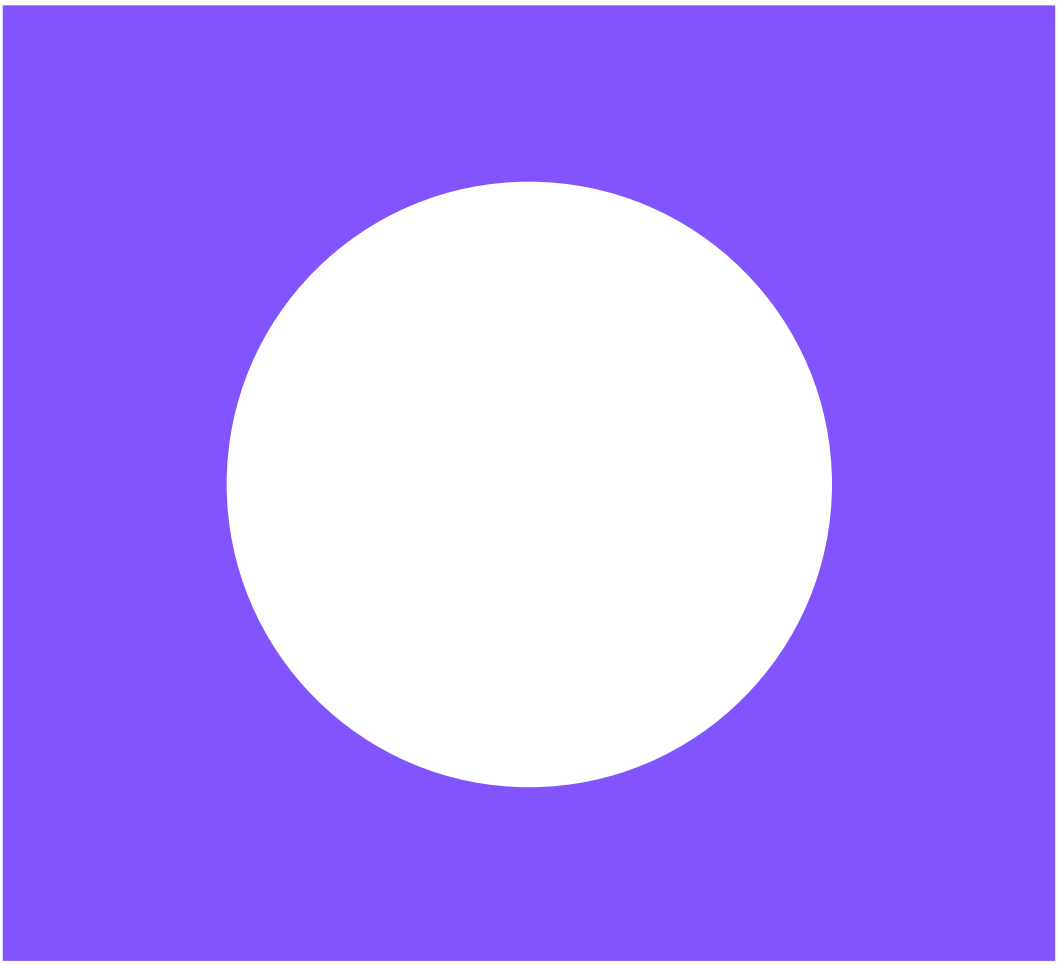
MOTT MACDONALD



68 - 80 Banks Avenue, Pagewood

Flood Impact and Risk Assessment

November 2025

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Flood Impact and Risk Assessment

November 2025

Issue and Revision Record

Revision	Date	Originator	Checker	Approver	Description
A	31/10/2025	N.McNamara	J.Mail	A.Tarshan	Initial Draft
B	11/11/2025	N.McNamara	J.Mail	A.Tarshan	Issue for SSDA

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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-83256472) for the construction of 224 social and market dwellings in 7-8 storey residential flat buildlings.

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

- The potential impacts of the proposed development on the flood risk to the existing community.
- The impacts and risks 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 1% AEP and probable maximum flood (PMF) have been assessed as they relate to the flood planning levels (FPL) for the development. The PMF is the largest flood that could conceivably occur at a location and defines the maximum extent of flood-prone land. Dry habitable areas above the PMF level are expected to be free from flooding under all scenarios.

Flood Impact Assessment

The key results of the flood assessment are summarised below:

- Changes in peak 1% AEP water level as a result of development:
    - Negligible increases in water level outside the boundary
    - A maximum 0.10m increase in peak water level is predicted on the East Jellicoe Park facing boundary of the Northern building because of the development, this is deemed to be acceptable due to the limited area affected.
- Change in 1% AEP flood velocity as a result of development:
    - Flood water velocities are not significantly changed by the proposed development, and no changes are expected outside the site boundary.
- Change in 1% AEP flood hazard as a result of development:
    - There are no changes in flood hazard outside the site boundary and flood hazard is limited to H2 within the site boundary.

Development Controls

The Bayside Development Control Plan (DCP) 2022 outlines flood planning provisions and controls in Clause *3.10 Flood Prone Land.*

The flood planning level for floor levels within Residential development for all habitable floor is to be no lower than the 1% AEP plus 0.5m freeboard and for below ground carpark entrances these areas must be physically protected from inundation for flood levels up to the 1% AEP flood level plus 0.5m freeboard. These are in accordance with the Bayside Council Development Control Plan (DCP) FPLs. Site specific flood planning levels are listed in Table 6.1 within the body of the report.

This FIRA has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued by the Department of Planning, Housing and Infrastructure (DPHI) for the subject SSDA. Whilst the Flood Risk SEAR requests a FIRA for the site (Table

1.1) the development falls within land identified by the Peak flood 1% AEP Design event, meaning the standard LEP clauses and relevant DCP controls related to flooding apply. To ensure a robust design, this FIRA has been developed to support the SSDA as outlined by Flood Risk Management Guideline LU01 (FIRA guide).

By implementing the design recommendations outlined in this report, direct flood risk to any person could be reduced and residual flood risk could also be reduced by complying with the Bayside DCP, 2022. Compliance with the DCP can be achieved without negatively affecting existing flood risk to the surrounding areas.

Design for Minimisation of Flood Risk

To summarise the outcome of the design:

- Flood Planning Level requirements and other Development Controls,
    - The minimum finished floor level of all habitable room(s) is to be at the height of the 1% AEP flood level plus 0.5 metre freeboard.
    - basement car parks must be physically protected from inundation by floods equal to or greater than the 1% AEP flood level plus 0.5m freeboard.

The flood emergency management (EM) strategy for the development has been assessed following advice provided in Springvale Drain and Floodvale Drain Flood study (DFS) (Botany Bay Council, 2014), Botany Bay Precinct Emergency Sub Plan, Springvale Drain Floodvale Drain Floodplain Risk Management Study and Plan (FRMSP) (Botany Bay Council, 2019) and relevant plans from the NSW SES.

The assessment established that the site is at risk of flash flooding as critical storm durations are less than 6 hours for a high-intensity, 1% AEP event and less than 3 hours for the PMF event. Inundation caused by flash flooding can typically occur with little or no warning and cause a rapid rise in water level over a brief period. Flood events of this nature do not last more than a few hours.

Flood impacts are present across all events up to and including the 1% AEP and PMF as the site under existing conditions is identified as being flood prone in the 1% AEP event.

Based on the 68-80 Banks Avenue FIRA (this report), the primary Emergency Management (EM) strategy would be to follow the directions of emergency responders before and during flooding events. In the absence of this guidance during these events a shelter in place policy, in line with DPHI proposed guidelines for flash flooding, can be considered as a reasonable contingency plan during a flood emergency, given the following constraints:

- The site is at risk from flash flooding; the interval between the observable causative event and the flood is less than 6 hours. Consequently, it is unlikely that there will be sufficient warning time to adequately evacuate the population of the wider precinct. Additionally:
    - The opportunities for horizontal evacuation during a storm are limited to prior to the onset of the storm, as surrounding streets Park Parade and Banks Avenue are subject to H1 and H2 flood hazards that present a risk to people. NSW SES advice is not to venture out during a storm or cross any area of flood inundation.
    - The rate of rise and extent of flooding in the most extreme events means that emergency evacuation centres may not get set up and evacuees would generally have to take shelter in private premises.
- The time of isolation is short, based on the duration of flooding around the precinct. A development which is isolated for a few hours by low hazard flood water in PMF does not pose a significant risk to life compared to requiring evacuation through flood waters.

- The redevelopment affords a means of creating a safe, on-site shelter above the 1% AEP + 0.5m freeboard, and PMF levels, suitable for vertical evacuation:
  - Redevelopment which caters for sheltering in place can be used to reduce existing risk to life for individuals, noting there is a considerable population who currently occupy the existing dwellings within reach of the floodplain.
  - Additional development controls can be imposed, which seek to manage the residual secondary risks to life caused by flood isolation to ensure that risks remain tolerable. This includes measures to manage risks relating to medical emergencies, fire, health and well-being. Bayside Council must consult NSW SES, Ambulance NSW, Health, and fire agencies to manage secondary risks during flooding and for 48 hours after, as no clear area-wide strategy exists.

1 Introduction

1.1 Background

This Flood Impact and Risk Assessment (FIRA) has been prepared for Homes NSW to assist the proposed development for the Site located at 68-80 Banks Avenue, Pagewood.

The proposed development sites, located at 68-80 Banks Avenue, Pagewood, is owned by Homes NSW. The location of the site is shown in Figure 1.1. The site is located adjacent to Jellicoe Park and opposite to Bonnie Doon Golf Course, the subject site has outlined the potential to realise a total of 9,262m^2 residential gross floor area (GFA).

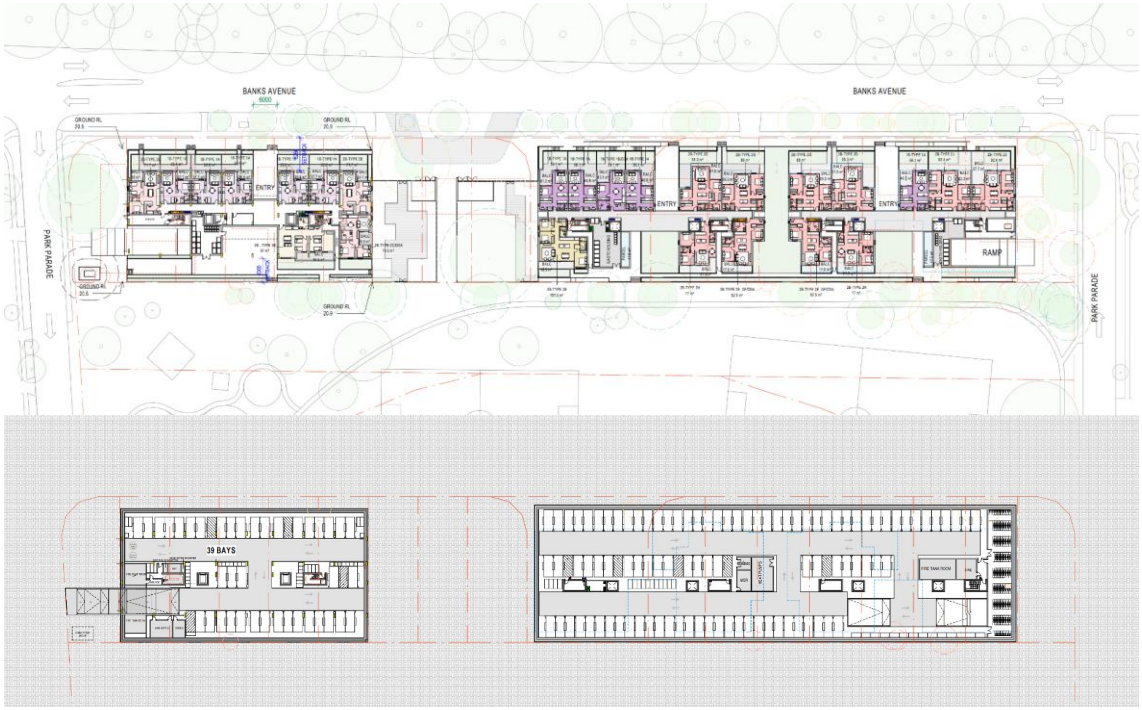
Figure 1.1: Site Location

Source: Google Earth Pro, 2025

The proposed development by BVN Architecture seeks to transform the existing site through the construction of approximately 251 social and market dwellings within two 6-8 storey residential flat buildings, thereby contributing to the overall goal of affordable housing.

The layout of the proposed development is shown in Figure 1.2

Figure 1.2: Proposed Development - Ground and Basement Floor



Source: BVN, 2025

The proposed development makes use of the existing road infrastructure with no modifications or adjustments proposed for either Banks Avenue or Park Parade besides the connecting hardstanding for vehicle access.

1.2 Project Context

The aim of the FIRA is to analyse and assess the SSD 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 risks 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 most up to date flood studies for the catchment, comprising the *DFS, 2014 and FRMSP, 2019,* have been reviewed and drawn from for the benefit of this assessment.

1.3 Site Description

The surrounding area of the site is predominantly comprised of low and medium-density residential land use, with intermittent clusters of mixed-use and commercial activity in the immediate surroundings.

1.4 Purpose

The purpose of this FIRA is to conduct a flooding analysis for the Site and to address the Secretary's Environmental Assessment Requirements (SEARs) for the project which identified the following specific assessment requirements.

Table 1.1: Project Specific SEARs

SEAR	SEAR Description	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 o The site access and egress routes o the potential effects of climate change, o any relevant provisions of the NSW Flood Risk Management Manual, and any other relevant guidelines	The 68-60 Banks Avenue Flood Impact and Risk Assessment (FIRA) Flood planning controls, Sections 4.2 and 6.1 Egress routes Sections 6.2 and 6.3. Climate change Section 5.3 Relevant guidelines Section 4
	• 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. • 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).	The 68-60 Banks Avenue Flood Impact and Risk Assessment (FIRA) Flood risk management measures are detailed in Section 6.

1.5 FIRA Requirements

The FIRA demonstrates compatibility of the proposed 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.

As previously stated, this site is located within a recent existing Flood Study which identified that the existing building footprint is affected by the 1% AEP event. Subsequently, the scope of this FIRA considers the potential impacts across minor to major events (up to 1% AEP) from development on-site as it could have a degree of influence on regional flooding. Existing FRM studies would be suitable in examining flood risk for areas external to the site.

Consequently, for this FIRA, to meet the desired aims of the guidance it requires an understanding of:

- A range of flood risk examining minor, major and extreme storms events.
- The constraints that flood places on the land (floodways, flood storage, flood hazard and emergency response issues).
- 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.

