Belmore, Affordable Housing, State Significant Development - SSD 83257708

Flood Impact and Risk Assessment

October 2025

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Issue and Revision Record

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Executive summary

This Flood Impact and Risk Assessment (FIRA) has been prepared by Mott MacDonald Pty Ltd (Mott MacDonald) on behalf of Homes NSW for a State Significant Development Application (SSD-83257708) at 270-278 Burwood Road and 54 Lakemba Street, Belmore. The site is 4,280sqm and located in the Canterbury - Bankstown Local Government Area (LGA).

The proposed development includes the construction of a residential flat building, comprising two eight storey buildings over a shared basement. It utilises the existing road infrastructure with no modifications or adjustments proposed for either Lakemba Street or Burwood Road.

Table 1.1: Industry Specific SEARs

SEARS Requirement	Section of report where response is provided
19. Flood Risk	
● Identify the flood planning area and level as set out in the relevant EPI and other supporting documents to determine; – The flood extent and velocity up to the Probable Maximum Flood and risk on-site having regard to adopted flood studies and, floodplain risk management studies and plans – The site access and egress routes – the potential effects of climate change, – any relevant provisions of the NSW Flood Risk Management Manual, and any other relevant guidelines	● Section 3 and Section 5
● Where the development is occurring on flood prone land a flood impact and risk assessment (FIRA) must be prepared having regard to the Flood Impact and Risk Assessment – Flood Risk Management Guide LU01. When determining the scope and category of the FIRA the requirements outlined in the FIRA guide must be considered.	● Section 5 and Section 6
● Detail any flood risk management measures that are to be incorporated as part of the development having regard to relevant guidelines (including any design solutions, flood modification measures, property modification measures, operational procedures or Flood Emergency Response Plan).	● Section 6

The site is impacted by flooding, as modelled in Canterbury LGA Overland Flow Study for the Cooks River Catchment, conducted by Cardno NSW/ACT Pty Ltd in 2015 (Overland Flow Flood Study). This includes the 1% Annual Exceedance Probability (AEP) storm event and Probable Maximum Flood (PMF) events. Consequently, the site is considered flood prone during the 1% AEP and PMF, and flood related development controls are applicable to development within the site.

The purpose of this report is to prepare a FIRA to support the proposed development to assess flood risk and identify any required mitigation measures. The scope of this report summarises the existing and proposed stormwater drainage design as well as the design approach, key assumptions, relevant references and standards applied to the development of the concept civil design documentation for the development to satisfy the relevant planning requirements.

Consultation with the NSW SES and the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) Conservation Programs, Heritage and Regulation (CPHR) Group will be sought through the submissions process for the proposed development. Early consultation with Council has helped to inform the flood emergency response plan. Residents should follow the advice of emergency service personnel, for each relevant emergency. For future development, NSW SES does not support the use of shelter-in-place as the primary strategy for the basis of development consent, as it is not without risks. If the development has access/egress available during flooding this can eliminate many of the associated emergency management risks.

This FIRA covers modelling methodologies which have enabled the assessment of the flood risk to the development and provides discussion on the design development to achieve the planning requirements. These discussions provide recommended flood mitigation parameters such as floor level and flood protection measures including coordinated design efforts with the stormwater management system designers.

Section 4.5 includes an assessment of climate change effects, with section 6 providing commentary on the outcome of mitigation strategies in relation to protection of the proposed development. The recommended methodology outlined in Understanding and Managing Flood Risk (2023, Department of Planning and Environment (DPE), now known as Department of Planning, Housing and Infrastructure (DPHI)) is to:

a) adopt temperature projections from the CSIRO future climates tool, and apply 7% change in rainfall intensity for each degree of change in mean temperature, or
b) select larger magnitude floods (i.e. 0.5% and 0.2% AEP) for use as proxy climate change events for the 1% AEP flood magnitude.

The approach adopted in this study is to a) assess the rainfall intensity change associated with the temperature uplift for events up to the 1% AEP to give a range of conditions to be expected under future scenarios. An assessment of the relative level changes to localised flooding resulting from temperature changes is summarised across existing and proposed development scenarios. These level increases with climate change are accepted noting the approach to protecting the proposed development, including Flood Planning Levels (FPL) is conservative.

It’s recommended that Department of Planning, Housing and Infrastructure (DPHI) consider the risk mitigation strategies described in this report, balanced against the increase in population that results from the provision of additional housing at the site.

1 Introduction

1.1 Overview

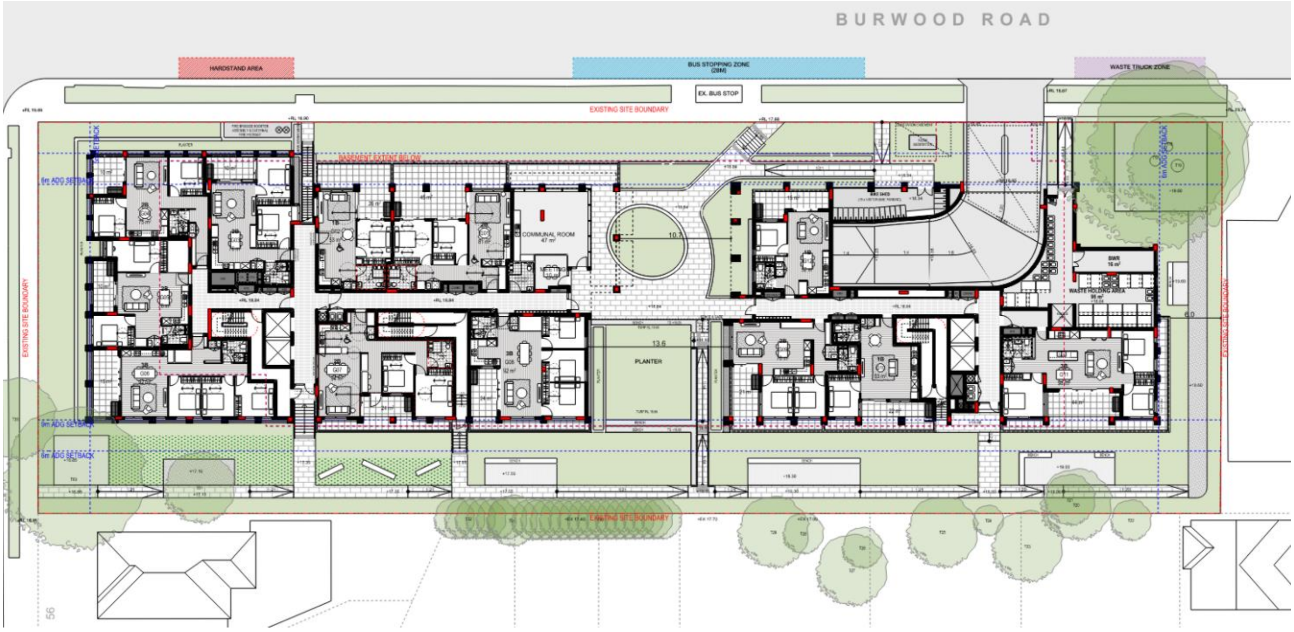
This Flood Impact and Risk Assessment (FIRA) has been prepared for Homes NSW to assist the redevelopment for the site at 270-278 Burwood Road and 54 Lakemba Street Belmore.

