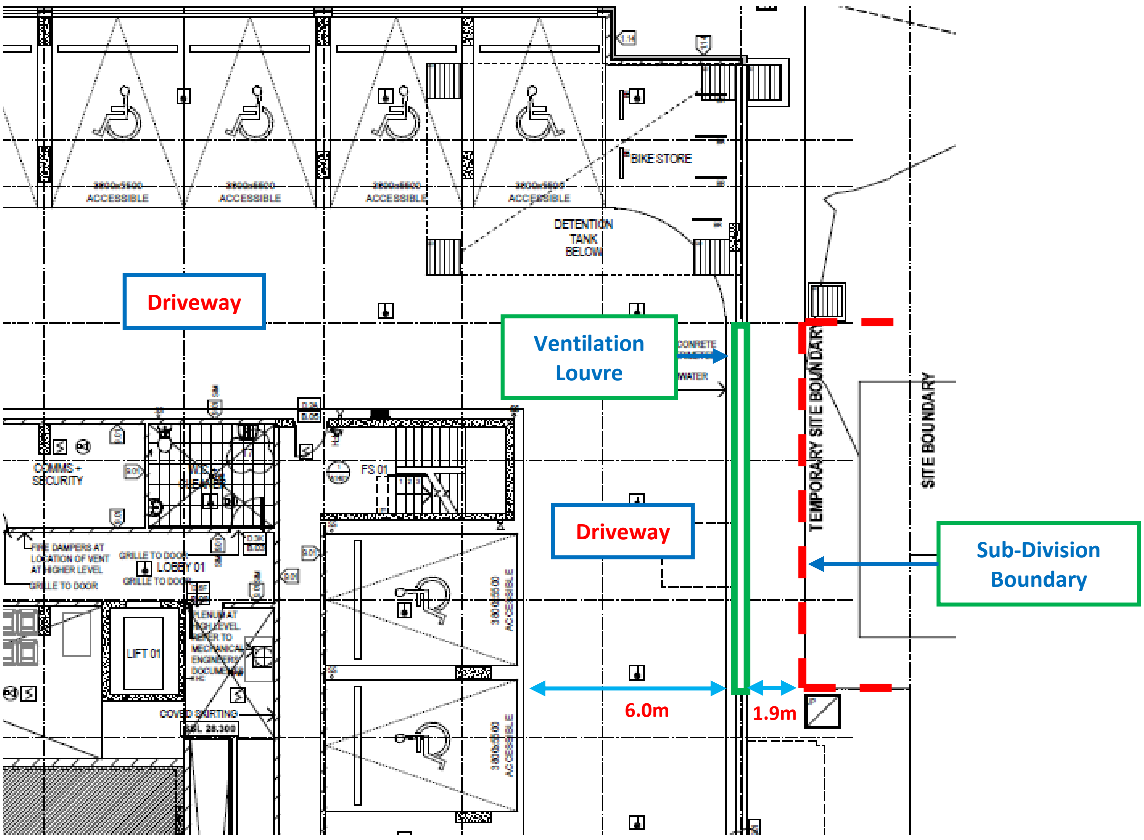


Figure 7: Part Basement Plan

Assessment of Fire Spread via Louvre

As shown in Figure 7 above the ventilation louvre is located adjacent to the entry driveway into the car park, which is approximately 6m wide. The driveway serves as the only entry and exit route for vehicles to and from the car park. Thus it is unlikely that combustible materials will be stored next to the louvred opening.

Therefore given the characteristics and use of the driveway located adjacent to the louvre, it is unlikely that a fire will originate on the driveway that could result in the spread of fire to the adjacent allotment via the louvre. Further, given that the driveway area is expected to be free of combustible materials, a fire on the allotment boundary is unlikely to result in the ignition of combustible materials within the car park via the louvre.

The car parking spaces within the basement level are the only areas adjacent to the louvre that are expected to comprise a stagnant fire load (i.e. parked cars). It is noted that these car parking spaces are located more than 6m from the allotment boundary (refer also Figure 7 above). Reference is made to Clause C3.2 of the BCA where openings within external walls of adjacent buildings are not required to be protected if they are setback 6m or more from each other. Therefore given that the true fire load within the car park (being the car parking spaces) is located more than 6m from the allotment boundary, the risk of fire spread between the car park and the boundary via the louvre is expected to be mitigated to the degree necessary.

Assessment of Fire Spread (13 & 17 Sturt Street, and 2a Evans Road)

As outlined previously, the existing buildings at 13 & 17 Sturt Street and 2a Evans Road are 3 storey low rise residential walk-ups, which are of relatively old construction. The building at 15 Sturt Street is a relatively new seven story residential building constructed over a basement car park (constructed Circa 2012).

Currently all 4 buildings are located on the same allotment, where parts of the external walls of each building are located within 6m of each other. As part of the design and construction of 15 Sturt Street (being a new building), a radiant heat assessment was documented within an Alternative Solution report prepared by Defire (Ref: SY100090, Revision R1.2, dated 8 March 2012 – refer also Appendix B for copy). The report demonstrated that those openings within the external walls that were located within 6m of each other did not require protection. Thus the risk of fire spread between buildings on the same allotment was likely to be avoided. *NOTE: The analysis contained within this report is comprehensive, and it is therefore not considered necessary to undertake a new radiant heat assessment.*

However it is now proposed to separate the building at 15 Sturt Street from the other buildings via sub-division boundaries (refer also Figure 4 above). As a result, the subject buildings will now be located on separate allotments, where the fire source feature is now deemed to be the proposed sub-division boundary. That is, the Deemed to Satisfy provisions of the BCA will require the subject buildings to be protected from a fire occurring on the allotment boundary.

Although the proposed sub-division boundaries are deemed under the BCA as being the fire source feature, the overall characteristics and use of the site has not changed. That is, provided the existing buildings are retained in their current location and configuration, the risk of fire spread between buildings will be no greater than that when the buildings where located on the same allotment.

It is noted that the creation of the sub-division boundaries is to allow the transfer of the building at 15 Sturt Street to Hume Community Housing. The remaining 3 buildings at 13 & 17 Sturt Street and 2a Evans Road will remain with FACS, and therefore the layout and configuration of these buildings is unlikely to change. Where future development works are proposed to the buildings (e.g. a re-build), then such works would be subject to BCA Compliance that may require the protection of openings within external walls were exposed to a fire source feature. Therefore protecting the subject openings in their current configuration is considered impractical and not cost effective.

Given that 15 Sturt Street is a new building, those openings within the external walls located less than 3m from the sub-division boundary will be protected with radiant heat attenuation screens (as outlined above). This will not only achieve compliance with the BCA, but 'future proof' the building against the construction of new buildings that may be located on the adjoining allotments.

Conclusion

In consideration of the characteristics and use of the overall site, not protecting the openings within the external walls of the existing buildings located at 13 & 17 Sturt Street and 2a Evans Road is not expected to increase the risk of fire spread between buildings on adjoining allotments.

Further, the installation of radiant heat screens to the windows within the external walls of 15 Sturt Street will ensure the subject building will be protected from the risk of fire spread in the event that new building works are undertaken on the adjoining allotments. Also, given the characteristics and use of the basement car park within 15 Sturt Street, the risk of fire spread via the ventilation louvre is expected to be mitigated to the degree necessary.

Therefore the proposed Alternative Solution is demonstrated to achieve compliance with BCA Performance Requirements CP2 and CP8.

11.5 Satisfying BCA Performance Requirements

The Alternative Solution has been shown to comply with BCA Performance Requirements CP2 and CP8, as shown in Tables 10 and 11 below.

Table 10: Assessment of Compliance with the BCA Performance Requirement CP2

Performance Requirement CP2	Discussion
(a) A building must have elements which will, to the degree necessary, avoid the spread of fire -	
(i) to exits; and	N/A
(ii) to sole-occupancy units and public corridors; and	N/A
(iii) between buildings; and	As discussed in Section 11.4. Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary.
(iv) in a building.	N/A
(b) Avoidance of the spread of fire referred to in (a) must be appropriate to -	
(i) the function or use of the building; and	As discussed in Section 11.4. Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary.
(ii) the fire load; and	Considered comparable to the DTS provisions of the BCA.
(iii) the potential fire intensity; and	Considered comparable to the DTS provisions of the BCA.
(iv) the fire hazard; and	As discussed in Section 11.4. Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary.
(v) the number of storeys in the building; and	N/A
(vi) its proximity to other property; and	As discussed in Section 11.4. Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary.
(vii) any active fire safety systems installed in the building; and	Considered comparable to the DTS provisions of the BCA.
(viii) the size of any fire compartment; and	N/A
(ix) fire brigade intervention; and	Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary. Therefore fire brigade intervention is considered comparable to the DTS provisions of the BCA.
(x) other elements they support; and	N/A
(xi) the evacuation time.	Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary. Therefore occupant evacuation from either building is unlikely to be affected.

Table 11: Assessment of Compliance with the BCA Performance Requirement CP8

Performance Requirement CP8	Discussion
CP8 Any building element provided to resist the spread of fire must be protected, to the degree necessary, so that an adequate level of performance is maintained -	
(a) where openings, construction joints and the like occur; and	As discussed in Section 11.4. Given the characteristics and use of the overall site, the risk of fire spread between the subject buildings, via openings within external walls, will be mitigated to the degree necessary.
(b) where penetrations occur for building services.	N/A

12.0 CONCLUSION

A Fire Engineering Assessment of an Alternative Solution to the DTS provisions of the BCA has been undertaken for an existing residential development located at 13-17 Sturt Street and 2a Evans Road, Telopea. Currently all 4 buildings are located on the same allotment. However it is proposed to separate the building at 15 Sturt Street (which is of relatively new construction) from the other buildings via sub-division boundaries. This is to allow the transfer of the building at 15 Sturt Street to Hume Community Housing. The remaining 3 buildings at 13 & 17 Sturt Street and 2a Evans Road will remain with FACS.

The Alternative Solution relates to the following variation to the DTS provisions of the BCA:

- To not protect the openings within the external walls of 13 & 17 Sturt Street, and 2a Evans Road, which will be located within 3m of the new sub-division boundaries.
- To protect the openings within the external walls of 15 Sturt Street that will be located within 3m of the new sub-division boundary with radiant heat attenuation screens, in lieu of a protection method given under BCA Clause C3.4.
- To not protect the car park louvre opening within the external wall of 15 Sturt Street that will be located within 3m of the new sub-division boundary.

Based on the Fire Engineering Assessment presented in this report, it is the opinion of Innova Services Pty Ltd that the proposed Alternative Solution will satisfy BCA Performance Requirements CP2 and CP8, subject to the implementation of the Fire Safety Requirements nominated in Section 2 (***Summary of Fire Safety Requirements***) of this report.

Appendix A - Radiant Heat Modelling Data

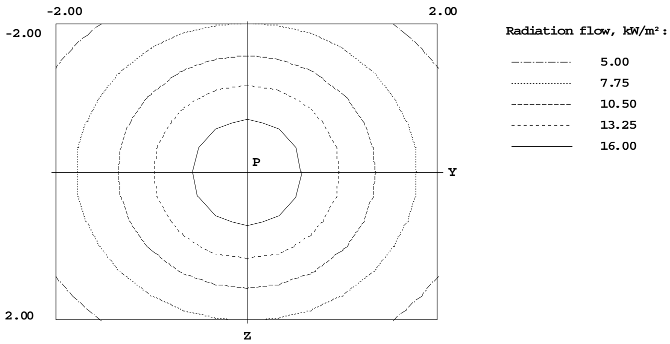
Opening Type 1: Emitted Radiation (on Boundary)

Program Radiation

(All dimensions are in meters)
X-sources:
Radiation temperature 1123°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
1.9	0	0	0.60	2.13	90

RADIATION MAP YZ



Nodal radiation data, kW/m²:

Z \ Y	-2.00	-1.00	0.00	1.00	2.00
-2.00	3.873	6.305	7.785	6.305	3.873
-1.00	5.687	10.73	14.37	10.73	5.687
0.00	6.559	13.07	17.99	13.07	6.559
1.00	5.687	10.73	14.37	10.73	5.687
2.00	3.873	6.305	7.785	6.305	3.873

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°,\ \varphi = 0.0°$

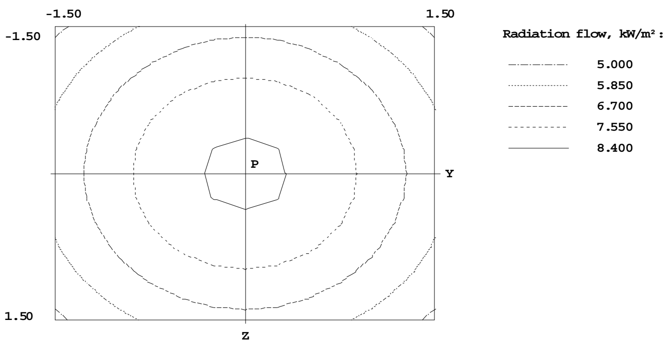
Opening Type 1: Emitted Radiation (1m over Boundary)

Program Radiation

(All dimensions are in meters)
X-sources:
Radiation temperature 1123°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
2.9	0	0	0.60	2.13	90

RADIATION MAP YZ



Nodal radiation data, kW/m²:

Z \ Y	-1.50	-0.75	0.00	0.75	1.50
-1.50	4.828	5.959	6.438	5.959	4.828
-0.75	5.767	7.289	7.951	7.289	5.767
0.00	6.138	7.826	8.566	7.826	6.138
0.75	5.767	7.289	7.951	7.289	5.767
1.50	4.828	5.959	6.438	5.959	4.828

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°,\ \varphi = 0.0°$

Opening Type 2: Emitted Radiation (on Boundary)

Program Radiation

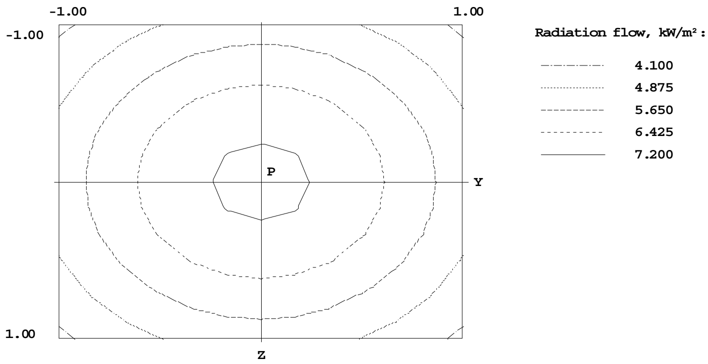
(All dimensions are in meters)

X-sources:

Radiation temperature 1123°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
1.9	0	0	0.60	0.75	90

RADIATION MAP YZ



Nodal radiation data, kW/m²:

Z \ Y	-1.00	-0.50	0.00	0.50	1.00
-1.00	3.939	4.858	5.245	4.858	3.939
-0.50	4.838	6.156	6.730	6.156	4.838
0.00	5.214	6.716	7.378	6.716	5.214
0.50	4.838	6.156	6.730	6.156	4.838
1.00	3.939	4.858	5.245	4.858	3.939

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°, \ \varphi = 0.0°$

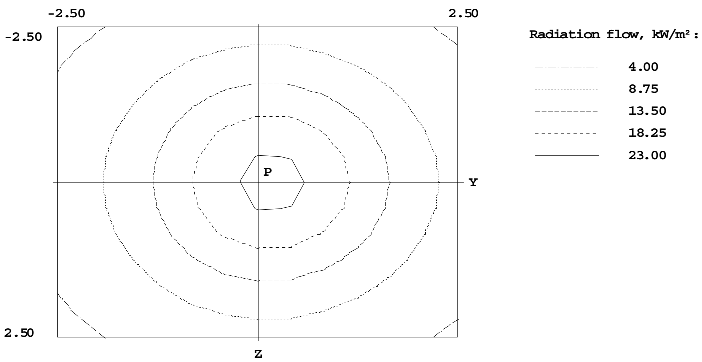
Opening Type 3: Emitted Radiation (on Boundary)