2 Background

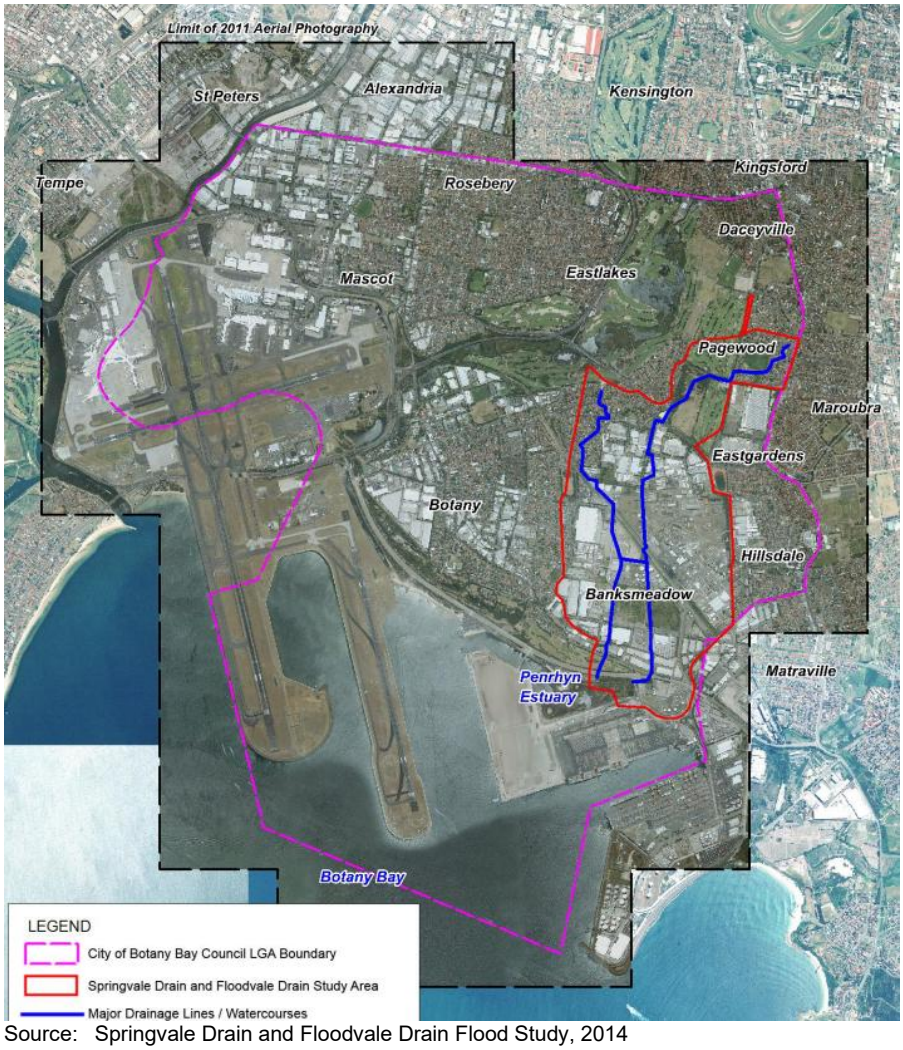
2.1 Study Area

The wider study area of Botany Bay Local Government Area (LGA) is shown in Figure 2.1, and the subject site boundary is identified in Figure 1.1 and Figure 2.2, located East of Banks Avenue and otherwise circled by Parks Parade, with an approximate area of 9,262m^2. The site is situated next to Jellicoe Park and adjacent to Bonnie Doon Golf Club.

The site is reasonably accessible by public transport with frequent bus services that run along Heffron Road and Bunnerong Road. Juniors Kingsford Light Rail Station is also located within 1.5km of the site.

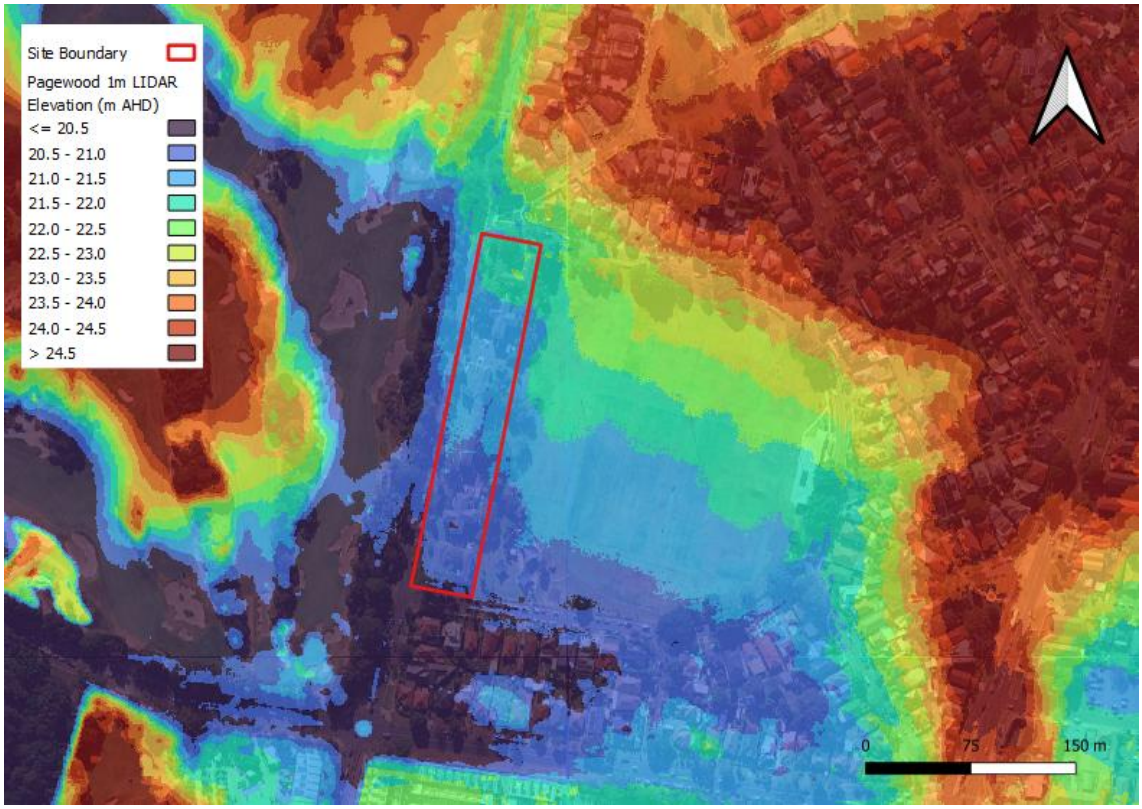
The area around the site has a minor slope from North to South of around 0.5 - 1%. The area around the Banks Avenue is relatively low lying, with elevations across the site itself ranging from 21.8m AHD in the North to 20.2m AHD in the South.

Figure 2.1: Study Area - Botany Bay LGA, Site Catchment



Source: Springvale Drain and Floodvale Drain Flood Study, 2014

Figure 2.2: 68-80 Banks Avenue, Site Boundary Location and Topography



Source: Satellite imagery © Google 2024

2.2 Existing Flood Behaviour

The subject site is located towards the upper reaches of the Springvale and Floodvale catchment. The site itself follows a shallow gradient downwards from North to South.

Under existing conditions, the site is prone to overland flooding and flow paths follow a similar route to the drainage network, with the 1% AEP storm event causing inundation across the site.

Flooding at the Heffron Rd and Banks Ave intersection and the nearby Bonnie Doon Golf Course is primarily caused by the nearby pit and pipe system between Maxwell Road and Kenny Road reaching its capacity in as early as the 20% AEP event (FRMSP, 2019).

During rainfall events, the trapped low point connecting Prince Edward Circle, Towner Gardens and Wark Avenue, located to the north of the study area, also collects runoff which may overflow south to the catchment via Banks Ave and drain to Boonie Doon Golf Course (DFS, 2014).

DFS 2014 states that “properties likely to be impacted by flooding are located east of this area, predominantly on Banks Avenue and Park Parade”, which almost completely encircle the site of 68-80 Banks Avenue. The FRMSP, 2019 also states that “the flooding duration is relatively short, with flood events typically lasting only a few hours, meaning that evacuation is not an appropriate floodplain risk mitigation option in this catchment”, subsequently, this should be considered when evaluating emergency response plans.

Flows from this area of the catchment drain west via Bonnie Doon Golf Course then south to Wentworth Avenue via Mutch Park. The open spaces in Mutch Park and Bonnie Doon Golf Course provide significant flood storage.

The following local flood depths are predicted in the 1% AEP event:

- Banks Ave north of intersection inundated up to 0.9m.
- Within the Heffron Road and Banks Avenue intersection inundation of up to 0.60 m.
- Heffron Road east of the intersection inundated up to 0.7m.
- Up to 2.0 m of ponding within the Bonnie Doon golf course West of Banks Road.

2.3 Flood History

From the DFS, 2014, historical flood data for the Springvale and Floodvale Drain catchments is scarce, with the most significant event recorded in February 1990 and more recent flooding occurring in February 2010. An additional internet search provided no additional information on recent significant rainfall events within the catchment area.

2.4 Available information

The Springvale Drain and Floodvale Drain catchment encompasses an area of approximately 3.75km^2 located within the (former) City of Botany Bay LGA in south-eastern Sydney. The Flood Study Model is a comprehensive catchment-wide flood model, ensuring that recent (and known upcoming) major developments were accurately accounted for, and that current best practice data and methods for estimating design floods were applied.

The extent of the catchment is shown in Figure 2.1 and is sufficiently large to represent the hydrological catchments around the proposed site at 68-80 Banks Avenue to analyse potential flood impacts of redevelopment.

3 Methodology Approach

3.1 Basis of Flood Model

A TUFLOW model was developed for the 2014 study and calibrated against the 1990 and 2010 flood events. This model has been reviewed to confirm as an appropriate configuration and has been incorporated into the basis modelling for the current study.

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 the 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 that will naturally follow the modelled topography.

The 1D component (called ESTRY) is a separate calculation engine incorporated into TUFLOW to manage flows through structures which cannot be accurately represented with 2d grid 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.

3.1.2 Modelling Scenarios

Flood model scenarios for 68 – 80 Banks Avenue precinct were based on the following:

- Existing conditions
    - An assessment of the current flooding conditions based on existing survey of the site
- Design conditions
    - An amendment to the existing conditions model was built to incorporate the proposed development layout as building block-outs

The 1% AEP and probable maximum flood (PMF) events have been assessed as they relate to the flood planning levels for the development and cover extreme flooding scenarios to enable emergency planning for the site. The PMF is the largest flood that could conceivably occur at a location and defines the maximum extent of flood-prone land. Dry areas above the PMF level are expected to be free from flooding under all scenarios.

- Climate Change
    - The Springvale Drain and Floodvale Drain Flood model was provided with hydrological rainfall increased outputs for 10%, 20% and 30% increases in design rainfalls in line with anticipated trends for rainfall with Climate Change in New South Wales (CSIRO, 2007) as well as a 0.4m increase in seal level by 2050 and 0.9m increase by 2100 to account for future climate sea level rise scenarios. This was based on the guidelines of Department of Environment, Climate Change and Water, 2009, which has since been succeeded by the Department of Climate Change, Energy, the Environment and Water (DCCEEW).

3.2 Planning and Development Advice

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.

The public domain design, grading and stormwater infrastructure was reviewed with the stormwater management design team to identify management of the overland flows and localised ponding to:

- Create a better access and amenity for the development.
- Improve safety through the public domain areas.

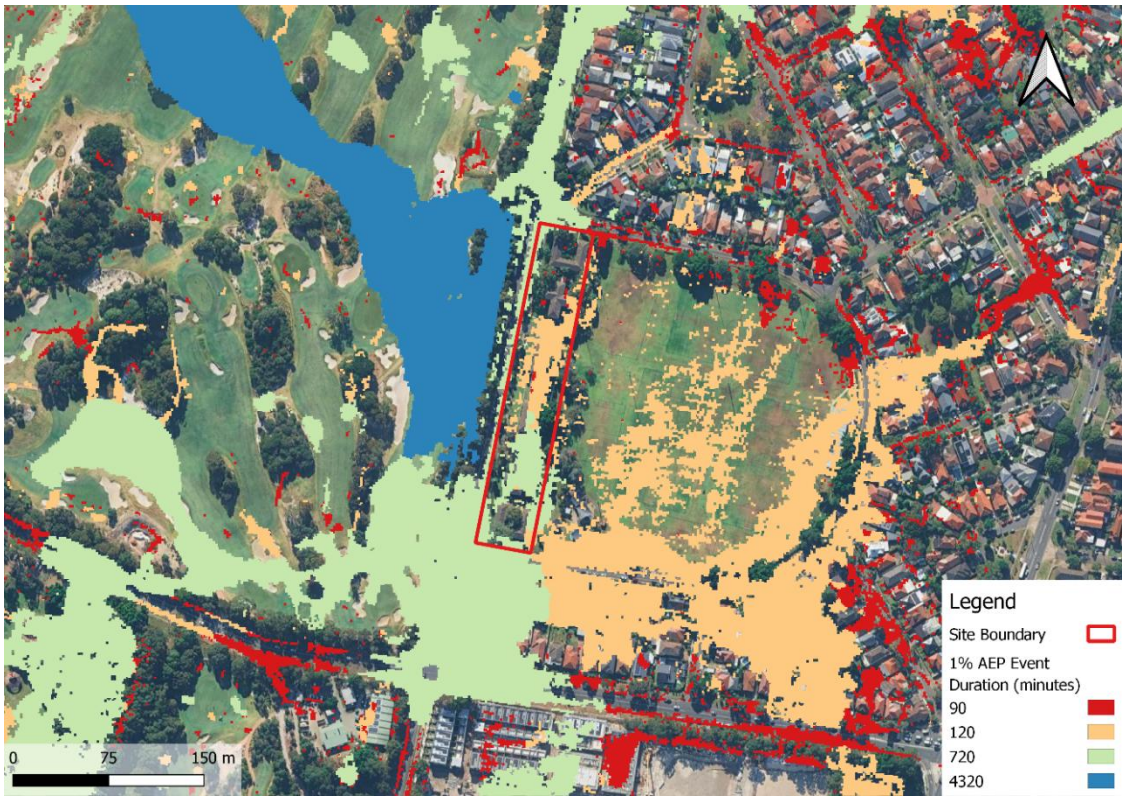
Floor level advice was coordinated with the design team regarding the relevant flood planning levels and potential basement entry levels appropriate to the preliminary design options, to ensure that the proposed development satisfied the design controls and relevant guidelines.

3.3 Critical Duration

As part of assessing the site, multiple durations were assessed from the previous council model, to locate the critical events across different scenarios within the site area (See Figure 3.1). The site suffers most significant depths during both the 2 and 12-hour duration and as such, event these two durations have been assessed as part of the study.