The aim of this FIRA is to support the proposed redevelopment where specific elements of the design may alter flood behaviour or introduce additional flood risk, to identify and analyse:

- The impacts of the proposed development on the flood risk to the existing community
- The Impacts and risk of flooding on the development and its users
- How these impacts can be managed to minimise the growth in risk to the community due to the development

The layout of the proposed development is shown in Figure 1.1

Figure 1.1: Proposed Development



Source: DKO Architectural Ground Floor Plan (DA202)

1.2 FIRA Requirements

The FIRA will demonstrate the compatibility of the development with any existing relevant state environmental planning policies (SEPPs), local environmental plans (LEPs), Development control Plans (DCP) or policies, as well as existing industry guidance, government guidance and reference documents.

For this FIRA to meet the requirements of the SEARs, it must consider:

- A range of flood risk examining minor, major and extreme storm events.
- The constraints that flooding places on the site and emergency response issues associated with the flooding constraints.
- The appropriateness of the development or development types for the location based on the flood constraints on the land.
- The adequacy of management measures and controls to
  - Effectively address these constraints to ensure the flood risks to the proposed development and its users are acceptable.
  - Manage flood and associated emergency management (EM) impacts to the existing community due to the development.
- Climate change impacts. Both existing and post-development flood behaviour needs to consider climate change impacts on flood behaviour so the robustness of decisions over time can be understood

Further statutory and local requirements that this design must satisfy with regard to flooding are summarised in Section 3.

2 Background

2.1 Study Area

The subject site boundary is identified in Figure 2.1 below, located at the junction of Lakemba Street and Burwood Road, Belmore, NSW with an overall area of 4280 sqm.

The site sits in the Cooks River Catchment and is graded sloping north-south LIDAR.

Figure 2.1: Site Boundary

2.2 Existing Flood behaviour

According to the Overland Flow Flood Study for the Cooks River Catchment, conducted by Cardno NSW/ACT Pty Ltd in 2015, the site is identified as flood-effected in the 1%AEP and PMF events. The maps from this flood study are provided in Section 4 of this report.

2.3 Flood History

A desktop assessment of historic flooding was undertaken using selective online search terms and social media accounts. No specific flood history information relating to this site was found.

2.4 Existing Emergency Management

NSW State Emergency Service (SES) provides general flood and storm safety guidance for communities within the Sydney South-West Region, including Belmore.

General advice for residents living in urban areas is provided for Belmore but there are no specific Local Flood Plans (LFP). General advice has been summarised from the NSW SES FloodSafe guide for Flash Floods and the StormSafe guide. In the absence of an LFP for this area, it is expected that the local Canterbury-Bankstown SES unit which covers the Cooks River Catchment area would coordinate delivery of any critical information to residences throughout the catchment. The NSW Communities FloodSafe guide relating to riverine floods is not applicable to the proposed development.

2.4.1 NSW SES Flash FloodSafe

The Flash FloodSafe guide outlines risks, impacts and the safest response to take when flash flooding occurs.

The NSW State Flood Plan (SFP) prepared by the NSW SES describes flash flooding as “flooding which is sudden and often unexpected because it is caused by sudden local or nearby heavy rainfall and typically occurs in small catchments. Technically, flash flooding means any flooding of short duration with a relatively high peak discharge in which the time interval between the observable causative event and the flood is less than six hours.” It also states that “larger urban areas of Sydney are at risk of flash flooding. Flash flooding also occurs when urban drainage systems are overwhelmed by intense rainfall and roads become “rivers” with flooding occurring at their low points.” These descriptions match the nature of flooding around Burwood Road.

The advice provided in the Flash FloodSafe guide includes (but is not limited to):

- Leave low-lying homes and businesses well before flooding begins, but only if it is safe to do so.
- Seek refuge in the highest part of a multi storey building if you are trapped by rising floodwater.
- Remain within the building and contact emergency services if rescue is required.
- Stay clear of flash flood areas when severe weather is forecasted.

2.4.2 NSW SES StormSafe

The NSW StormSafe Guide outlines key storm risks, impacts and the safest response to take when severe weather occurs. These include but are not limited to:

- Move indoors when Severe Weather warnings and Severe Thunderstorm Warnings are issued but only before the storm arrives.
- Never enter or travel through floodwater
- Stay indoors and clear of windows.
- If flash flooding is likely, evacuate low lying homes or businesses early, provided it is safe to do so.

3 Design Controls

The following guidelines and standards relate to civil works as they potentially influence flood behaviour and form the basis of engineering decisions regarding stormwater management and the provision for overland flow within and surrounding the site. Key controls directly influencing the design include:

- Floor level to meet the Flood Planning Level (FPL), as a minimum. State and local legislation requires the development to achieve an FPL of 1% AEP + 500mm, with detailed requirements noted in this section and summarised in Table 3.2. Section 6 notes the design consideration of FPL.

Table 3.1: Design Standards and Guidelines

Reference	Title	Version or Date
AS/NZS 3500.3	Plumbing and Drainage – Stormwater Drainage	2021
ARQ	Australian Runoff Quality – A Guide to Water Sensitive Urban Design (National Committee for Water Engineering)	2006
BCA	Building Code of Australia	2019
Geoscience Australia	Australian Rainfall & Runoff	v4.2
Blue Book	Managing Urban Stormwater - Soils and Construction, Volume 1, 4th edition, March 2004, Landcom	Mar 2004
Department of Planning, Housing and Infrastructure (formerly Department of Planning and Environment)	Flood Risk Management Manual (formerly Floodplain Development Manual)	2023
Department of Planning, Housing and Infrastructure (formerly Department of Planning and Environment)	NSW Flood-prone land package	2022
Canterbury Bankstown Council	Canterbury Bankstown Local Environmental Plan (LEP)	2024
Canterbury Bankstown Council	Canterbury Bankstown Development Control Plan (DCP)	2023
Department of Environment and Heritage	Flood Risk Management Toolkit	2024

3.1 Australian Rainfall and Runoff (v4.2)

Published by Geoscience Australia, Australia Rainfall, and Runoff – A guide to Flood Estimation was written to provide “Australia designers with the best available information on design flood estimation.” It contains procedures for estimating stormwater runoff for a range of catchments and rainfall events as well as design methods for urban stormwater drainage systems. The document has been updated as major revision with a more refined methodology for hydrological analysis in 2016, a subsequent intermediate update based on the latest hydrological data gathered in 2019, and a further refinement with regard to climate change guidance (amongst other updates) in 2024.