Program Radiation

(All dimensions are in meters)
X-sources:
Radiation temperature 1123°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
1.9	0.6	0	0.60	0.75	90
1.9	0	0	0.60	2.13	90

RADIATION MAP YZ



Nodal radiation data, kW/m²:

Z \ Y	-2.50	-1.25	0.00	1.25	2.50
-2.50	2.992	5.255	6.974	5.755	3.442
-1.25	4.714	10.49	16.60	12.30	5.800
0.00	5.635	13.96	24.24	17.38	7.230
1.25	4.714	10.49	16.60	12.30	5.800
2.50	2.992	5.255	6.974	5.755	3.442

Orientation of maximum radiation flow
at point P(0,0,0): $\theta = 90.0°, \ \varphi = 4.5°$

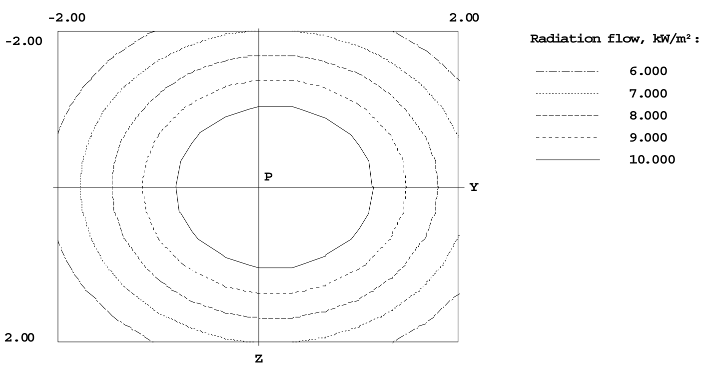
Opening Type 3: Emitted Radiation (1m over Boundary)

Program Radiation

(All dimensions are in meters)
X-sources:
Radiation temperature 1123°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
2.9	0.6	0	0.60	0.75	90
2.9	0	0	0.60	2.13	90

RADIATION MAP YZ



Nodal radiation data, kW/m²:

Z \ Y	-2.00	-1.00	0.00	1.00	2.00
-2.00	4.385	6.054	7.014	6.459	4.894
-1.00	5.711	8.401	10.09	9.143	6.551
0.00	6.292	9.493	11.57	10.43	7.309
1.00	5.711	8.401	10.09	9.143	6.551
2.00	4.385	6.054	7.014	6.459	4.894

Orientation of maximum radiation flow
at point P(0,0,0): $\theta = 90.0°, \ \varphi = 3.0°$

Opening Type 3: Emitted Radiation (3m over Boundary)

Program Radiation

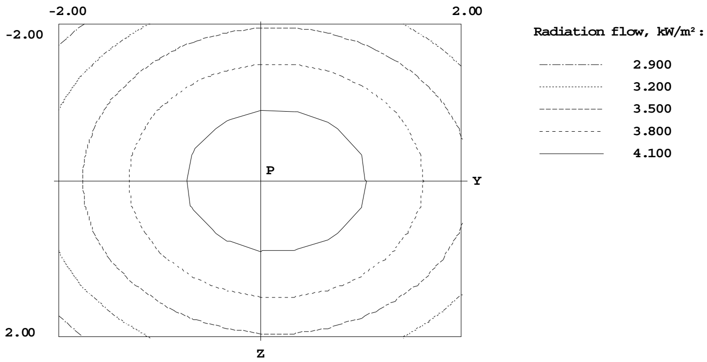
(All dimensions are in meters)

X-sources:

Radiation temperature 1123°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
4.9	0.6	0	0.60	0.75	90
4.9	0	0	0.60	2.13	90

RADIATION MAP YZ



Nodal radiation data, kW/m²:

Z \ Y	-2.00	-1.00	0.00	1.00	2.00
-2.00	2.766	3.239	3.463	3.342	2.930
-1.00	3.171	3.769	4.059	3.904	3.380
0.00	3.328	3.977	4.295	4.126	3.555
1.00	3.171	3.769	4.059	3.904	3.380
2.00	2.766	3.239	3.463	3.342	2.930

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°$, $\varphi = 1.8°$

APPENDIX B - PREVIOUS FIRE ENGINEERING REPORT

Alternative solution report

Defire
Innovative fire safety
Sydney Canberra Brisbane Adelaide

Housing NSW – Telopea sites

Client	Housing NSW.
Report number	SY100090
Revision	R1.2
Report issued	8/03/2012

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Amendment schedule

Version	Date	Information relating to report			
R1.0	29/05/2010	Reason for issue	Final report issued to Housing NSW and Turner Associates.		
			Prepared by	Prepared by	Prepared by
		Name	Rohan Defries	Magdalena Angerd	Micael Lundqvist
		Signature			
R1.1	23/11/2011	Reason for issue	Report updated to include assessments to address protection of openings and discharge of fire stair. Report issued to Housing NSW, Turner Associates, Davis Langdon Australia and Phil Chun and Associates.		
			Prepared by	Reviewed by	Approved by
		Name	Richard Kathage	Micael Lundqvist	Micael Lundqvist
		Signature			
R1.2	08/03/12	Reason for issue	Report updated to include new assessments to address setback of the external hydrant pumpset and booster assembly from the building. Report issued to Housing NSW, Turner Associate, Davis Langdon Australia and Phillip Chun and Associates.		
			Prepared by	Reviewed by	Approved by
		Name	Rohan Defries	Chris Jamieson	Micael Lundqvist
		Signature			
		Reason for issue			
			Prepared by	Reviewed by	Approved by
		Name			
		Signature			

Executive summary

This alternative solution report documents the findings of a fire safety engineering assessment undertaken to determine whether the proposed development for Housing NSW – Telopea Sites complies with the relevant performance requirements of the Building Code of Australia 2009 (BCA). Defire undertook the assessment in accordance with the International Fire Engineering Guidelines (IFEG) at the request of Housing NSW.

The project comprises the construction of three new residential flat buildings. The buildings are located on the following sites:

1. 15-17 Sturt Street, Telopea
2. 1-5 Shortland Street, Telopea (building A1)
3. 1-5 Shortland Street, Telopea (building A2)

The buildings proposed are over 6-7 storeys and will have a smoke alarm system in accordance with clause E2.2a of the BCA.

The design of the buildings includes areas which do not comply with the deemed-to-satisfy (DTS) provisions of the BCA. Table 1 describes the BCA requirements associated with the alternative solutions.

No	Description of alternative solutions	DTS provision	Performance requirements (A0.10)	Method of meeting performance requirements (A0.5)	Assessment method (A0.9)
1.	15-17 Sturt Street, Telopea - No protection is required for openings in the external walls which are >3.2m of the adjoining buildings.	Clause C3.2	CP2	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(i)
2.	All sites - Travel distance to a single stair or point of choice on residential floors is up to 8m in lieu of 6m.	Clause D1.4	DP4	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(ii)
3.	15-17 Sturt Street, Telopea - Fire-isolated stairway 1 discharges into a covered area that is less than 3m in height and less than 1/3 perimeter.	Clause D1.7	CP2, DP5 and EP2.2	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(ii)
4.	15-17 Sturt Street, Telopea - The fire hydrant pumpset enclosure and the fire hydrant booster assembly are located at distances from the external wall of the building less than prescribed by AS2419.1-2005.	Clause E1.3 and AS2419.1-2005	EP1.3	Complies with performance requirements A0.5(b)(ii)	Verification method A0.9(c)

Table 1 BCA requirements associated with the alternative solutions

The fire safety engineering assessment undertaken found that the design f the buildings achieve compliance with the relevant performance requirements of the BCA, subject to the following recommendations:

- This report and the fire safety measures listed in section 5 must be implemented into the design and identified on the fire safety schedule for the buildings. They must be maintained and certified in accordance with the Environmental Planning and Assessment Regulations 2000 and relevant Australian standards.
- If there are building alterations or additions, a change in use or changes to the fire safety system in the future, a reassessment will be needed to verify consistency with the assessment contained in this report.

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1. Introduction

This alternative solution report documents the findings of a fire safety engineering assessment undertaken to determine whether the proposed development for Housing NSW – Telopea Sites complies with the relevant performance requirements of the Building Code of Australia 2009 (BCA)[1]. Defire undertook the assessment in accordance with the International Fire Engineering Guidelines (IFEG) [2] at the request of Housing NSW.

2. Fire engineering brief

The purpose of the fire engineering brief (FEB) is to consult with the relevant stakeholders to define the scope of the project, to agree upon the objectives, fire safety measures, methods of analysis and acceptance criteria for the alternative solutions. The IFEG states that the scope of the project and the method by which it will receive regulatory approval dictates the extent of the FEB process required.

The proposed alternative solution is considered to be a simple departure from the deemed-to-satisfy (DTS) provisions of the BCA.

An FEB was conducted over the phone on 7 April 2010 between Shewanna Mendis of Turner Associates and Rohan Defries of Defire to discuss the proposed alternative solutions. At the end of the discussion it was agreed that the proposed design and alternative solutions were suitable for detailed analysis.

The main points of the discussion included:

- Travel distances on residential floors were in excess of DTS requirements. 8m was shown to be the limit of the non-compliance.
- An 8m travel distance non-compliance could be addressed on a performance basis. Subject to assessment smoke seals may be required to unit entry doors and illuminated exit signs are likely to be specified.

Further discussion with the PCA appointed for the project was held to confirm the performance requirements which needed to be addressed. The appointed PCA confirmed that DP4 was the only appropriate performance requirement on 5 May 2010.

Subsequent to the submission of Defire alternative solution report SY100090 R1.0 it was identified that the discharge of the fire-isolated stairway 1 on the basement level of 15-17 Sturt Street, Telopea site did not comply with clause D1.7 of the BCA. In addition it was proposed to remove the requirement to protect openings in the external walls of the 15-17 Sturt Street, Telopea site which are located less than 6m from adjacent buildings on the same allotment. Further discussions were held between Charles Slack Smith of Davis Langdon Australia and Richard Kathage of Defire on the 16 November 2011. The following was discussed:

- The assessment to address the openings exposed to neighbouring buildings on the same allotment will be based upon a radiant heat assessment.
- The assessment to address the discharge of the fire stair will be based upon the discharge area of the stair being fire separated away from the other parts of the level.

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[1] Building Code of Australia 2009, Australian Building Codes Board, Australia, 2009.
[2] International Fire Engineering Guidelines – Edition 2005, Australian Building Codes Board, Australia, 2005.

The relevant stakeholders identified for this project are listed in Table 2.

Name	Role	Organisation	Contact details
Vasudev Parulekar	Project Manager / client	Housing NSW	02 8753 8147
Shewanna Mendis	Architect	Turner Associates	02 8668 0000
Frank De Pasquale	PCA	Phillip Chun and Associates	02 9412 2322
Charles Slack-Smith	BCA consultant	Davis Langdon Australia	02 9956 8822
Rohan Defries / Richard Kathage	Fire safety engineer	Defire	02 9211 4333
Micael Lundqvist	Accredited fire safety engineer C10 – BPB 237	Defire	02 9211 4333

Table 2 Stakeholders

In early February 2012 it was brought to Defire's attention that the position of the fire hydrant pumpset and the hydrant booster assembly were located at distances less than that prescribed by AS2419.1-2005. Whilst the distances may be considered to be marginal, the locations meant that either additional fire rating to the enclosures and/or the adjacent building behind the enclosures would be necessary. Alternatively, the issues could be addressed on a performance basis.

In mid February 2012 dialogue occurred between Rohan Defries of Defire and Shewannna Mendis of Turner Associates architects, as well as Charles Slack-Smith of Davis Langdon Australia. The following points were discussed:

- The possibility of fire rating the pump enclosure
- The distances from the building
- Whether Fire and Rescue NSW referral would be necessary
- The construction of the external walls of the building closest to the equipment.

The outcome of these discussions being that the primary stakeholders considered that it was possible and appropriate to address the setback distances on a performance basis.

During discussions with the primary stakeholders – including the PCA – it was indicated that referral to FRNSW would not be required. Accordingly, the alternative solution report will be issued to the stakeholders listed in Table 2 after finalisation of the report.

3. Description of the building and alternative solutions

3.1 Building description

The project comprises the construction of three new residential apartment buildings. The proposed buildings – known as 15-17 Sturt Avenue and Blocks A1 and A2 1-5 Shortland Street, Telopea – are over six and seven storeys respectively and will have a smoke alarm system in accordance with E2.2a of the BCA.

A site plan of 15-17 Sturt Avenue is illustrated in Figure 1 with 1-5 Shortland Street in Figure 2 and Figure 3.

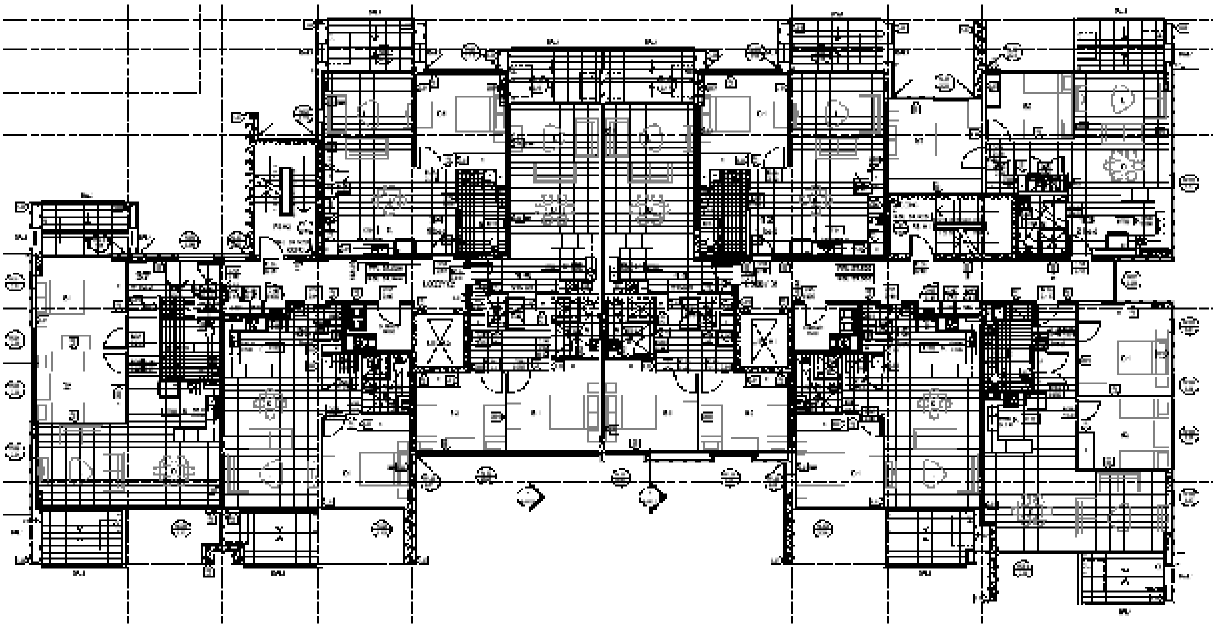


Figure 1 Typical floor plan – 15-17 Sturt Avenue, Telopea

A description of the main characteristics of the buildings for the purpose of determining compliance with the BCA is given in Table 3. The proposed use and classification of the buildings or part in accordance with clause A3.2 of the BCA is described in Table 4.