A gap in information was identified due to the provision of only a single temporal pattern within the model. As a result, a meaningful assessment of temporal pattern variability could not be undertaken.

Figure 3.1: 1% AEP Critical Duration



Source: SATELLITE IMAGERY © GOOGLE 2024

4 Flood Related Requirements

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 of overland flow. The relevant Codes and Guidelines are summarised in Table 4.1: Codes and Guidelines.

Table 4.1: Codes 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
Institution of Engineers Australia	Australian Rainfall & Runoff	2019
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
Bayside Council	Bayside Local Environmental Plan (LEP)	2021
Bayside Council	Bayside Development Control Plan (DCP)	2022
Department of Environment and Heritage	Flood Risk Management Toolkit	2024

4.1 Australian Rainfall and Runoff (v4.2)

Prepared by the Institution of Engineers, Australian Rainfall, and Runoff – *A Guide to Flood Estimation* was written to provide "*Australian 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 with major revision to version 4.0 in 2016 (from the previously used 2001 version) with a more refined methodology for hydrological analysis based on the latest hydrological data gathered. Subsequent updates largely relate to the application of climate change science, alongside minor general updates. The current version was published in 2024 by Geoscience Australia.

4.2 Bayside Council Documents

4.2.1 Bayside Council Local Environment Plan (2021)

Bayside Local Environmental Plan (LEP) 2021 outlines the flood planning provisions in accordance with the relevant standard environmental planning instrument under Section 3.20 of the Act. Additionally Bayside Council has not adopted Clause 5.22 *Special Flood Considerations* as part of their LEP 2021. Clause 5.21 *Flood Planning* outlines:

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, taking into account projected changes as a results 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.

4.2.2 Bayside Council Development Control Plans (2022)

The Bayside Council's Development Control Plans (2022) chapter 3.10, Flood Prone Land 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 Bayside Council, being all land potentially inundated by floods up to and including probable maximum flood (PMF).

Chapter 9.5.4 states that where a new development may impact the flood behaviour in a flood affected area the flood impacts are to be assessed for the existing and proposed development to ensure that the existing flood hazard is not increased.

Floor levels for both high and low flood hazard based on residential land and also commercial and industrial land use are to follow the planning controls A1 and A3:

A1 – Habitable floor levels to be no lower than the 1% AEP flood level plus 0.5m freeboard.

A3 – non-habitable floor level to be no lower than 1% AEP flood level.

In case of critical & sensitive land use planning control A2 applies:

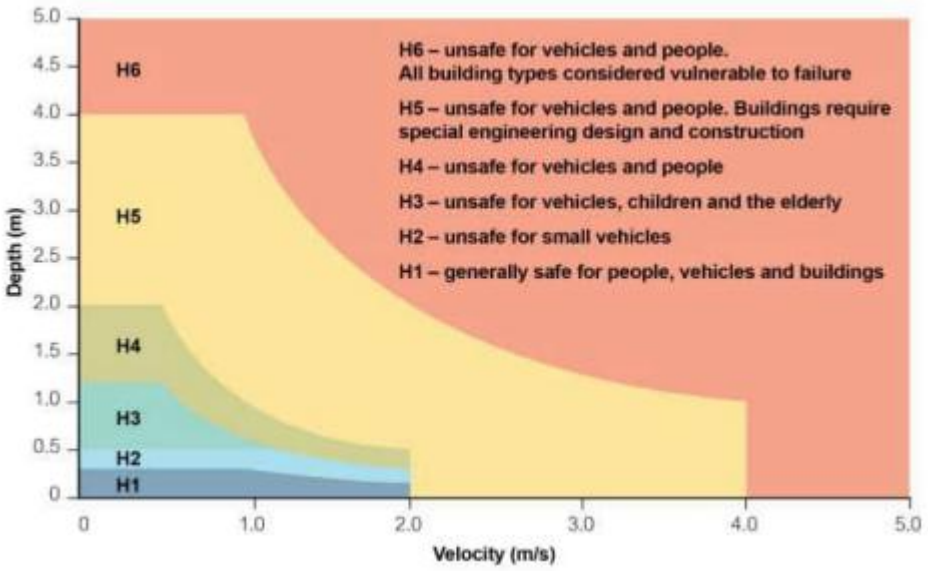
A2 – Habitable floor level shall be at or above the PMF level or 1% AEP flood level plus 0.5m freeboard, whichever is higher.

4.3 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 provides additional guidelines for ensuring safe overland flow paths are provided. These guidelines adopt the hazard categorisation which has been developed by Australian Emergency Management Institute in 2014, defining hazard into six categories. The categories relate to the flood vulnerability curves shown in Figure 4.1.

Figure 4.1: General Flood Hazard Vulnerability Curve



Source: Australian Emergency Management Institute (2014)

4.4 Emergency Management

NSW State Emergency Services (SES) provides community advice for urban areas throughout Sydney during flooding events. General advice for residents living in the Pagewood catchment is provided by Bayside Council and also NSW SES FloodSafe guide for Flash Floods and the StormSafe guide. The NSW Communities FloodSafe guide relating to riverine flooding which is not applicable to riverine flooding is not applicable to the Pagewood proposed development.

4.4.1 NSW SES Flash FloodSafe

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

The NSW State Flood Plan (SFP) 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 a 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 this proposed development.

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 safe to do so
- Seek refuge in the highest park of a story 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 forecast.

4.4.2 NSW SES StormSafe

The NSW SES StormSafe guide outlines key storm risks, impacts and the safest responses 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
- When flash flooding is likely, leaving low-lying homes and businesses well before flash flooding begins is the best course of action to take, but only if safe to do so.

4.5 Shelter in Place Guideline for Flash Flooding (2025)

Published by the Department of Planning, Housing and Infrastructure (DPHI), this guideline aims to assist consent authorities to undertake site specific, risk-based assessment to assess if shelter in place is a suitable emergency management strategy for development proposed in flash flood environments.

The intent of the guideline is to:

- guide proponents on where shelter in place may be considered in land use planning
- provide consent authorities guidance on matters that may be considered in assessing planning proposals and development applications where shelter in place is proposed
- assist councils when considering the role of shelter in place within their own local guidelines, policies, and development control plans.

The shelter in place guideline defines the following:

- Shelter in place - the internal movement of a building's occupants to an area within the building above the probable maximum flood (PMF) level before their property becomes inundated by flood waters
- Flash flooding – flash flooding is "flooding that occurs within 6 hours of the precipitating weather event, and often involves rapid water level changes and flood water velocity"[1]
- Flood behaviour
    - Flash flooding is the only flood risk present at the site, whether it be from overland flooding, a nearby creek or riverine flooding
    - The flooding occurs within less than 6 hours from the commencement of causative rain and the duration of shelter in place due to isolation by floodwaters is less than 12 hours from the commencement of rainfall

[1] Flash flooding as defined in Emergency Planning and Response to Protect Life in Flash Flood Events (2018) AFAC (Australasian Fire and Emergency Service Authorities Council)

- The development is not subject to high hazard flooding (e.g. floodways, high hazard H5 or H6 areas) or surrounding roadways are not subject to high hazard flooding[2]

[2] Flood Risk Management Guideline FB03 Flood Hazard, DCCEEW, 2023

5 Hydraulic Modelling

The subject site is affected in the 1% AEP storm event and during the PMF event. As such, it is recommended that the proposed development complies with flood-related development controls applicable to both 1% AEP and PMF scenarios. While the site currently meets Council's requirements for flood-affected land, further flood modelling is recommended to confirm existing conditions and assess any potential impacts resulting from the proposed development. The findings of the Flood Advice Certificate for the site are outlined in Table 5.1.

5.1 Bayside Council Flood Advice

Beyond the flood-related development controls provided in Bayside Council Development Control Plan 2022 and 4.2.2 of this report, a flood advice certificate was obtained from Council for the site of 68 – 80 Banks Avenue. A summary of the findings is shown below.

Table 5.1: Summary of Bayside Council's Flood Advice Certificate

Is this property affected during the 1% AEP Flood Event?	**Yes**
Is this property affected during the PMF Event	**Yes**
1% AEP Flood Hazard	**H1**
1% AEP Flood Function	**Flood Fringe**
1% AEP Flood Level (maximum level for property)	**21.39m AHD**

5.2 Model Results

5.2.1 Existing Flood Model Behaviour (Base Case)

5.2.1.1 10% AEP Storm (1 in 10 year)

Flood Depths and Extents

The received Council flood model 10% AEP storm has been used to represent a minor storm event. While 'minor' in the context of flood risk, the 10% AEP storm has an average annual recurrence of 1 in 10-years and is still considered uncommon. During a 10% AEP storm, flooding is present in the adjacent roads and shallow flooding within the site with the greatest depths predicted in the golf course storage areas, shown in Figure 5.1.

Banks Avenue

Flood depths along the site interface at Banks Avenue are generally shallow ranging between 0.10 m and 0.20 m. Greater flooding depths (> 0.50 m) are predicted at the Banks Avenue intersection with Heffron Road.

Park Parade

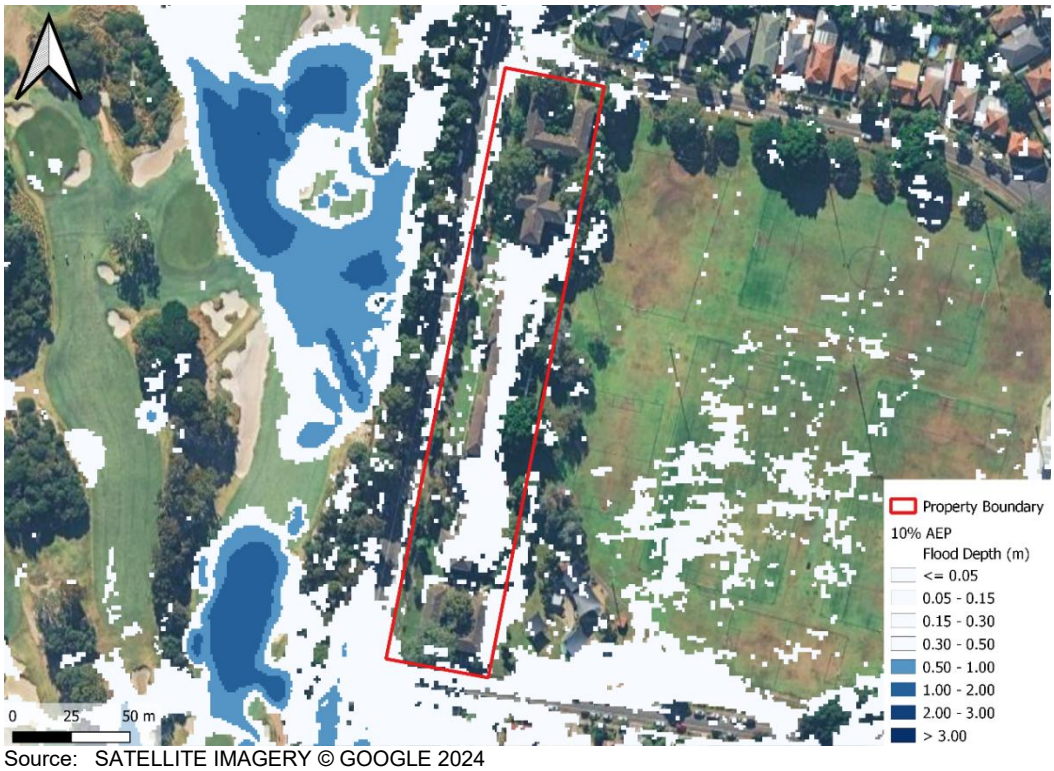
The south segment of the site which borders park parade show flood depths are generally shallow, ranging between 0.10 m and 0.20 m.

Flood Hazard

Category H1 to H4 is considered low hazard, however, they can still present a risk to vehicles, children and the elderly (see Figure 4.1) while H5 and H6 are considered high hazard. The entirety of the site falls within low H1 flood hazard as shown in Figure 5.2. The surrounding

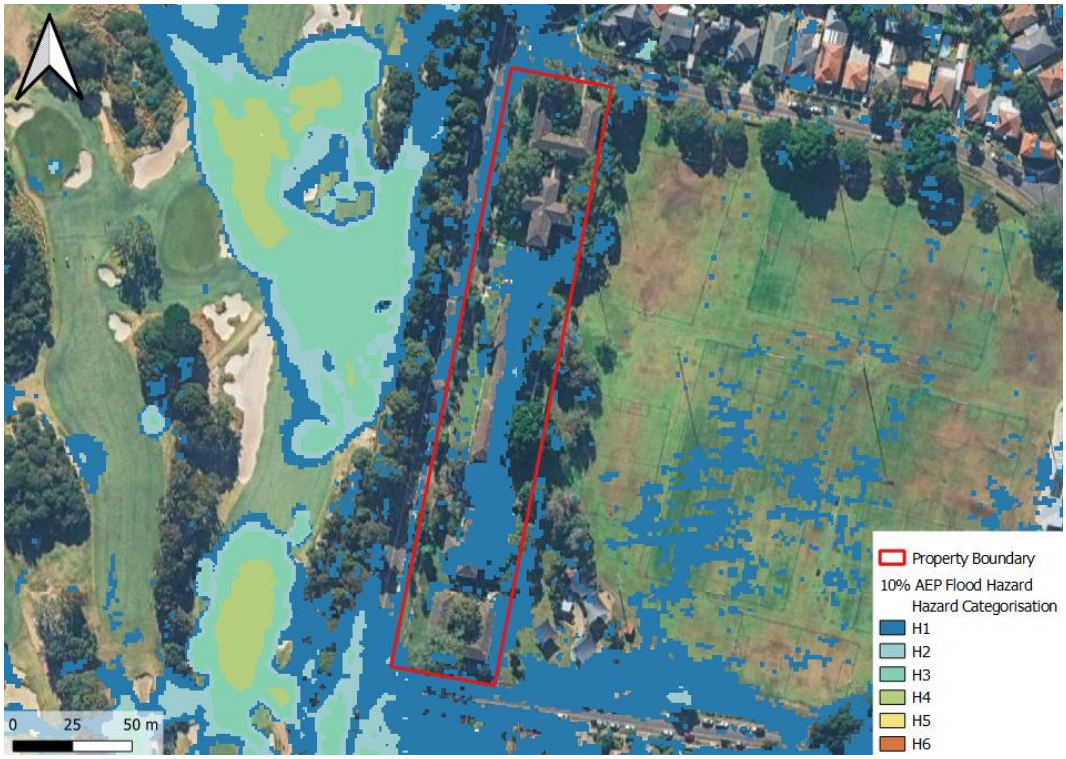
roads begin to show increasing risk but no sign of high hazard anywhere within the surrounding area for a 10% AEP flood event. Velocities across the site are less than 1m/s.