3.2 Canterbury Bankstown Council Documents

3.2.1 Canterbury-Bankstown Local Environment Plan (2024)

Canterbury Bankstown Local Environmental Plan 2023 outlines the flood planning provisions in accordance with the relevant standard environmental planning instrument under Section 3.20 of the Act.

Flood planning

1. The objectives of this clause are as follows—
    a. to minimise the flood risk to life and property associated with the use of land,
    b. to allow development on land that is compatible with the flood function and behaviour on the land, considering projected changes as a result of climate change,
    c. to avoid adverse or cumulative impacts on flood behaviour and the environment,
    d. to enable the safe occupation and efficient evacuation of people in the event of a flood.
2. Development consent must not be granted to development on land the consent authority to be within the flood planning area unless the consent authority is satisfied the development-
    a. Is compatible with the flood function and behaviour on the land, and
    b. Will not adversely affect flood behaviour in a way that results in detrimental increase in the potential flood affectation of other development or properties, and
    c. Will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and
    d. Incorporates appropriate measures to manage risk to life in the event of a flood, and
    e. Will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourse.
3. In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters-
    a. The impact of the development on projected changes to flood behaviour as a result of climate change
    b. The intended design and scale of buildings resulting from the development,
    c. Whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,
    d. The potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flood or coastal erosion.

4. A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

5. In this clause—

Considering Flooding in Land Use Planning Guideline means the *Considering Flooding in Land Use Planning Guideline* published on the Department's website on 14 July 2021.

Special flood considerations have not been adopted in this LEP.

3.2.2 Canterbury-Bankstown Development Control Plan (2023)

The Canterbury-Bankstown Council's Development Control Plans (2023, amended August 2024) chapter 2.2, Flood Risk Management outlines the policy required to be undertaken to flood prone areas within the council. Land which this policy applies to are all flood-prone land within the Canterbury-Bankstown Council, being all land potentially inundated by floods up to and including probable maximum flood (PMF).

Sections 9-10 provides objectives and controls for stormwater and flood management and applies to all development with the aim of reducing developmental impacts.

Development controls

9.1 Do not obstruct any overland flow path. Council will enforce the removal of any obstruction to overland flow within private properties and recover from the owners the cost of carrying out such work.

9.2 Do not obstruct existing runoff, entering the site from upstream properties or sub-catchments, from flowing into the subject site, or redirect it to increase the quantity or concentration of surface runoff entering adjoining properties. Note: During periods of heavy rainfall, it is anticipated that there will be potential runoff, across boundaries of some properties, which will enter downstream sites from upstream properties due to the local contours of the area.

9.3 Consider potential runoff at the design stage and design so it will not have any adverse impact on adjoining properties. Overland flow should not be obstructed from flowing naturally and is not to pond or concentrate along boundaries of adjoining properties. Suitable channels, open dish drains, walls or any other measures may be necessary to accommodate the existing and potential overland flow paths throughout the subject site.

9.4 Care must be exercised to ensure that provision of any of the above remedial measures will not result in diverting runoff into the OSD system, if this is unattainable, then the OSD system must be designed to cater for the additional stormwater runoff anticipated from upstream catchment area(s).

9.5 Council may require that the design specify the extent of the overland flow path through the site, and that the development be located/modified clear of the overland flow path or set at an appropriate freeboard.

10.1 Submit a survey plan to Council showing the relative levels to AHD, prepared by a registered practicing surveyor.

10.2 Floor levels of all habitable rooms should be 0.5m or more above the standard flood level. A certificate by a registered practicing surveyor certifying the level of the completed building will be required.

10.3 Where Council considers flooding could damage a proposed development, no work should be commenced until a qualified structural/civil engineer has submitted a certificate of structural adequacy with regard to stability as a result of flooding.

10.4 Where the development relates to an existing building, a certificate is to be provided from a qualified practicing structural or civil engineer stating that the existing building is capable of withstanding the likely floodwaters and impact from debris in those waters without sustaining structural damage.

10.5 Developments such as sporting grounds and open-air car parks will be considered on flood liable land. Any consent for such development will require certificates from surveyors and engineers as referred to above.

10.6 Habitable rooms include bedrooms, bathrooms, living rooms, study, lounge rooms, dining rooms, games rooms, kitchens, halls, garages, offices, laundries, utility rooms, manufacturing rooms/areas, classrooms, storage areas.

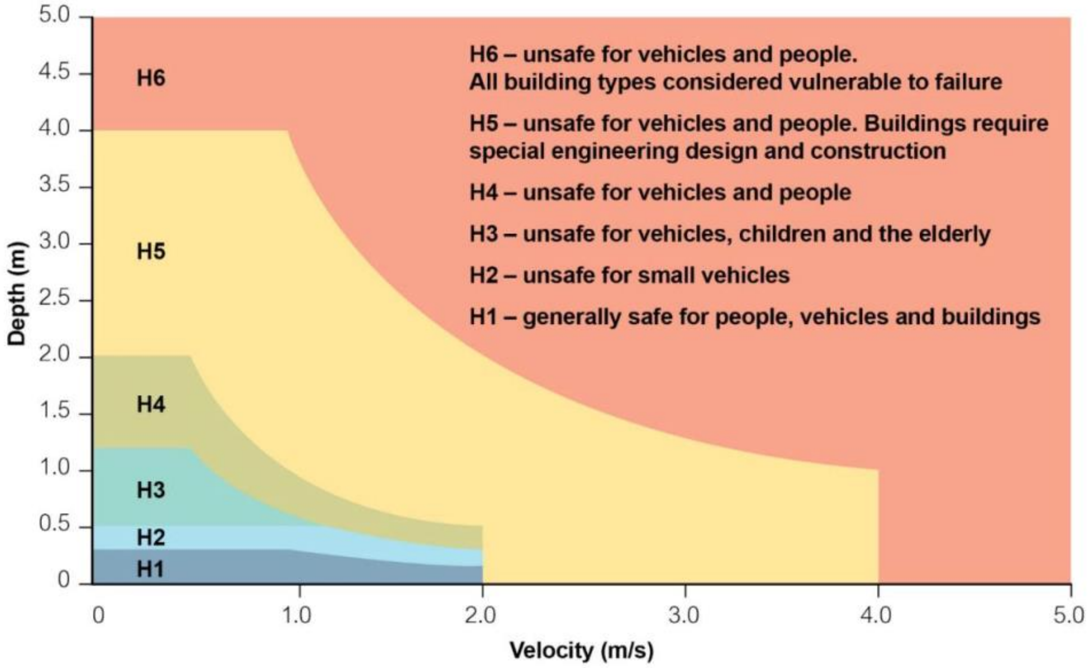
10.7 Non-habitable floor space includes decking, sports grounds and car parks.