Characteristic	BCA clause	Description
Effective height	A1.1	Less than 25m
Type of construction required	C1.1	Type A
Rise in storeys	C1.2	Six (all)

Table 3 Main building characteristics

Part of building	Use	Classification (A3.2)
Basement - 15-17 Stuart Avenue	Carparking	Class 7a
Basement – building A2, 1-5 Short Street	Carparking	Class 7a
Ground floor to level 5 – all buildings	Residential	Class 2

Table 4 Use and classification

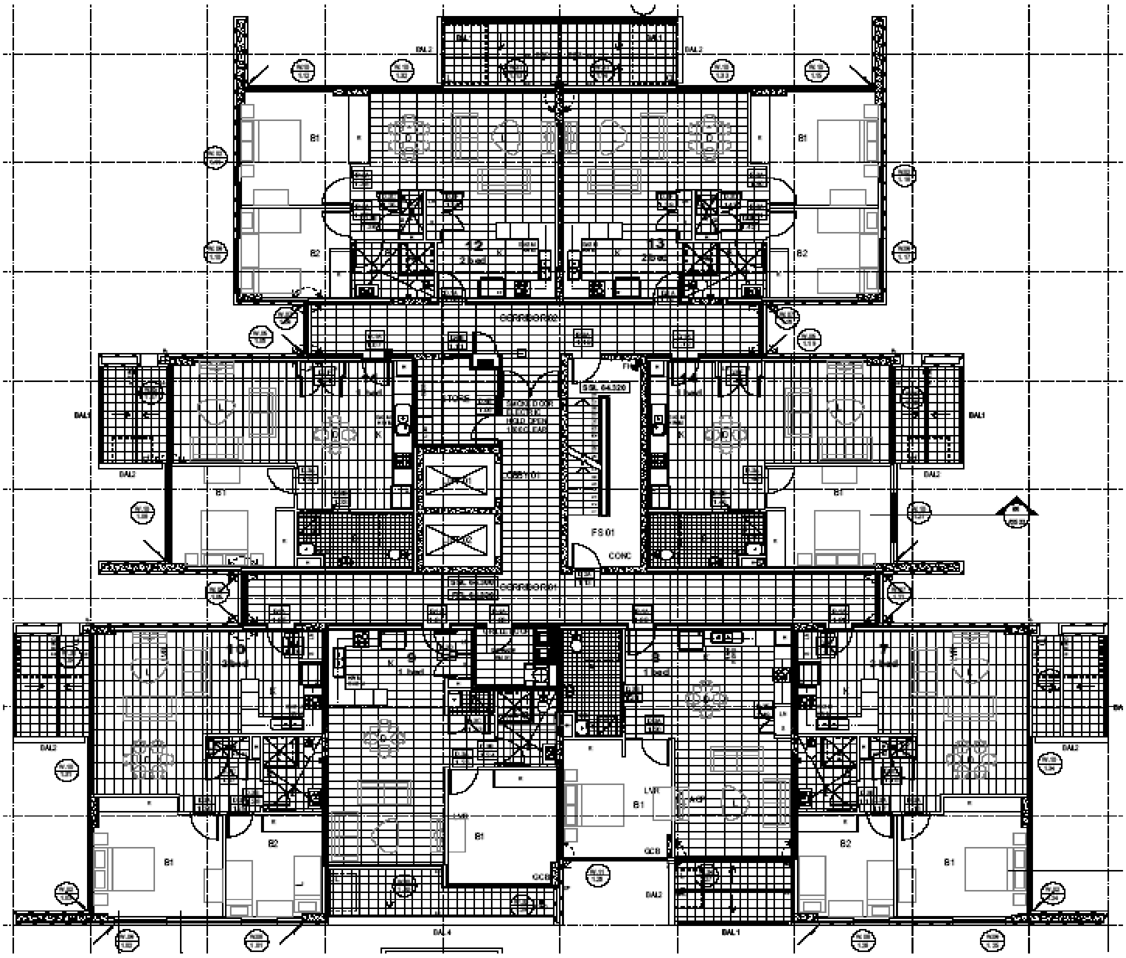


Figure 2 Typical floor plan – 1-5 Shortland Street, Telopea (building A1)

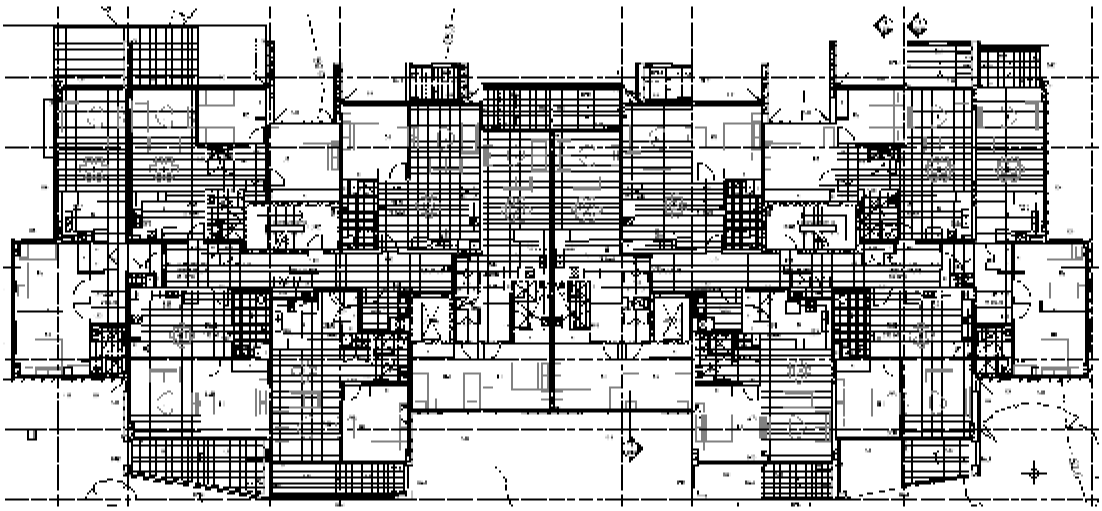


Figure 3 Typical floor plan – 1-5 Shortland Street, Telopea (building A2)

3.2 Preventative and protective measures

The building will be provided with the major fire safety measures required by the DTS provisions of the BCA listed as follows. A comprehensive list of fire safety measures is to be provided by the certifier as part of the building approval process. Additional fire safety measures required as part of the alternative solution are listed within section 5.

- Building occupant warning system
- Emergency lighting
- Fire rated construction bounding the units
- Fire doors
- Fire hydrant system
- Smoke alarms in the units
- Smoke alarms and/or detection in the common corridors
- Exit signs

3.3 Occupant characteristics

The characteristics of the occupants expected to be in the buildings are listed in Table 5.

Characteristic	Description
Familiarity	Occupants in the residential sole-occupancy units are expected to be long-term residents who are familiar with the building layout and exit locations.
Awareness	Residential occupants may be asleep at the time of a fire which could delay their response time for evacuation.
Mobility	Occupants are assumed to have the same level of mobility as the general population. This may include a limited proportion of mobility impaired occupants. These occupants may require crutches, a wheelchair or similar to evacuate on their own or need assistance from other occupants.
Age	Occupants of all ages may be present within the building.
Language	Although occupants may have English as their second language, they are expected to understand signs and verbal instructions in English to the degree necessary to not adversely impact upon evacuation.
Occupant load	No population densities are specified under table D1.13 of the BCA for residential uses. A population has been estimated on the basis of two persons per bedroom per unit. This is considered to be conservative.

Table 5 Occupant characteristics

3.4 Alternative solutions

The design of the building includes areas that do not comply with the DTS provisions of the BCA. We intend to use a performance-based fire safety engineering approach to develop alternative solutions to the DTS provisions of the BCA. Table 6 describes the BCA requirements associated with the alternative solutions.

No	Description of alternative solutions	DTS provision	Performance requirements (A0.10)	Method of meeting performance requirements	Assessment method
1.	15-17 Sturt Street, Telopea - No protection is required for openings in the external walls which are >3.2m of the adjoining buildings.	Clause C3.2	CP2	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(i)
2.	All sites - Travel distance to a single stair or point of choice on residential floors is up to 8m in lieu of 6m.	Clause D1.4	DP4	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(ii)
3.	15-17 Sturt Street, Telopea - Fire-isolated stairway 1 discharges into a covered area that is less than 3m in height and less than 1/3 perimeter.	Clause D1.7	CP2, DP5 and EP2.2	Complies with performance requirements A0.5(b)(i)	Verification method A0.9(b)(ii)
4.	15-17 Sturt Street, Telopea - The fire hydrant pumpset enclosure and the fire hydrant booster assembly are located at distances from the external wall of the building less than prescribed by AS2419.1-2005.	Clause E1.3 and AS2419.1-2005	EP1.3	Complies with performance requirements A0.5(b)(ii)	Verification method A0.9(c)

Table 6 BCA requirements associated with the alternative solutions

4. Scope, objective and assumptions

4.1 Scope and objective

- The scope of this report is limited to the alternative solutions described in section 3.4.
- The objective of this report is to demonstrate compliance with the fire safety aspects of the performance requirements of the BCA. Matters such as property protection (other than protection of adjoining property), business interruption, public perception, environmental impacts and broader community issues – such as loss of a major employer and impact on tourism – have not been considered as they are outside the scope of the BCA.
- This report considers single point arson as a source of ignition. Arson involving accelerants or multiple ignition sources is not considered in this assessment as it is outside the scope of the BCA.
- The scope of our works is limited to considering evacuation and fire safety issues for people with disabilities to the same degree as the DTS provisions of the BCA. Specifically, consideration of evacuation from the building by people with disabilities under the provisions of the Disability Discrimination Act 1992 is excluded.
- If there are building alterations or additions, a change in use or changes to the fire safety systems in the future, a reassessment will be needed to verify consistency with the assessment in this report.
- The data, methodologies, calculations and conclusions documented within this report specifically relate to the building and must not be used for any other purpose.
- A number of issues within the BCA are recognised to be interpretive in nature. Where these issues are encountered, interpretations are made that are consistent with standard industry practice.
- The documentation that forms the basis for this report is listed within Appendix A.
- This report has been prepared based upon information provided by others. Defire has not verified the accuracy and/or completeness of this information and shall not be responsible for any errors or omissions which may be incorporated into this report as a result.

4.2 Assumptions

- The design complies with the current DTS provisions of the BCA except for the specific alternative solutions described within section 3.4.
- All of the fire safety systems are assumed to be designed, installed and operate in accordance with the appropriate Australian standards, other design codes, legislation and regulations relevant to the project unless specifically stated otherwise.
- For a satisfactory level of fire safety to be achieved, regular testing and maintenance of all fire safety systems and measures, including management-in-use systems, is essential and is assumed in the conclusion of this assessment.

5. Fire safety measures

The fire safety measures required as part of the alternative solution are:

5.1 General

1. The design must comply with the current DTS provisions of the BCA unless specifically mentioned. This section does not provide a comprehensive list of fire safety measures required by the DTS provisions of the BCA. The fire safety measures listed within this section relate only to the alternative solutions. The fire safety measures must be read in conjunction with the DTS provisions of the BCA.
2. This report and the requirements listed in this section must be implemented into the design and identified on the fire safety schedule for the buildings. They must be maintained and certified in accordance with the Environmental Planning and Assessment Regulations, 2000 and relevant Australian standards.

5.2 Compartmentation and separation

3. Smoke seals are required to be fitted to all unit entry doors and must comply with specification C3.4 of the BCA. The smoke seals must achieve the following additional criteria:
   a. be medium temperature rated – ie capable of resisting exposure to 200˚C for 30 minutes
   b. be fitted to all sides of the door including under the door blade.

5.3 Protection of openings

4. Openings that are located within 6m of the neighbouring buildings on the 15 – 17 Sturt street, Telopea site as identified in Figure 4, are not required to be protected in accordance with clause C3.4.
5. Confirmation is required that the external walls of the existing buildings that are within 6m to the 15 – 17 Sturt street, Telopea building achieve a minimum FRL integrity of 60 minutes.

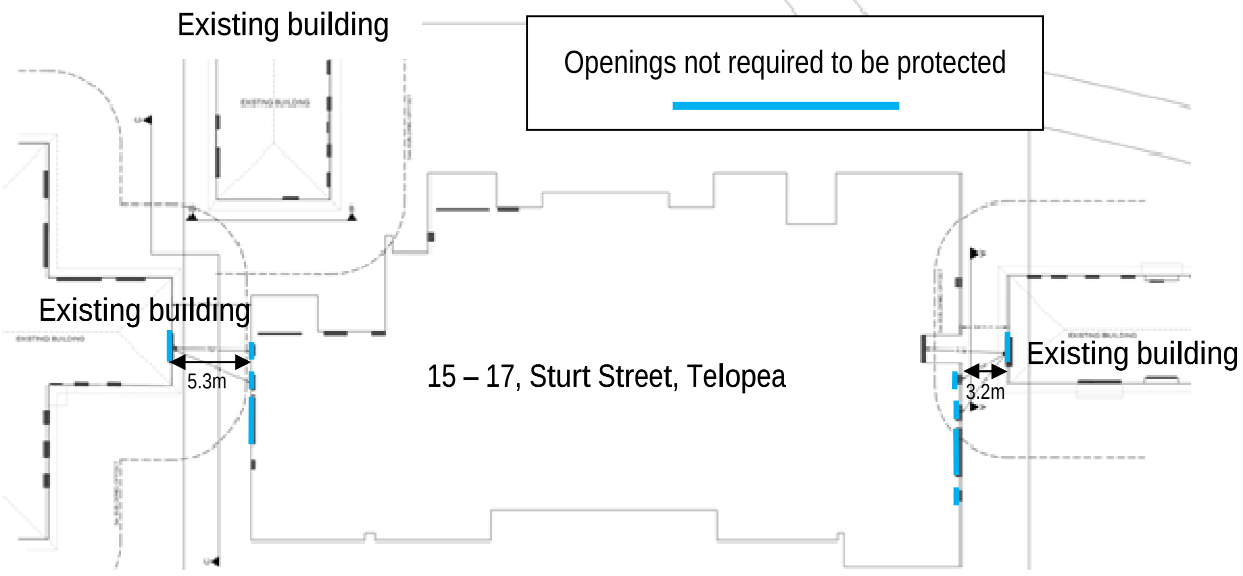


Figure 4 Site plan outlining exposed openings – similar for all levels

5.4 Access and egress

6. Travel distances from the sole-occupancy units to the exits on the residential floors of all buildings may be up to a maximum of 8m with the exception of the storey at the level of egress to a road or open space where it may be up to 20 m from a single exit serving the storey.

7. Fire-isolated stairway 1 of the 15–17, Sturt street, Telopea site may discharge into a covered area which does comply with clause D1.7 (b) (iii) of the BCA. The following is to be achieved:

   a. The area is to be separated with construction achieving a minimum FRL of 120/120/120 as indicated in Figure 5.

   b. Any doorways in the construction are to be self-closing fire doors which achieve an FRL of -/60/30. The doorways are to be provided with smoke seals in accordance with specification C3.4 of the BCA.