Figure 5.1: 10% AEP Flood Depth and Extent Map (Base Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

Figure 5.2: 10% AEP Flood Hazard (Base Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

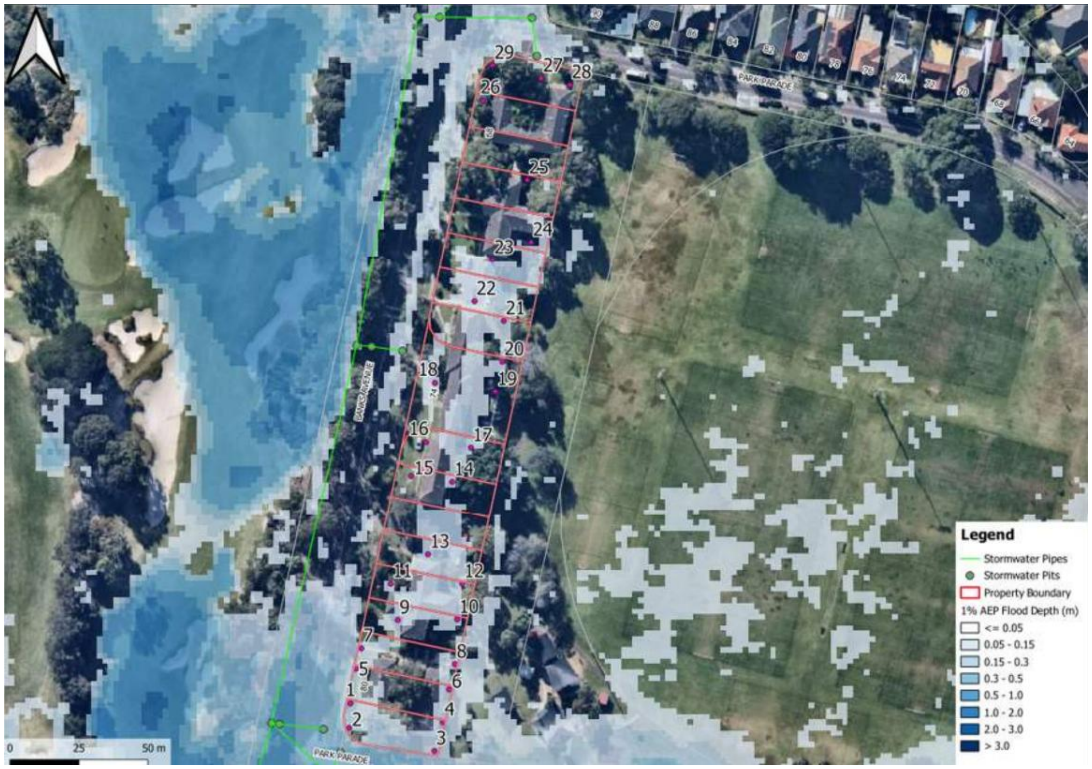
5.2.1.2 1% AEP Storm (1 in 100 year)

The 1% AEP storm forms the basis of Council's flood planning levels. The storm is very rare, having a 1% chance of occurring during any given year.

Flood Depths and Extents

Flooding is present in the roads surrounding the Banks Avenue site with the greatest depths predicted in Banks Avenue and Heffron Road, shown in Figure 5.3.

Figure 5.3: 1% AEP Flood Depth and Extent (Base Case)



Source: Satellite imagery © Google 2024

Banks Avenue

Flood depths along the site interface at Banks Avenue are generally shallow ranging between 0.2 m and 0.70 m. Greater flooding depths (> 0.70 m) are predicted at the Banks Avenue intersection with Heffron Road, up to around 0.9m.

Park Parade

The North segment of the site which borders Park Parade shows low flood depths from 0.1m to 0.25m, with the deepest areas being near the connection to Banks Avenue.

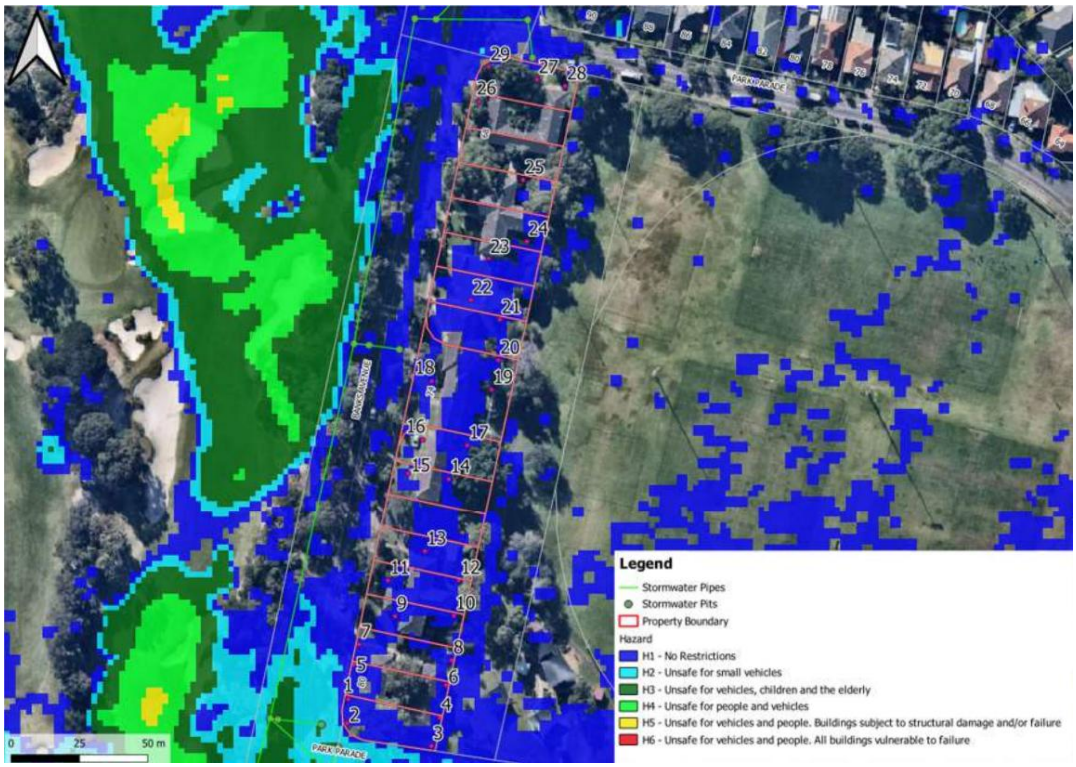
The south segment of the site which borders Park Parade show medium flood depths ranging between 0.20 m and 0.50 m.

Flood Hazard

1% AEP flood hazard is shown in Figure 5.4. The model predicts low flood hazard surrounding the site at 68-80 Banks Avenue. H2 hazard encroaches on the South of the site although this is still deemed low hazard. There are some isolated high hazards (H5 and H6) within the golf course and H3 hazards within and north of the Banks Avenue and Heffron Road intersection.

Velocities across the site and surrounding do not exceed 1m/s, however along Banks Avenue North of the site, velocities do peak at 1.67m/s.

Figure 5.4: 1% AEP Flood Hazard (Base Case)



Source: Satellite imagery © Google 2024

5.2.1.3 Probable Maximum Flood (PMF)

PMF results are provided for flood planning requirements, emergency planning and form part of the flood impact assessment. The PMF is a theoretical maximum flood that can occur at a location with an approximate equivalent probability of occurring between 1 in 100,000 and 1 in 10,000,000 in any year.

Flood Depths and Extents

The area around the site is subject to deep ponding during the PMF as the low-lying area around the road intersection and golf course fills with water, acting like a detention basin for the area. Flood depths and extents are shown in Figure 5.5.

Banks Avenue

Flood depths along the site interface at Banks Avenue are generally deep ranging between 0.20m and 1.1m. Greater flooding depths (> 1.1 m) are predicted at the Banks Avenue intersection with Heffron Road, up to around 1.5m.

Park Parade

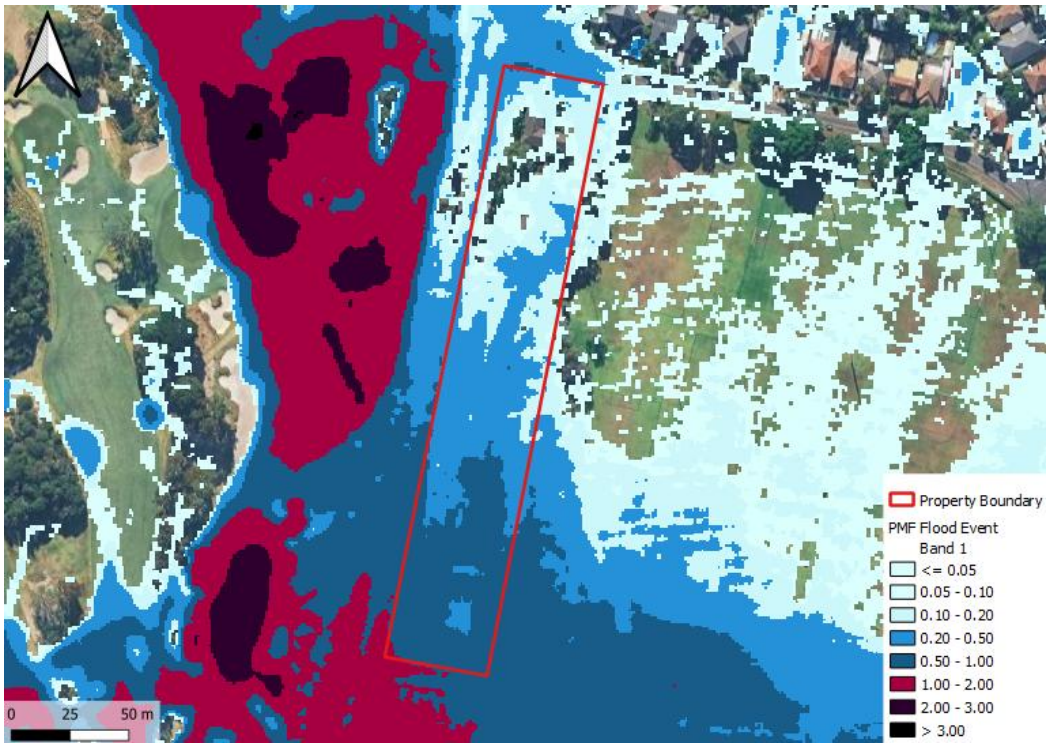
The North segment of the site which borders Park Parade shows between low flood depths from 0.1m to 0.5m. The south segment of the site which borders park parade show medium flood depths ranging between 0.50 m and 1.2 m.

Flood Hazard

For the PMF flood hazard, the model predicts low flood hazard within the site boundary (H1-H3) and an intermediate hazard (H3-H4) in the corners of the site bordering Banks Avenue and Park

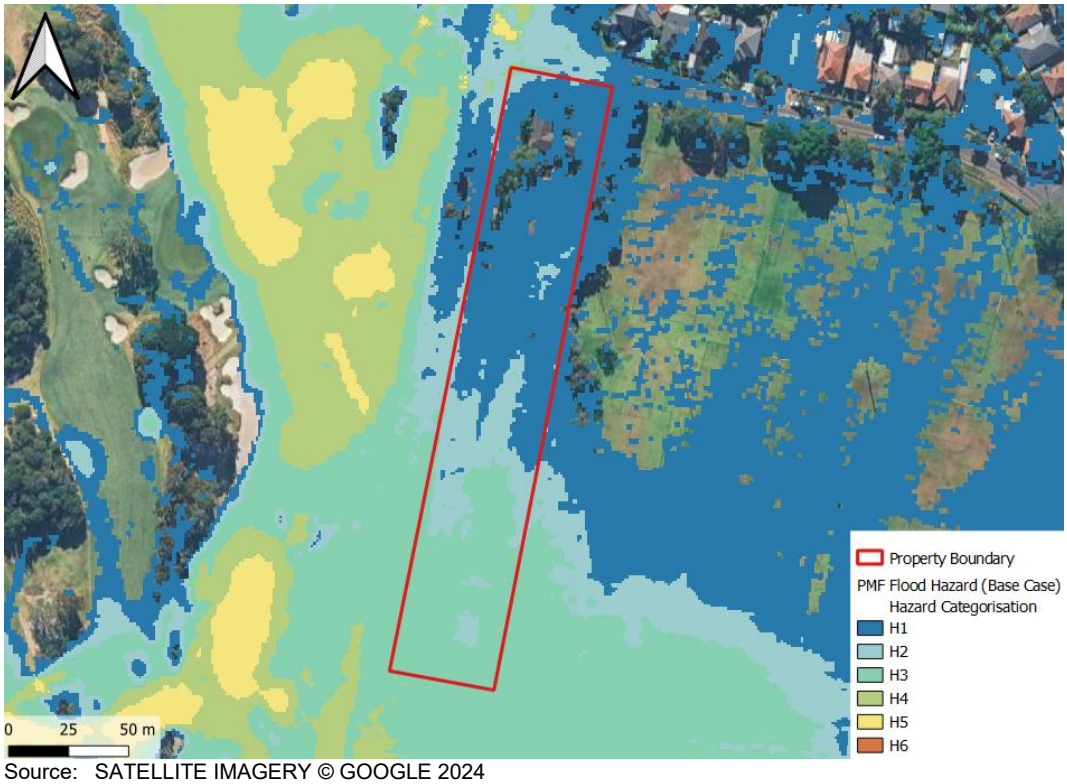
Parade. There are some significant areas of high hazard (H5) within the golf course and on stretches of Banks Avenue and Heffron Road intersection, largely due to the higher depths.