3.3 NSW Flood Risk Management Manual (June 2023)

The NSW Government's manual supersedes the previous Floodplain Development Manual – the Management of Flood Liable Land (2005) and is concerned with the management of the consequences of flooding as they relate to the human occupation of urban and rural developments. The manual outlines the floodplain risk management process and assigns roles and responsibilities for the various stakeholders.

The manual applies to all development and includes additional guidelines for ensuring safe overland flow paths are provided. These guidelines adopt the hazard categorisation which has been developed by the Australian Emergency Management Institute in 2014, defining hazard into six categories. The categories relate to the flood vulnerability curves shown in Figure 3.1.

Figure 3.1: Flood Hazard Categorisation



3.4 DPHI Shelter-in-place Guidelines for flash flooding (January 2025)

As of January 2025, the Department of Planning, Housing and Infrastructure (DPHI) finalised their guidelines for Shelter-in-place during a Flash Flooding event, with the aim to provide clear and consistent guidance for when shelter-in-place can be used appropriately.

This guideline states that the consent authority should consider the following design criteria:

- The floor level of the shelter-in-place part of the development be above the PMF, and
- Structural soundness for conditions in a PMF event, considering flood and debris forces, be verified by a suitably qualified structural engineer, and
- Area, and access to the area, does not rely on access to electricity, and has clearly marked internal access for all people on site, including consideration of access for potential occupants and/or visitors.

Additionally, these guidelines also outline that a consent authority may also consider the following design controls:

- Protection from weather and appropriate heating and cooling
- Access to personal hygiene facilities such as a toilet
- A minimum floor space of $2m^2$ per person

- Items for self-sufficiency that are stored, maintained and are regularly updated in an accessible location above the PMF, including sufficient drinking water and food for occupants, fire extinguishers, radios and torches with spare batteries, and a first aid kit with an automated external defibrillator (AED).
- Centralised communal shelters may be considered but must always be freely accessible internally and externally accessible during events.
- Access is provided to onsite systems that generate power for the shelter-in-place location during and after the event for a full range of flood events up to the PMF.
- Detail how these requirements will be maintained and enforced for the life of the development.

3.5 Application Matrix

The matrix of controls has been prepared below in Table 3.2 to group the key design controls from different sources. The adopted criteria applicable to the design has been identified in ***bold*** text.

Table 3.2: Design Control Matrix

Design Aspect	State Legislation	Council Control	Other Guidelines	NSW Homes Direction	Notes
Non-habitable	n/a	***5% AEP***	n/a	n/a	Not relevant to design of building ground floor at DA stage
Habitable Floor Level	1% AEP + 0.5m	1% AEP + 0.5m	* Minimum 1% AEP + freeboard	***PMF level***	PMF adopted to enable shelter-in-place * Defined Flood Event (DFE) recommended by NSW Flood Risk Management Manual guidelines
Basement Carpark Protection	n/a	n/a	n/a	***PMF level***	PMF adopted as risk-based approach to design. PMF level is greater than 1% AEP + 0.5m
Shelter-in-place communal spaces	n/a	… an area of refuge above the PMF	***^ PMF level***	n/a	^ NSW DPHI Shelter-in-place guidelines (2025)

4 Methodology and Approach

4.1 Available Information

The following data has been made available for this assessment:

- Final Overland Flow Flood Study for the Canterbury LGA Cooks River Catchment (April 2016)
  - The Final Overland Flow study for Canterbury LGA Cooks River Catchment was prepared by Cardno (NSW/ACT) Pty Ltd. The objectives of this study were to review flood modelling, inspect problem areas, assess climate change impacts, analyse model sensitivity, and gather information for SES to plan and mitigate potential impacts.
- In addition to this, LiDAR data was downloaded from ELVIS[1] to gain an understanding of flood levels.
- City of Canterbury and Bankstown also provided a Stormwater System Report, providing flood and stormwater information about the site for existing ground conditions for 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events.

Table 4-1: Council issued flood levels

Event	Burwood Road Flood Level (mAHD)	Lakemba Street Flood Level (m AHD)
1%AEP	16.73	17.20
PMF	18.07	18.27

- Detailed topographical and utility survey for the project area
- ARR datahub and Bureau of Meteorology rainfall database

Extracts from the Council Stormwater System Report are provided in the following images, indicating flood extents and levels.

[1] LiDAR and spatial information service provided by Geoscience Australia

Figure 4.1: Council 1% AEP Flood Extent Map

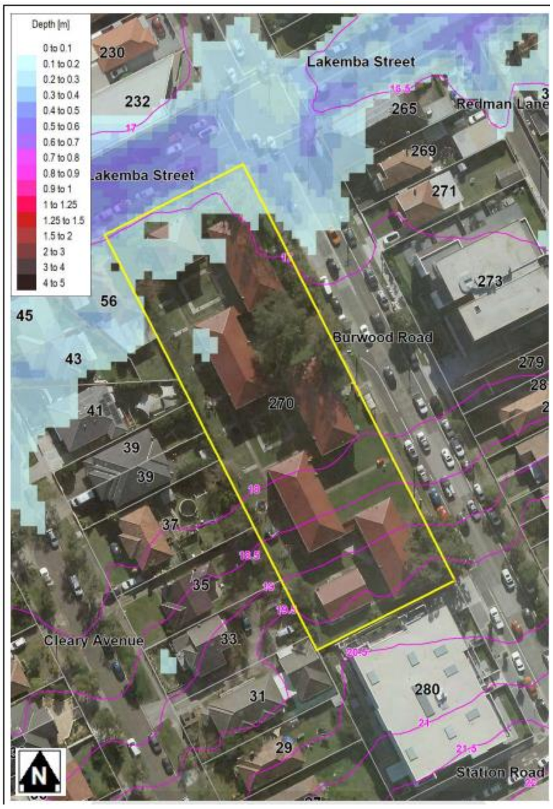
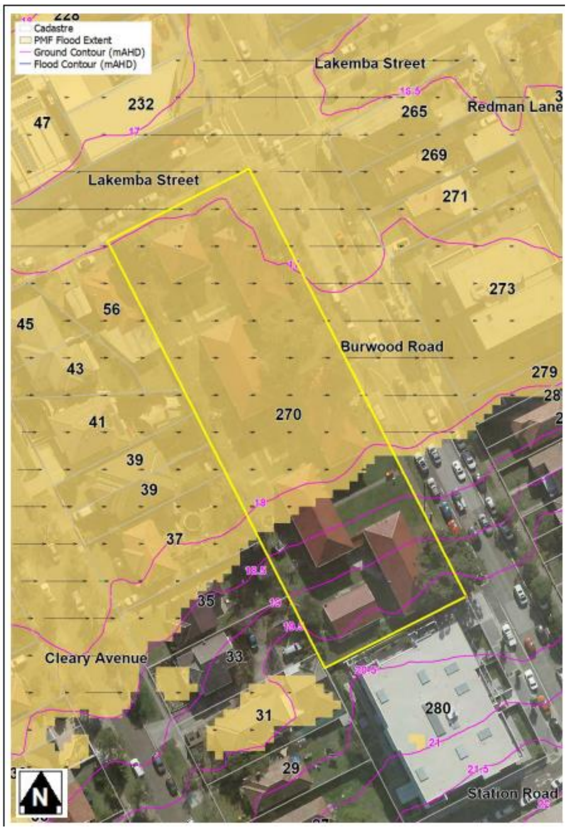