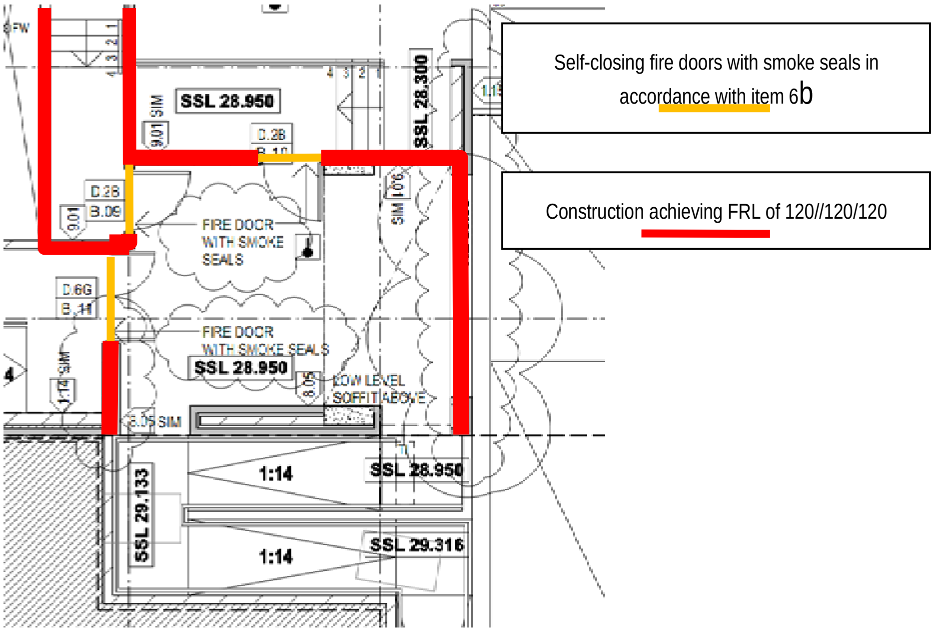


Figure 5 Discharge of fire-isolated stairway 1

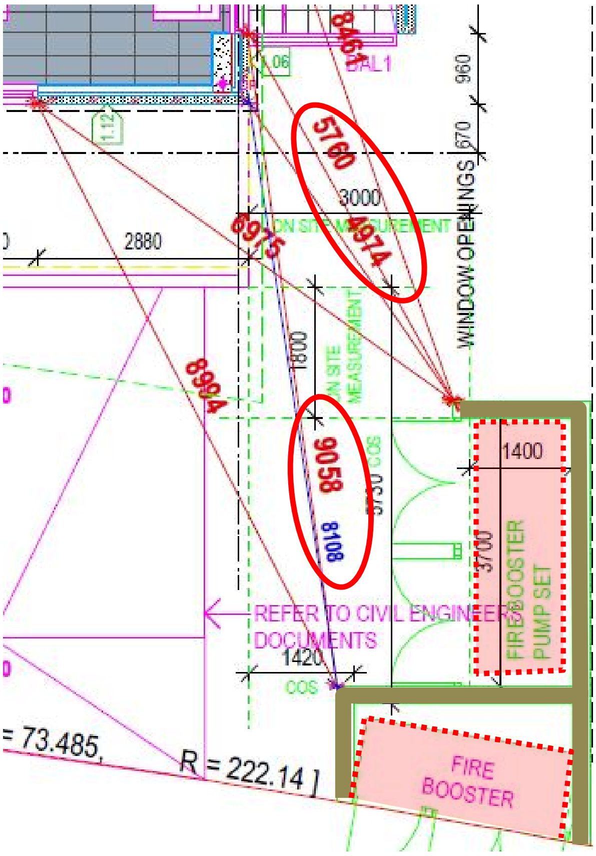
5.5 Services and equipment

5.5.1 Fire fighting equipment

8. A fire hydrant system must be installed throughout the building in accordance with the requirements of clause E1.3 of the BCA and AS 2419.1-2005 unless otherwise specified in this report.

   Please note that the fire hydrant booster assembly connections and all fire hydrant valves must be fitted with Storz aluminium alloy delivery couplings manufactured and installed in accordance with clauses 7.1 and 8.5.11.1 of AS 2419.1-2005. Blank caps must be fitted to the couplings via a screw thread. Refer to guide sheet no. 4 'Hydrant system connectors' prepared by Fire and Rescue NSW for more information. This document is available at www.fire.nsw.gov.au.

9. The fire hydrant pumpset and the fire hydrant booster assembly are proposed to be located in 230mm thick brick enclosures with a metal deck roof. The location of the onsite equipment is illustrated in Figure 6.



The following setbacks apply to the pumpset and booster equipment:

4974mm from the closest point of brick veneer external wall and carpark entry to the 230mm brick pumpset enclosure.

5760mm from the nearest window opening in the external wall to the 230mm brick pumpset enclosure.

8108mm from the closest point of brick the veneer external wall and carpark entry to the 230mm brick booster enclosure.

8994mm from the nearest window opening in the external wall to the 230mm brick booster enclosure.

Figure 6 Location of the booster assembly

5.5.2 Smoke hazard management

10. A smoke alarm or detection system must be installed throughout the buildings in accordance with clause 3 or 4 of specification E2.2a of the BCA.

5.5.3 Emergency lighting, exit signs and warning systems

11. An emergency lighting system must be installed throughout the buildings in accordance with clauses E4.2 and E4.4 of the BCA and AS 2293.1-2005.

12. Exit signage throughout the buildings must be illuminated and comply with clause E4.5 of the BCA – ie the concession for non-illuminated exit signage in class 2 buildings granted by clause E4.7 of the BCA is not applicable.

6. Alternative solution 1 – Protection of openings

6.1 Introduction

Under clause C3.2 of the BCA any openings in the external walls of a building that are required to achieve an FRL are required to be protected in accordance with clause C3.4 of the BCA if they are located within 6m of another building located on the same allotment. This is to mitigate the risk of fire spread between buildings.

The proposed design of the 15 – 17, Sturt Street, Telopea site contains openings in the external walls which are within 6m of adjacent buildings – refer to Figure 4 and as such are required to be protected in accordance with clause C3.4.

This assessment was undertaken to demonstrate that the design complies with performance requirement CP2 of the BCA.

6.2 Intent of the BCA

The Guide to the BCA [3] says that the intent of clause C3.2 is 'to require any opening in external walls to be protected, only where the wall is required to have an FRL, to prevent the spread of fire from the boundary of an adjoining allotment, or one building to another building on the same allotment.' The guide expands further that 'openings in an external wall must be protected if within 3 metres of a side or rear boundary.'

6.3 Methodology

The assessment undertaken for the building was a quantitative absolute assessment involving sub-system C – Fire spread and impact and control.

6.4 Acceptance criteria

The acceptance criteria for evaluating the risk of fire spread is derived from CV2 and clause C3.2 of the BCA. Where openings are located more than 6m apart, protection is not required. Applying verification method CV2 this equates to a maximum radiant heat exposure of 20kW/m^2. Hence, it is considered reasonable to assume that the risk of fire spread has been adequately mitigated provided the received radiant heat does not exceed 20kW/m^2.

At this radiant heat level several minutes of exposure is required onto a combustible and relatively easily ignitable material such as a thin light curtain etc.

6.4.1 Verification method CV2

Verification method CV2 of the BCA states:

'CV2

Compliance with CP2 to avoid the spread of fire between buildings on the same allotment is verified when it is calculated that-

(a) Is capable of withstanding the heat flux set out in column 2 of table CV2 without ignition; and

(b) Will not cause heat flux in excess of those set out in column 2 of table CV2.

[3] Guide to the BCA 2011, Australian Building Codes Board, Australia, 2011.

Column 1	Column 2
Location	Heat flux (kW/m^2)
0m	80
2m	40
6m	20
12m	10

Table CV2

6.5 Method of analysis

The method of analysis used is described below:

- Identify openings in the building that could act as a source of fire spread – via radiant heat – to adjacent properties.
- Identify openings in the adjacent residential buildings that could act as a source of fire spread to the proposed design.
- Establish the dimensions of the identified openings. An augmentation factor of 25% is applied to the height of the openings to account for flames emanating out of the window in accordance with Appendix B of AS 2118.2.
- Using 'Radiation' from the 'Firewind' [4] suite of computer programs, calculate the levels of radiant heat flux at the exposed openings and determine whether they are less than the critical value of 20kW/m^2.
- The emitting radiant heat source from a flashover fire within the buildings are assumed to have flame temperature of 900°C. This temperature is based upon a series of full-scale residential fire tests[5, 6 & 7].
- The emitting radiant heat source from a car fire within the carpark located in the proposed building is conservatively assumed to have flame temperature of 1000°C.
- The emitting radiant heat source is conservatively assumed to have a minimum emissivity of 0.9[8].
- Develop a strategy to protect openings that receive more than the critical level of radiant heat flux of 20kW/m^2 from neighbouring buildings.

[4] Firewind, Version 3.6, Fire Modelling & Computing, 66 Westbrook Avenue, Wahroonga, NSW 2076, Australia.
[5] Report of Test FR 3995, Santa Ana Fire Department Experiment at 1315 South Bristol, NIST, 14 July, 1994.
[6] Report of Test FR 4009, Full-Scale House Fire Experiment for InterFIRE VR 6 May, 1998.
[7] Full-Scale Room Fire Test – Report No. NIST GCR 97-716, NIST, June, 1997.
[8] Buchanan AH, Structural design for fire safety, John Wiley & Sons, England, 2001, p 52.

6.6 Assessment

6.6.1 Fire scenarios to be evaluated

summarises the openings to be evaluated and the associated credible design fire scenarios assessed to determine potential fire spread from the buildings. The scenarios are considered to be representative of the openings for the purposes of determining the maximum radiant heat flux levels emitted to adjoining buildings.

For the exposed opening within the carpark, a localized carpark fire will be assessed. The location of the fire is shown in . The location is considered to represent the worst case scenario, in terms of radiant heat emitted to the neighbouring buildings openings due to the proximity of the fire.

Studies conducted by Denda[9], suggests that the probability of fire spread between cars in a carpark is low. The data examined was based on 404 carpark fires of which 28 spread from the vehicle of origin to another vehicle, which equates to approximately 7%. The car fire is also located in the trafficable area and is therefore considered unlikely to involve more than one car. As such for this assessment only a single car fire has been assessed.

Scenarios 1 and 2 represent a fire within the individual units within the existing buildings. Scenario 3 represents a single car fire within the carpark in the proposed building. Scenarios 4 and 5 represent a fire within the individual units within the proposed building.

Fire scenario	Description of fire scenario	Identified openings
1	Fire within unit in exiting residential building to the west	1
2	Fire within unit in exiting residential building to the east	2
3	Fire within proposed building carpark	3
4	Fire within unit in proposed building on east side	4 - 7
5	Fire within unit in proposed building on west side	8 - 10

Table 7 Fire scenarios

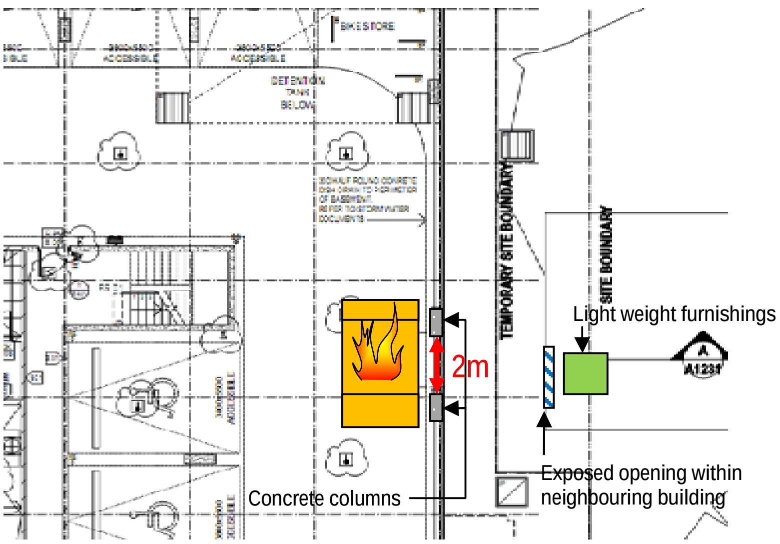


Figure 7 Carpark fire scenario

[9] Dale F Denda 1992, Parking Garage Fires – A Statistical Analysis of Parking Garage Fires in the US:1986-1988,

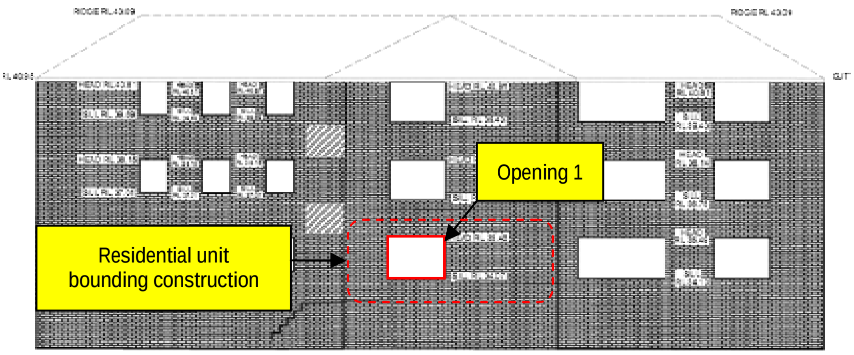
6.6.2 Radiant heat sources

The location, size and orientations of openings of the proposed design and existing buildings used to calculate the radiant heat flux emitted for various fire scenarios are identified in Table 8 and Figure 8 to Figure 10. In identifying potential radiant heat sources the following assumptions have been made:

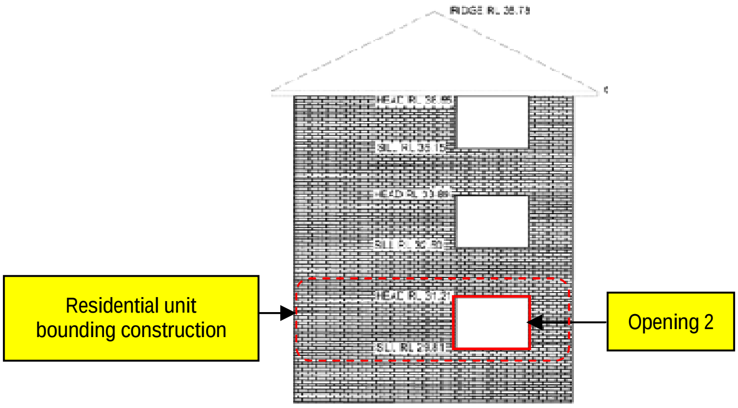
- The external walls of the proposed design which house the exposed openings are to achieve an FRL of 90/60/30. Similarly the adjacent existing residential buildings are comprised of external masonry walls and are to be confirmed that they achieve a minimum FRL of 60/60/60 as per the fire safety measures outlined in section 5. As such for this assessment only the openings within the walls have been considered as credible radiant heat sources and not the external walls.
- The units within the class 2 buildings are separated by a concrete slab, fire rated construction and self-closing fire doors to the unit entries, as such it is unlikely that fire will spread internally between units. As such only the openings in a single residential unit within each building have been assessed – ie all openings in building facade have not been included as shown in Figure 8 to Figure 10.
- The openings within the residential corridors have also not been included in the assessment on the basis that flashover is no expected to occur within this area, due to the limited fire load and non-combustible floor, ceiling and wall linings used in this area.