Figure 5.5: PMF Flood Depth and Extent Map (Base Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

Figure 5.6: PMF Flood Hazard (Base Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

5.2.2 Post Development Flood Behaviour (Design Case)

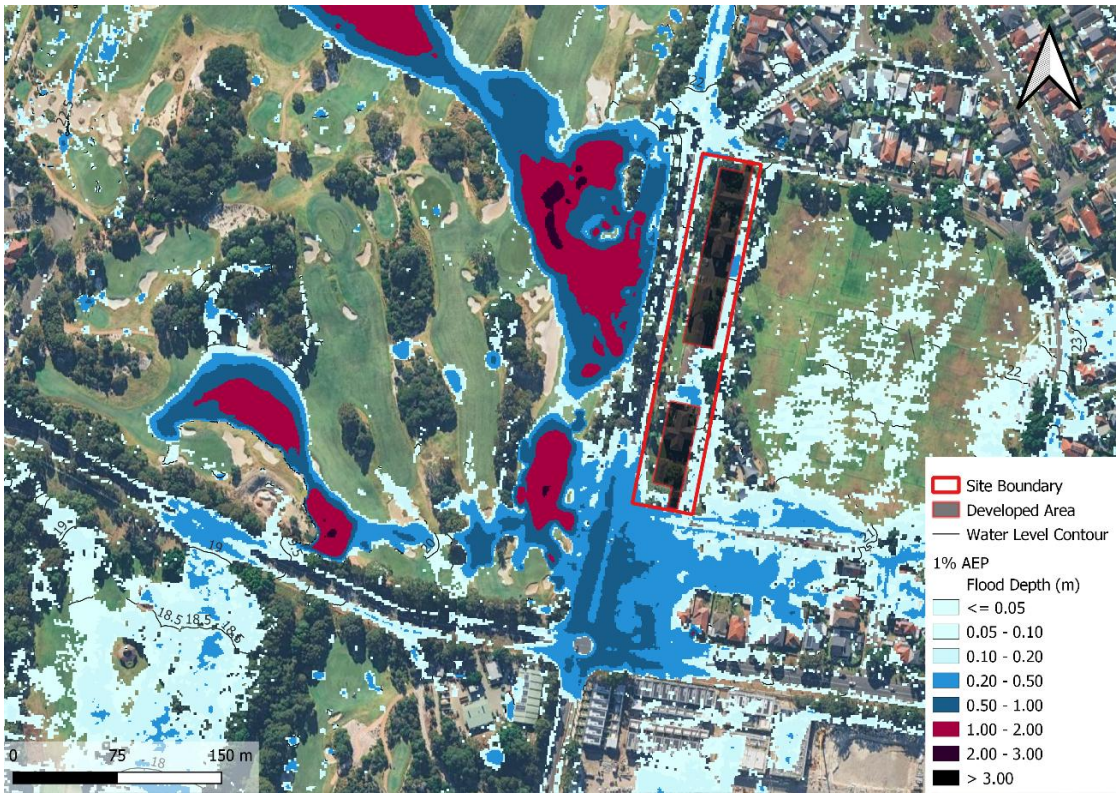
To represent the 68 – 80 Banks Avenue post-development case, a new building block out was included in the model covering the proposed site. This assumes that the site will be immune from flooding in the 1% AEP storm by adopting the Council Flood Planning Level (1% AEP + 500 mm freeboard), preventing any water from encroaching into the building footprint itself.

5.2.2.1 1% AEP Storm (1 in 100 year)

Flood Depths and Extents

The design case 1% AEP flood risk shows little change from the base case with flooding present in the roads surrounding the site.

Figure 5.7: 1% AEP Flood Depth and Extent (Design Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

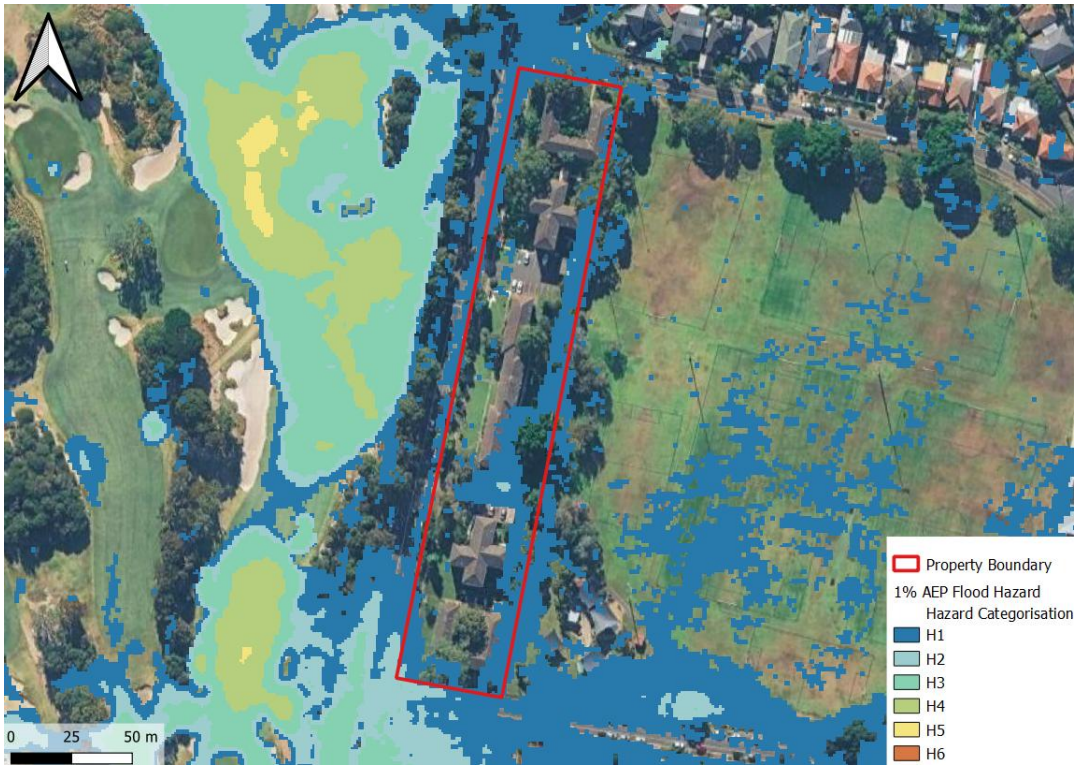
Flood Hazard

There is no change in flood hazard compared to the existing condition. Refer to the 1% AEP flood hazard shown in Figure 5.8.

Afflux

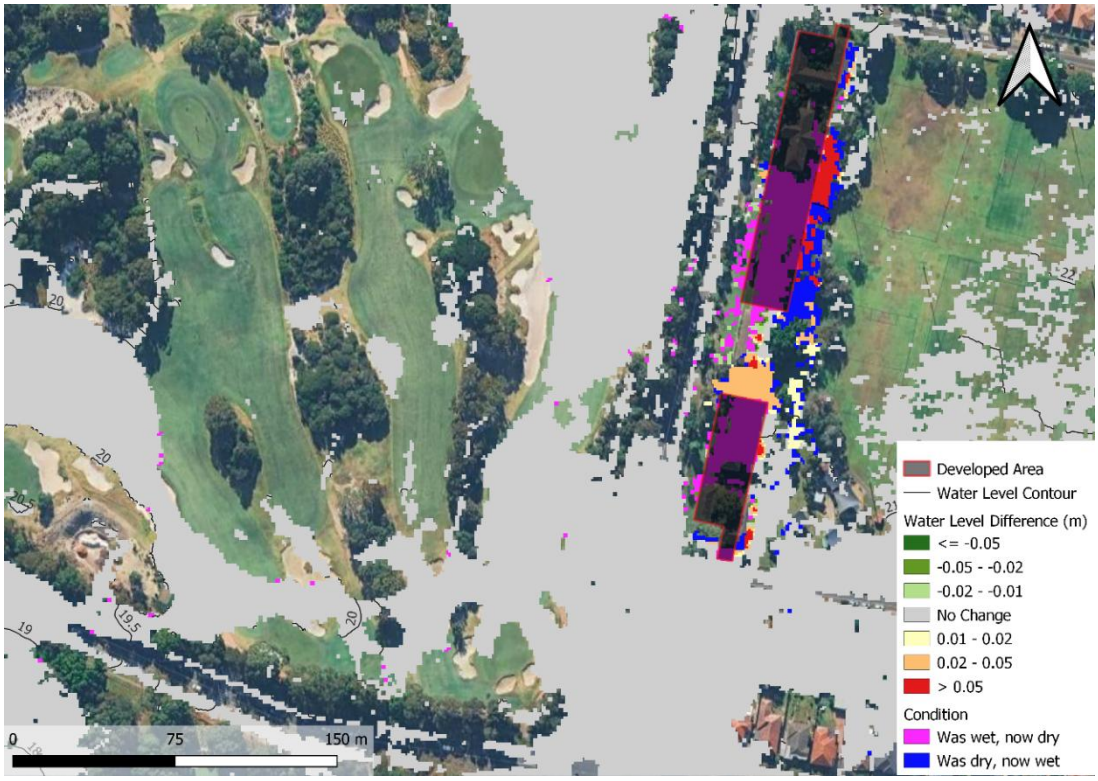
The inclusion of the development is not predicted to cause adverse changes in flooding during the 1% AEP, as indicated by the water level difference map in Figure 5.9. The mapping shows some flood depth increases surrounding the footprint of the building, with patches of increase and decrease to water levels predicted. The maximum flood depth within the site boundary is 350mm, which is only 10mm greater than the existing site maximum flood depth of 340mm. This peak afflux is located along the Eastern boundary of the proposed market building.

Figure 5.8: 1% AEP Flood Hazard (Design Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

Figure 5.9: 1% AEP Water Level Difference (Afflux)



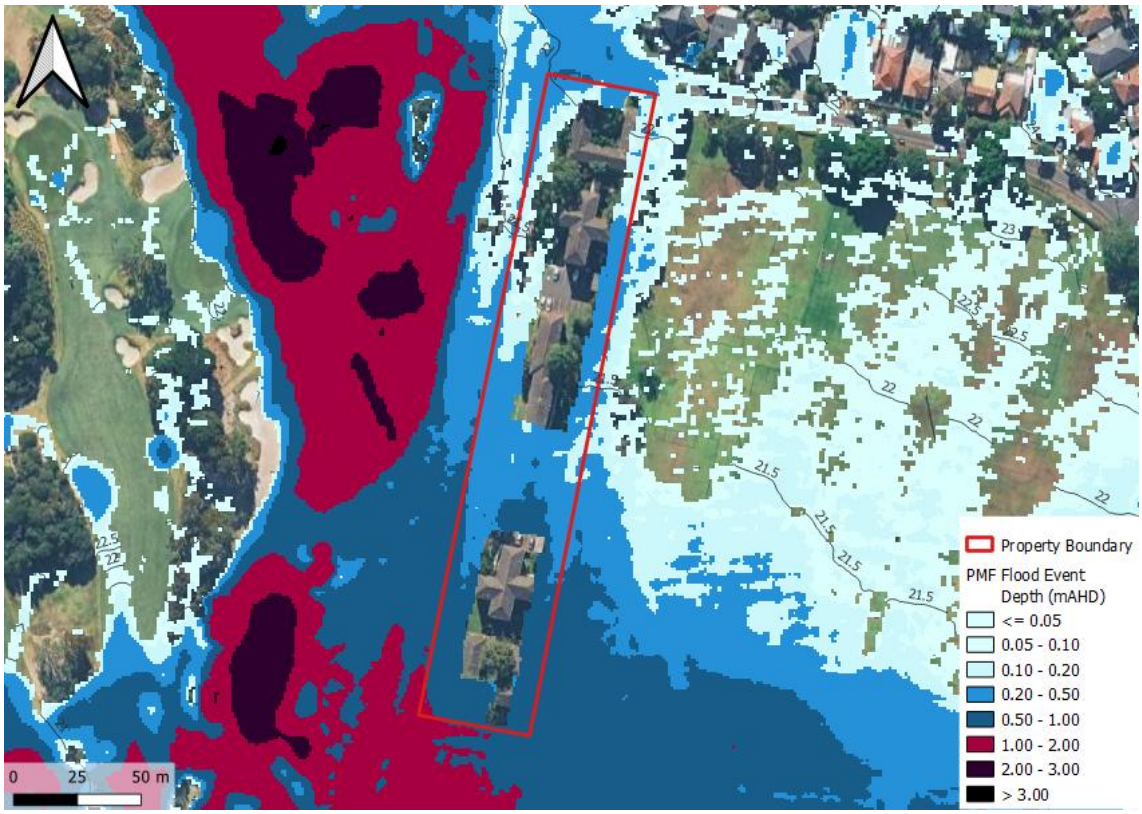
Source: SATELLITE IMAGERY © GOOGLE 2024

5.2.2.2 Probable Maximum Flood (PMF)

Flood Depths and Extents

The design case PMF flood risk shows little change from the base case with flooding present in the roads surrounding the site.

Figure 5.10: PMF Flood Depth and Extent (Design Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

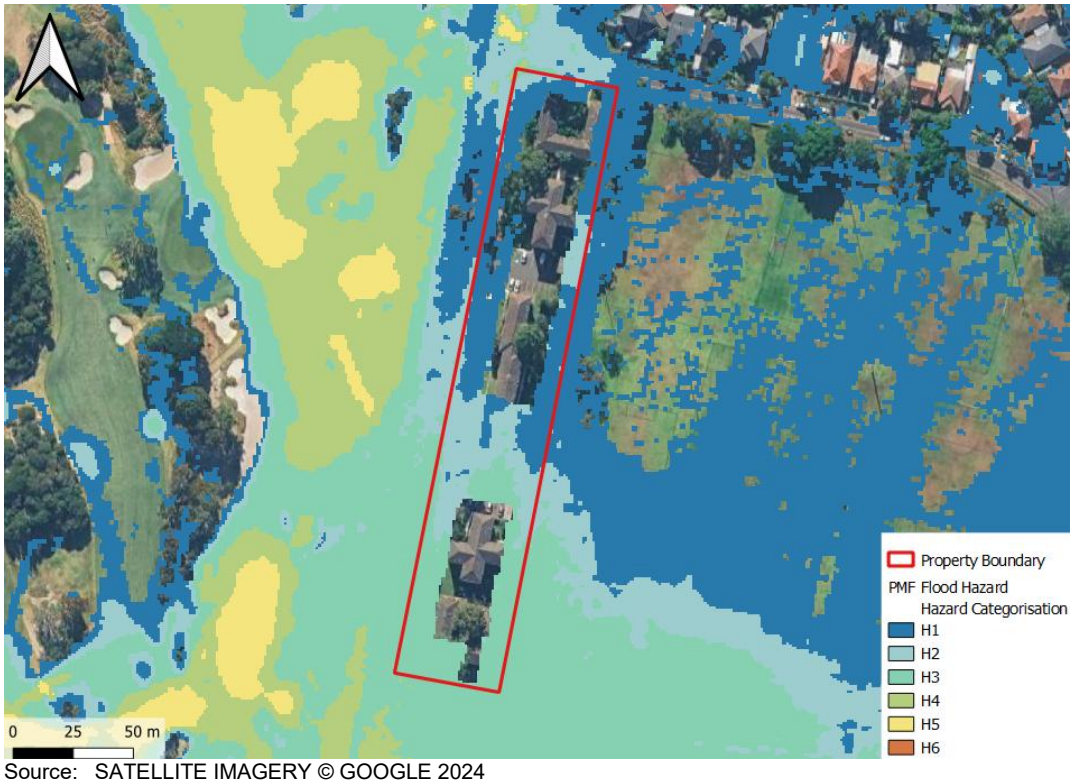
Flood Hazard

The flood hazard for the PMF remains effectively unchanged from base case, with a marginal increase from H1 to H2 within the site, particularly in the East of the Central building, where the most significant depth increases are seen in all scenarios for the site. See Figure 5.11. The velocities within the site peak at 1.5m/s at the very North East corner of the site, although rapidly reduces to less than 1m/s moving away from the roadway. The maximum velocity outside of the site boundary is North, up Banks Avenue, indicating a maximum velocity along the road of 2.8m/s.