Figure 4.2: Council PMF Flood Extent Map



4.2 Data Gap Analysis

Modelling for the regional catchment undertaken for Council previously was undertaken with a modelling software package not commonly used in Australia anymore. This regional modelling was based on LiDAR representation of the ground levels only. The project design team selected TUFLOW for use as the modelling software package as it is the industry standard tool. The team had access to detailed survey information, and this higher resolution data for finished ground levels around the site was input into the flood modelling to get more accurate results.

4.3 Modelling Approach

4.3.1 Basis of Flood Model

4.3.1.1 TUFLOW Software Package

TUFLOW is a one and two-dimensional (1D/2D) hydraulic modelling program that simulates the flow of water across a landscape and through any conveyance structures such as pipes or culverts.

The 2D component of TUFLOW software package determines overland flow paths by dividing the landscape into a grid of individual cells. The flow of water between cells is then computed repeatedly at regular time steps by solving two-dimensional shallow water equations to estimate the spread and flow of the water. Flows are routed in the direction water will natural follow based upon the modelled topography.

The 1D component (called ESTRY) is a separate calculation engine incorporated in TUFLOW to manage flows through structures which cannot be accurately represented with 2d grids cells. ESTRY is a network dynamic flow program suitable for mathematically modelling floods and tides (and/or surges) in a virtually unlimited number of combinations. ESTRY has been developed in conjunction with TUFLOW to resolve complex 1D-2D flows across the floodplain interface.

4.3.1.2 Modelling Scenarios

The modelling scenarios were reviewed to determine flooding constraints from the existing conditions that provide inputs to the design, comprising overland flow paths, existing stormwater infrastructure and ponded levels that influence design floor levels and access considerations. This is referred to herein as the existing conditions scenario.

Following the identification of constraints, the design team coordinated the development of a design approach that focussed on the mitigation of flood risk. Building layout, composition and the access arrangements were all coordinated across disciplines to optimise the design in preparation for the submission for development approval. This was assessed in the flood model through the use of a post development (or design) scenario.

The risk management strategies embedded into the design, and mitigation for flood risk and flood impact based on this assessment are outlined in Section 6.

4.4 Planning and Development Advice

For setting floor levels, further modelling has been undertaken as discussed in section 5. The minimum floor level is established by the 1% AEP flood level with the addition of 0.5m freeboard. Basement entries were raised above the PMF level to reduce the potential for inundation of the basement (in extreme flood events) and also provide for egress opportunities by vehicle at the southern end of the development where access to higher ground is available, facilitating evacuation routes. This approach was discussed with Council in consultation working group which included Council's stormwater and flooding engineer. Upon SSDA submission, Council will have the opportunity to confirm the approach as detailed here and in Section 6.

4.5 Climate Change

Climate change guidance from the Australian Rainfall and Runoff (ARR) v4.2 (2024) documentation refers to research undertaken to develop an interim recommendation to factor rainfall based on temperature scaling. The recommended methodology outlined in Understanding and Managing Flood Risk (DPE, 2023) is to either:

- adopt temperature projections from the CSIRO future climates tool, and apply 7% change in rainfall intensity for each degree of change in mean temperature, or
- select larger magnitude floods (i.e. 0.5% and 0.2% AEP) for use as proxy climate change events for the 1% AEP flood magnitude.

The approach adopted in this study is to assess the range of conditions to be expected under future scenarios with increased temperatures resulting in rainfall uplift. This is presented in the latest ARR guidance as Shared Socioeconomic Pathways (SSP), which are selected from their use in climate modelling, summarised in the Intergovernmental Panel on Climate Change (IPCC) Assessment Report 6 (AR6).

The modelling presented in this FIRA includes a range of events up to the PMF. This adopted approach represents the linearity of flood risk, serving to represent a scenario of increased flood intensities of the 1% AEP towards the extreme event PMF by reviewing 1% AEP SSP scenarios:

- 1% AEP with SSP2 rainfall uplift to 2030
- 1% AEP with SSP3 rainfall uplift to 2100