No.	Height (m)	Adjusted height (+ 25%) (m)	Width (m)	Distance to nearest opening	Fire scenario	Comment
Existing building located on the west side of the allotment						
1	1.40	1.75	2.00	5.30	1	Residential unit
Existing building located on the east side of the allotment						
2	1.40	1.75	2.00	3.30	2	Residential unit
Proposed building – east side						
3	1.60	2.0	2.00	3.30	3	Carpark opening
4	0.60	0.75	0.60	3.30	4	Residential unit
5	1.75	2.20	1.00	3.30		
6	1.00	1.25	3.30	3.30		
7	1.70	2.125	1.90	3.30		
Proposed building – west side						
8	1.00	1.25	3.30	5.30	5	Residential unit
9	1.75	2.20	1.00	5.30		
10	0.60	0.75	0.60	5.30		

Table 8 Summary of openings assessed



Existing building to the west



Existing building to the east

Figure 8 Exposed openings within existing buildings

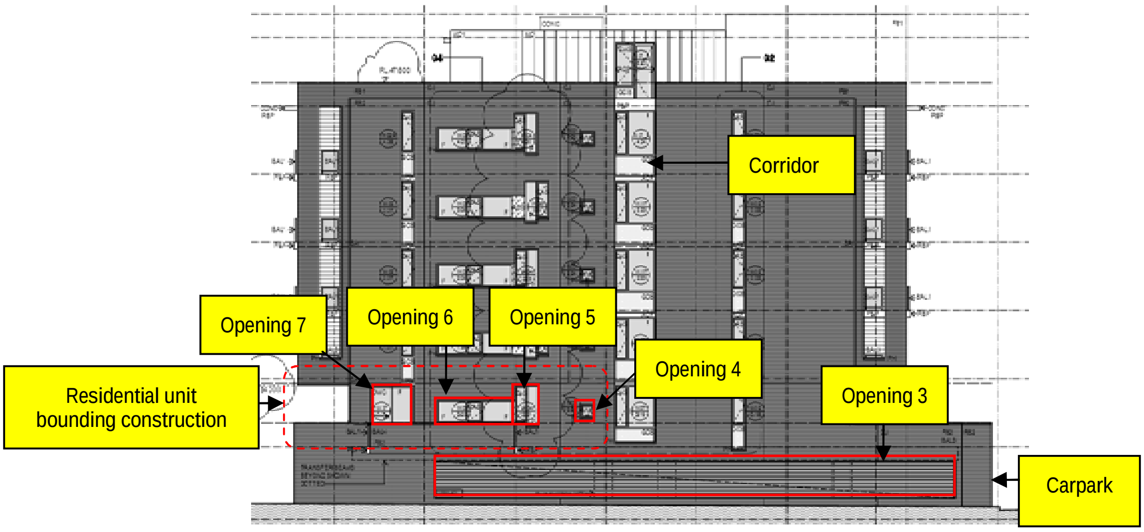


Figure 9 Exposed openings on east elevation of proposed building

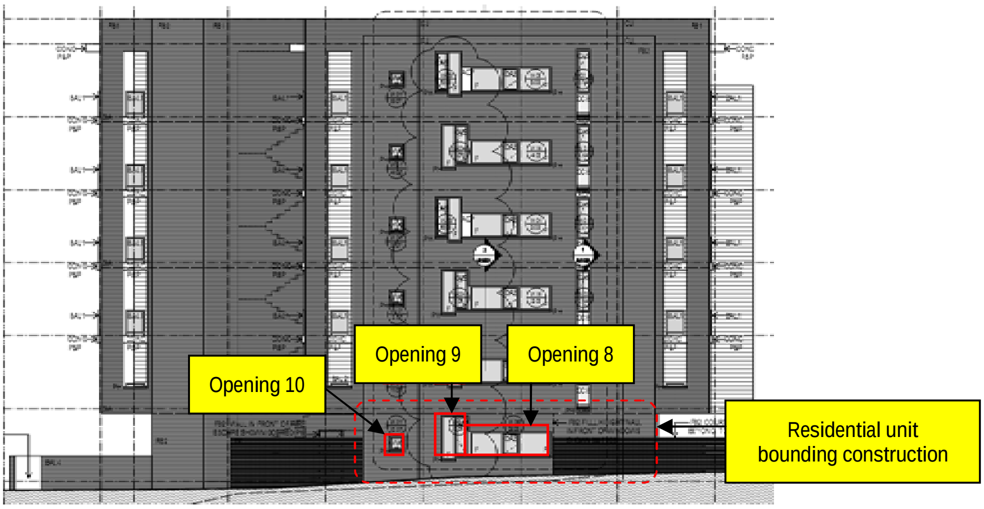


Figure 10 Exposed openings on west elevation of proposed building

6.6.3 Calculation of radiant heat

The radiant heat levels emitted between the buildings were calculated using program ‘Radiation’ of the ‘Firewind’ suite of computer program. Table 9 contains a summary of the level of radiant heat flux emitted from the identified credible design fire scenarios for each of the buildings. This is reported in terms of heat flux received at various locations including that received at any openings. The output data has been included in Appendix B.

Scenario	Maximum flux received (kw/m^2)
Maximum heat flux permitted by verification method CV2	20
1	4
2	9
3	14
4	14
5	6

Table 9 Radiant heat emitted from openings at nominated in fire scenarios

The assessment indicates that the heat fluxes emitted by the identified openings to the adjacent buildings are less than the nominated acceptance criteria of 20kW/m^2 in accordance with section 6.4.

6.7 Conclusion

The assessment undertaken for the proposed design of the 15-17, Sturt street, Telopea site demonstrates that the risk of fire spread between buildings is limited to the degree necessary. The proposed design of the building is therefore considered to achieve compliance with performance requirement CP2 of the BCA, subject to compliance with the fire safety measures given in section 5.

7. Alternative solution 2 – Travel distances within residential levels

7.1 Introduction

Clause D1.4(a)(i) of the BCA states that 'the entrance doorway of any sole-occupancy unit must be not more than 6m from an exit or from a point from which travel in different directions to 2 exits is available.'

The proposed design of the residential levels incorporates travel distances which are up to 8m to an exit or a point of choice. An example of the extended travel distances from sole-occupancy unit entrance doorways to an exit are illustrated in Figure 11.

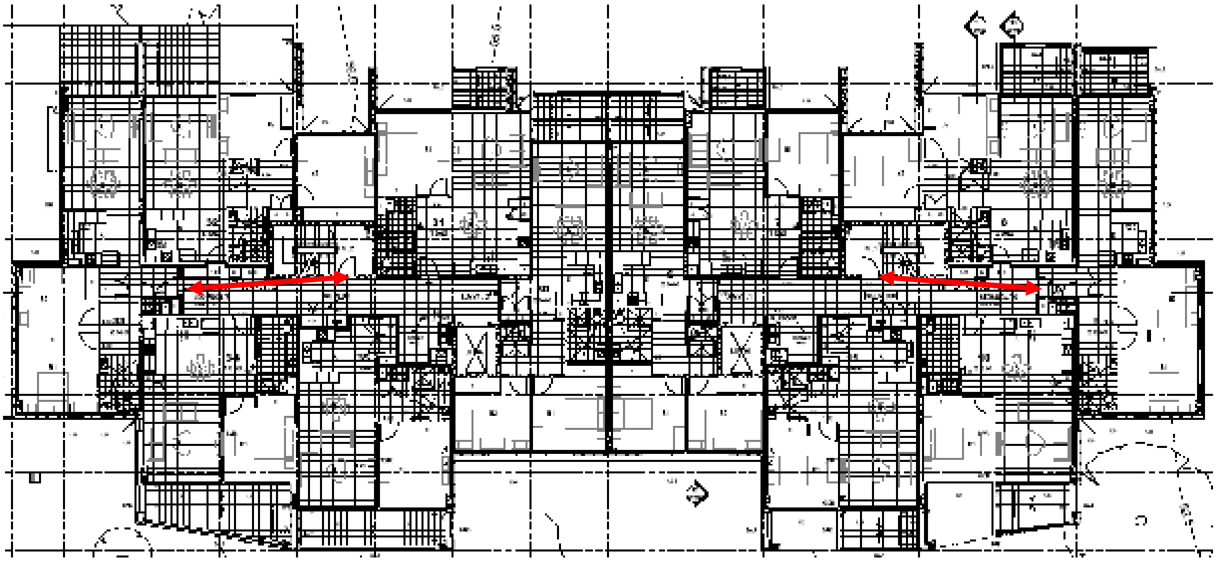


Figure 11 Maximum travel distances from units (1-5 Shortland Street, building A2 shown)

This assessment was undertaken to demonstrate that the design complies with performance requirement DP4 of the BCA.

7.2 Methodology

The assessment undertaken for the building was a qualitative absolute assessment involving the following sub-systems:

- Sub-system B – Smoke development and spread and control
- Sub-system E – Occupant evacuation and control

7.3 Intent of the BCA

7.3.1 Travel distance to a single exit or point of choice – clause D1.4

The Guide to the BCA [10] says that the intent of clause D1.4 is 'to maximise the safety of occupants by enabling them to be close enough to an exit to safely evacuate.' The guide expands further that 'D1.4(a)(i)(A) and (B) require a shorter travel distance, to a single exit, for class 2 and class 3 buildings and class 4 parts than is required for class 5 to class 9 buildings.

The distance occupants of sole-occupancy units in class 2 and class 3 buildings and class 4 parts must travel to leave their unit is not part of the distance specified in D1.4. Accordingly, the permitted distance of travel from the point at which the occupant leaves the unit must take account of the time needed for the occupant to reach that point from within the unit.

Distance of travel must factor in the time occupants need to wake up, become alert to their predicament, and exit in a state of confusion. This process of becoming alert will inevitably require more time to exit. Therefore the distance of travel to an exit should be shorter.'

It is considered that the travel distance requirement for residential buildings of 6m to a single exit or point of choice also relates to the potential exposure of occupants to a fire affected unit while evacuating. While not directly related to travel distance, increasing the distance to an exit or point of choice increases the risk of the means of escape being obstructed by a fire in an intervening unit. While it is expected that the door to the unit would be closed, a significant amount of smoke is able to leak around the leaf of a fire door.

7.4 Acceptance criteria

The acceptance criterion for this assessment is to demonstrate that the risk of smoke spread to the exit path is mitigated and adequate exit signage is provided to facilitate safe occupant evacuation.

7.5 Assessment

The hazard associated with the building must be assessed in terms of the ability of the occupants to safely undertake an evacuation should a fire occur. The reason that clause D1.4 of the BCA stipulates travel distance requirements is to ensure that all occupants of the building are within a reasonable distance of an exit so that they can safely evacuate in the event of a fire.

The maximum travel distances stipulated in the BCA are notional figures. These requirements are conservative in nature as they relate to all possible design scenarios. They do not take into account the layout of the building or active fire safety systems within the building.

7.5.1 Occupant familiarity with the building layout

The Guide to the BCA states that occupants of class 2 residential apartments 'tend to be long-term occupants, and aware of their surroundings'. This means that the occupants are likely to be familiar with the layout of the building and the location of the exit with respect to their unit entry door.

This is not the case for a class 3 residential building – such as a hotel, serviced apartments – where occupants may be unfamiliar with the layout of the building and the location of the exits. The requirements of clause D1.4 of the BCA are considered conservative for residential apartments buildings because they do not distinguish between short term and long term residential buildings with regard to travel distance.

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[10] Guide to the BCA 2009, Australian Building Codes Board, Australia, 2009.

This beneficial impact of occupant familiarity is exemplified in the Swedish evacuation design guide [11] by allowing an increase in the travel distance to a point of choice or single exit in long term residential buildings to 10m compared to 7m for short term accommodation.

7.5.2 Occupant evacuation

Observations and experiments have shown that evacuation flow speed of a group is a function of the population density [12,13,14]. If the population density is less than about 0.54 persons/m^2 of exit route individuals will move at their own pace, independent of the speed of others. If the population density exceeds approximately 3.8 persons/m^2, no movement will take place until enough of the crowd has passed from the crowded area to reduce the density. Between the density limits of 0.54 and 3.8persons/m^2 the relationship can be considered as a linear function. This linear function is given by Equation 1 with Figure 12 showing the relationship between speed and density. The maximum speed occurs when the density is less than 0.54 persons/m^2.

$$S = k - 0.266\,kD$$

where :

S = speed along the line of travel (m/s).

D = density in persons/ m^2.

k = constant.

Equation 1 Evacuation speed as a function of density

[11] Evacuation design guide (Utrymningsdimensionering), Boverket rapport 2006, Sweden, June 2006 (Swedish).
[12] Predtechenskii, V.M., and Milinskii, A.I., Planning for Traffic in Buildings (translated from the Russian), Stroizdat Publishers, Moscow, 1978. English translation published for the National Bureau of Standards and the National Science Foundation, Amerind Publishing Co., New Dehli, India, 1978.
[13] Fruin, J.J., Pedestrian Planning Design, Metropolitan Association of Urban Designers and Environmental Planners Inc., New York, 1971.
[14] Pauls, J.L., Effective Width Model for Evacuation Flow in Buildings, in Proceedings, Engineering Applications Workshop, Society of Fire Protection Engineers, Boston, 1980.

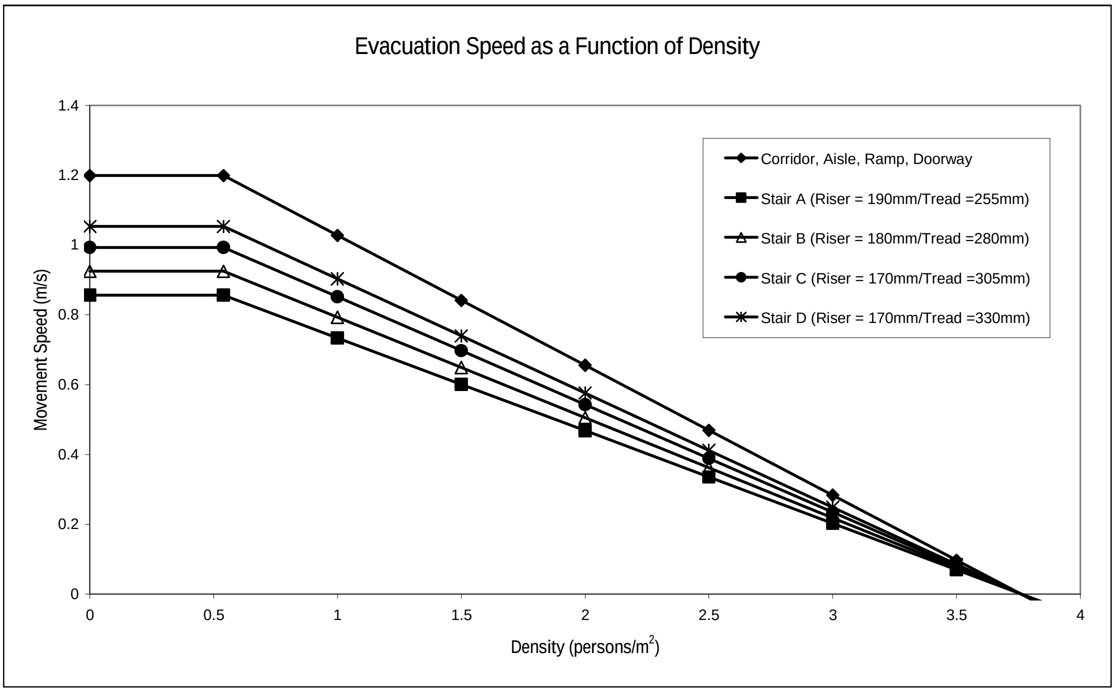


Figure 12 Evacuation speed as a function of density

The population density within a residential building is expected to be less than 1.0 persons/m^2. Travel speeds at 1.0 person/m^2 are approximately 1.0 m/s in corridors. The addition of a maximum of 2m to the travel distance from the sole-occupancy unit to the fire-isolated exit or point of choice will increase the time to reach the exit by approximately 2 seconds.

The additional 2 seconds resulting from the increase in travel distance must be considered in conjunction with the likely pre-movement time of the occupants after receiving a cue to evacuate the building. The Fire Code Reform Research Program has published data on the Times to Start Action in response to a cue [15] which is summarised in Table 10. This data was compiled from 53 cases in the Response in Fires Database. The data indicates that the mean and maximum time for occupants in a residential building to investigate the fire and begin evacuation are 220 and 360 seconds respectively when an alarm cue is received and occupants are asleep. Without alarms these times were found to increase to 282 and 1260 seconds respectively.

According to CIBSE Guide E the pre-movement time for residential buildings can be up to 30 minutes. [16] Taking the pre-movement time for the building occupants into account, the additional 2 seconds travel time to the exit amounts to between 0.5 – 0.9% of the total evacuation time. On this basis, it is considered that the exit is located within a 'reasonable distance' of the sole-occupancy units as intended by clause D1.4 of the BCA and that the additional 2 seconds is expected to have minimal impact on the ability of the occupants to safely evacuate the floor in the event of a fire.