Afflux

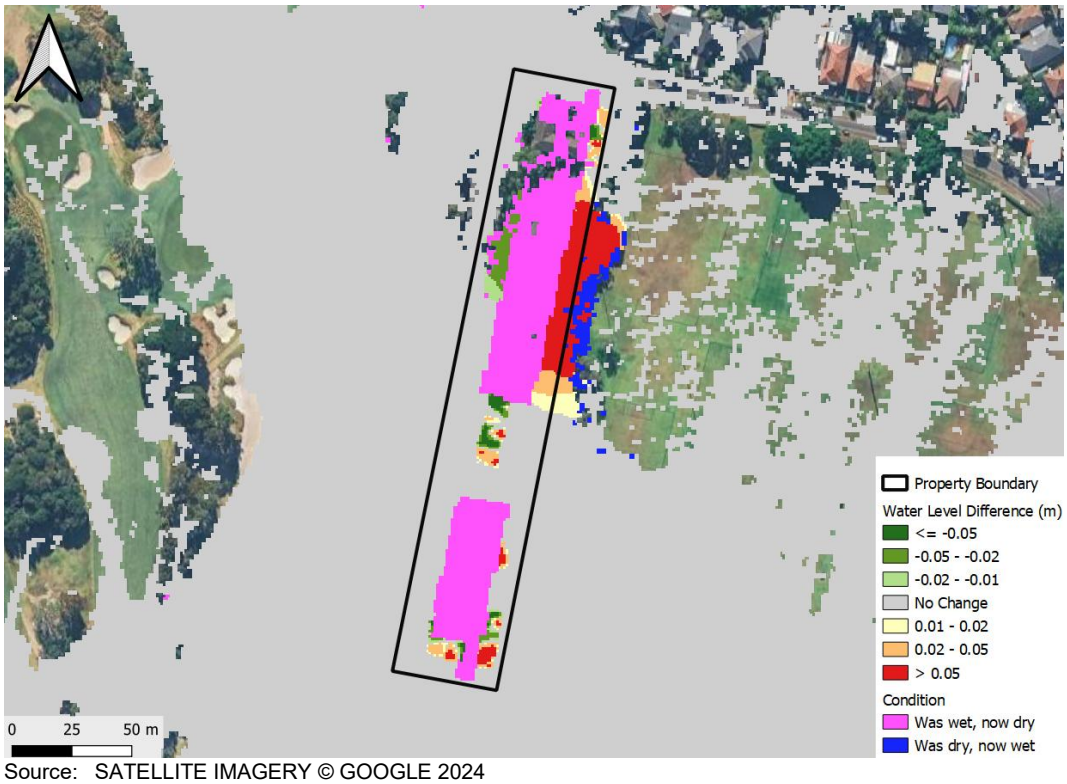
The inclusion of the development is not predicted to cause adverse changes in flooding during the PMF, as indicated by the water level difference map in Figure 5.12. The mapping shows some flood depth increases surrounding the footprint of the building, with a maximum of 155mm increase within the site boundary, again on the East side of the proposed market building.

Figure 5.11: PMF Flood Hazard (Design Case)



Source: SATELLITE IMAGERY © GOOGLE 2024

Figure 5.12: PMF Water Level Difference (Afflux)



Source: SATELLITE IMAGERY © GOOGLE 2024

5.2.2.3 Post Development Flood Impacts

The flood impact assessment has identified that there is no material change in flood risk around the site, even with the conservative approach of ignoring additional stormwater system capacity for storage.

The key outcomes of the flood assessment are summarised below:

- Changes in peak PMF water level
    - the changes in peak water level because of the development do not exceed the recommended thresholds [3]for habitable buildings or residential zoned land
    - no cumulative impacts predicted
    - no new areas of flood inundation
- Change in PMF flood velocity
    - flood water velocities are not significantly changed by the proposed development
    - there are no changes in flood water velocity outside the site boundary
- Change in PMF flood hazard
    - there are no changes in flood hazard outside the site boundary

5.3 Climate Change

Several Climate Change scenarios were modelled for the 1% AEP flood event as part of the Springvale and Floodvale DFS. The flood study adopted the following 1% AEP scenarios to assess the sensitivity to climate change:

- 0.4m rise in tailwater level in the Botany Bay
- 0.9m rise in tailwater level in Botany Bay
- 10% increase in design rainfall intensity
- 20% increase in design rainfall intensity
- 30% increase in design rainfall intensity
- Combinations of the above

The impacts of both rainfall increase and tailwater rise show a general increase in flood levels across the entire catchment. The results concluded that even in the worst-case combination, with 0.9m rise in tailwater level and 30% increase in design rainfall intensity to the 1% AEP results in approximately a 90 mm maximum increase in peak levels within the site boundary.

Based on the proposed floor levels, the water level elevation remains below the 500 mm freeboard applied in the Flood Planning Level (FPL). Therefore, projected climate change impacts would not result in a diminished flood immunity.

The guidance of the latest version of ARR (v4.2) on applying climate change relates to the consideration of Shared Socioeconomic Pathways (SSP). A range of SSPs are considered in the guidance, which is based on a range of climate modelling futures, reported in the Intergovernmental Panel on Climate Change's (IPCC) Assessment Report 6.

Using the global warming projections provided by ARR datahub for the Pagewood area, SSP2 rainfall uplifts for the 2030 to 2100 range of future horizons is 16 to 35%, applicable to short duration flooding. For the longer 12-hour duration flooding these same SSP2 rainfall uplift

[3] Recommended thresholds are available in Australian guidelines such as Austroads

projections are 11 to 24% for the 2030 to 2100 future year horizons. These projections indicate that the already assessed 10%, 20% and 30% rainfall uplifts provide a reasonable range of climate futures that are equivalents of the latest projections from ARR v4.2.

According to the latest projections after assessment of global review policy settings, SSP2 is the closest of the SSPs to the projected 2.7 degree global warming level for the end of the century[4].

5.4 Blockage

Structure blockages have the potential to substantially increase the magnitude and extent of property inundation through local increases in water level, redistribution of flows on the floodplain, and activation of additional flow paths. The design event modelling has considered both a 0% and 50% blockage factor of all stormwater drainage structures (pit inlets, pipes, culverts and bridges). Within the study area of 68 – 80 Banks Avenue, the design case model simulations indicated the 50% blockage factor produced a maximum increase in peak water level of 56mm within the site boundary compared to the unblocked design case.

5.5 Managing Flood Risks

The area around the Banks Avenue Road is significantly flood affected with regional flooding issues identified by the Springvale and Floodvale flood model. It is beyond the scope of this development to alleviate these flooding issues, however, the overall intent behind the design is to make the proposed site as resilient to flooding as is practicable.

The PMF depths along the Southern part of the site are the only area that show significantly greater flood levels than the 1% AEP dept. This limits opportunities to prevent water ingress into the basement via lift shafts and basement access in the Southern Social building. The Bayside DCP allows basement openings to be at the Flood Planning Level (1% AEP + 500 mm freeboard).

The design of the site has located basement car park ramps at suitable locations on Park Parade in the North and South which are not subject to the larger PMF depths and low flood hazard. The ramps connecting each vehicle access point from Park Parade (both the Southern social building single basement car park and Northern market dual basement car park) has been raised with a crest within the site boundary to meet the required level to mitigate flood water ingress to the basement. This complies with E3 of Table 13 within the Bayside DCP, which notes: “The crest of the driveway shall be located within the property boundary”.

The ground levels for both buildings are entirely above the level of the PMF and the new multi-storey building will be stable during flooding up to the PMF and all non-ground floor residents in multi-storey development would be only exposed to an indirect flood risk. Ultimately, the two proposed buildings at 68 – 80 Banks Avenue are still flood affected; therefore, unless evacuation is enacted prior to the onset of flooding, the safest course of action for occupants and visitors should be to remain in place in a flood event and wait for flood waters to recede.

5.5.1 Amplification of Existing Stormwater Networks

The Springvale Drain formalised pipe and pit drainage network commences along Banks Avenue and Park Parade converging at the Banks Avenue/ Heffron Road intersection where ponding across the roadway north of the intersection is expected as the drainage network is near capacity (DFS, 2014). The flood model estimates that the drainage network around the site reaches full capacity in storms as frequent as the 20% AEP (1 in 5 year storm). Therefore,

[4] https://climateactiontracker.org/global/emissions-pathways/

upgrading the capacity would require further investigation as it would likely include additional areas upstream and downstream.

The opportunity to increase the capacity of existing stormwater networks around the site within Park Parade and the intersection of Heffron Road and Banks Avenue has not been explored in this study but was reviewed as part of the FRMSP in 2019. The outcome of this was to lower a section of the Bonnie Doon golf course and add additional drainage to convey flows more rapidly to Bonnie Doon Golf course to ease drainage from Banks Avenue, resulting in a reduction in peak flood levels in the range 0.02m to 0.2m, with the greatest benefits being the residential lots where 68 – 80 Banks Avenue is situated. This has not been reviewed within this study as this would be a significant undertaking involving the Council, Sydney Water and Transport for New South Wales (TfNSW) estimated in 2019 as $7.5m and lies beyond the scope of the development project.

A similar drainage upgrade was also proposed within the FRMSP, 2019 to lower Jellicoe Park by 2.5m and provide additional drainage pits and pipes to form a retarding basin. This solution, however, was not deemed economically feasible and requires further investigation to determine its benefit.

5.5.2 Flood Detention

Building / Lot-Based Detention Options

Through the coordinated civil design of open spaces, storage volumes can be achieved through lowering ground levels within landscaped areas and recreational areas that do not serve a flood emergency management function, such as the area between the two buildings or land adjacent to Jellicoe Park and recreational areas within the precinct.

Additional flood storage is also created through integrating soft Water Sensitive Urban Design (WSUD) features which typically sit below the adjacent ground level such that these features are fed runoff water from the precinct ground level via gravity. This serves to create flood storage volumes in addition to their primary function in treating runoff water quality.

5.5.3 Water Sensitive Urban Design (WSUD)

Stormwater management design will effectively manage nuisance flooding around the precinct by introducing new stormwater network, above ground detention and/or WSUD features that can detain or convey shallow surface water flows. Examples of soft WSUD features include:

Vegetated Swales

Vegetated swales are linear features that convey stormwater along the surface within a wide, shallow channel, typically at gentle longitudinal grades (<5%). The linear form of swales makes them ideally suited to a linear environment in both rural and urban areas, as well as locations without defined drainage systems.

Bioretention / Raingardens

Bioretention basins are non-linear features that do not convey stormwater but they may be designed to provide a detention function. The basins can be a range of scales and shapes and therefore flexible in their design and location. They have the advantage of being able to be distributed throughout the precinct at regular intervals.

Permeable Pavements

Porous/permeable pavements promote infiltration through the pavement surface to a subsurface collection system or to the subsoil. Porous pavements allow for infiltration through the structure

of the material itself. Porous/permeable pavements are usually only suitable under light traffic loads but can be included in many locations such as car park and pedestrian thoroughfares.

Green Roofs

Providing green roofs will aid in reducing surface water runoff. Not only do they provide additional water storage capacity which helps reduce flood risk, but they also have other benefits such as filtering out pollutants from stormwater runoff and improving air quality in urban environments.

6 Design Recommendations

6.1 Flood Planning Levels

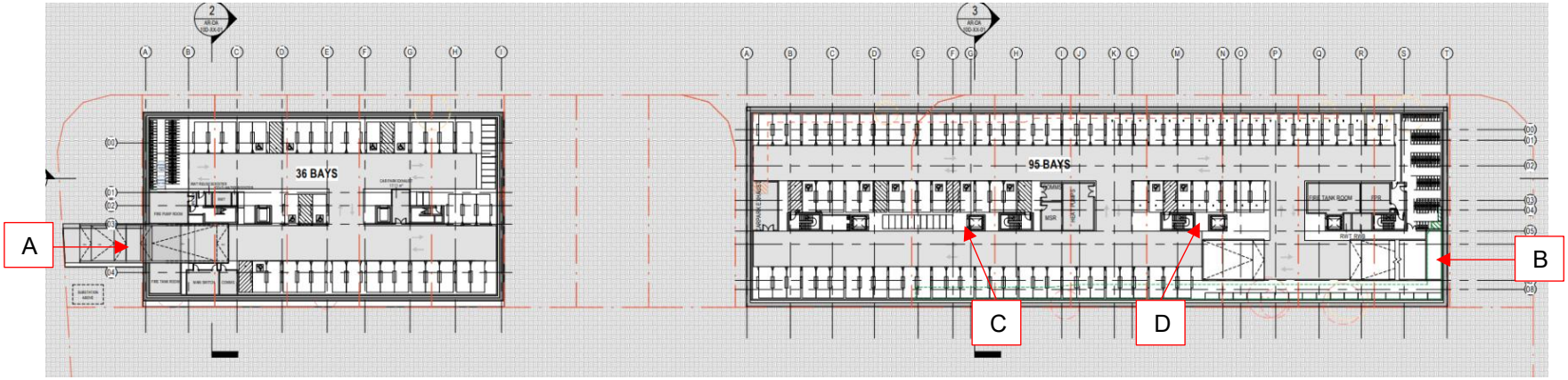
The Flood Planning Level is to be greater than or equal to the 1% AEP flood level + 500mm freeboard according, to the Bayside DCP 2022, for habitat floors and basement entries of a residential development.