5 Hydraulic Modelling

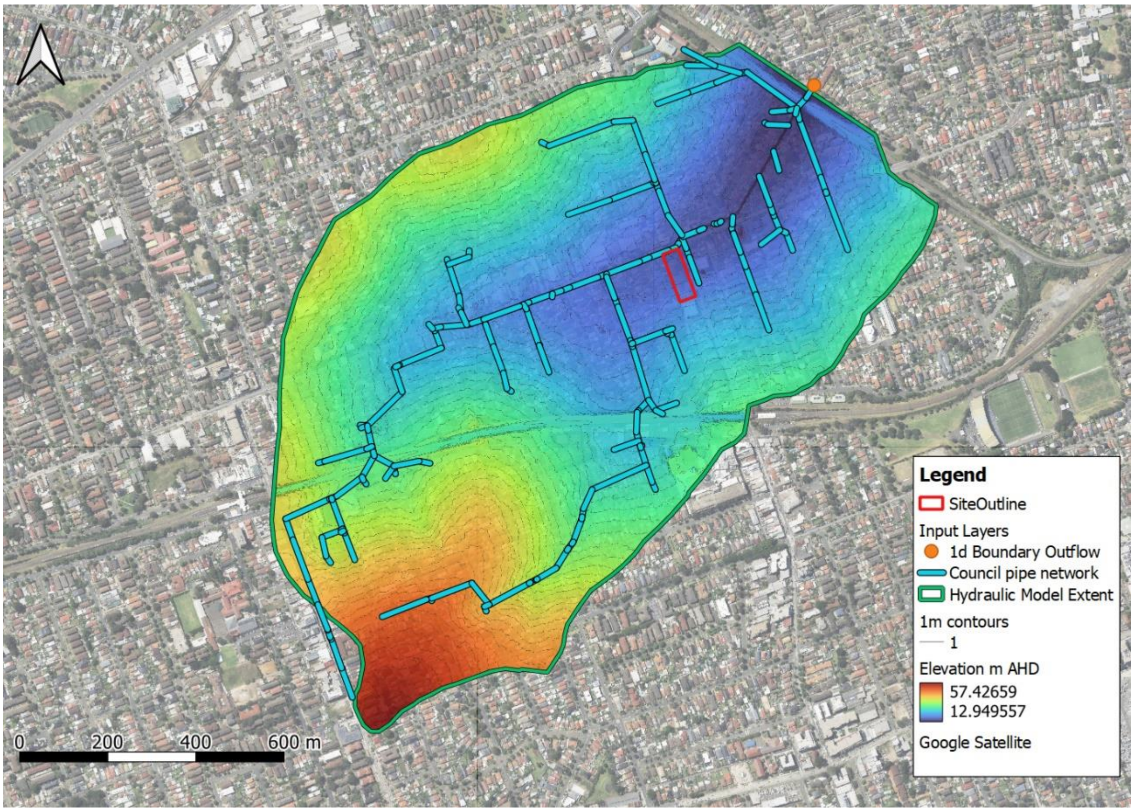
5.1 Flood Model Development

5.1.1 Model Extent and Topography

The hydraulic model extent was adopted to appropriately cover the project area and areas contributing to flooding. This extends from the upstream catchment areas to the downstream of the project area to a suitable distance to ensure boundary conditions do not influence flood results in the area of interest. The existing case topography was based on 1-metre resolution LiDAR data captured in 2020. The model topography is based on a 2-metre cell size, which provides an adequate representation of ground levels and drainage paths within the model domain. To improve the resolution of the terrain model a select area (approximately 40% of the model area) was represented with quadtree, effectively halving the cell size across areas which experience consolidated flow paths. To ensure the low points were adequately represented sub-grid sampling was also adopted at a sampling distance of 1m and 0.5m for the full model extent, and quadtree extent respectively.

Additionally, to fill the depressions in the lidar, the model applied an initial water level (IWL) condition across the catchment of 14m to avoid over representation of flood storage in the receiving stormwater system. The TUFLOW hydraulic model layout is shown in Figure 5.1.

Figure 5.1: Hydraulic Model Layout



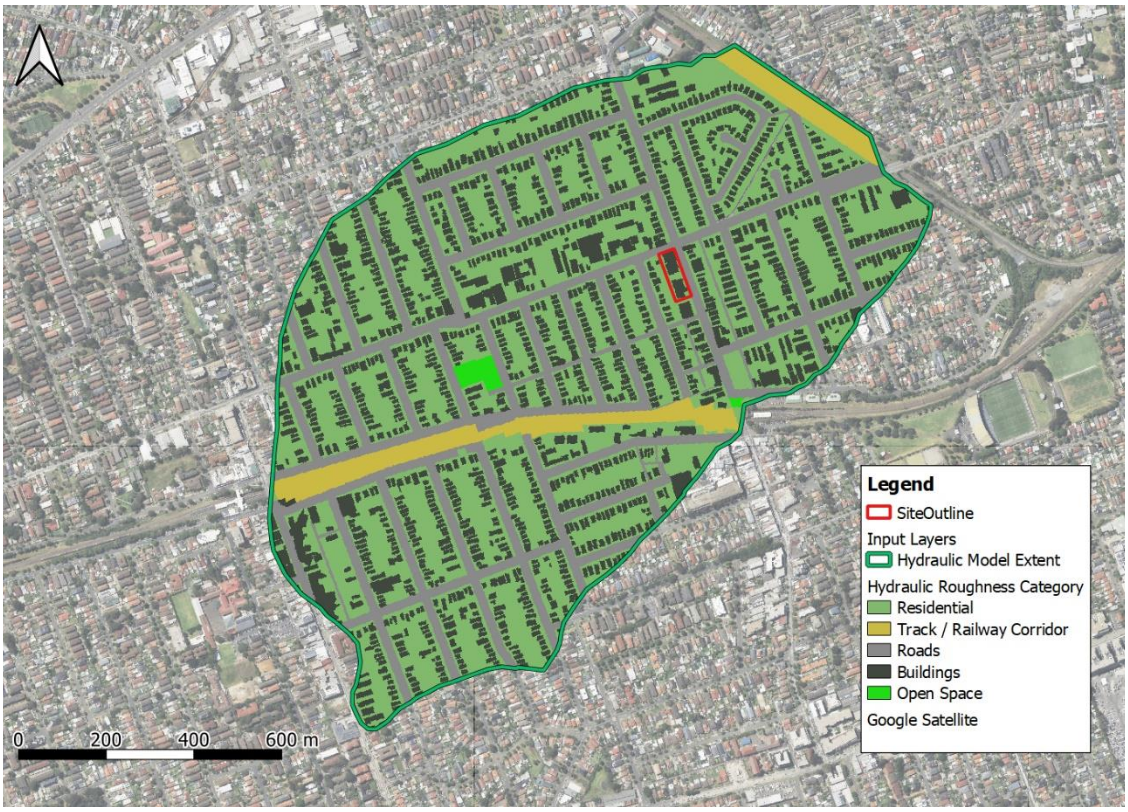
5.1.2 Hydraulic Roughness

Recent aerial imagery from NSW Six Maps and publicly available building footprint data were used to inform the hydraulic roughness in the model, and values were maintained from the previous Overland Flow Study, where appropriate. TUFLOW uses Manning's 'n' values to represent hydraulic roughness and associated resistance to flow. The differing roughness areas were spatially delineated into the categories and Manning's 'n' values noted in Table 5-1. A depth varying roughness was adopted to represent buildings within the model. This was done to represent the shallow flow of rainfall on roofs with a lower roughness while deeper flow through the building is represented by a higher roughness. Figure 5.2 shows the spatial delineation of the roughness values in the model.

Table 5-1: Hydraulic Roughness Categories

Hydraulic Category	Manning's 'n' Value
Road and Impervious Area	0.018
Track/Railway Corridor	0.02
Residential with buildings excluded	0.30
Buildings	Depth varying 0.01 (<0.03m) 0.02 – 0.3 (interpolated between 0.03m and 0.1m) 0.3 (>0.1m).
Open Space (grass)	0.05
Drainage Path	0.015