[15] Fire Code Reform Research Program, Response in Fires Database, Technical Report FCRC-TR 97 – 12, February 1997
[16] CIBSE Guide E, The Chartered Institution of Building Services Engineers London, 2nd edition 2003, p.4-10

Cases & Condition	N	Mean	D.3	25%ile	75%ile	Min. time	Max. time
All	13	282	313	107	345	40	1260
Asleep	8	356	378	152	375	120	1260
Awake	5	165	127	65	300	40	330
70+ year (all asleep)	3	590	590	150		150	1260
<70 years	10	190	112	94	285	40	380
<70, asleep	5	215	102	138	310	120	380
<70, awake	5	165	127	65	300	40	330
Light smoke (all awake)	3	230	125	90		90	330
Alarms	4	175	136	60	315	40	360
Alarm, asleep	3	220	125	120		120	360
Warning (all asleep)	5	437	469	153	820	150	1260

Table 10 Total time from the cue to start of investigation until start of evacuation

7.5.3 Risk of obstruction

The worst case fire scenario for occupants of the units located further than 6m from an exit is where a unit along the path of travel to the exit is on fire. The entry doors to the units with extended travel distances to the single exit are located at the end of the corridor. If the design of the building was altered so that these doors were located within 6m of the exit, occupants would still be required to pass by at least one other unit to reach the exit. This is not different for travel at 6m or 8m in distance.

Therefore, the increase in the travel distance to an exit from the unit will not result in an increased risk of occupants being exposed to another unit that is on fire.

7.5.4 Smoke seals

It is proposed to provide medium temperature smoke seals to all unit entry doors which open onto the corridors. When smoke seals are fitted to the fire doors, the available path for smoke flow through the entry doors into the corridor is significantly reduced when they are in the closed position. The smoke seals can be expected to limit the spread of smoke through the clearances around a door leaf perimeter, up to room temperatures of at least 200°C, at which time it begins to degrade.

The Guide for the Design of Fire Resistant Barriers and Structures [17] includes calculations comparing smoke leakage around a typical door with and without smoke seals. The calculations assume that medium temperature smoke and full mixing of the smoke forming a uniform concentration. For the worst case scenario considered – a flaming plastic fire – the calculations demonstrate that the adjoining enclosure becomes untenable in < 1 minute for the scenario without smoke seals, and after 14 minutes with smoke seals.

Although the leakage rates around the perimeter of the door frame will vary depending on the clearance to the door frame and the specific smoke seals used, the results of this research indicate that the presence of smoke seals will significantly increase the time to untenable conditions. On this basis, the provision of smoke seals is considered to compensate for the additional 2 seconds of travel time to reach the exit from the subject sole-occupancy units.

[17] England J.P., Young S.A., Hui M.C. and Kurban N. 2000, Fire Resistant Barriers and Structures, Building Control Commission, Melbourne, p. 148.

7.5.5 Visibility through smoke

Clause E4.7 of the BCA provides a concession for class 2 buildings whereby normal illuminated exit signage complying with clause E4.5 of the BCA can be replaced with text on the exit door. Clause E4.7 of the BCA states that 'E4.5 does not apply to—

(a) a class 2 building in which every door referred to is clearly and legibly labelled on the side remote from the exit or balcony—

   (i) with the word "EXIT" in capital letters 25 mm high in a colour contrasting with that of the background; or

   (ii) by some other suitable method.'

This concession is granted on the basis that the risk associated with class 2 building does not warrant compliance with clause E4.5 of the BCA due to occupant familiarity with the building and the location of exits.

Whether or not objects are illuminated has a significant impact on how easily perceived they are through smoke. Visibility in smoke is described in terms of the furthest distance an object can be perceived S (m) and a light extinction coefficient K (m^{-1}) where:

- for light emitting signs K x S = 8
- for light reflecting signs K x S = 3

The light extinction coefficient K is a product of the mass concentration of smoke aerosol. Assuming an equivalent smoke concentration, it can be calculated that light emitting signs can be expected to allow occupants to see 2.66 times further through smoke than light reflecting signs. For example, a light reflecting sign which is visible at a DTS complying travel distance of 6m through smoke would be visible from approximately 15m if illuminated. As the class 2 residential portions of the building will be provided with illuminated exit signage complying with clause E4.5 of the BCA, occupants can be expected to locate exits more easily through smoke when compared with a design complying with the DTS provisions of the BCA with complying travel distance and application of the clause E4.7 concession.

7.6 Conclusion

The assessment undertaken for the proposed design with up to 8m to a single exit or point of choice from the entrance doorway of a number of units provides for safe occupant evacuation. The proposed design of the building is therefore considered to achieve compliance with performance requirement DP4 of the BCA, subject to compliance with the fire safety measures given in section 5.

8. Alternative solution 3 – Discharge of exits

8.1 Introduction

Clause D1.7 of the BCA requires that each 'fire-isolated stairway or fire-isolated ramp must provide independent egress from each storey served and discharge directly, or by way of its own fire-isolated passageway –

(i) to a road or open space; or

(iii) into a covered area that—

> (A) adjoins a road or open space; and
>
> (B) is open for at least 1/3 of its perimeter; and
>
> (C) has an unobstructed clear height throughout, including the perimeter openings, of not less than 3 m; and
>
> (D) provides an unimpeded path of travel from the point of discharge to the road or open space of not more than 6 m'.

Fire-isolated stairway 1 of the 15 – 17, Sturt Street, Telopea site discharges into a covered area which is less than 3m high and does not achieve the required opening for 1/3 of the perimeter.

This assessment has been prepared to demonstrate that the proposed design complies with performance requirements CP2, DP5 and EP2.2.

8.2 Methodology

The assessment undertaken for the building was a qualitative absolute assessment involving the following sub-systems:

- Sub-system B – Smoke development and spread and control
- Sub-system C – Fire spread and impact and control
- Sub-system D – Fire detection, warning and suppression
- Sub-system E – Occupant evacuation and control

8.3 Intent of the BCA

The Guide to the BCA [18] says that the intent of clause D1.7 is 'to enable occupants to safely enter a fire-isolated exit which discharges to a safe location.'

'Discharge to areas not roads and open spaces—D1.7 (b)

D1.7(b)(i) requires fire-isolated exits to discharge to roads or open spaces. However, there are some exemptions:

- D1.7(b)(ii) sets out the requirements for a fire-isolated exit to discharge into an area within a building (including the requirement that it be open for at least two thirds of its perimeter, to aid smoke ventilation); and

[18] Guide to the BCA 2011, Australian Building Codes Board, Australia, 2011.

- D1.7(b)(iii) sets out the requirements for a fire-isolated exit to discharge into a covered area outside the building (including the requirement that it be open for at least one third of its perimeter, to aid smoke ventilation).'

The intent of BCA Clause D1.10 is to "require the safe discharge from an exit to a road or open space".

The Guide to the BCA uses the term "to the degree necessary" in order flexibility is provided in the way this provision is implemented. It also stresses the fact "that compliance with CP2 is not compulsory if alternative means can be found to satisfy the appropriate authority that the performance requirements will be achieved".

8.4 Fire hazard

The hazard associated with the discharge of the stairway is the potential for fire or smoke to enter the space and affect the ability of occupants to evacuate. As noted in section 8.3 the intent of clause D1.7 of the BCA is to ensure that occupants discharge to a safe location.

The discharge location is approximatley 21m^2 and has a periemeter of 18m. The area will be fire separated and only be used for pedestrian access and is expected to contain limited combustibles, including PVC piping.

Three doorways open into the area, one from the fire-isolated stairway, one from the garbage room and one from the carpark area. All three doorways will be protected by self-closing -/60/30 fire doors. The doors will also be provided with smoke seals.

8.5 Acceptance criteria

The fire-isolated exit must discharge to a location where occupants are provided with a safe path of travel leading to a road or open space which is adequately protected from fire hazards within the building.

8.6 Assessment

The discharge area will be fire separated away from the building with fire rated construction achieving an FRL of 120/120/120. Doorways in the construction will be protected by self-closing -/60/30 fire doors with smoke seals. The separation provided is considered to protect occupants from fire and smoke similar to a complying fire-isolated passageway.

In a DTS compliant design where a fire-isolated stair discharges into a covered area, there is no requirement for fire separation of the discharge area from the remainder of the building or limitation of the combustibles within the discharge area. As such there is a risk that a fire occurring in or adjacent to the discharge location could spread significant amounts of smoke into the area and result in a risk of obstruction due to fire and radiant heat. The risks associated with such a scenario are mitigated by the DTS provisions to a degree, by requiring a 1/3 open perimeter for smoke ventilation and also by limiting the maximum distance to reach open space.

Although the proposed design of the discharge location of the fire-isolated stairway does not comply with ventilation and height requirements of clause D1.7 of the BCA, the area is fire separated from the remainder of the building and is expected to be free of combustibles – with the exception of PVC piping. The proposed design is therefore considered to mitigate the risk of fire and smoke obstructing the discharge location and is considered to protect occupants from a fire within the building similar to an extension of the fire-isolated exit.

8.7 Redundancy

In the event that a fire occurs within the vicinity of the discharge location occupants may evacuate the building through the carpark using an alternative exit as shown in Figure 13.

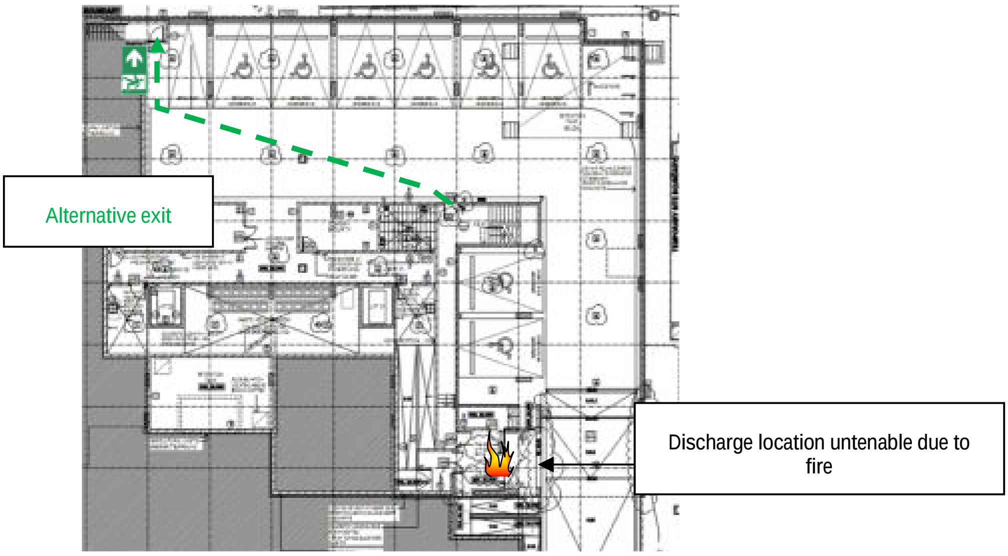


Figure 13 Alternative exit

8.8 Conclusion

The assessment of the proposed design for the discharge of fire stairway 1 within the 15-17 Sturt street, Telopea site, demonstrates that occupants are provided with a safe pathway to an open space. The proposed design of the building is therefore considered to achieve compliance with performance requirements CP2, DP5 and EP2.2 of the BCA, subject to compliance with the fire safety measures given in section 5.

9. Alternative solution 4 – Fire hydrant equipment location

9.1 Introduction

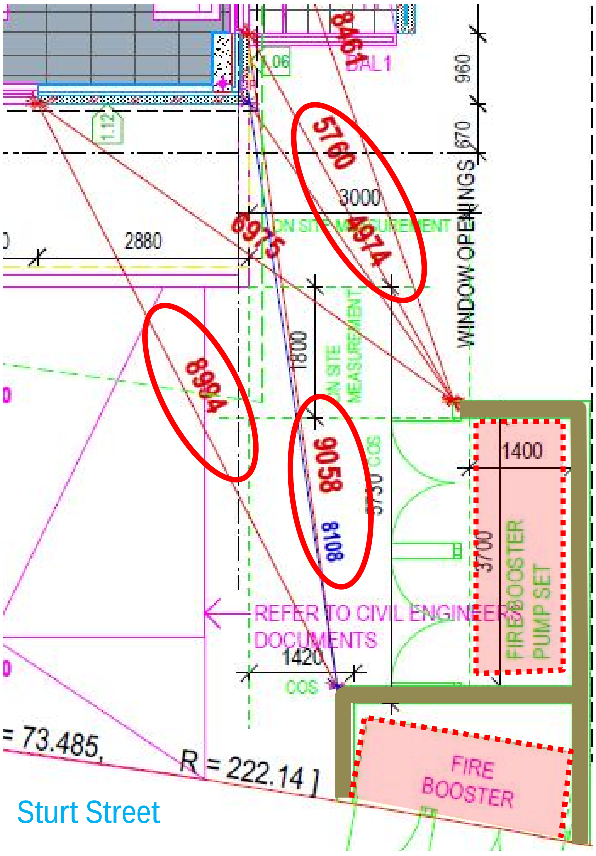
Sections 6.4.3 and 7.3(c)(ii) of AS 2419.1-2005 requires that where pumpsets and boosters are provided external to the building they must be not less than 6m and 10m respectively.

Where these distances cannot be achieved, the pumpset must be protected by enclosing walls with an FRL not less than that for a fire wall based on the classification of the same building. In this case, that means 90/90/90.

For external fire hydrant booster facilities, a shield wall is required 2m either side of and 3m above the upper booster connection. The FRL required to be achieved is again 90/90/90.

Neither the pumpset nor the booster is proposed to have this level of protection. The location and design is provided in Figure 14.

An alternative solution is proposed to demonstrate that the design of service does not unduly affect fire brigade intervention and therefore complies with performance requirement EP1.3 of the BCA.



The following setbacks apply to the pumpset and booster equipment:

4974mm from the closest point of brick veneer external wall and carpark entry to the 230mm brick pumpset enclosure.

5760mm from the nearest window opening in the external wall to the 230mm brick pumpset enclosure.

8108mm from the closest point of brick the veneer external wall and carpark entry to the 230mm brick booster enclosure.

8994mm from the nearest window opening in the external wall to the 230mm brick booster enclosure.

Figure 14 Location of the booster assembly

9.2 Methodology

The assessment to be undertaken for the building is a quantitative comparative assessment involving sub-system F – Fire services intervention.

9.3 Intent of the BCA

To assess whether the design complies with performance requirement EP1.3 of the BCA, the intent of clause E1.3 must be understood. The Guide to the BCA [19] says that the intent of clause E1.3 is 'to require the installation of suitable fire hydrant systems to facilitate the fire brigades fire fighting operations.'

9.4 Acceptance criteria

The acceptance criterion for the assessment is that the proposed setback provides an equivalent level of fire protection to a similar DTS compliant design to allow the brigade personnel to conduct fire fighting intervention and operations as intended.

9.5 Fire hazards

The fire hazard to be assessed is increased risk to fire fighters and pump equipment as a result of the reduced setback distance of the equipment and radiant heat emanating from the building.

Two fire scenarios are to be investigated being a fire within the nearest sole-occupancy unit on ground level and a fire within the carpark vehicles entry on the basement level.

9.6 Assessment

9.6.1 Introduction

The hydrant pumpset and booster assembly is located off Sturt Street. The setback distances are illustrated in Figure 14. The booster and pumpset is located off the front boundary adjacent to the basement driveway ramp and is within site of the main entrance.

The distances specified are marginally less than those specified by AS2419.1-2005 which results in the non-compliance with clause E1.3 of the BCA.