Table 6.1: Flood Planning Levels

Location ID	Description	1% AEP Flood Hazard	1% AEP Water Level (mAHD)	PMF Water Level (m AHD)	1% AEP + 0.5m (mAHD)	Adopted Flood Planning Level (mAHD)
A – Park Parade	Basement Car Park Ramp/Vehicle entry and fire stair egress	Low	20.69	21.41	21.19	21.19
B - Park Parade	Basement Car Park Ramp/Vehicle entry and fire stair egress	Low	21.84	22.07	22.34	22.34
C – Lift	Basement fire egress and lift entries	Low	21.41	21.51	21.91	21.91
D – Lift	Basement fire egress and lift entries	Low	21.41	21.51	21.91	21.91
E – Banks Avenue	Lift Entries to Basement	Low	20.85	21.41	21.35	21.35
F – Jellicoe Park	Basement Fire Stair Egress	Low	20.90	21.42	21.40	21.40
G – Banks Avenue	Basement Fire stair Egress	Low	21.06	21.42	21.56	21.56
H – Banks Avenue	Basement Fire stair Egress	Low	21.17	21.43	21.67	21.67
I – Banks Avenue	Basement entry and fire stair egress	Low	21.41	21.48	21.91	21.91
J – Jellicoe Park	Basement Car Park Ramp/Vehicle entry and fire stair egress	Low	21.50	21.51	22.00	22.00
K - Park Parade	Basement Car Park Ramp/Vehicle entry and fire stair egress	Low	21.84	22.07	22.34	22.34

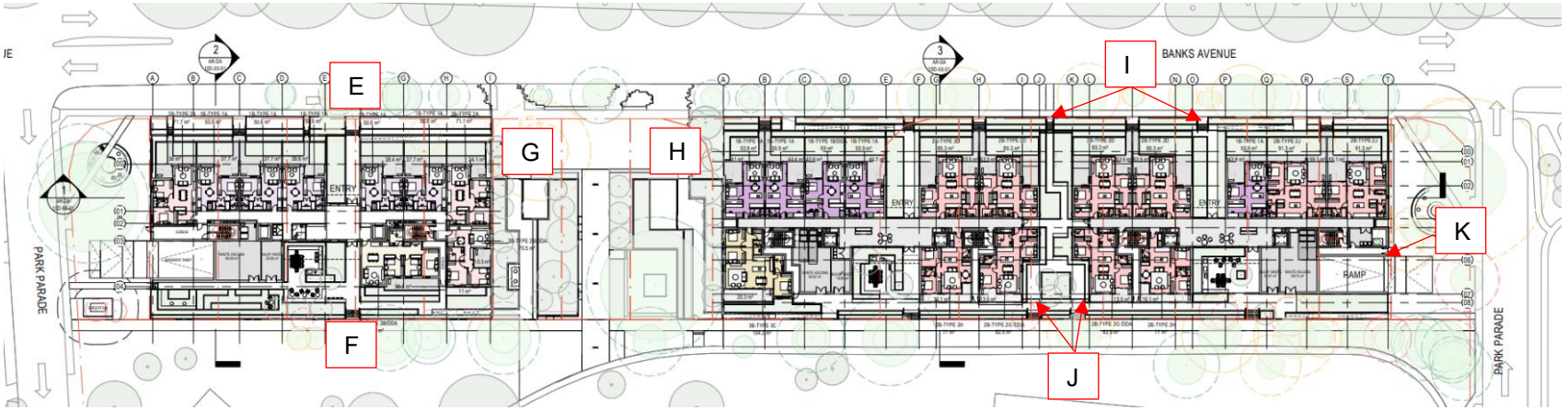
Given the proposed property sits within a low flood hazard classification for the 1% AEP flood event, there is a requirement for basement car parking to have all access and potential water entry points above the Flood Planning Level (1% AEP flood level plus 0.5m freeboard). Levels determined without reviewing the LiDAR data and may be slightly elevated, as it does not fall within the intended footprint. Ground levels are subject to variation due to changes in the surrounding landscape or adjacent level adjustments.

Figure 6.1: Basement Level - 68 - 80 Banks Avenue



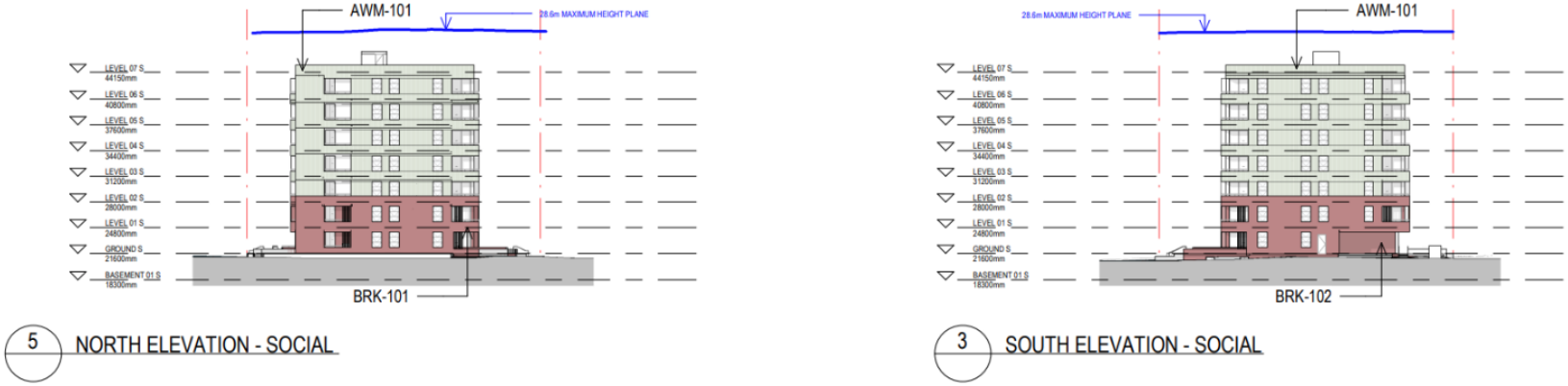
Source: BVN, 2025

Figure 6.2: Ground Level - 68 - 80 Banks Avenue



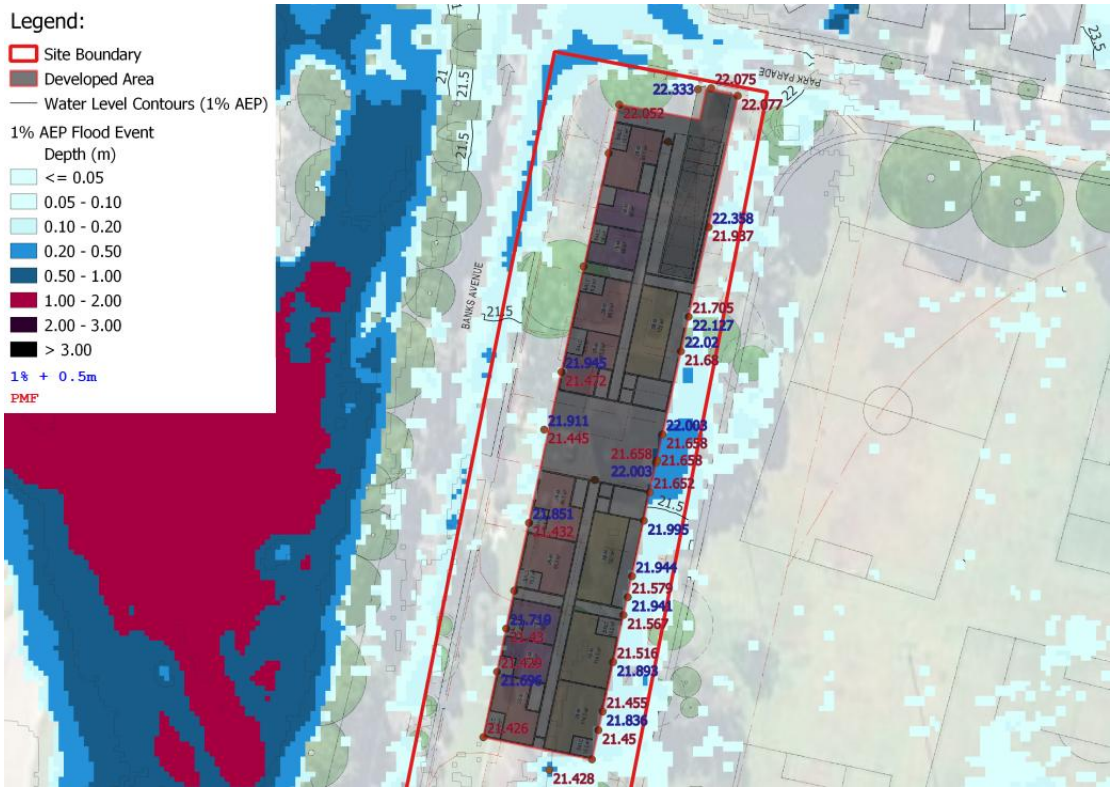
Source: BVN, 2025

Figure 6.3: 68 - 80 Banks Avenue Social and Market Building Sections



Source: BVN, 2025

Figure 6.4: Flood Planning Levels - North Market Building



Source: SATELLITE IMAGERY © GOOGLE 2024

Figure 6.5: Flood Planning Levels - South Social Housing

Source: SATELLITE IMAGERY © GOOGLE 2024

6.1.1 Habitable Floor Levels

Habitable floor levels have been set at a minimum of the Flood Planning Level as per the Bayside DCP 2022.

6.1.2 Non-Habitable Flood Levels

Table 13 of Bayside DCP 2022 states “non-habitable floor levels to be no lower than 1% AEP flood level. The minimum finished floor level of all non-habitable rooms is above the height of the 1% AEP.

6.1.3 Basement Entry Points

68 – 80 Banks Avenue has both a single (Social building) and dual basement car park (Market building) with entry to both located on either end of Park Parade (Locations A and B, Figure 6.1).

There are two primary means for water to enter the basement car park; via the vehicular entry ramps or via lift shafts that link the basement to the ground floor level (other features such as air vents may also be present in the future design, however, these have not been factored into the design at this stage).

All potential water entry points to the basement have been set to the Flood Planning Level (1% AEP + 0.5m). This is deemed acceptable to the DCP which notes “basement garages/ storage/ car parking, low-level driveways must be physically protected from inundation by floods equal to or greater than the 1% AEP flood level plus 0.5m freeboard and all access, ventilation, driveway crests and any other potential water entry points to any enclosed car parking shall be above the 1% AEP flood level plus 0.5m freeboard level”.

6.2 Flood Emergency Management

The flood emergency management (EM) strategy for 68 – 80 Banks Avenue has been assessed following advice provided in Flood risk management guideline EM01 - Support for emergency management planning (DPE 2023), Bayside Local Emergency Management Plan, 2021, relevant plans from the NSW SES and the Springvale Drain and Floodvale Drain Floodplain Risk Management Study and plan (FRMSP), 2019.

The EM01 guideline provides advice on how the flood risk management (FRM) framework and process described in the Flood risk management manual: the policy and manual for the management of flood liable land (DPE 2023) can consider and support flood EM. Emergency Management in NSW is run at three levels of scale, at a state-wide level, at a regional level, and a local level. Each subsequent level provides additional local detail in emergency management.

To help minimise the flood risk to future occupants, it is important that developments consider flood emergency response. There are two main forms of response that may be adopted:

- Evacuation
    - Horizontal evacuation of occupants from the floodplain before the properties and/or evacuation routes becomes flooded
- Shelter-in-place
    - Vertical evacuation of occupants in a building to a level higher than the PMF level who then shelter from the flood until it is safe to return to the ground floor and external areas

6.3 Emergency Planning

It has been established that roads around the site are at risk of flash flooding as critical storm durations cause inundation within less than 2 hours up to high hazard level, see Figure 3.1. Inundation caused by flash flooding can occur with little or no warning and cause a rapid rise in water level over a brief period of time. Flood events of this nature do not last more than a few hours.

Severe storms can arrive with little warning or intensify over a short period of time posing a challenge to evacuation as an EM strategy. An EM strategy for the site has been considered for two separate time periods with the emphasis of self-preparation and self-evacuation:

- The period of time prior to the arrival of a storm when surrounding roads are free from flooding.
- The period of time during and after the storm when surrounding roads may be inundated.

6.3.1 Emergency Management Strategy – Prior to Storm

SES advises that when flash flooding is likely, the best action to take is to leave low-lying homes and businesses (evacuation) well before flooding begins, but only if it is safe to do so. This self-evacuation would need to take place in the hours preceding a predicted storm event before flooding begins to impact the road network.

There are no evacuation centres identified within the NSW State Flood Sub Plans, FRMSP or NSW State Emergency Management Plan (EMPlan). It is recommended that evacuation centres for flood events be reviewed and updated for use in all types of emergencies.

The surrounding arterial roads do not provide the means of moving to safer locations, whether that is the nominated evacuation centre or away from a forecasted storm area. Evacuation centres are set up at the discretion of the SES incident controller, however, they may not be operating or may take time to get up and running in the event of a flash flood.

Enacting this strategy would require local monitoring of forecasts issued by Bureau of Meteorology (BoM), including the daily Thunderstorm Forecast and the more specific Regional Severe Thunderstorm Warning and Detailed Severe Thunderstorm Warnings. This could be undertaken by a nominated flood warden for the precinct via the PA system for the buildings.

The forecasts have the following approximate lead times:

- Thunderstorm Forecast
  - 24-48 hours – forecasts likelihood of severe thunderstorms developing across NSW from ‘possible’ through to ‘likely’
  - if the forecast indicates severe thunderstorms are likely then advice should be issued to residents to prepare accordingly. This may entail more active monitoring of BoM forecasts, activating a Home FloodSafe Plan, preparing their property (if located on ground floor) or preparing to self-evacuate

- Regional Severe Thunderstorm Warning
  - 3 hours - forecasts broad areas where severe thunderstorms are occurring or may occur in the next 3 hours
  - the regional warning indicates severe storms are likely, giving less than three hours warning. This time period is the last feasible window where occupants could evacuate to safer areas prior to the storm arriving. However, due to local storm activity and storm tracks, arterial roads surrounding the precinct area may already be affected by flooding

  - a previous state of readiness should allow the rapid mobilisation to evacuate to a nearby hub or to seek shelter in higher parts of the buildings prior to the arrival of a severe storm

- Detailed Severe Thunderstorm Warning
  - less than 60 minutes - detailed warnings are issued when individual severe thunderstorms are within range of the city weather radars
  - they indicate the forecast direction of movement for 60 minutes and immediate Threat Area ahead of the storm
  - if the Detailed Severe Thunderstorm Warning or Threat Area encompasses the site of 68 – 80 Banks Avenue then it is likely too late to safely evacuate before the storm arrives

6.3.2 Emergency Management Strategy – Evacuations during a Storm

68 - 80 Banks Avenue is located in an area of flooding concern. It is noted that the rate of rise, resulting flood depths and the size of the floodplain would make it unsafe to evacuate through the surrounding roads during a storm.

Evacuation by either vehicle or on foot from this area will be difficult for affected occupants. SES and emergency access to the site during flooding may also be difficult as it is adjacent to the roads within areas of the floodplain with significant flood depths. Due to these problems special shelter-in-place provisions should be provided as the primary evacuation method if conditions to not allow for safe horizontal evacuation to higher, non-inundated roads.

The Springvale and Floodvale FRMSP highlights that “the short warning time, rapid rate of rise and short duration of flooding in the catchment mean evacuation improvements would have little benefit, and focus should be placed on education and preparedness”, reinforcing the need for a shelter in place strategy.

6.3.3 Emergency Management Strategy – Shelter in Place (SIP) during a Storm

NSW SES StormSafe advises the following during a storm:

- never enter or travel through floodwater,
- stay indoors,
- stay clear of creeks, drains, causeways, gutter and streams.