Figure 5.2: Hydraulic Roughness



5.1.3 Boundary Conditions

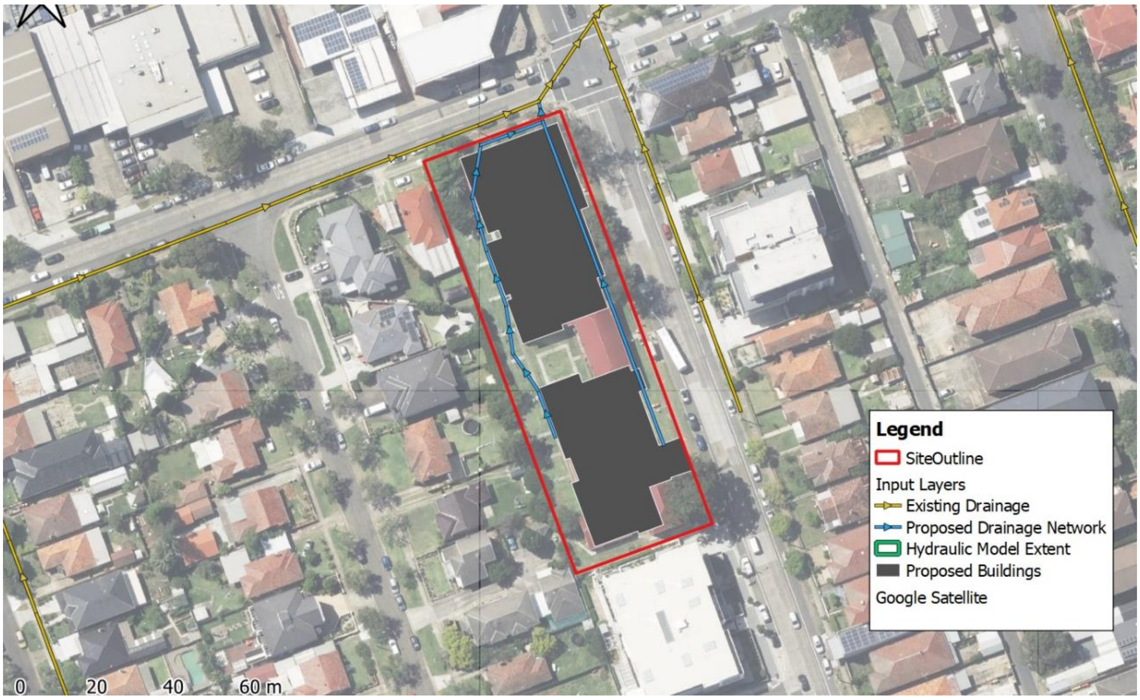
Downstream boundary conditions were based on ‘HQ’ boundaries. “HQ” boundaries automatically create a stage-discharge relationship based on Manning’s equation with a user-defined stream slope. 1-D pipe outlets adopted ‘HT’ (water level versus time) relationships with the tailwater level set using pipe performance data from the Overland Flow Flood Study. The downstream boundaries are set at a sufficient distance downstream of the site to ensure the assumptions made for the downstream boundary conditions do not affect flood levels at the site.

5.1.4 Drainage Network

Drainage network information to develop the hydraulic model was determined from Council’s SOBEK flood model. The pit network has been modelled using type ‘R’ 2mx0.15m pits, which assumes the flow is inlet controlled and uses the weir equation for unsubmerged flow or orifice flow for submerged flow. No blockage has been applied to the drainage network, noting that the modelled inlet flow in grid-based models is typically a low representation of the theoretical pit capacity given the inherent variability in kerb and gutter elevation definition based on LiDAR data sources. This tends to result in a conservatively low depth value used in determining pit flow capture.

The proposed drainage network, shown in Figure 5.3, has been designed to provide adequate site drainage and demonstrate that the proposed development can be implemented with an acceptable impact on flooding conditions.

Figure 5.3: Proposed Drainage Network



5.2 Model Results

Table 5.2 provides the modelled flood levels from modelling prepared for this development application. Comparison is made with Council provided flood levels from earlier regional modelling, and the following figures represent the spatial distribution of flood depth and hazard associated with the various modelling scenarios.

1% AEP flood depths approach 0.5m in depth in Burwood Road, on approach to the Lakemba Street intersection. Depths are shallower in the inner-lane than the outer-lane, being further from the kerb line, up to maximum depth of approximately 0.4m. In Lakemba Street there is a significant flow path from west to east, and flood depth approaches 1m at the kerb line on the northern boundary of the site.

Table 5.2: Flood Levels (m AHD)

Event	Burwood Road Flood Level	Lakemba Street Flood Level
1% AEP site specific modelling	16.98	17.22
1% AEP Council provided levels	16.73	17.20
PMF site specific modelling	18.83	18.84
PMF Council provided levels*	18.07	18.27

Source: *Council's adopted PMF levels have been used for design purposes.

Flood hazard is generally H1 or H2 category in the urban area, with the exception of the major flow path that follows Lakemba Street. Hazard north of the site within this flow path is generally H4, following the kerb alignment, transitioning to H5 hazard through the Lakemba Street/Burwood Road intersection and then remains H5 as flows continue downstream. This is indicated in Figure 5.5 for the existing 1% AEP hazard and Figure 5.7 for the post development hazard.

Figure 5.4: 1%AEP Existing Flood Depth

Figure 5.5: 1%AEP Existing Flood Hazard

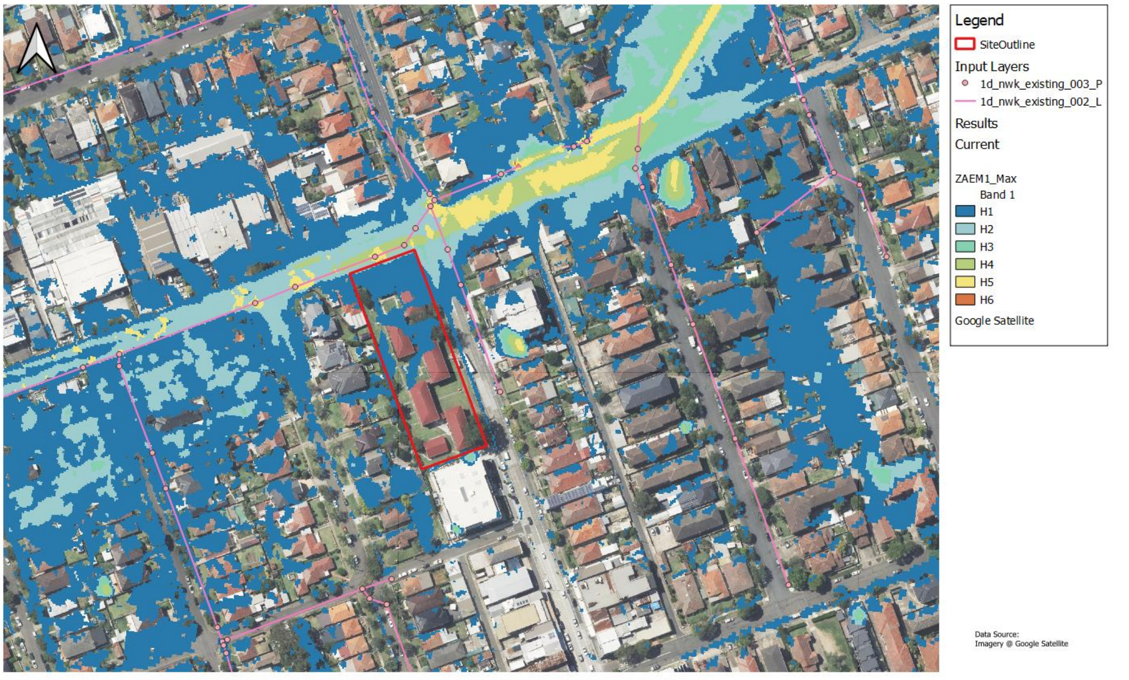


Figure 5.6: 1% AEP Post Development Flood Depth

Figure 5.7: 1% AEP Post Development Flood Hazard

Figure 5.8 represents the afflux or change to 1% AEP levels as a result of the proposed development, compared to existing conditions. It shows the impact is generally within 50mm of existing conditions. In addition, due to the increased pipe system capacity of the proposed drainage within the site there is additional storage available to the stormwater system, which has a modestly beneficial impact on flooding levels.