9.6.2 Fire brigade intervention

The building is located in Telopea with multiple fire stations, including Rydalmere (2.0km), Eastwood (4.3km), and Parramatta (5.5km) considered relatively short distances from the site. As the building is provided with an AS1670.1-2004 smoke detection and alarm system it can be conservatively assumed that the fire brigade will arrive within approximately 10 minutes and initiate fire-fighting within 20 minutes. The presence of multiple fire stations within a short distance mitigates potential delays due to the closest fire station being on call when a fire occurs.

The statistics presented below represent data collected by the FRNSW between 1998 and 2003 [20]. The median value fire brigade arrive time is:

- Between four and five minutes in the sprinklers present cases.
- Between five and six minutes in the sprinklers not present cases.

In 90% of fires the fire brigades had arrived in:

- Between eleven and twelve minutes for commercial buildings with sprinklers not present.
- Between ten and eleven minutes for commercial buildings with sprinklers present.

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[19] Guide to the BCA 2011, Australian Building Codes Board, Australia, 2011.
[20] NSW Fire Brigades annual statistical report 2001/02. incorporating a ten year review 1989/90 to 1998/99: NSW Fire Brigades 2003.

- Between twelve and thirteen minutes for residential buildings with sprinklers not present
- At about seven minutes for residential buildings with sprinklers present.

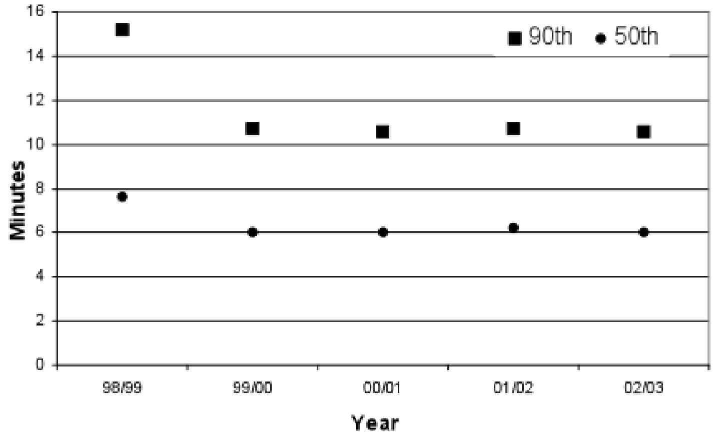


Figure 15 Response times for structure fires

Response times for structure fires at the 50th and 90th percentiles have remained fairly static during the last four years. In 1998/99 the median response time for structure fires was 7.6 minutes and improved to 6 minutes in 2002/03. At the 90th percentile, response time for structure fires was 15.2 minutes in 1998/99 and improved to 10.6 minutes in 2002/03.

94.7% of calls within the greater Sydney area were responded to within 10 minutes. The average response time for calls outside the greater Sydney area was 8.9 minutes.

The average duration of actual fires fluctuated over the reporting period from 44 minutes per call in 1989/90 to a low of 36 minutes in 1992/93 and a peak of 48 minutes in 1993/94, thereafter falling to 38 minutes in 1998/99. The average duration at calls for fires over the ten years was 42 minutes.

Building fires had longer average duration time that for all fire types each year resulting in a higher ten-year average of 54 minutes. The average building fire duration time increased from 49 minutes in 1989/90 to 62 minutes in 1998/99.

Non-fire rescue calls had the highest level of average duration at calls with a ten-year average of 60 minutes. The figures generally rose from a near low of 50 minutes in 1989/90 to high of 68 minutes in 1997/98. The year 1997/98 included the Thredbo landslide, which significantly contributed to the peak for that year. The average duration at non-fire rescue calls fell back to a low of 49 minutes in the following year 1998/99.

Hazardous condition incidents increased in average duration time from 44 minutes in 1989/90 to 51 minutes in 1998/99 with a peak of 65 minutes in 1993/94. More accurate reporting systems in later years may have contributed to these results. These increases in on-scene time may reflect FRNSW's increased emphasis on recovery.

It is considered that the 60 minute fire rating for the external non-loadbearing brick walls provides sufficient time for fire brigade to initiate early intervention activities with an appropriate margin of safety.

9.6.3 Setback distances

A conservative view has been taken in relation to the method of measurement of setback distances. Figure 14 illustrates that the closest distances from external walls of equipment enclosures and window openings to the building rather than the operational (or standing) distance between fire fighters and the risk source, ie the location where fire fighters would be expected to be in undertaking their duties and the closest opening in the external wall.

The closest operational distance with consideration of the source of outgoing radiant heat for the fire hydrant pumpset is more than 6m. This calculation takes into account that the external wall achieves an FRL of -60/60 and access to the pumpset is the distance shown in Figure 14 (5760mm) plus the 230mm thick brick wall plus internal clearances (min 100mm) between equipment and the enclosure wall ie, the closest position a fire fighter would be expected to stand at the equipment is 6190mm.

Similarly, the booster arrangement is accessed directly off the footpath, not at the closest point of the enclosure from the building. The setback distance to the risk source is therefore 8994mm and with consideration of the depth of the enclosure itself (1575mm) a fire fighter at the enclosure to the booster assembly is operating at a distance of 10569mm. This is illustrated in Figure 16.

It is noted that the carpark vehicle entry is located closer than this but the fire severity in this area is expected to be less due to the limited fire load. This is demonstrated in the comparative analysis in section 9.6.4.

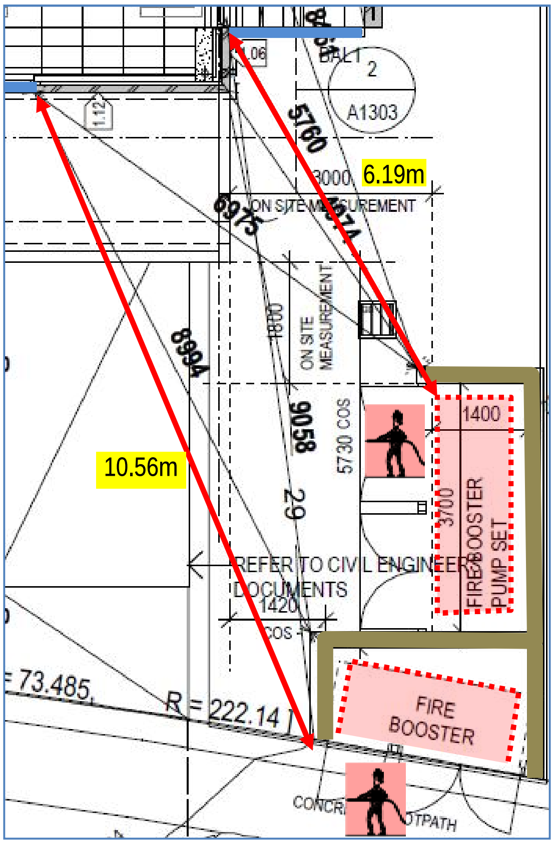


Figure 16 Distances and indicative locations of fire fighters

9.6.4 Radiant heat received at the setback distances

The relevant DTS design scenario for the purpose of this comparison is based on sections 6.4.3 and 7.3(c)(ii) of AS 2419.1-2005 which requires that where pumpsets and boosters are provided external to the building they must be not less than 6m and 10m respectively.

Assuming a full sized window opening in the ground floor SOU similar to that on the levels above located parallel with the pumpset and booster the radiant heat levels expected can be calculated for the DTS design case.

The same calculations are then done for the proposed design with a reduced window size and the pumpset and booster is offset 7.5m and 6m respectively from the centre of the window opening. A fire within the carpark vehicle entry is also assessed with a lesser fire temperature given the low fire load expected.

Scenario	Fire temperature and emissivity	Setback	Maximum flux received (kw/m^2)
Fire in SOU with 7m wide and 2.7m high opening	845°C and 0.9 resulting in an outgoing radiation of 80kW/m^2.	6m to pumpset	10.7
		10m to booster	4.4
Fire in SOU with 4.5m wide and 1.6m high opening	845°C and 0.9 resulting in an outgoing radiation of 80kW/m^2.	7m to pumpset (4m out and 5.5m to side)	1.2 (<10.7)
		9m to booster (8m out and 4m to side)	1.4 (<10.7)
Fire in vehicle entry 7m wide and 2.7m high opening	600°C and 0.9 resulting in an outgoing radiation of 30kW/m^2.	5m to pumpset (4m out and 3m to side)	2.0 (<4.4)
		8m to booster (8m out and 1.5m to side)	1.7 (<4.4)

Table 11 Radiant heat received at pumpset and booster

9.7 Conclusion

The assessment undertaken for the proposed design demonstrates that the fire fighter equipment is located at an adequate distance from the building and provides an equivalent level of fire protection to a similar DTS compliant design in relation to facilitating fire fighter intervention and operations.

The proposed design of the building is therefore considered to achieve compliance with performance requirement EP1.3 of the BCA, subject to compliance with the fire safety measures given in section 5.

Appendix A Drawings and information

15-17 Sturt Avenue, Telopea

Drawing title	Dwg no	Revision	Date	Drawn
Basement level floor plan	1201	M	8.11.11	Turner Associates
Ground level floor plan	1202	F	24.03.10	Turner Associates
Level 1 floor plan	1203	E	24.03.10	Turner Associates
Level 2 floor plan	1204	D	24.03.10	Turner Associates
Level 3 floor plan	1205	D	24.03.10	Turner Associates
Level 4 floor plan	1206	D	24.03.10	Turner Associates
Level 5 floor plan	1207	D	24.03.10	Turner Associates
East elevation	1222	K	20.07.11	Turner Associates
West elevation	1224	K	20.07.11	Turner Associates
Detail and levels of existing and new buildings at Moffats south elevation, section A – A, section C- C	110092-DT01-2	A	31.10.11	Crux surveying

1-5 Shortland Street, Telopea (building A1)

Drawing title	Dwg no	Revision	Date	Drawn
Ground level floor plan	2201	E	24.03.10	Turner Associates
Level 1 floor plan	2202	E	24.03.10	Turner Associates
Level 2 floor plan	2203	D	24.03.10	Turner Associates
Level 3 floor plan	2204	D	24.03.10	Turner Associates
Level 4 floor plan	2205	D	24.03.10	Turner Associates
Level 5 floor plan	2206	D	24.03.10	Turner Associates

1-5 Shortland Street, Telopea (building A2)

Drawing title	Dwg no	Revision	Date	Drawn
Basement level floor plan	2211	E	24.03.10	Turner Associates
Ground level floor plan	2212	F	24.03.10	Turner Associates
Level 1 floor plan	2213	F	24.03.10	Turner Associates
Level 2 floor plan	2214	E	24.03.10	Turner Associates
Level 3 floor plan	2215	D	24.03.10	Turner Associates
Level 4 floor plan	2216	D	24.03.10	Turner Associates
Level 5 floor plan	2217	E	24.03.10	Turner Associates

Appendix B Radiant heat emitted by openings

B.1 Emissivity of flames

Emissivity is defined as the ratio of the radiant heat flux emitted by an object to that emitted by a black body at the same temperature and under the same conditions, where emissivity is a measure of the efficiency of a surface of the object as a radiator [21]. The emitting radiant heat source is assumed to have a minimum emissivity of 0.9 [22].

B.2 Compartment temperatures

The emitting radiant heat source from a flashover fire within the residential sole-occupancy units of the adjacent houses is conservatively assumed to have flame temperature of 900°C. This temperature is based upon a series of full-scale residential fire tests[23, 24 & 25].

The flame temperature for the carpark fire is conservatively assumed to be 1000°C.

B.3 Summary of results

Table 12 contains a summary of the level of radiant heat flux emitted from the identified credible design fire scenarios for the building. The emissivity of the flames has been taken into account.

Scenario	Radiant heat emitted to adjacent buildings (kW/m^2)
1	3.68
2	8.93
3	13.98
4	13.81
5	5.95

Table 12 Radiant heat emitted from openings to adjacent building openings

[21] Drysdale D, An Introduction to Fire Dynamics – Second Edition, John Wiley and Sons Ltd, England, 1998.
[22] Buchanan AH, Structural design for fire safety, John Wiley & Sons, England, 2001, p 52.
[23] Report of Test FR 3995, Santa Ana Fire Department Experiment at 1315 South Bristol, NIST, 14 July, 1994.
[24] Report of Test FR 4009, Full-Scale House Fire Experiment for InterFIRE VR 6 May, 1998.
[25] Full-Scale Room Fire Test – Report No. NIST GCR 97-716, NIST, June, 1997.

B.4 Fire scenario 1

Program Radiation

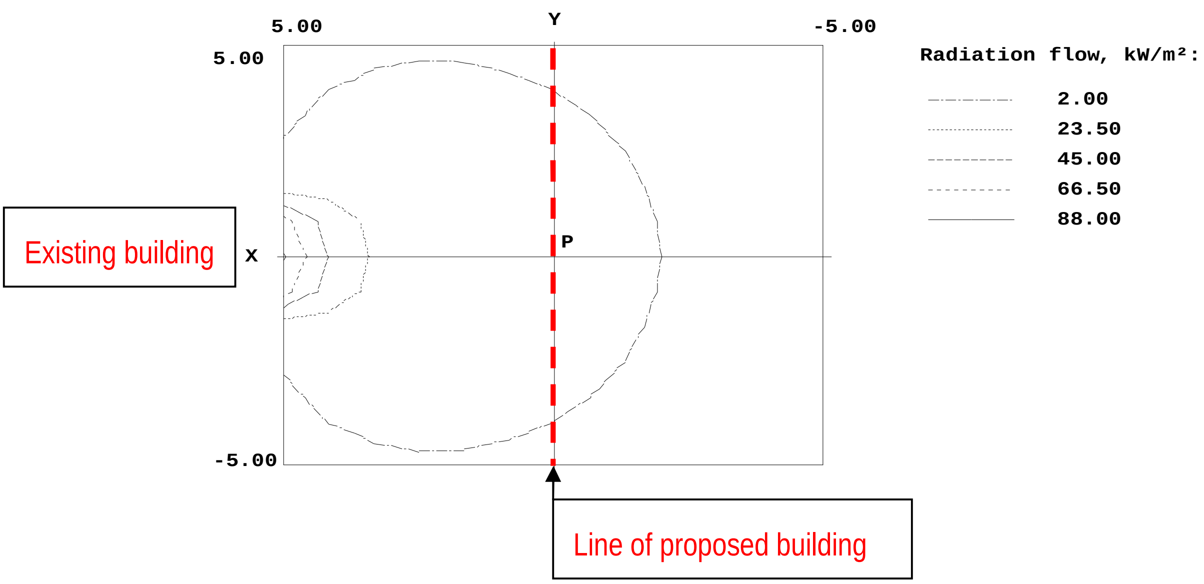
(All dimensions are in meters)

X-sources:

Radiation temperature 900°°

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
5.30	0	0	2.	1.75	90

RADIATION MAP XY



Nodal radiation data, kW/m²:

Y \ X	5.00	2.50	0.00	-2.50	-5.00
5.00	0.273	1.643	1.477	1.051	0.735
2.50	2.521	5.678	2.780	1.508	0.923
0.00	89.11	11.96	3.680	1.737	1.004
-2.50	2.521	5.678	2.780	1.508	0.923
-5.00	0.273	1.643	1.477	1.051	0.735