Section 5.1.7 in the NSW State Flood Plan describes Shelter in Place (SIP) is an appropriate strategy to be considered where significant constraints to evacuation exist. Shelter-in-place is determined as a refuge occurring above the PMF level and may occur when there is a risk to public safety and other means of evacuation are not possible.

6.3.4 Compatibility with Shelter in Place Guideline for Flash Flooding

The Shelter in place (SIP) guideline for flash flooding (DPHI 2025) indicates that SIP is a suitable emergency management strategy for development proposed in flash flood environments. Table 6.1 outlines the decision-making process for 68 – 80 Banks Avenue, based on the advice provided in the Shelter in place guideline for flash flooding.

Table 6.2: Compatibility with Shelter in Place Guideline

Shelter in Place Consideration	Decision	Relevant FIRA Section
Understanding the full range of flood behaviour up to and including the PMF	A range of storms has been assessed to understand the range of flood behaviour from minor (10% AEP) to major (1% AEP) and the PMF	5
Does shelter in place align with existing emergency management strategies for the area	Yes – There is no formal evacuation procedure or routes identified for the site, other than those proposed in the NSW SES Local Flood Plan (2023)	6.3.1
Has evacuation off-site (the primary emergency management strategy) been investigated and determined to be unachievable	Yes – Access has been investigated and is unachievable in both 1% and PMF events.	6.3.2
Does the development include medical centres, emergency service and community facilities, and sensitive and hazardous land uses, some of which may not be suitable for shelter in place	No	6.3.2
Shelter in place for greenfield development is not supported	The site is not a greenfield development	1.3
Whether there is existing government developed flood warning systems that give advanced detailed forecasts of flash flooding to allow sufficient time to evacuate to the proposed refuge locations	Due to the flash flood nature of 68 – 80 Banks Avenue, warning times are limited, especially during rapidly rising events. There is no evidence of sufficient warning time (FRMSP, 2019).	6.3.1
Can the community effectively be informed of the risks associated with the emergency management strategy	Yes	6.3.1, Springvale and Floodvale Floodplain Risk Management Study and Plan Review
Detailed assessment of evacuation off-site (the primary emergency management strategy) to determine that evacuation off-site is not achievable	Yes, the surrounding road networks are not free from flooding.	6.3
Flash flooding is the only flood risk present at the site	Yes, critical storm durations are up to 6 hours for the site	2.2

6.3.5 Emergency management strategy – Residual risks

6.3.5.1 Education

Community awareness of flooding is a significant issue within the floodplain due to the infrequency of severe floods and the anticipated depths of these floods in a PMF event. The Precinct Manager need to be aware of the flood risk and their obligation to evacuate the basement car park and ground floor levels when inundation begins to occur. Residents need to be aware of the flood risk and the response requirement during a PMF flood event. As part of this procedure, evacuation drills should be conducted regularly to ensure residents are aware of the procedures for sheltering within the site.

6.3.5.2 PA System

The building PA system can be used to communicate evacuation directions and safety messages to the population in the lead-up to and during a flood to assist in improving the safety of the community.

6.3.5.3 Medium and high-density residential buildings

Make buildings as safe as possible to occupy during flood events. An area of habitable floor of any residential development should be located above the PMF with the building structurally designed for the likely flood and debris impacts. The buildings should include:

- Alternative power source, with capacity for at least 8h for essential needs
- Automatic fire suppression systems
- Emergency telecommunication system
- Toilet facilities accessible to people with disabilities
- First-aid kit
- Emergency supplies kit
- Shelf-stable food

6.3.6 Emergency Management Considerations

Table 6.3 details key considerations and the advised outcomes related to each flood risk emergency management.

Table 6.3: Emergency Management Considerations

Shelter in Place Consideration	Decision and Evidence	Relevant FIRA Section	Outcome
Is warning time available to onset of flooding?	No - The time to flooding and flood duration are typically very short with minimal warning time. Critical storm durations in the catchment are less than 6 hours with flood warnings limited to severe weather warnings for the area and no specific advice on local impacts of flash flooding	6.3.1	Unable to evacuate in rapid onset event
Can development be modified to allow evacuation?	No	6.3.2	No requirement for stormwater drainage system amendments, outcome should revolve around safe evacuation either to a communal location outside the floodplain or shelter in place.
Is time of isolation short?	The period of worst-case inundation in the area surrounding the site is within 12 hours	6.3.1	Consider development types and apply controls
Are occupants able to be safe and self-sufficient for duration of flooding	Yes - FPLs are designed to keep the buildings free from flooding under the most extreme circumstances Flood-free areas exist within the precinct that could be used as muster points in the event of a flood emergency	6.1	Consider development types and apply controls
Are residual risks associated with SIP tolerable	Yes - Low flood hazard predicted within the precinct during the most extreme storms FPLs are designed to keep the buildings and below ground car parks free from flooding under the most extreme circumstances Flood-free areas located within the precinct could be used as a muster point or shelter location Building PA system can be used to relay emergency information to residents	6.1 6.3.5	Consider development types and apply controls

6.4 Compatibility with Design Controls

The Design Recommendations within this FIRA have been proposed to meet the requirements of the Design Controls applicable to the site. A summary of the site compatibility is presented below:

- The NSW Flood Prone Land 2021 package notes a planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Environmental Protection Zones to a Residential, Business, Industrial or Special Purpose Zones. These land use changes represent a change in land use which could potentially increase flood risk
    - The SSD does not propose changes to any land zoned as Recreation, Rural, Special Purpose or Environmental Protection Zones
    - The zoning will remain as Residential, under which residential flats are permitted in both the existing and the proposed zones. The main purpose of the SSD is to increase the permissible density of the land for the purpose of affordable housing.
- This FIRA has been undertaken in accordance with the NSW Government's Flood Prone Land Policy and the principles of the Flood Risk Management Manual

The precinct enables the increase in density in line with endorsed NSW Government strategies. While the NSW Flood Prone Land 2021 package notes a planning proposal must not permit a significant increase in development density, the proposed intensification of the proposed site at 68 – 80 Banks Avenue is required to accommodate the additional residents in Pagewood over the near future. The proposed intensification will be in the form of vertical development with maximum height and Floor Space Ratio (FSR) increases to accommodate the growing population.

It is possible that direct flood risk to any person could be reduced by implementing the design recommendations and that the residual flood risk could be also reduced. To summarise:

- **Intensification within a brownfield site,**
    - This type of development can elevate the higher risk residential use above the PMF level and can make allowance for shelter-in-place refuge and vertical evacuation which is considered an improvement on the current flood exposure.
    - Intensified development offers more shelter-in-place opportunities as it will likely provide more floor space for refuge above the PMF level compared to the existing residential dwellings.
    - The expected number of persons located on ground floors can be limited to current occupation or increased if the raised ground floor level reduces the risk to future occupants.
- **FPL requirements and other Development Controls,**
    - The Upper Ground level and all first-floor storeys would be above the PMF level in most instances.
    - It is expected that new multi-storey buildings will be stable during flooding up to the PMF and that all non-ground floor residents in multi-storey residential development would be only exposed to an indirect flood risk.

- **Implementation of Flood Emergency Response Plan (FERP),**
    - A developed site specific FERP could address the flood risk faced directly and indirectly by future residents in contrast to the flood risks faced by existing residents in flood affected locations. It is likely most of these properties have no established site-based flood emergency response plan.
    - It is conceivable that a high-rise residential development with an effective flood emergency response plan and vertical evacuation opportunities may have a lower residual flood risk than existing housing limited opportunities for vertical evacuation.

6.5 Summary of Flood Emergency Management

Section 6.3 outlines the relative flood risk that the site at 68 – 80 Banks Avenue is exposed to. The site is affected by flash flooding caused by overland flows within the surrounding highly urbanised catchment. This flooding characteristic is a product of the short times associated with flash flood events, the speeds and depths associated with these events, and difficulties associated with evacuation to a safe location.

In flash flood catchments, the onset of flooding and flood duration are typically short with minimal warning time. Warnings to the community are often limited to severe weather warnings or flood watches for the general area. There is often no specific advice available on the local impacts of flash flooding and there may be little time between the start of flood-producing rainfall and flooding of roads, property and potentially buildings.

To help minimise the flood risk to future occupants, the first response that should be adopted in a flood emergency event for 68 – 80 Banks Avenue should be to follow the directions of emergency responders during flooding events, in the absence of this information and as a reasonable contingency to this plan shelter in place has also been considered suitable as the flood warning time and flood duration are both less than six hours for the site. Flooding along Banks Avenue and Park Parade also limits the horizontal evacuation potential for the area, whereas vertical evacuation is possible within the site due to resilience up to and including the PMF storm event within the proposed development. The lack of pre-determined evacuation locations and the rapid onset of flooding in the catchment leads to sheltering being the most suitable means of emergency management, as a contingency in the absence of any advised alternate information on emergency response.

7 Conclusions

This FIRA has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) issued by the Department of Planning, Housing and Infrastructure (DPHI) for the subject SSDA.

The Springvale and Floodvale Flood Risk Management Study was made available for this flood impact and risk assessment. The model was developed using TUFLOW in 2012 by BMT WBM and reviewed in 2014 and received by Mott MacDonald. It is the current Council adopted model for the catchment.

The Flood Risk SEAR requests a FIRA for the site (Table 1.1) to support the SSDA in accordance with the principles of the Flood Risk Management Manual and Flood Risk Management Guideline LU01.

Flood model scenarios for 68 – 80 Banks Avenue were based on the following:

- Existing conditions:
    - An assessment of the current flooding conditions based on the existing survey of the site.
- Design conditions with mitigation measures:
    - An amendment to the existing conditions model was built to incorporate the proposed development layout as building block-outs.

The 10% AEP, 1% AEP and PMF have been assessed as they relate to the Bayside DCP 2022 Flood Planning Levels and emergency management measures for the development. The PMF is the largest flood that could theoretically occur at a location and defines the maximum extent of flood-prone land. Dry areas above the PMF level are expected to be free from flooding under all scenarios.

There is flooding predicted within the site and surrounding roads of 68 – 80 Banks Avenue. The stormwater networks have relatively low capacity (typically less than 20% AEP) with excess flows being conveyed along adjacent roads to the lowest part of the catchment both within the nearby Bonnie Doon Golf club and intersection between Banks Avenue and Heffron Road. This includes main flow routes along Banks Avenue. 1% AEP flood depths in the precinct of the proposed development are typically up to 350 mm with this value increasing along Banks Avenue and Park Parade as highlighted in Section 5.2.

To represent 68 – 80 Banks Avenue post development case, a new building block out was included in the model covering the proposed site. This assumes that the site will be immune from flooding in the 1% AEP storm by adopting the Council Flood Planning Level (1% AEP + 500 mm freeboard).

The flood model highlights the following:

- Changes in peak 1% AEP water level
    - the changes in peak water level because of the development do not exceed the recommended thresholds for habitable buildings or residential zoned land
    - No cumulative impacts predicted
    - there is no new flooding to existing properties
- Changes in peak 1% AEP flow:

  - the changes in peak flow are negligible
- Change in 1% AEP flood velocity
  - flood water velocities are insignificantly changed by the proposed development
  - there are no changes in flood water velocity outside the site boundary
- Change in 1% AEP flood hazard
  - there are no changes in flood hazard outside the site boundary. The flood emergency management (EM) strategy for the site has been assessed following advice provided in Flood risk management guideline EM01 - Support for emergency management planning (DPE 2023) and relevant plans from the NSW SES.
- Changes in peak PMF water level
  - the changes in peak water level because of the development do not exceed the recommended thresholds for habitable buildings or residential zoned land
  - no cumulative impacts predicted
  - no new areas of flood inundation
- Change in PMF flood velocity
  - flood water velocities are not significantly changed by the proposed development
  - there are no changes in flood water velocity outside the site boundary
- Change in PMF flood hazard
  - there are no changes in flood hazard outside the site boundary

Aspects of this development are required to meet flood related development controls, and the key risks as addressed through design are noted here:

Flood Levels and Appropriate Immunity

The design Flood Levels in Table 6.1 highlight the minimum required floor levels to appease this requirement. According to the development-specific advice and development controls of the Council relating to the habitable rooms, 1% AEP + 0.5m freeboard is required to meet the Bayside Council Flood Policy to enable a level of flood resilience for the residences and provide a reasonable level of flood mitigation. The proposed minimum entrance levels being 21.56 m AHD for the Social building and 22.34 m AHD for the market building habitable floor levels and basement car park entrances/stairways. As noted on the architectural drawings, the habitable floor levels of 21.6 m AHD for the Social building and 22.40 m AHD fully comply with the required habitable floor levels and vehicle access ramp levels from both Bayside Council's LEP 2021 and DCP 2022 requirements and FIRA guidance.

Emergency and potential evacuation during flood events

The required emergency and potential evacuation during flooding events for the site have been considered regarding both the severity of flooding and duration of flooding events. The site is affected by overland flow flooding and there is risk of extended periods of flood risk that could lead to isolation or a need for prior preparations of flooding provisions in the modelled 1% AEP event which showed critical durations of 12 hours.

Based on this FIRA and the Springvale and Floodvale Flood Risk Management Study, an evacuation strategy and a shelter in place policy during a flood emergency can be effectively implement over the lifecycle of the development as it is the most feasible EM approach to protect life, given the following constraints:

- The roads surrounding the site are partially at risk from flash flooding; flooding that has a relatively high discharge over a short duration – the interval between the observable

causative event and the flood is less than six hours. Given, if the site does have sufficient warning time to adequately evacuate the population of the precinct, this should be preferable, however it should be made clear that:

  - The opportunities for horizontal evacuation during a storm are limited as surrounding streets such as the intersection between Banks Avenue and Heffron Road are subject to H2-H4 flood hazards that present an unacceptable risk to people and vehicles. NSW SES advice is not to venture out during a storm or cross any area of flood inundation.
  - The rate of rise and extent of flooding in the most extreme events means that emergency evacuation centres may not get set up and evacuees would generally have to take shelter in other private premises that may not have robust flood controls.

- The time of isolation is short, based on the duration of flooding around the precinct. A development which is isolated for a few hours by flood water in PMF does not pose a significant risk to life:
  - Redevelopment affords a means of creating a safe, on-site shelter above the PMF – redevelopment which caters for sheltering in place can be used to reduce existing risk to life for individuals who currently occupy the floodplain, but it is likely to increase the number of individuals at risk.

- Additional Development Controls can be imposed which seek to manage the residual secondary risks to life caused by flood isolation to ensure that risks remain tolerable. To manage secondary risks during flooding, Bayside council should consult NSW SES, Ambulance NSW, the relevant Health functional area and the local fire agency to identify appropriate risk mitigation measures. As no area-wide strategy exists, plans must address these risks for the entire flood duration and up to 48 hours afterwards to allow restoration of external services.