There is a residual impact indicated by the flood impact analysis to surface flows at the confluence of Lakemba Street and Burwood Road drains, within and north of the intersection. This is considered a minor impact and is contained to a very limited area, within the road reserve.

No significant change in flood hazard is observed as a result of development.

Figure 5.8: 1% AEP Flood Impact (change in water level)

Note there is a range of potential PMF levels indicated in the results Table 5.2. There is uncertainty in the generation of extreme event flood levels, and upon review of likely causes of this range of PMF estimates it was identified that multiple sources of model input data and parameters likely contribute. To maintain consistency with other development in the area the Council adopted levels for PMF were selected.

5.2.1 Climate Change Scenarios

The warming of global average temperatures as a result of climate change results in increased rainfall intensity and therefore higher flood levels. In a 1% AEP scenario with Shared Socioeconomic Pathway (SSP2) at 2030[2] uplift, the flood level increase is 10mm in the Burwood Rd/Lakemba St intersection relative to non-factored rainfall data. Flow paths in Lakemba Street and Burwood Road respectively are up to 70mm and 60mm higher than under non-factored rainfall 1% AEP event. This scenario is shown in the flood depth figure below.

Figure 5.9: 1% AEP Post Development Flood Depth with SSP2 at 2030

[2] Guidelines for flood assessment of climate change scenarios in Australia provide rainfall uplift factors for multiple SSP scenarios, each across a range of future years. Each SSP is representative of the potential conditions considered in one particular global climate model.

In a 1% AEP scenario with SSP3 at 2100 uplift, the flood level increase is 15mm in the Burwood Rd/Lakemba St intersection relative to non-factored rainfall data. Flow paths in Lakemba Street and Burwood Road are up to 260mm and 130mm higher respectively than under non-factored rainfall 1% AEP event. This scenario is shown in the flood depth figure below.

Figure 5.10: 1% AEP Post Development Flood Depth with SSP3 at 2100

6 Design Strategy

The reduction in potential flood exposure for future residents and visitors has been an integral design objective for this proposed development.

Flood Planning Level and Floor Level

Legislation only requires FPL to achieve 1%AEP + 500mm, not the PMF, however to reduce risk to human life the proposed development has been designed so all habitable spaces and the basement entry are above the PMF flood level. The Council provided PMF levels of 18.07m and 18.27m in Burwood Road and Lakemba Street respectively are noted being lower than the site specific modelling of PMF levels which were used as the standard of flood protection.

Noting the uncertainties that are associated with extreme event flood modelling, the recommendation made following a risk assessment for potential extreme event conditions was to raise floor levels to as high as is reasonably practical. For the ground floor generally this design level was identified at 18.84m AHD. The basement entry ramp is also raised as high as practical, to 18.83m AHD. The structure was elevated as much as possible to provide immunity to increased overland flow in Burwood Road and Lakemba Street in intense storm scenarios.

Risk Management

The flood hazard shown spatially and discussed in section 5.2 indicates dangerous conditions in Lakemba Street. This largely informs the potential flood emergency response options, limiting the available actions in the event of major flooding to either sheltering in place, or evacuation from the site to the south onto Burwood Road and moving south to higher ground over the railway corridor. The internal route to safety is indicated in Appendix A.

Through the provision of new structures, designed to modern engineering requirements and to the potential loadings of major to extreme flood events, the post development scenario represents a significantly lower risk profile than the existing conditions with respect to the stability of structures during flood events. As the structures are adjacent areas of high hazard in Lakemba Street during major flood events, the flood emergency response strategy considers any residual risk even where structures are designed for the potential flood loadings.

Flood Mitigation

As a result of the provision of On-site Detention (OSD) to the stormwater system there is flood storage provided within the site. The new drainage system also provides for storage within the pipes themselves.

Through maintaining open space on site there is a preservation of localised overland flow flood storage. This is temporary flood storage, mimicking the existing conditions whereby rainfall falling on the site flows overland toward either Lakemba Street or Burwood Road.

Emergency Response Strategy

The recommended response to flood emergencies at the site is evacuation. Rising road egress route to south provides for a safe evacuation route away from (the likely flooded) Lakemba Street. The detailed design stage should address the appropriate warning signage that should be provided to the development to support the flood emergency response. The internal route to safety is indicated in Appendix A.

7 Conclusions

The flooding assessment provides the relevant engineering constraints for the design team to ensure that the development meets the requirements of Council and relevant engineering standards and guidelines.

The assessment of post development flooding conditions and changes to flooding as a result demonstrates that the proposed development can be implemented with an acceptable impact on flooding conditions. With refinement of the design through detailed design stage there can be further optimisations to the flood mitigation strategy to reduce the residual flood impacts.

This FIRA has not sought to redefine PMF flood levels for the catchment, noting they have been determined through the regional assessment in the Overland Flow Flood Study and summarised by Council as noted in section 4.1. The PMF levels determined in the site specific flooding assessment are 18.83m and 18.84m in Burwood Road and Lakemba St respectively. By designing a structure with floor levels above the PMF (and well above the 1% AEP + 0.5m freeboard) the risk of inundation events is drastically reduced. The design ground floor level of 18.84m AHD and basement entry ramp threshold level of 18.83m AHD are above the PMF level of the site specific modelling.

A safe response to flood emergencies for all events up to and including the PMF is for evacuation following the identified southern egress route along Burwood Road. The internal route to safety is indicated in Appendix A. The state and local legislation doesn't require PMF immunity for the development, however the ground floor level and basement entry ramp levels have been raised as high as is practical to best protect the development from potential extreme flood events. With this approach a much higher standard of protection is achieved than is required under the legislation. The Flood Emergency Response Plan (FERP) will be prepared in detailed design for Council's approval. The design of the development has ensured that the development is suitable for shelter-in-place in accordance with the NSW Shelter-in-place Guidelines for flash flooding.

It's recommended that Department of Planning, Housing and Infrastructure (DPHI) consider the risk mitigation strategies described in this report, balanced against the increase in population that results from the provision of additional housing at the site.

A. Evacuation Route Planning