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°, \ \varphi = 0.0°$

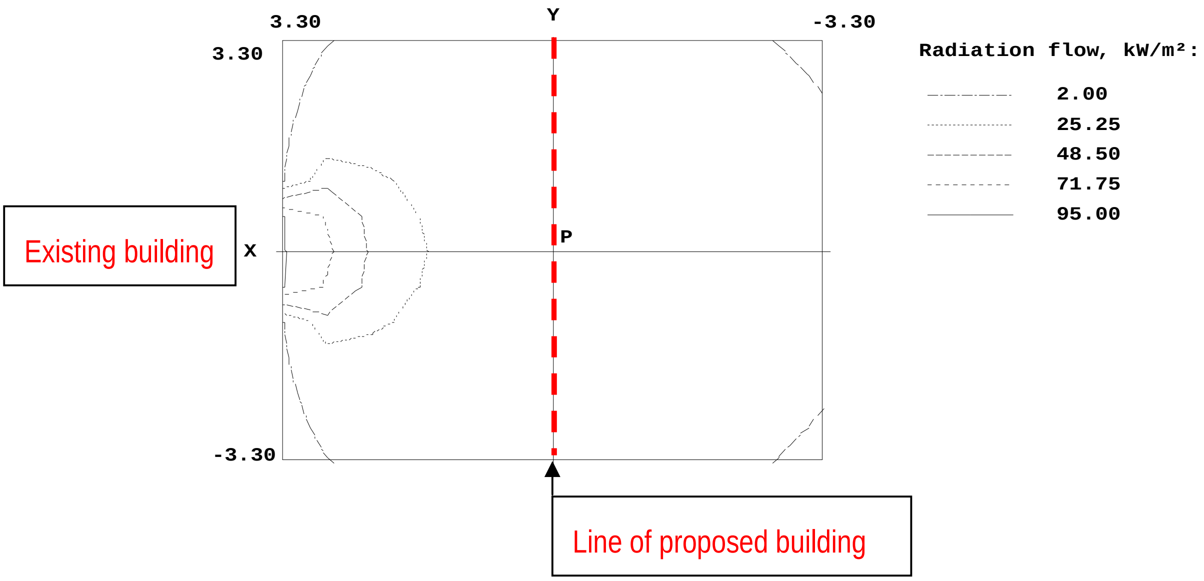
B.5 Fire scenario 2

Program Radiation

(All dimensions are in meters)
X-sources:
Radiation temperature 900°°

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
3.3	0	0	2.	1.75	90

RADIATION MAP XY



Nodal radiation data, kW/m²:

Y \ X	3.30	1.65	0.00	-1.65	-3.30
3.30	0.000	3.777	3.514	2.505	1.748
1.65	0.000	13.96	6.742	3.631	2.209
0.00	96.67	27.76	8.930	4.195	2.408
-1.65	0.000	13.96	6.742	3.631	2.209
-3.30	0.000	3.777	3.514	2.505	1.748

Orientation of maximum radiation flow
at point P(0,0,0): $\theta = 90.0°$, $\varphi = 0.0°$

B.6 Fire scenario 3

Program Radiation

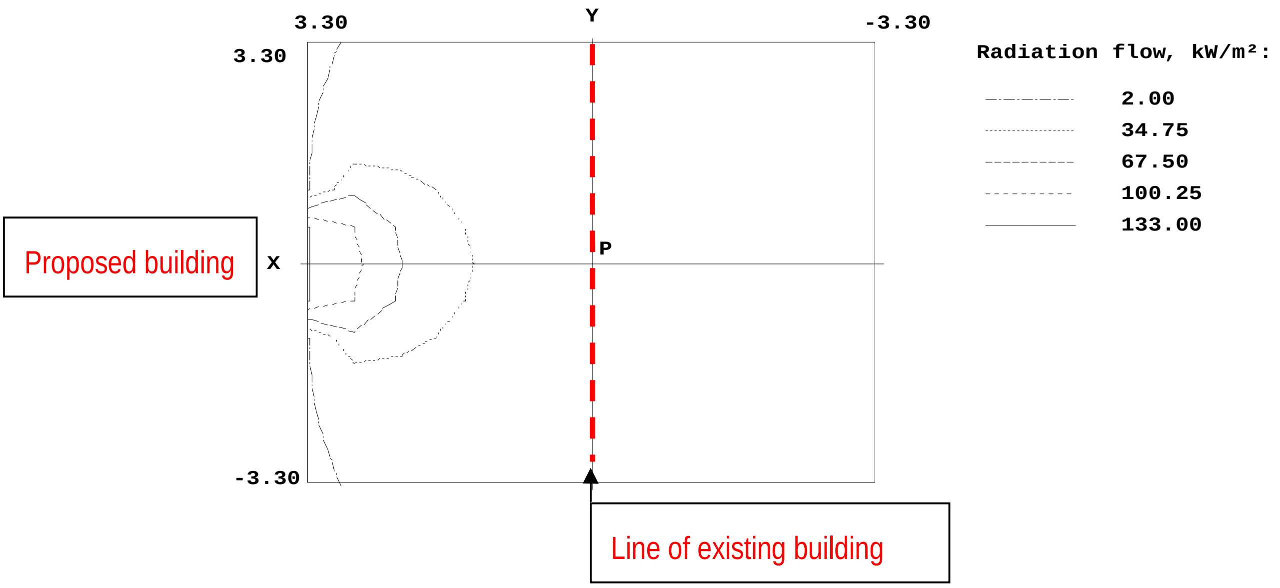
(All dimensions are in meters)

X-sources:

Radiation temperature 1000°C

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
3.3	0	0	2	2	90

RADIATION MAP XY



Nodal radiation data, kW/m²:

Y \ X	3.30	1.65	0.00	-1.65	-3.30
3.30	0.000	5.914	5.531	3.954	2.764
1.65	0.000	21.52	10.57	5.724	3.490
0.00	134.09	42.32	13.98	6.609	3.803
-1.65	0.000	21.52	10.57	5.724	3.490
-3.30	0.000	5.914	5.531	3.954	2.764

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°, \varphi = 0.0°$

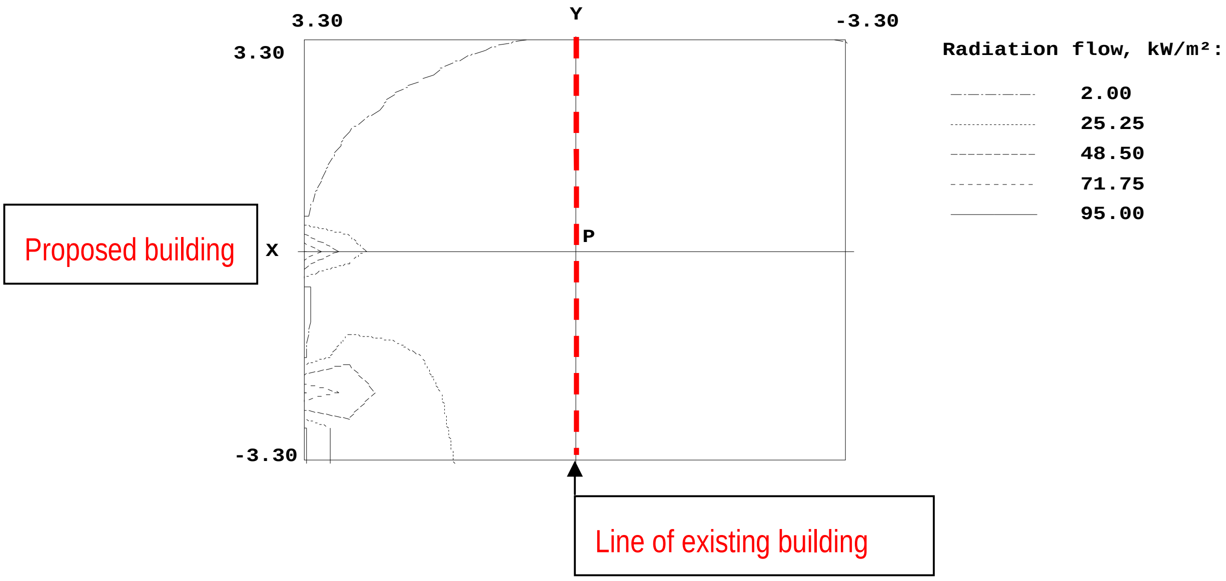
B.7 Fire scenario 4

Program Radiation

(All dimensions are in meters)
X-sources:
Radiation temperature 900°°

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
3.3	0	0	0.6	0.75	90
3.3	-2.2	0	1.0	2.2	90
3.3	-5	0	3.3	1.25	90
3.3	-8	0	1.9	2.125	90

RADIATION MAP XY



Nodal radiation data, kW/m²:

Y \ X	3.30	1.65	0.00	-1.65	-3.30
3.30	0.000	1.539	2.130	2.160	1.979
1.65	0.000	4.101	3.937	3.352	2.764
0.00	96.67	10.41	6.981	4.995	3.720
-1.65	0.000	21.87	10.89	6.816	4.702
-3.30	0.000	27.08	13.81	8.302	5.501

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°, \ \varphi = -36.6°$

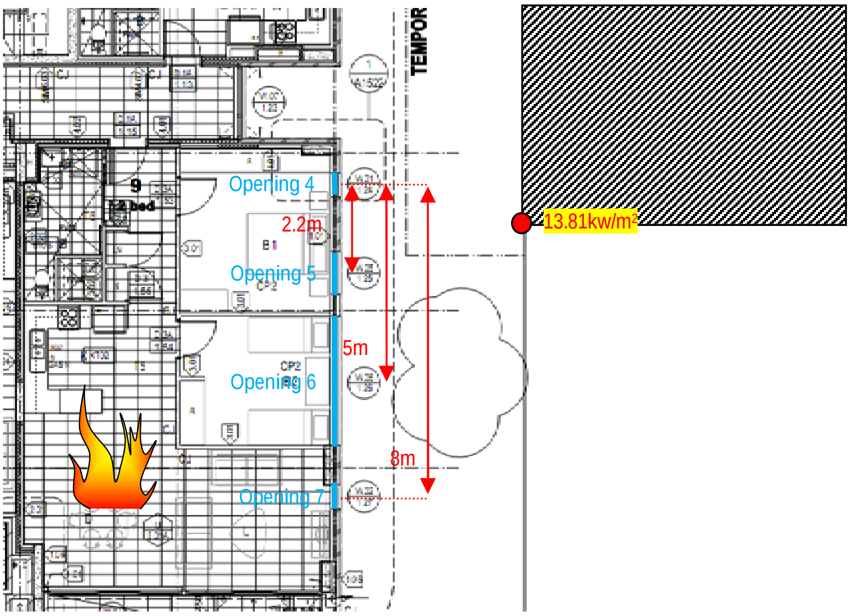


Figure 17 Summary of radiant heat emitted for fire scenario 4

B.8 Fire scenario 5

Program Radiation

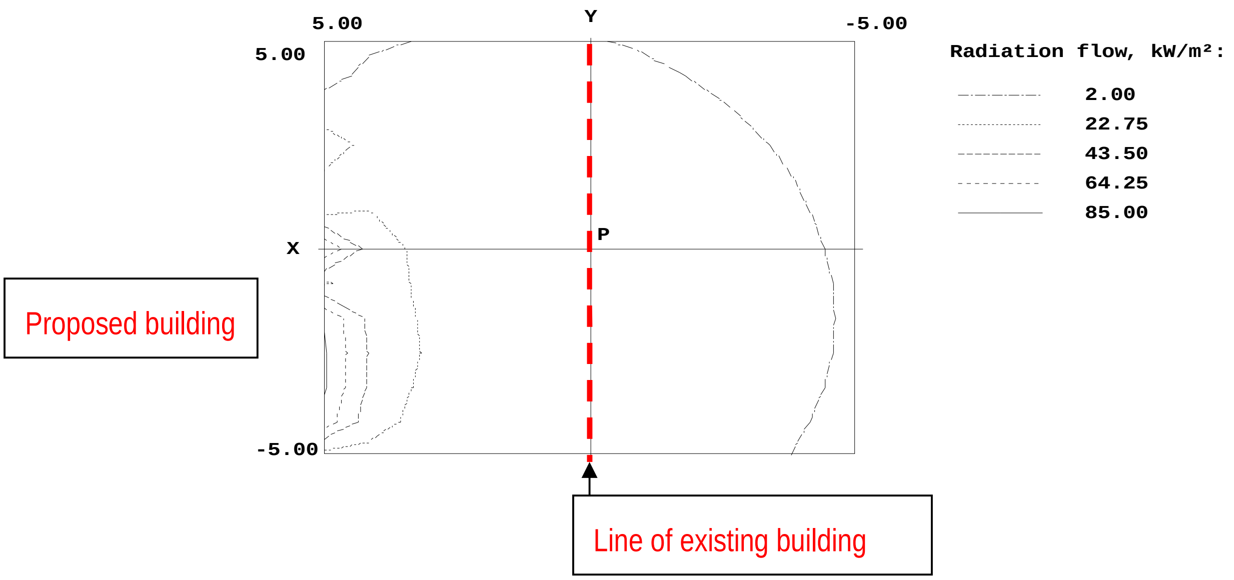
(All dimensions are in meters)

X-sources:

Radiation temperature 900°°

Distance	Offset		Size of source		Opening
X	Yx	Zx	Y	Z	%
5.3	2.2	0	0.6	0.75	90
5.3	0	0	1.0	2.2	90
5.3	-2.8	0	3.3	1.25	90

RADIATION MAP XY



Nodal radiation data, kW/m²:

Y \ X	5.00	2.50	0.00	-2.50	-5.00
5.00	0.435	2.252	2.057	1.578	1.178
2.50	41.99	6.554	3.766	2.321	1.533
0.00	82.45	13.62	5.587	2.949	1.794
-2.50	86.75	15.56	5.959	3.052	1.831
-5.00	11.95	9.029	4.400	2.536	1.621

Orientation of maximum radiation flow

at point P(0,0,0): $\theta = 90.0°, \quad \varphi = -12.2°$

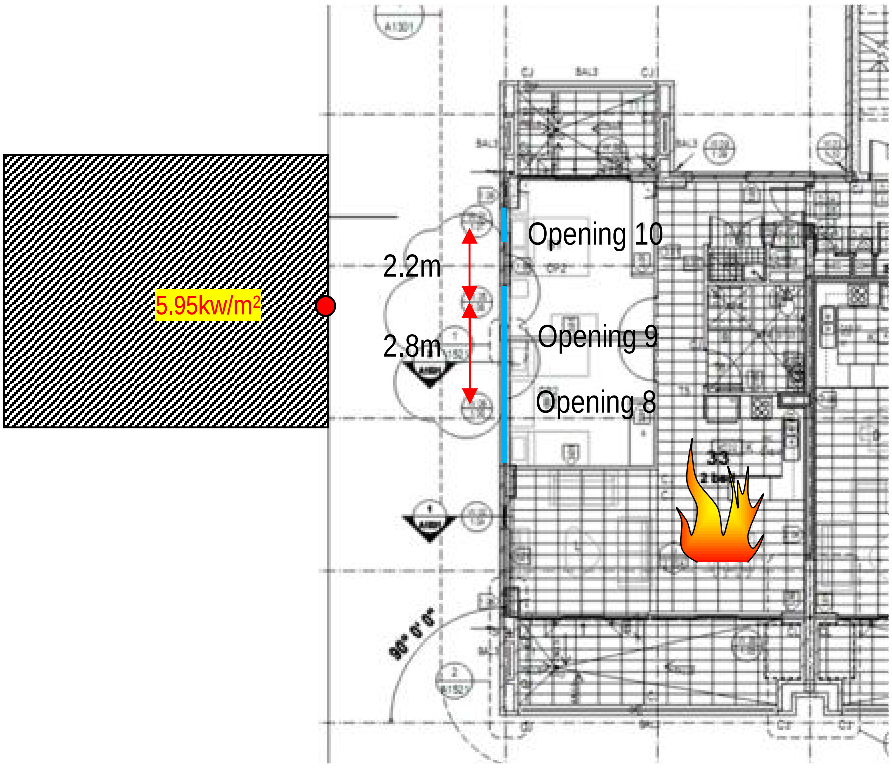


Figure 18 Summary of radiant heat emitted for fire scenario 5